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Contents
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THEORETICAL, REGULATORY AND PRACTICAL IMPLICATIONS OF LOGISTICS

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ABSTRACT. Background: The logistics has its practical input in creating economical strategies as well as in creating modern economic environment. Processes of planning, designing and functioning of logistic systems must be based both on the theoretical knowledge covering various areas as well as practical experiences to provide the required support. To provide logistic services in the rational way, it is necessary to learn the complicated set of implications resulting from three areas covering the theoretical knowledge, practical ones as well as the regulation by the law.

Methods: The triad of three concepts: theory, practice and regulation is the main area of consideration in relation to tasks of the logistic support provided by any organization for any production process. The aim of this paper focuses on the necessity of taking into account implications among theory, practice and regulation during the process of analyzing, designing and implementation of systems of the logistic support. The lack of awareness of differences between various implications or ignoring them must lead to irrational behaviors.

Results: The implications among theory, practice and legislative regulation of logistics presented differently than usually, broaden the logistic knowledge and at the same time provide the tool of the rationalization of logistic services in all kinds of activities.

Conclusions: The correct identification of tasks and functions of the logistics leads to the recognition of its subject and tasks and correct identification of implications occurring among theory, practice and regulation. This knowledge is indispensable in the process of creation of projects of logistic services of each activity, both business and non-business one.

Key words: logistic support model, implications among theory, practice and regulation, rationalization of logistic activities.

INTRODUCTION

The triad of three concepts: theory, practice and regulation, being the main subject of this paper, creates the excellent platform for contemplation to learn the essence of the logistics as well as its functions in economic and social systems.

The implications describe logical relationships between phenomena (in pairs), where one of them implicates the other one. The implication means assigning a feature to something or resulting in something. Hence in relation to the subject discussed, it means that the logistic practice originates from the theory of the logistics as well as from regulations of legal, organizational, technical or technological nature, which determine the final scope and the character of possibilities of the implementation of logistics. Additionally, the theory, i.e. the logistic knowledge results from the experience and the practice as well as from accepted regulations, which determine the conditions of the logistics support for any activity (e.g. Highway Code, regulations for environmental protection). Therefore the concepts of theory, practice and regulation in relation to the logistics create pairs of mutual logical

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relationships. The theory determines the practice, but also requires specific regulations by the law, which enables the implementation of the logistics. On the other hand, the practice implicates the development of the theory but also some agreements of the organizational and legal nature of logistic processes. Therefore the concepts of theory, practice and regulation create logical relationships, which could be expressed not only but a conjunction *and* but also by: *also*, *but*, *although*, *despite*, *then.* Due to occurring implications, the specific features can be assigned to the logistics.

The logistics has its own practical input in creating of economic strategies as well as modern economic environments. It is conducted by various applications of organizational, technical, technological and optimizing solutions of logistic processes and systems, directly based on the theoretical knowledge covering various scientific fields. The effective realization of logistic tasks in logistic systems cannot be obtained without legal regulations at every level of the social and economic system - starting from global level (e.g. interoperational issues in transport), especially at the level of international organizations, through national and regional regulations (existing economic and trade law), as well as legal regulations and procedures defined at the level of individual business and non-business organizations.

The aim of this paper is to point out the necessity of analyzing, designing and implementation of systems of the logistic support, which takes into account implications occurring between theory, practice and legal regulations. The methods of understanding of the essence of the logistics and its significance in the practice, is the foundation of the development of existing and creating of new more rational implications between theory, practice and regulation in logistics. Due to the restricted possibilities to present this subject (in the form of this paper) in broader context and all dependences, the aim of this paper is mainly to present the framework of this problem. The Author expresses the hope, that by adding his remarks and comments to the discussion on the fundamental basis of the logistics, he will increase this discussion by proposing to look at objects and functions of logistics through the mutual relationships of theory, practice and regulation.

AIMS AND FUNCTIONS OF LOGISTICS

Before making an attempt to interpret relationships given in the title of this paper, it is necessary to refer to some essential assumptions of the essence of the logistics, which are primary and fundamental to any other considerations, both of the theoretical and practical nature. Due to the fact, that they are already well described in other Author's publications [Chaberek 2000, Chaberek 2002, Chaberek 2006], their presentation in this paper will be limited only to pointing out most important threads:

– whether each transport or warehouse activity can be treated sensu stricto as the logistic activity. The second question concerns the word *right*, which is used by describing aims of the logistics, because the aim of the logistics is: to provide right resources, in right quantities, in right locations, of right quality, in right time and with right cost (6R rule). Therefore, what determines the subject and the scope of features included in aims of the logistics, how the values of these "indicators" should be evaluated. These questions lead to the assumption that the logistic process can be discussed only as a process supporting other process, original to the logistic one. At first, there is a need, the fulfillment of which requires the production of a specific good or service. The intention to produce a specific good determines the kind and the quantity of resources required for the production of this good. As mentioned above, activities related to physical obtaining of specific resources are the subject of the logistic process. Therefore the relationship between the production process (described as a primary one) and activities supporting this process within the logistic process defines the conditions of aims of the logistics, described by word "right" as fully measurable and being able to be identified. Only using such definition of relationships between these processes, it can express costs, lead-time, required quantity of resources, etc. in a measurable way. The subject of the logistics cannot and should not be identified only by the type of realized activities, especially as a sum of bigger or smaller numbers of such processes as transport, warehousing or handling, even if the postulate of the adequate level of their integration in one logistic process is taken into account.

- it should be pointed out, that such activities as transport, warehousing or handling are market goods themselves and therefore they are the subject of market exchange. Logisticians, owners of logistics processes of the company, responsible for the proper logistic support for production processes in their companies, have a choice: either to conduct tasks based on the sourcing model or to use the outsourcing solutions. In this way, the demand on the market of logistic services starts to occur. It is fully covered thanks to the rule of supply and demand for such services as transport, warehousing, crossdocking or even whole packets of such services. The behavior of suppliers of logistic services are of a classic type, like any other participant of the market. The utilization of economic situation and possible business is always the most important issue. Business effects depend directly on the level of the adjustment of these goods (realized logistic services) to clients' requirements (real owners of logistic processes). The fundamental aims of the logistics, described as 6R, have a form of concrete expectations of recipients of logistic services. On the other side, providers of these services operating on the developed market, try to recognize the requirements of their potential clients and to adapt their logistic services to the market demand and even more, they try to create the competitive offer regarding the scope of services, their quality or the price. The logistic company acts as any other company on the market. The logistic operators do not create any real logistic functions, but only response to the demand and eventually they create this demand both in marketing and in real sphere.
- The logistic company, which conducts its own production process of logistic services, requires also the logistic support. Therefore we have an analogical universal model - there is a basic process (production of transport service, warehousing service, etc.) and it requires the logistic support according to 6R rule. These processes also require the analogical logistic support. For example, classical resources necessary to the production of the transport service are fuel, tires, loading devices, navigation devices, drivers, etc. The assurance of their provision determines the main process (in this case - providing transport services).
- The logistics has always a supporting function in the relation to other process, which is the main one (primary in the relation to the logistic process). There is no logistics, no need for logistic services without another process, which is primary to the logistic process. The main process determines the scope of required services, provided by the logistics. The supporting activities can be defined only in relation to the main production process. The supporting activities provide right resources, in right time, in right location, in right quantities, of right quality and in right prices (6R). The rule 6R without the main process and its requirements becomes only an empty slogan.
- Beside the service function, the integration function of the logistics is also an important one. Although it was already defined many times, the interpretations of this definition do not touch the crux of the matter. The integration function of the logistics can be rightly compared to the role of interfaces. The logistics can be compared to functions of interface between the main process and the process responsible for providing the real physical access to necessary resources to conduct the main process. Therefore it leads to the function of "fitting" two processes to each other: the main one (production) and the other one, responsible for providing indispensable resources for the main process. This is a particularly important function of the modern logistics. The method and the range of its fulfillment forejudges about the competitiveness of many markets and economic systems. It is worth to mentioned, that the clear symptoms are observed, that this function undergoes also economic market rules. At present, the development of the new branch of logistic services can be observed. The good example of this situation can be the developing function of the logistic *orchestrator*, as a real logistic offer of the

complex logistics services, connected with providing the whole range of logistic services to the third party [Chaberek, Trzuskawska-Grzesinska, 2011].

Taking into consideration the above mentioned remarks, it should be declared that the logistics is a process, which provides services of any rational activity of human being, aiming to any given goal, and which consists in providing required resources in right place and time, in right quantities and of right quality and for right price in such a way, that the whole scope of activities aimed to reach the main goal is realized in effective, efficient and beneficial way.

To conduct each process, it is necessary to possess right tools, methods and techniques. So, looking at the logistic components from the system point of view, it can be stated, that the logistics covers both logistic processes as well as logistic systems, required to conduct these processes. They assure services to any human activity, resulting in the production of material and immaterial goods by providing right resources in right location and time, in right quantity of right quality and having the acceptable cost (price) of their production in the integrated method under condition that the whole scope of these activities should be conducted at minimum costs and giving the maximum satisfaction of the final consumer.

The subject and tasks of the logistics presented in this way, reflects the commonness of logistic activities. The reason of this commonness is logistic services for production processes (also in non-business area), in and outside the company and for each organizational structure: governmental one, local one, household or non-profit organization. The logistic support is indispensable in processes, which lead to cover any human demand. Each type of these activities requires specific resources, in right place and time, in right quantities and by acceptable cost (price). Moreover, this commonness should be related also to the fact, that logistics is necessary in every step of the main process, in case of the production process - also in the phase of supplying, production and distribution.

INTERDISCIPLINARY IMPLICATIONS OF LOGISTICS

As it results from above mentioned considerations, the service tasks of the logistics are conducted by planning and organizing of logistic processes. The structure of logistic processes is analogical to any other business production process. Therefore for the management and optimizing these processes, the broad range of tools is accessible: identification, description, modeling, rationalizing. This knowledge could and should be enriched and broaden together with the development of other sciences and theories. The logistics should utilize the whole range of the scientific output, which is its natural environment but also look for inspirations in other sciences. It is a fundamental condition of the development of the logistics. The significant remark of M.Ciesielski [2004] should be cited here, that the logistics uses the knowledge from various scientific areas (praxeology, economy, management, cybernetics and IT) and theory (network theory, transaction costs theory, relations theory, system theory, resources theory).

There are many subsequent features of logistics, specific for other sciences and theories [Długosz 2000]. The assumptions, contents and methods of individual concepts penetrate each other and therefore create a set, difficult to be split out. This set could be described by a specific interference. Logistic processes must be conducted in an effective and efficient way and therefore the whole knowledge covering various areas must be used in the integrated way. The praxeology provides the polarization of these multi-aspect relationships. From the praxeology point of view, the logistic activity will be more effective when it will be more adjusted to the main process. Therefore the efficiency of the logistics support can be presented as a sum of various detailed indicators like: efficiency, economy, productivity, savings, and rationality. These indicators always compare some values but at the same time they are always in relation to the goal (in this case - to goals of logistic support of specific main process) [Pszczołowski 1982]. The acceptance of praxelogical foundations of the scientific description of the logistics allows creating a few important conclusions, very significant both of theoretical and practical points of view [more information in Chaberek, Karwacka 2011]:

- the decision whether the logistic activity was successful or not, can be evaluated only when the goal of this activity is strictly defined and the real effect of this activity was obtained. Therefore the activity is efficient when it leads to the intended goal [Pszczołowski 1982, Kotarbiński 2000]. If the intended goals of logistic activity are not reached, it means that the appropriate resources for the given main process were not provided in right qualities, in right time and place, which means, this activity was not successful. Therefore it can be concluded, that the measure of the efficiency is the progress of reaching goals (reaching or allowing reaching them). But this criterion of efficiency cannot be used in case of logistic activities. If the logistic support of a specific main process, does not fulfill the criterion of providing indispensable resources in time, place and quantity required for the main process (in defined conditions), then this activity is not sensu stricto a logistic activity (from a point of view of the logistics' definition), because it will have always a negative (improper) influence on the main process. The above mentioned conclusions are not referred to the estimation of the efficiency of the main process. The production process, realized even with not full logistic support, can create a good, which finally is able to cover a specific demand. The effectiveness of the main activity can be gradated, but the gradation of the effectiveness of the logistic support cannot be considered on its merits. Any other than effective activity, cannot be described as the logistic activity due to the fact, that it does not fulfill the conditions of the definition of the logistics and does not secure the realization of all logistic goals (6R).
- The 6-criteria evaluation method of the management efficiency includes also the criterion of costs of the logistic support. This cost covers the value of used resources: place, time, materials, tools and energy [Ison, Wall 2007]. The resources can be used "..in more efficient way, i.e. the less resources can be used to obtain a specific goal, if the used method would be different or more efficient. It means, with less resources involved, the better results could be reached [Kotarbiński 1975]. The rule of efficiency means, people lead to more economic behaviors, i.e. obtaining more savings or bigger effectiveness. It means also to reduce costs or to increase effects. Regarding the logistic support, only one economic rule can be applied, the rule of savings, due to fact, that the main process requires only specific and limited resources (quantity and quality), therefore the activity will be rational, if it will assure the required resources by the lowest cost. Maximizing effects (providing more materials and raw materials than required for a given production task) has no sense. The efficiency rule can only be used in relation to the logistic system (or some of its subsystems) as a set of specially selected components, enabling the realization of logistic processes. The production capability of the logistic system should have the biggest possible productivity. In such situation, the unit fix cost decreases and the effectiveness of the whole system is bigger.
- The aim of the logistic support can be obtained with various benefits [Pszczołowski 1982]. Jan Zieliński analyzed various variants of the economization and noticed that in case of similar increase of results and costs, the economic results are the same but the advantage of such situation is the achievement of better results. Therefore he introduced a new concept connected with economic results for describing such cases. In case of evaluation of economic results, costs are subtracted from results. In previous case of the economization, the effects are divided by costs. Therefore the methods of logistic activities should be changed in such way that each subsequent variant of a given family will be more efficient and economic than the previous one. The economization of logistic activities consists of their improvement, which leads to the increase of economic indicators [Zieleniewski 1981].

Beside the effectiveness and the economization, the general concept of the efficiency includes other characteristics of the practical behavior, like simplicity, preparation, cleanness, neatness, accuracy and others. These characteristics could be connected with the aim of logistic support called "right quality".

PRACTICAL IMPLICATIONS OF LOGISTICS

The commonly accepted opinion is that the logistics is a type of the practical knowledge. It means that the whole logistic knowledge is focused on its practical application. At the same time, the practice, experiences and real logistic processes are the sources of the original information. The theory of the logistics is created and broadened on the base of this information. There are many examples of rational practical behaviors in the logistic area, which were not initiated by already existing theory. The observation and experiences suggested e.g. how to calculate lead-times of orders for raw materials, how to determine the order quantity, how to organize the work in the warehouse, etc. The modern information systems specialized to solve optimizing problems in logistics are in many cases the computer reflection of methods already used in the practice.

The language of logistics, passing from the practice to its theory, shows the significant influence of the practice on the development of the logistic theory. There are many words and concepts of describing or of comparative nature in the publications about logistics, which create almost a kind of logistic slang. The concepts of the logistic channel and the distribution channel are treated synonymously in many publications. The similar situation is with concepts of the logistic centre and the distribution centre. The concepts of the supply chain and the logistic chain in theoretical publications are treated also synonymously or have specific imprecise interpretation [Gibson, Mentzer, Cook 2005]. They are imprecise concepts, even unscientific one, due to the fact that they are undefined both in Polish and in foreign literature. Gibson and other authors, describing the problem of the cohesion of definitions related to the management of supply chains, found more than 20 such definitions. To check how the definition of the supply chain is understood, they conducted a questionnaire research among members of the Council of Supply Chain Management Professionals (CSCMP) [Gibson, Mentzer, Cook 2005]. The lack of the language precision influences directly the rationality of logistic activities as well as an efficient and effective use of the logistics in order to improve the competitiveness of business systems. This situation makes an impression of the eclecticity of the whole discipline.

The practical logistic goals become almost paradigms of modern business strategies [Chaberek 2011]. The concept of a strategy based on equivalent and simultaneous leading to an optimum of production costs, quality and time was created during nineties especially in the American economy. The time criterion is treated here multi-dimensionally. The time is a resource, which is specially limited. It could be used or not. Time prejudges the costs of freeze up of the production factors. The more efficient the production the smallest cost of it, because there is the shorter time of freeze up of production factors. The problem of the lack of the substitution of the time factor in the production is underlined especially by P. Dracker [2002]. All three main criteria (costs, time, quality) of modern business, appear in a natural way in business logistic strategies. Therefore the primary questions of modern business are practical logistic questions: what? (to provide), how much? when? They appeared much earlier before the logistic theory was created and originated by e.g. localization decisions. The correct localization of the decoupling point between dependent and independent demands allowed to have more benefits, even before the time, the decoupling point obtained its scientific name. The same situation occurred with such choices as trade off ones, which were practically solved long before the theory and optimization algorithms on this subject were prepared.

REGULATORY IMPLICATIONS OF LOGISTICS

The second function of the logistics, beside the service function, is the integration function. Its implications in the practice and the theory of logistics are multi-level and multi-threads. It concerns the right integration of the main process with the logistic process as well as the right integration of internal components of the logistic process. The various range of integration is available, from the coordination through the synchronization up to the full integration. The aim of the integration of logistic systems of companies, towns, regions, countries and groups is the creation of conditions for the smooth flow of resources. Logistic processes gained the significance due to the development of populations, urbanization, agglomeration processes, economic development and occurring specially recently deglomeration tendency. Therefore logistic systems, due to their economic and social character, are the subject of interest of both local authorities, national authorities as well as international ones. The various regulatory tools (legislative, economic, technical, technological) are used to achieve the required level and range of the integration at all above mentioned levels.

The problems of the integration of national logistic components are already mentioned in Treaty on European Union or in Union decrees. The legislative integration activities, conducted in last century, were sufficient in the situation, when the logistic tasks and logistic providers had only national, regional or local character. At present, the more spectacular actions could be observed covering the global scale. On the other hand, it is not possible to characterize sufficiently the whole range of undertaken integration actions in one paper as well as to discuss all regulatory tools used and to show effects of their implementation. Therefore only three selected integration actions, realized at the EU level, will be presented. It will allow signalizing the variety of necessary integration actions in the European logistics as well as the wide range of needed transpositions of regulatory solutions at the national level.

The review of White Paper from 2001 year “European transport policy 2010, time for decision” indicated that the logistics has a significant meaning to secure the balanced mobility and contributes to the realization of such goals like cleanness of environment, security of energy supplies, etc. The Union report “Europe in movement - balanced mobility for our continent” [COM 20006] presented initiatives, which influence the liberalization of business activities in the area of logistics, harmonization, development of the infrastructure, standardization of logistic solutions and their promotion. One of the most important initiatives is the assurance of the security of the supply chain together with the demand that solutions, connected with the security, do not collide with the idea of the free flow of goods and services.

The interoperational activities problem deserves underlying, when analyzing all integration tasks in the logistics and realized by the logistics [Chaberek, Karwacka 2012]. The big undertaking both at the European and national level is connected with the above mentioned concept. The example of train transport as the European logistic subsystem is used to present the sense of this undertaking. This system is not unusually integrated from the point of view of possibilities to realize efficient flows of resources, due to the fact, that each transit of goods between different countries is connected with various technical problems: various gauge of rail, various voltage, various rule of organization of train traffic, etc. The plan covers the development of interoperational activities and removing or at least reducing these limitations. The interoperational activity is a new approach to the technical harmonization and standardization. It is also a global approach to researches and the certification of components of the logistic system as well as a mechanism of the transposition of components of discussed activities at the national level. It concerns also the notification of norms and regulations. The scale of undertaken activities to secure such functionality of systems within European Union is big.

The regulation area in the range of transport services (of public character) is an example of a little other type of the integration of logistic systems. This case is connected with long-term investment processes. Such investments are undertaken by operators only if they have long-term contracts for the realization of transport services of public character and they receive surcharges covering the difference between profits from tickets and real service costs plus benefits. Therefore there is a question, how to deal with such expectations together with the rules of the free competitiveness and a method of a choice of suppliers of public transport services? The decree of European Parliament of Council of European Union on public services in rail and road passengers' transport was published on 23rd of October 2007, after many years of preparations. Based on this document, the act determining the rules of organization and functioning of the system of public transport services in Poland was created. It defines the regulatory rules and the rule of the use of implications related to the organization and the realization of transport services of public character.

CONCLUSIONS

The most important areas related to the integration at EU level were defined as a conclusion of the research on implication interactions of logistics on its practice and theory. They are:

- elimination of all bottlenecks in logistic systems and processes,
- information and telematics technologies,
- integration of statistical data and information date about logistics,
- integration of the logistic infrastructure, especially in the range of sea highways and rail transport,
- increasing the quality of logistic services,
- supporting and simplification of multimodal chain and loading units.

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TEORETYCZNE, REGULACYJNE I PRAKTYCZNE IMPLIKACJE LOGISTYKI

STRESZCZENIE. **Wstęp:** Logistyka ma swój jednoznaczny wymiar praktyczny w budowaniu strategii gospodarczych, w kształtowaniu współczesnego porządku gospodarczego. W celu zapewnienia pełnej funkcjonalności i racjonalności systemów wsparcia logistycznego, procesy ich planowania, projektowania budowy i funkcjonowania muszą bezpośrednio czerpać ze źródeł wiedzy teoretycznej wielu dziedzin i dyscyplin naukowych, jak również z dotychczasowego bogatego już doświadczenia. Uwarunkowania wynikające właśnie z tych trzech obszarów: wiedzy, praktyki i obowiązujących regulacji prawnych tworzą skomplikowany splot implikacji, poznanie których jest warunkiem realizacji wszelkiej obsługi logistycznej w sposób racjonalny.

Metody: Główną płaszczyznę merytoryczną rozważań zawartych w artykule stanowi triada pojęć: teoria, praktyka, regulacja, odniesiona do zadań wsparcia logistycznego dowolnej organizacji, dowolnych, lecz celowo realizowanych procesów wytwórczych.

Celem artykułu jest zwrócenie uwagi na konieczność uwzględniania w procesie analizowania, projektowania i wdrażania systemów wsparcia logistycznego, na charakterystyczne dla logistyki implikacje pomiędzy teorią, praktyką i sferą regulacyjną. Brak świadomości co do odmienności niektórych implikacji, lub ich ignorowanie prowadzić musi do nieracjonalności zachowań.

Wyniki: Przedstawione, w sposób odmienny od powszechnie uznawanych, implikacje pomiędzy teorią, regulacją i praktyką wsparcia logistycznego, poszerzają wiedzę o logistyce, stanowiąc tym samym narzędzie racjonalizacji obsługi logistycznej wszelkich celowych aktywności.

Wnioski: Właściwa identyfikacja zadań i funkcji logistyki jest podstawą prawidłowego rozpoznania jej przedmiotu i zadań oraz poprawnej identyfikacji implikacji zachodzących pomiędzy teorią, regulacją i praktyką. Wiedza ta jest niezbędna w procesie kreowania projektów obsługi logistycznej każdej aktywności tak biznesowej, jak i niebiznesowej.

Słowa kluczowe: model wsparcia logistycznego, implikacje pomiędzy teorią, regulacją i praktyką logistyczną, racjonalizacja działalności logistycznej.

THEORETISCHE, REGULATIVE UND PRAKTISCHE IMPLIKATIONEN DER LOGISTIK

ZUSAMMENFASSUNG. Einleitung: Logistik übt einen eindeutigen praktischen Einfluss auf den Aufbau von wirtschaftlichen Strategien sowie auf die Ausgestaltung der gegenwärtigen Wirtschaftsordnung aus. Zwecks der Gewährleistung einer vollen Funktionalität und Rationalität der logistikunterstützenden Systeme müssen die Prozesse deren Planung, Projektierung und Funktionsbetätigung direkt aus den Quellen des theoretischen Wissens aus vielen Bereichen und Wissenschaftsdisziplinen sowie der bisherigen, mittlerweile umfangreich gewordenen Allgemeinerfahrung schöpfen. Die aus den drei Bereichen: dem Wissen, der Praxis und den obliegenden Rechtsregulierungen resultierenden Einflussfaktoren bilden eine komplizierte Verflechtung von Implikationen, deren Ermittlung und Kennenlernen eine Vorbedingung für eine rationelle Ausführung jeder Art von logistischen Dienstleistungen ist.

Methoden: Die Hauptebene für die betreffenden sachlichen Erwägungen im Rahmen des vorliegenden Artikels bildet eine Triade von Sachbegriffen: Theorie, Praxis, Regulation, die auf die Aufgaben der logistischen Unterstützung einer beliebigen Wirtschaftseinrichtung oder beliebiger, aber zweckmäßig betätigter Produktionsprozesse zurückgeht.

Das Ziel des Artikels ist es, auf die Notwendigkeit der Berücksichtigung der logistikunterstützenden Systeme bei der Analyse, Projektierung und Einführung eines Vorhabens sowie auf die für die Logistik charakteristischen Implikationen zwischen der Theorie, der Praxis und der rechtsregulativen Sphäre hinzuweisen. Der Mangel an Bewusstsein bezüglich der Eigenart mancher Implikationen oder deren Ignorierung müssen zu irrationellen Verhaltensweisen führen.
Ergebnisse: Die anders als allgemein anerkannt dargestellten Implikationen zwischen der Theorie, der Regulation und der Praxis der logistischen Unterstützung erweitern das Wissen über die Logistik und werden zum Werkzeug für die Rationalisierung der logistischen Dienstleistung innerhalb jeglicher, zweckmäßig betätigter Aktivitäten in diesem Bereich.
Fazit: Die richtige Ermittlung von Aufgaben und Funktionen der Logistik bildet eine Grundlage für die richtige Erfassung deren Gegenstandes und Aufgabenstellungen sowie für die fachgerechte Identifikation der vorkommenden Implikationen zwischen der Theorie, der Regulation und der Praxis. Dieses Wissen ist unentbehrlich im Prozess der Ausgestaltung von logistischen Dienstleistungsprojekten für die sowohl kommerzielle, als auch nicht kommerzielle Betätigung.

Codewörter: Modell für logistische Unterstützung, Implikationen zwischen Theorie, Regulierung und logistischer Praxis, Rationalisierung logistischer Aktivitäten.

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CUSTOMER SATISFACTION WITH THE QUALITY OF THE LOGISTIC SERVICES

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ABSTRACT. Background: Logistics services are evaluated mainly by measuring customer satisfaction. Measurement of the customer satisfaction provides the information about how organizations operate as well as how to effectively satisfy customer needs. The aim of this paper is to propose an evaluation model of the customer satisfaction of the quality of the logistic services provided. The research in this paper was focused on the evaluation of the level of customer satisfaction in the context of logistics service as well as on the analysis of importance of ten logistic services attributes influencing customer satisfaction.

Methods: The research was conducted on the basis of the questionnaire designed for purchasers of logistic services. The subjects of the research were companies which are using refrigerated transport.

Results: To define relation between level of customer satisfaction in the context of logistic service and logistic service attributes impacting this satisfaction Pearson's correlation method was used. In turn the model to evaluate the customer satisfaction in the context of logistic services in scope of refrigerated transport was built using multiple regression and stepwise regression methods.

Key words: quality, customer satisfaction, logistic services, refrigerated transport.

INTRODUCTION

Subject of logistics services is to present universe of discourse in research among others such as authors e.g.: Świtała [2013]; Wejers, Glöckner and Pietras [2012]; Kilibarda and Andrejic [2012] as well as Strojny [2008]. Logistics services can be evaluated first of all by measurement of customer satisfaction. The concept of customer satisfaction can be defined in different ways in literature. According to one's definition customer satisfaction is "feeling, that to experience purchaser after the service is used which fulfil his expectations" [Kotler, Armstrong, Saunders, Wong 2000]. In order to evaluate customer satisfaction experienced service needs to be measured on the basis of customer expectations compared to what was delivered. Then the subjective feelings accompanying the usage of the offered service are the basis for effective and reliable evaluation as well as to assure the right picture of perceived service. Measurement satisfaction delivers information to the point function about organization and satisfying customer needs in an effective way. During evaluating customer satisfaction a different scope of guild services can be considered.

Factors influencing customer satisfaction in opinion B. Filipiak and A. Panasiuk [2008] are among others: timeliness of deliveries, completeness of deliveries (productive capacity to realization of ordering products), promptness of deliveries, accurately invoiced, accurately of deliveries, flexibility of deliveries, keeping the commitment

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(conditions of agreement), transportations conditions, terminal conditions (theft protection, work organization, furnishings, etc.) and complexity of services.

Term of extent customer satisfaction in TSL area was H. Brdulak's research subject [2009]. In "Perfect profile of logistics services company" as seen by customer due to quality of service six parameters were considered such as: transport of undamaged condition, meeting deadlines, keeping the commitment, certainty of avoiding theft or missing commodity, promptness of order realization and complexity of service. However M. Kozerska's research [2010] in order to term of extent customer satisfaction connecting with level of quality logistics services considered twenty two following parameters: meeting deadlines, successful service on the first attempt, documentation free for mistake, good information flow between logistics service provider and buyer, transport of undamaged condition, complexity of service, kindness, politeness, competence, professionalism, realization, appearance, availability, flexibility, quick reaction to customer requirements, interest in solving customer issues, complains, damages, recommendation another customers, financial credibility, operation time of company on the market and credibility of management.

However research conducted by Logistics Operator of the Year [Special Report 2009], [Special Report 2010], [Special Report 2011] connected with extent of customer satisfaction from quality level logistics services reflected thirteen criteria of evaluation logistics services such as: accurately of deliveries, timeliness of deliveries, completeness of deliveries, price according to the offered quality, information flow to the point of condition deliveries, promptness of deliveries, flexibility of deliveries, experience and credibility, executive potential, reply period to offer inquiry, disputes and complaints, geographic range of deliveries, computerization, complexity of services and innovativeness.

MATERIAL AND METHODS OF OWN RESEARCH

The aim of conducting research was to propose an evaluation model of the customer satisfaction of the quality of the logistic services provided. To the analysis were taken ten quality features from among thirteen logistic services features influencing customer satisfaction, propose by Logistics Operator of the Year, because this features are most widespread, and research conducted systematic [Special Report 2009], [Special Report 2010], [Special Report 2011].

The conducted direct research had quantitative character. It was prepared two questionnaires to realization of research aims. One's was referred to group of 1321 subject and was received from 269 companies which are using refrigerated transport.

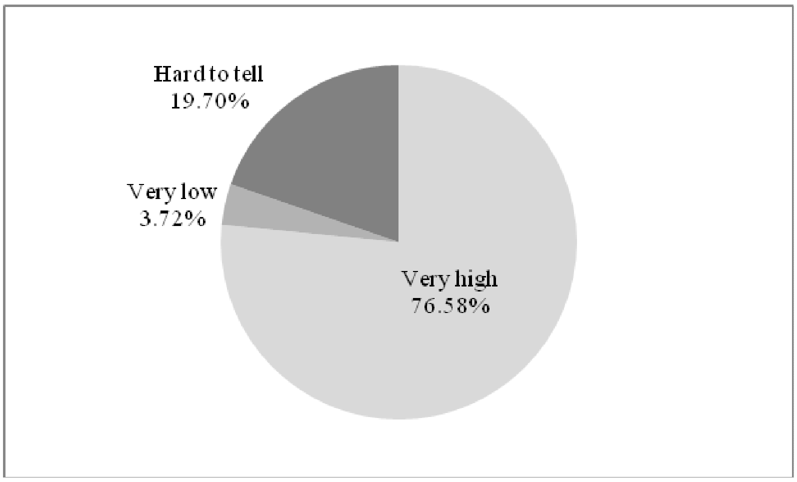
In order to describe relation between evaluation of satisfaction from logistics services quality in refrigerated transport area on evaluation of an importance of a feature of logistic service influencing customer satisfaction from service quality a Pearson's correlation was applied. To propose an evaluation model of the customer satisfaction of the quality of the logistic services provided multiple linear regression was applied. In this case of analysis forward stepwise regression [Wątroba 2003] was selected. It was determined, that evaluation model of the customer satisfaction of the quality of the logistic services provided as theoretical description of researching the phenomenon will be characterize by following features: a simplification of reality, in a sense of criteria convergent with reality, enough simple that will be conceivable analysis this model comprehensible methods and will be source about researching phenomenon [Findeisen, Gutenbaum 1985].

RESULTS AND CONCLUSIONS

Quality of logistics services provided should be evaluated first of all on the basis of evaluation of customer satisfaction. In this connection logistics purchasers were asked about opinion in the area of evaluation of an importance of a feature of logistic service influencing customer satisfaction from service quality. Results including hierarchy of evaluation of an importance of a feature were announced in table 1.

Table 1. Evaluation of an importance of a feature of logistic service influencing customer satisfaction from service quality
Tabela 1. Ocena ważności cech usługi logistycznej wpływających na satysfakcję klienta z jakości usługi

Features of logistic service	Average evaluation of an importance (pt.)	Percentage of responses [%]					
		Not important (0 pt.)	Very small importance (1pt.)	Small importance (2 pt.)	Medium importance (3 pt.)	High importance (4 pt.)	Very high Importance (5 pt.)
Timeliness of deliveries	4.43	0	1.49	0.37	9.29	31.23	57.62
Completeness of deliveries	4.37	0	0.74	0.74	10.04	37.55	50.93
Accurately of deliveries	4.36	0	0.74	0.74	13.75	36.43	48.33
Promptness of deliveries	4.31	0	1.49	2.97	13.75	40.52	41.26
Keeping the commitment	4.24	0	0.74	1.49	15.24	26.39	56.13
Accurately invoiced	4.17	0	1.12	0.74	22.68	41.26	34.20
Flexibility of deliveries	4.07	0	1.49	2.23	14.50	46.10	35.69
Transportations conditions	4.05	0	1.49	3.35	16.36	46.47	32.34
Terminal conditions	3.87	0	0.74	2.97	26.02	48.70	21.56
Complexity of services	3.78	0	4.46	5.58	31.23	36.80	21.93



Source: Own research

Fig. 1. Satisfaction level from logistics services quality in refrigerated transport (% of indication)
Rys. 1. Poziom satysfakcji z jakości świadczonych usług logistycznych w zakresie transportu chłodniczego (% wskazań)

It was essential, to get to know the opinion of logistics purchasers about satisfaction level from logistics services quality. Results of evaluation logistics purchasers' satisfaction were announced in figure 1.

On the basis of research results it was affirmed that most respondents is pleased with quality level from logistics services. Only 4% of respondents is not pleased with quality level from logistics services and almost 20% from among them is not decided and unequivocally cannot describe quality level from logistics services in refrigerated transport area. It can be provided that customers do not attach importance to quality provided logistics services in refrigerated transport area, what is unlikely or they do not possess sufficient of knowledge in this area.

Relation between satisfaction level and evaluation of an importance of a feature of logistic service was announced in table 2.

Table 2. Relation between evaluation of satisfaction from logistics services quality in refrigerated transport area on evaluation of an importance of a feature of logistic service influencing customer satisfaction from service quality
Tabela 2. Zależność oceny poziomu satysfakcji z jakości świadczonych usług logistycznych w zakresie transportu chłodniczego od oceny ważności cech usługi logistycznej wpływających na satysfakcję klienta w zakresie jakości usługi

Features of logistic service	Level of satisfaction Value of correlation coefficient r
Timeliness of deliveries	0.72
Completeness of deliveries	0.69
Promptness of deliveries	0.63
Accurately of deliveries	0.63
Flexibility of deliveries	0.46
Keeping the commitment	0.61
Transportations conditions	0.49
Terminal conditions	0.38
Accurately invoiced	0.51
Complexity of services	0.48

Source: Own research.

Table 3. Summary of multiple regression between satisfaction from logistics services quality in refrigerated transport and evaluation of an importance of a feature of logistic service influencing customer satisfaction from service quality after elimination meeting commitments and complexity services
Tabela 3. Podsumowanie regresji wielorakiej pomiędzy satysfakcją z jakości świadczonych usług logistycznych w zakresie transportu chłodniczego, a ważnością cech usługi logistycznej wpływających na satysfakcję klienta w zakresie jakości usługi po wyeliminowaniu pełnego dotrzymywania zobowiązań i kompleksowości usług

Features of logistic service and absolute term	Summary of multiple regression: R=0.75; R^2=0.56; F=114.06; p<0.0000; standard forecast of estimation =0.69					
	Beta	Standard forecast Beta	B	Standard forecast B	t(265)	p
Timeliness of deliveries	0.348621	0.083527	0.456080	0.109273	4.173762	0.000041
Completeness of deliveries	0.258133	0.075906	0.356147	0.104728	3.400697	0.000776
Accurately of deliveries	0.212475	0.059133	0.261718	0.072837	3.593180	0.000389
Absolute term			-0.253567	0.261105	-0.971129	0.332370

Source: Own research.

On the basis of results announced in table 2 it was shown strong connection between evaluation of satisfaction from logistics services quality in refrigerated transport area and evaluation of an importance in case of five features logistic services influencing customer satisfaction from service quality: timeliness of deliveries, promptness of deliveries, completeness of deliveries, accurately of deliveries and keeping the commitment (r>0,5). However in case of timeliness of deliveries value of coefficient r is the highest, also it can be hint that this feature to a largest extent influence on level of satisfaction from logistics services quality. Moreover in case of all features of logistics services value of coefficient r assumes the positive value. Furthermore for all the attributes of logistics service a correlation coefficient is positive which means that the higher the evaluation of the importance of the feature of logistic service influencing customer satisfaction from service quality the greater the evaluation of customer satisfaction level from logistics services quality in refrigerated transport area.

As a result of estimation of multiple linear regression obtained satisfactory of the customer satisfaction of the quality of the logistic services provided in refrigerated transport area including essential statistical features of logistic service from service quality, what was shown in table 3.

Statistical analysis forward stepwise regression method showed that model did not get five following features of logistics services: promptness of deliveries, accurately invoiced, flexibility of deliveries, terminal conditions and transportations conditions. Moreover it was affirmed that essentials statistical features of logistics services influencing customer satisfaction from service quality are: timeliness of deliveries, completeness of deliveries and accurately of deliveries. On the basis of this it was affirmed that the company provides logistics services at the highest level, the level of satisfaction from logistics services quality in refrigerated transport area is higher, what the value of coefficient r really shows.

On the basis of coefficient of determination (R^2=0.56) it was affirmed that consideration essential statistical features of logistics services enables to reveal about 60% original changeability level of customer satisfaction from service quality in refrigerated transport area. In case of forecast level of customer satisfaction on the basis of regression model forecast error would be equal about 0.7.

Obtained model of the customer satisfaction of the quality of the logistic services provided in refrigerated transport area to assume following form is:

$$Y= 0.46x_1 + 0.36\, x_2 + 0.26\, x_3 - 0.25$$

where: Y means forecast (on the basis of model) evaluation of customer satisfaction from quality logistics services in refrigerated transport area,
x_1 - timeliness of deliveries,
x_2 - completeness of deliveries,
x_3 - accurately of deliveries,
$x_1, \ldots, x_3$ (value of evaluation)={0,1,2,3,4,5 pt.}.

On the basis of model of evaluation customer satisfaction from quality logistics services it can describe profile levels of satisfaction originally change of level in case of higher of evaluations two of three criteria. Then profile levels of satisfaction will be following:

- if evaluation Y is less than 0.83 pt. - lack of satisfaction,
- if evaluation Y is equal or greater than 0.83 pt., and less than 1.5 pt. then - level of satisfaction is very low,
- if evaluation Y is equal or greater than 1.5 pt. and less than 2.53 pt. then - level of satisfaction is low,
- if evaluation Y is equal or greater than 2.53 pt., and less than 3.61 pt. - level of satisfaction is medium,
- if evaluation Y is equal or greater than 3.61 pt., and less than 4.69 pt. - level of satisfaction is high,
- if evaluation Y is equal or greater than 4.69 pt. - level of satisfaction is very high.

On the basis of this model it was described profile five levels of customer satisfaction as well as it was proposed for each value of evaluation each of quality criteria (from 5 to 0 pt.) appropriate value of logistics measure [Kisperska-Moroń 2006].

The analysis of case studies as well as analysis of evaluation customer satisfaction feeling from quality services provided and appointed basis of propose model was pleased for positive evaluation of usefulness model of evaluation satisfaction [Gajewska 2012].

SUMMARY

The conducted research and statistical analysis results were pleased to propose an evaluation model of the customer satisfaction of the quality of the logistic services provided. In propose an evaluation model of the customer satisfaction of the quality of the logistic services provided in refrigerated transport was considerated more important criteria of evaluation quality services such as: timeliness of deliveries, completeness of deliveries and accurately of deliveries.

Usefulness this model consist in possibility take a simple and buick comparative of researches basis of more important three qualitative criteria, taking different their importance into consideration and classification of evaluation customer satisfaction to specific level.

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SATYSFAKCJA KLIENTA Z JAKOŚCI NABYWANYCH USŁUG LOGISTYCZNYCH

STRESZCZENIE. **Wstęp:** Usługi logistyczne oceniane są przede wszystkim poprzez pomiar satysfakcji klienta. Pomiar satysfakcji dostarcza informacji na temat działania organizacji i efektywnego zaspokojenia potrzeb klientów. Celem niniejszej pracy jest zaproponowanie modelu oceny satysfakcji klienta z jakości świadczonych usług logistycznych. Podjęte badania dotyczyły oceny poziomu satysfakcji klienta z jakości usług oraz ważności dziesięciu cech usługi logistycznej wpływających na satysfakcję klienta w powyższym zakresie.
Metody: Badania przeprowadzono w oparciu o opracowany kwestionariusz ankiety badawczej skierowanej do nabywców usług logistycznych. Podmiotami badań były przedsiębiorstwa korzystające z usług w zakresie transportu chłodniczego. W celu określenia zależności pomiędzy poziomem satysfakcji klienta z jakości usługi, a cechami usługi logistycznej wpływającymi na tą satysfakcję wykorzystano korelację liniową Pearsona. Natomiast do zbudowania modelu oceny satysfakcji klienta z jakości świadczonych usług zastosowano moduł regresji wielorakiej oraz metodę krokową postępującą.
Wnioski: Zaproponowany model oceny satysfakcji klientów z jakości nabywanych usług logistycznych w zakresie transportu chłodniczego oraz wyznaczenie charakterystyki poziomów tej satysfakcji zostały pozytywnie zweryfikowane w wyniku przeprowadzonych następnie badań empirycznych.

Słowa kluczowe: jakość, satysfakcja klientów, usługi logistyczne, transport chłodniczy

DIE ZUFRIEDENHEIT DES KUNDEN MIT DER QUALITÄT LOGISTISCHER DIENSTLEISTUNGEN

ZUSAMMENFASSUNG. Einleitung: Die Dienstleistungen in der Logistik werden in erster Linie mit Hilfe der Messung der Befriedigung von Bedürfnissen und der Zufriedenheit der Kundenschaft eingeschätzt, was direkte Informationen über die Kondition der Organisation und die effektive Befriedigung der Kundenbedürfnisse liefert. Das Ziel dieses Konzepts ist die Modellierung der Bewertung der Zufriedenheit der Kunden auf der Basis der Qualität der geleisteten logistischen Dienstleistungen zu empfehlen.
Methoden: Die durchgeführten Forschungen haben die Einschätzung des Grades der Zufriedenheit des Kunden aus der Perspektive der Qualität der Dienstleistungen bestätigt, und dies bei der Berücksichtigung der Sonderbedeutung und der Relevanz von 10 Kerneigenschaften der logistischen Dienstleistung, die auf die Zufriedenheit des Kunden im obigen Umfang einen enormen Einfluss ausüben. Die Forschungen wurden in Anlehnung an eine Forschungsumfrage, die an die Erwerber der logistischen Dienstleistungen gerichtet worden sind, konzipiert. Die Subjekte der Untersuchung bildeten die Unternehmen, die logistische Dienstleistungen im Bereich des Kühltransports anbieten.
Ergebnisse: Um die Zusammenhänge zwischen dem Grad der Zufriedenheit des Kunden in Anbetracht der Qualität der Dienstleistung sowie die Eigenschaften der logistischen Dienstleistung, die auf diese Zufriedenheit einen Einfluss haben, zu bestimmen, hat man die Pearson-Korrelationsformel benutzt. Um das Modell der Bewertung der Zufriedenheit des Kunden mit der Qualität der geleisteten Dienstleistungen korrekt zu errichten, wurden die Multiple Regression und die progressive Segmentmethode eingesetzt.
Fazit: Das empfohlene Modell der Bewertung der Zufriedenheit bei den Kunden mit der Qualität der erworbenen logistischen Dienstleistungen im Bereich des Kühltransports und die Bestimmung der Charakteristik des Grades dieser Zufriedenheit wurden infolge der dann durchgeführten empirischen Forschungen überprüft und als positiv eingeschätzt.

Codewörter: die Qualität, die Zufriedenheit der Klientel, logistische Dienstleistungen, der Kühltransport

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LOGISTIC INNOVATIONS IN TRANSPORT

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ABSTRACT. Introduction: The article discusses the issue of logistic innovations in transport. The essentials of logistic innovations in transport together with some examples of specific innovations are presented. The role of the client's needs in transport innovations is indicated. The most vital postulates affecting the innovativeness of shipping companies and derived from the author's experience as well as scholarly publications, are time, safety, reliability as well as comprehensiveness of service offer. Following the analysis of the issue, and on the grounds of Kaizen's and Lean's method, the concept of continuous innovations is suggested as very useful for the development of transport. The potential of clusters as the source of logistic innovations in transport is emphasised.

Methods: The discussion of the issue was preceded by the author's analysis of written sources on innovativeness, the evaluation of ratings of innovativeness as well as the analysis of rewarded innovative solutions in transport subsequent to the businesses participation in the programme of innovative solutions in transport. The role of innovation practical business operations is argued following the analysis of some strategic documents such as: 2011 White Paper and the Strategy for the Development of Transport by 2020 adopted by the Polish government in 2013.

Aim: The aim of the article is to present the role and significance of the issue of logistic innovations in transport and to cite instances of practical solutions implemented by shipping companies, the solutions which resulted in measurable effects. Following the author's observation of the instances of innovative solutions as well as his analysis of the ratings of innovativeness, the article aims to present the conclusions as for the specific kinds of activities which are indispensable to foster innovativeness in transport.

Conclusions: The conclusions derived from the author's analyses and observations show that logistic innovations in the Polish transport are of imitative character. It is essential to introduce new methods and modern business culture which are propitious to innovations. Transportation clusters may become the stimulus for innovativeness in TSL sector. The author, subsequently to his observation of instances of innovative solutions as well as his analysis of ratings of innovativeness, presents conclusions with reference to specific actions which should be taken in order to improve innovativeness in transport.

Key words: Innovations, Transport, Transport Innovations, Kaizen, Clusters.

INTRODUCTION

Reports on innovativeness in Poland are disturbing. A report issued under the auspices of EU positions Poland as a country of very low level of innovativeness. The results of the European report are confirmed by the Global Innovation Index of 2012 where Poland is ranked as 44th and scores only 40,4 points out of total 100. In another rating, by Boston Consulting Group, which evaluated 50 most innovative businesses, there is not a single Polish business entity. American firms excel and Asian businesses overshadow the European ones. The reasons for poor innovativeness in Poland are as follows: [Ratnicyn, 2012]

- Structure of the Polish economy does not foster innovativeness;
- Poor co-operation between businesses and academic centres (majority of innovative solutions are funded by academic centres in Poland while elsewhere they are financed by private sectors);

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- Lack of technological clusters;
- Infrastructure deficiencies, especially evident in rail transport (poor line infrastructure, railway network modernization incommensurate with the needs);
- Low contribution of Polish organizations to foreign patents (there is an increasing tendency in Poland to buy foreign licences and patents, the level of national inventiveness looks bleak in the case of products and services;
- Conservativeness of entrepreneurs and managers.

Above factors, together with relatively low expenditures on innovativeness (several times lower than in other countries, e.g. 2 billion euro in Poland against nearly 68 billion euro in Germany) will make it impossible to improve Poland's position in innovativeness without some outright actions, changes in attitudes, promotion of innovative solutions or increased funds on research and development. There are no haulage contractors in these ratings.

The aim of the article is to present, on the basis of written sources, observation of ratings of innovativeness as well as the author's practical experience, the role and significance of the notion of innovativeness in transport. Further, following the author's own experience-based evaluation, the article presents instances of innovative solutions in transport, solutions which have resulted in measurable effects for the engaged companies.

INNOVATIONS IN TRANSPORT - ESSENTIAL ISSUES

In transport, there is an urgent need for innovative changes which would improve its image and strengthen its market position. Rail transport in particular is in need of modification. However, as Burnewicz sees it [Burnewicz 2009], rail transport is an especially difficult area to implement innovations due to some institutional barriers of the sector, political character of decisions involving structural and technical modifications and, finally, insufficiency of investment funds in rail businesses. Burnewicz claims [Burnewicz 2009] that the smaller a given sector and its market, the bigger reluctance to invest in innovations which would change its technological quality and prospects for development.

Business entities which operate in transport sector could be innovating companies. They are the entities which invest in new transportation technologies, in research and development, in new products, in refining of management processes and the processes of transportation services rendition, finally they invest in the organization of the transportation process. As Schumpeter [Olejniczuk-Merta 2013] sees it, innovation is neither a little improvement nor the process of implementing inventions. Innovation represents crucial changes in the service creation and processes which, as a matter of fact, have social context.

In every business we can find innovations in the product, the service as well as in the sphere of skills and activities. The more so, as the aim of a business is to win its own clientele, and, given that, as already mentioned by Drucker [Drucker 1994], in every business there are two most important functions - marketing and innovation. Innovations may arise from the needs of the market and the client. The need is one of the basic elements of marketing concept for running a business. The aim of an innovation is to effectively satisfy existing needs as well as to create new needs that will come from the clients' demands. As Gattorna [Gattorna 2013] writes "there is only one reliable way to introduce an innovation - to properly interpret the market and the client's needs". However, an innovation could be also represented by a new production line, streamlined sale system or more efficient personnel management. In transport, technical, technological and product innovations may become the means to outdo competitors. In other words, better and more efficient transportation services ought to be offered.

Transportation need is a derivative need and it is expressed by demand for transportation services generated by the economy. A characteristic feature of demand for transportation services are the clients' demanding expectations from the offered transportation service. Demands which affect the innovativeness of haulage contractors are such as, for instance, time of service delivery, safety, reliability of services, comprehensiveness of the services range. To get to know these demands in their quality as well as quantity will allow a transportation business to meet the clients' expectations halfway and to assess the level of their satisfaction. Pursuit of satisfying transportation demands and clients' preferences are, in Niedzielski's view [Niedzielski 2003] the source of innovating processes in transportation businesses. A need becomes the primary source of innovation in transport. However, innovations in transport may be determined also by space, time, and dynamic character of a transportation service. This comes from the fact that in a dynamic transportation chain, the freight covers specific distance in a specific time between the despatch point and delivery point, sometimes in mixed technology system. In the course of freight handling, employees who represent haulage firms directly contact the dispatching party or the recipient and, subsequently, build up mutual relations and create the business image. In the present time of economic downturn and competition, one cannot think of establishing and developing a business without thinking about innovations or their implementation. Innovations include a variety of actions which concern market novelties such as streamlining of the existing transportation services or designing new transportation offers.

The idea of innovation itself has various definitions. According to Drucker [Drucker 2000], innovation is a specific tool for entrepreneurs by which they get an opportunity to undertake a new business activity or to render services. According to Oslo Manual [Ratnicyn] "innovativeness means the ability of a business to create and implement ideas which so far have not been in practical use". Innovations may also be interpreted as an instrument to exploit financial resources in order to obtain particular, profit-raising ideas. An innovation could also be understood as a change in what a business offers, a change in a business model or in a service, which should significantly improve the comfort of the service recipients. Kotler [Kotler at al. 2002] defines innovation as an idea, a product or a technology element which is developed and offered to clients who, in turn, perceive it as new or innovative.

Innovativeness in transport is understood as the actions which consist in the introduction of new solutions or processes concerning all changes which add to the increase in economic, technical, technological effectiveness of the business environment of transportation systems in order to maximize social effects and performance results of both the public and private sectors. [Centre for Transportation and Infrastructure Analysis 2012]. In Burnewicz's understanding [Burnewicz 2010] the need for innovation exists in the entire transportation system (country, city) as well as in particular branches and forms of transport. In his opinion, the effect of innovation in the former case should be the offer of a new generation of the service while in the latter case, the innovations are seen as cutting-edge transportation means, new generation of infrastructure, modern techniques of traffic control, new means of enhanced security, new ways of easing ecological and social nuisance. Impetuses for innovativeness in transport should derive from the policy of transport. Given the fact that transport policy aims at achieving well-balanced transport system (in technical, spacial, economic and environmental terms) with co-operation across Europe on a unified transport market, this policy should include the assumptions of transport innovativeness. Innovative transport policy, obviously, contributes towards well-balanced development of transport through proper creation, stimulation and financing of transport investment.

In logistic terms, logistic innovations for transport were presented in the action plan of European Union Commission for the logistics of freight transportation. They are, for instance, electronic freight transportation (e-Freight) and intelligent transportation systems (ITS) [European Commission 2007]. This has been confirmed by the White Paper of 2011 "Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system" [European Commission 2011]. The White Paper focuses on technological innovations in, among others, the exploitation of transport networks and their safer and more reliable usage owing to information technology and communication systems.

There are proposals for innovations within the area of transport which attract attention. They are proposals for transport solutions within logistic supply chains, with the use of intermodal transport, e.g., intelligent container terminals, ultramodern bimodal systems or underground systems for the transportation of freight across cities. Among the innovations which consist in modernizing the process of a transportation service, there is one important example of activities whose ultimate aim is to ensure efficiency of the transportation process, to streamline the flow of freight and to overcome technical-operational barriers which arise during the entire process of, for example, the rail service rendition within the European network. Other examples concern electronic way of planning transportation routes and legal solutions to expedite the development of intermodal transport. The Strategy for Transport Development by 2020 [Ministry of Transport, Construction and Maritime Economy 2013] features innovative projects of technical and pro-ecological character. The most vital ones forecast redevelopment and assurance of inner interoperability of telematic systems which serve particular transport branches, such as ITS - road transport, ERTMS - rail transport, SESAR - air transport, VTMS - sea transport, and RIS - river transport.

INNOVATIVE SOLUTIONS IN TRANSPORT

European Commission places a high value on innovativeness in transport. In the new planning-budget perspective for 2014-2020, the essential goal is to develop collaboration between science and business. However, this requires enhanced interest in such relation on both sides. The key objectives for research and innovations in transport are presented in chart 1. In Poland close co-operation of science and economic practice is a prerequisite for the growth of innovativeness and the implementation of inventions. As is being reflected in reports from the Central Statistical Office [Innovators in transport 2012, 2012] innovativeness in Polish haulage businesses is developing very slowly. This does not mean, though, that Poland does not have innovative solutions in transport. Quite the contrary, there are substantial solutions. Gattorna [Gattorna 2013] emphasises an important role of innovations in raising efficiency in business operations. He puts forward the example of Michelin's e-tire, the device which resembles RFID that monitors the level of air pressure in tires. This in turn allows for optimum functioning of a tire and extends its durability. Wronka, for that matter, directs attention to innovative information practices in the intermodal transport [Wronka 2010] and adduces the international Brawo project which has been implemented by intermodal transport operators such as Kombiverkehr as well as rail hauliers from Germany, Austria and Italy. The project features advanced organizational and technological solutions for the development of intermodal transportation along the Brenner corridor. The following solutions are incorporated:

- coherent system of carriage management;
- multisystem train engines;
- radio control system for train engines;
- advanced system of managing information and the quality of services;
- prototypes of innovative technology for pocket carriages.

Substantial effects arose, for instance, punctuality increased by 90 %, transport records reliability achieved 100 %, number of carriage services grew by 16 %, clients' satisfaction with the quality of services rose. In transport it is required not only to initiate innovative activities but also to exploit marketing instruments for the support of innovative thinking and promotion of pro-innovative behaviour. Having analysed the two significant events representing Polish innovative solutions at the turn of 2012, one cannot disregard on-going changes. Centre for Transportation Innovations Foundation, in December 2012, organised I Forum for Transportation Innovations where 36 innovative projects were presented. The projects showed technological and financial solutions as well as organisation and management patterns for innovations. The projects' fields concerned road, rail, air, maritime and city transport. Events like that prove that there is a growing interest and capital in the Polish science and practice. All submitted projects were very interesting. One of them, as an example, is worth mentioning here [see: Innovators in Transport 2012, 2012] - group purchase of transportation services (T -

scale). Innovativeness of the project consists in the full coordination of the realised processes in order to achieve well-balanced exploitation of all available transportation resources, i.e. coordination and consolidation of orders allow for optimisation of transportation costs which results from the economies of scale. The effects are 15 % costs savings on given lines. Subsequently, vehicles' empty mileage is reduced by 21 %. Another analysed case was the choice of innovative products in logistics in 2012. It appeared that among the awarded ones there were products from the transport sector, products which allowed for the sector optimisation. However, the presented innovative products were not quite breakthrough but rather of derivative nature. To give an example, one of the rewarded logistic innovations in transport was DEGAmix - Dual Fuel System installation which consisted in the provision of two types of fuel for the DERVs, i.e. diesel oil ON and LPG. Such installation enables exploitation costs cut down to 10 - 15 %.

Effective and ecologically balanced mobility – improved efficiency of vehicles - new generation of low-emission or no-emission vehicles; – alternative fuel; – intelligent transportation systems; – optimised management of demand;	**Improved mobility** – less traffic congestion; – easier availability; – integrated door-to-door transport and logistics; – enhanced intermodality and transport planning; – fewer road accidents; – better security for passengers and freight along the whole supply chain
Competitiveness of European transport systems – new generation of equipment and transportation concepts; – smarter steering systems; – more efficient production processes; – shorter development time	**Support for policy-making** – better understanding of socio-economic trends and perspectives; – supply of evidence-based data and analyses

Source: Innovating for a competitive and resource-efficient transport system, Office for Official Publications of the European Union, Luxemburg, 2012.

Chart. 1. Goals in key areas of research and innovation in transport by 2020
Rys. 1. Cele w kluczowych obszarach badańi inowacji w transporcie do 2020

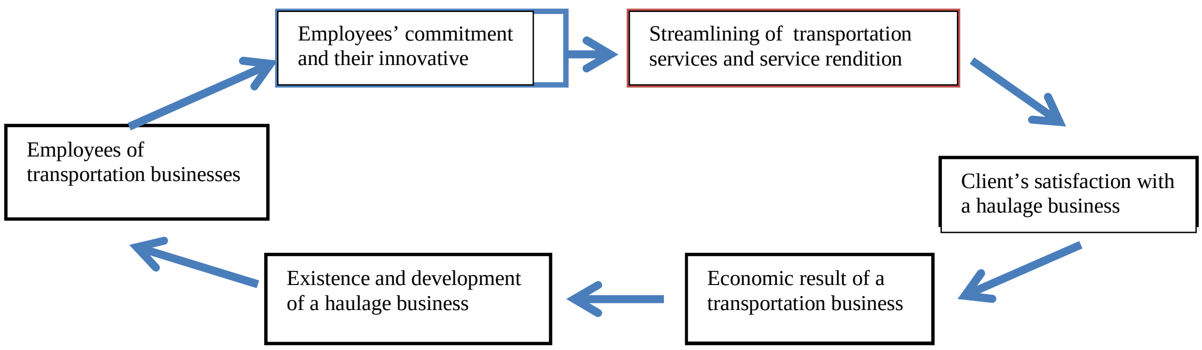
The above short survey of innovations in transport justifies the claim that Polish scientists and practitioners are the authors of a variety of interesting solutions as regards information technology, engineering, construction and management. Consequently, a question arises why knowledge and practical experience in innovative developments in transport are being restrained. What are the reasons and what must be done in order to reverse the tendency?

QUESTIONS ABOUT THE FUTURE OF INNOVATIVENESS IN TRANSPORT

Undoubtedly, the mechanisms for ensuring development of transport in Poland are rooted in its adaptability to innovation-derived changes. The ultimate goal of actions in transport should be to maximize the effects of innovativeness which result from the implementation of transportation projects. Moreover, while one is considering various innovations in transport, for example in process, technology or marketing, one must not forget about the organisational innovations which consist, for instance, in putting into practice either new organisation of running a haulage business or the incorporation of lean management in the course of running a transportation process. Taking advantage of the lean organisation, according to Womack and Jones [Womack and Jones 2003], helps to eradicate wastage and to optimize the processes which combine to create a transport service. The fundamental steps to implement lean organisation - conducive to innovations are: [Locher 2012]

- stability;
- standardization;
- visualization;
- continuous pursuit of excellence.

To manage a transportation process by the lean management principles aids the implementation of organisational innovations in transportation services together with the employment of the Kaizen method [Imai 2006, Dąbrowska 2011]. Kaizen is the method of continuous innovations. The essence of Kaizen philosophy in transportation services is presented in chart 1. Such approach converges with the views presented by Bes and Kotler [F. Trias de Bes, P. Kotler 2013]. They understand innovativeness as the creation of company culture which allows for continuous stream of small, evolutionary innovations to be directed onto the market. The idea is to work out and sustain the culture of innovation both in the transport sector and all representing businesses as well as among the employees of all transportation businesses.



Source: Author's own source. Based on: M. Imai, Gemba Kaizen, MT Business 2007; and M. Dąbrowska: Innovations in the services sector, PARP 2011

Chart. 2. Essence of Kaizen in transportation services
Chart.. 2. Istota Kaizen w usługach transportowych

An important instrument which influences innovativeness in transportation services may also be clusters. Cluster may be defined as a network of neighbouring and often informally related organisations, which co-operate in the spheres where the achievement of synergy effects is plausible. Forefather of the concept of clusters was Porter [Porter 2001] for whom cluster meant a group of businesses, all located in one area, and related institutions functioning in a particular field, all connected by similarities and complementary to one another. [Ratajczak - Mrożek 2012]. Cluster may also be understood as the space and sector concentration of business entitities which operate for the benefit of either economic development or of innovativeness of scientific units or, finally, of entrepreneurs who run competing businesses or co-operate in the same or allied businesses interconnected within co-operation network. [Booras, Tsagidis 2011]. It is essential for transport that the implementation of cluster solutions together with the established cluster structures ensure integration and collaboration of the business, science and public service. An example of such cluster initiative, crucial for innovativeness in transport, is "Interdisciplinary Partnership for the benefit of Innovative Development of Transport and Infrastructure". The objective of a cluster is to effectively obtain European and national funds to conduct research and developmental work, to promote innovation in the transport sector and also, to establish positive business relations as regards the implementation of transport innovations. There are subject groups functioning within a cluster, such as management of transportation systems, modern intermodal transport and logistics, IT and ITS technology, innovative technologies in rail transport, modern management of mobility, development of pro-innovative competence and good practice in transport and infrastructure. In the case of transport services, managing aspects are important which aim at adequate motivation of employees, adequate management of human resources, and also, the management of knowledge which will inspire employees to come up with new initiatives and to make use of their underlying knowledge. One of the types of clusters are so called logistic clusters which were discussed by Sheffi [Sheffi 2012] and which provide logistic services such as, for instance, transportation and storage, reloading and forwarding, or some ancillary services, such as financial or insurance. They offer platform for business operations of innovative business entities such as Kiva Systems [Mountz 2013] which employs mobile robots to complete and pack ordered goods in warehouses.

CONCLUSIONS

The idea of innovativeness in transport poses a challenge. To foster its further development, it requires the promotion of innovation culture through the employment of the following actions: [Antonowicz 2013]

- Formation of stable platforms and mechanisms for co-operation between public and private sectors, research and scientific units. These platforms may be in the forms of clusters which effect in synergy in establishing competitive edge. Clusters may constitute the strength of a region or a country;
- More efficient and effective exploitation of the European funds within the programme "Intelligent development". EU funds will constitute the primary financial source for transport projects;
- Co-operation between private and public sectors within public-private partnership;
- Comprehensive information activities which will support innovative behaviour. Set-up of the innovation cult as the drive for the development of businesses and the country.

Consequently, success of innovation in transport depends on the understanding of the transportation services market dynamics, co-operation, including the co-operation with those transport users who generate demand for transport services and set expectations for the offered services. Businesses which operate within the transport sector, in order to foster innovations, should also employ those elements which are derived from the research done by McKinsey and Company [Wessel, Christensen 2013, Fast 2013], i.e., the development of processes and functions connected with innovations, frequent reallocation of resources, improvement of technological and operative efficiency, support for the business culture oriented at the client's needs, and finally, drawing from the experience of other business sectors as well as from foreign businesses.

The question of logistic innovation in the Polish transport is a strategic issue. The indication of the sources of innovation as well as the tool which, undoubtedly, is the first Polish cluster of innovativeness in transport, logistics and infrastructure, determines the novelty of the approach to the issue of innovativeness. By means of this article, the author has shown that to realise the client's needs by a business is a prerequisite for changes in transportation services; moreover, that the organizational innovations lead to changes in the business model; finally, the author has determined the kinds of actions which result in the achievement of the culture of innovativeness in the Polish transport.

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INOWACJE LOGISTYCZNE W TRANSPORCIE

STRESZCZENIE. **Wstęp:** Artykuł dotyczy problematyki innowacji logistycznych w transporcie. Przedstawiono w nim podstawy zagadnienia innowacji logistycznych w transporcie wraz z przykładami konkretnych innowacji. Wskazano w nim na rolę potrzeb klienta w innowacjach transportowych. Do najistotniejszych postulatów mających wpływ na innowacyjność przedsiębiorstw transportowych na podstawie doświadczeń i publikacji naukowych zaliczono czas transportu, bezpieczeństwo, niezawodność usług, kompleksowość oferty usługowej. W oparciu o analizę problematyki zaproponowano jako przydatną dla rozwoju transportu koncepcję ciągłych innowacji w oparciu o metodę Kazein i Lean. Management. Wskazano na potencjał klastrów, jako źródła innowacyjności logistycznej w transporcie.
Metody: Dla wyjaśnienia problematyki zastosowano analizę literaturową zagadnienia innowacyjności, ocenę rankingów innowacyjności oraz analizę przykładów nagrodzonych rozwiązań innowacyjnych w transporcie w oparciu o metodę obserwacji własnej i ocenę wynikająca z uczestnictwa w wyborze rozwiązań innowacyjnych w transporcie. Rolę innowacji w praktyce działalności gospodarczej uzasadniono także w oparciu o analizę dokumentów o charakterze strategicznym np. Białej Księgi z 2011 r. oraz Strategii Rozwoju Transportu do 2020 r. przyjętej przez Rząd Polski w 2013 r.
Cel: Celem artykułu było przedstawienie roli i znaczenia problematyki innowacji logistycznych w transporcie oraz wskazanie praktycznych przykładów logistycznych rozwiązań innowacyjnych w transporcie skutkujących wymiernymi efektami dla przedsiębiorstw je wdrażających. Na podstawie przeprowadzonych obserwacji przykładów rozwiązań innowacyjnych i analiz rankingów innowacyjności przedstawianie wniosków w zakresie konkretnych rodzajów działań niezbędnych do poprawy innowacyjności w transporcie.
Wnioski: Wynikające z analiz i obserwacji wnioski wskazują, iż innowacje logistyczne w polskim transporcie mają raczej charakter odtwórczy. Niezbędne jest wprowadzanie nowych metod i kultury organizacyjnej sprzyjającej innowacjom. Klastry transportowe mogą stanowić instrument pobudzający rozwój innowacji w sektorze TSL. Autor na podstawie przeprowadzonych obserwacji przykładów rozwiązań innowacyjnych i analiz rankingów innowacyjności przedstawiania wnioski w zakresie konkretnych rodzajów działań niezbędnych do poprawy innowacyjności w transporcie..

Słowa kluczowe: inowacje, tranport, inowacje w transporcie, Kaizen, klastry.

INNOVATIVE LOGISTIKLÖSUNGEN IM TRANSPORT

ZUSAMMENFASSUNG. Einleitung: Der Beitrag bezieht sich auf die Problematik innovativer Logistiklösungen im Transport. In ihm wurden die grundlegenden Fragestellungen der innovativen Logistiklösungen für den Transport samt den Beispielen von konkreten Einführungen dargestellt. Dabei hat man auf die Rolle der Kundenbedürfnisse bei den transportmäßigen Einführungen hingewiesen. Zu den wesentlichsten Postulaten, die einen Einfluss auf die innovativen Fähigkeiten von Transportunternehmen ausüben, zählte man aufgrund der gewonnenen Erfahrungen und wissenschaftlichen Veröffentlichen: Transportzeit, Sicherheit, Zuverlässigkeit von Dienstleistungen, Komplexität des Dienstleistungsangebotes. Gestützt auf die Analyse der Problematik wurde ein für die Entwicklung des Transportes brauchbares Konzept der permanenten innovativen Logistiklösungen gestützt auf die Methoden von Kazein i Lean Management vorgeschlagen. Dabei hat man auf das Potenzial der Cluster als Quellen der innovativen Logistik im Transport hingewiesen.
Methoden: Für die Erläuterung der Problematik hat man die Analyse der Gegenstandsliteratur und Beurteilung von innovativen Rankings, sowie die Analyse der Beispiele von preisgekrönten Innovationslösungen im Transport in Anspruch genommen. Die Ermittlung der besten Lösungen erfolgte aufgrund der Selbstwahrnehmung und der auf die Teilnahme an der Auswahl der innovativen Lösungen für den Transport schließenden Beurteilung der Einführungen. Die Rolle der innovativen Einführungen in der Wirtschaftspraxis auch hat man in Anlehnung an die Analyse der Dokumente vom strategischen Charakter wie zum Beispiel an die Analyse des Weißen Buches aus dem Jahre 2011 und der von der polnischen Regierung 2013 angenommen Strategie der Transportentwicklung bis 2020 begründet.
Ziel: Das Ziel des Beitrags war es, die Rolle und die Bedeutung der Problematik der innovativen Logistiklösungen für den Transport darzustellen sowie auf die praktischen Beispiele von innovativen Einführungen im Transport, die für die einführenden Unternehmen mit brauchbaren Effekten resultiert haben, hinzuweisen. Auf Grund der durchgeführten Wahrnehmung der Beispiele von innovativen Lösungen und der Analysen von innovativen Rankings galt es,

die Ergebnisse in Form von konkreten, für die Verbesserung der innovativen Fähigkeiten im Transport nötigen Aktivitäten zu projizieren.
Ergebnisse: Die von den Analysen und Wahrnehmungen hervorgehenden Schlussfolgerungen weisen darauf hin, dass die innovativen Lösungen im polnischen Transportwesen einen eher nachbildenden Charakter besitzen. Daher ist es unentbehrlich, neue Methoden und die neue, den innovativen Logistiklösungen entgegentretende Organisationskultur einzuführen. Die Transport-Cluster können dabei als das die Entwicklung des innovativen Potenzials im TSL-Sektor anspornendes Instrument in Funktion treten. Der Autor projiziert auf Grund der selbst durchgeführten Wahrnehmung der Beispiele von innovativen Lösungen und der Analysen von innovativen Rankings die Ergebnisse in Form der konkreten, für die Verbesserung der innovativen Fähigkeiten im Transport nötigen Aktivitäten und Einführungen.

Codewörter: innovative Lösungen, Transport, innovative Logistiklösungen im Transport, Kaizen, Cluster.

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REAL TIME MODEL FOR PUBLIC TRANSPORTATION MANAGEMENT

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ABSTRACT. Background: The article outlines managing a public transportation fleet in the dynamic aspect. There are currently many technical possibilities of identifying demand in the transportation network. It is also possible to indicate legitimate basis of estimating and steering demand. The article describes a general public transportation fleet management concept based on balancing demand and supply.

Material and methods: The presented method utilizes a matrix description of demand for transportation based on telemetric and telecommunication data. Emphasis was placed mainly on a general concept and not the manner in which data was collected by other researchers.

Results: The above model gave results in the form of a system for managing a fleet in real-time. The objective of the system is also to optimally utilize means of transportation at the disposal of service providers.

Conclusions: The presented concept enables a new perspective on managing public transportation fleets. In case of implementation, the project would facilitate, among others, designing dynamic timetables, updated based on observed demand, and even designing dynamic points of access to public transportation lines. Further research should encompass so-called rerouting based on dynamic measurements of the characteristics of the transportation system..

Key words: public transportation, management model, transportation fleet.

INTRODUCTION

The organization of public transportation is one of the basic fields of activity comprising the logistics of public transportation. This is due to the fact that its organization directly impacts traffic conditions of every transportation network. Poorly organized public transportation causes an increase in the volume of private transportation, the observable outcome of which is traffic congestion [An et al. 2009, Kauf 2010, Mallinckrodt 2010, Pawlak 2012]. This in turn has a negative impact on all aspects of logistics, including: transportation, freight forwarding, warehousing and safety [Szymczak 2008, Kauf 2010]. Public transportation, in the form developed in the 20th century, is inadequate in relation to the social expectations voiced today. The observed dynamics of social and economic changes that have taken place within the last two decades have led to the situation that public transportation, based on determined characteristics of demand and supply, cannot successfully compete with individual forms of commuting. This pertains to practically all determined aspects of public transportation: a fixed transportation fee, predetermined distribution, fixed points of access to the transportation network, fixed public transportation route along the transportation network, lack of justified variability of fleet capacity, unvarying quality of provided services, etc. The article focuses on such characteristics of public transportation supply as: carriers' time and spatial schedules as well as fleet capacity. Public transportation supply,

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offered on hitherto principles, is unable to satisfy fluctuating demand due to the lack of spatial and time uniformity of the latter. Currently observed commuting behavior, especially in large towns and agglomerations, reflect social and economic changes. The number of trips realized on a 24-hour and weekly cycle, so-called mobility, is increasing. This is due to an increase of trips to and from work. The road-traffic structure in urban areas is also undergoing changes. This is linked with, inter alia, suburbanization and a change in the spatial distribution of those participating in traffic. The hitherto cure for this dichotomy between demand and supply in public transportation, in the form of traffic research (KBR and others), does not keep up with the dynamics of observed changes [Celiński and Sierpiński 2012, Pawlak 2011, Szymczak and Sienkiewicz-Małyjurek 2011]. The mobility of a city's residents is also increasing, mainly as a result of easier access to individual forms of transportation. Public transportation, despite being endorsed by national and international policies, is experiencing stagnation; this especially applies to railroads [Our Common Future 1987, White Paper 2001, White Paper 2011]. Solutions to the problem must aim to implement the accomplishments methods of Intelligent Decision Systems in Transportation (genetic algorithms, neural networks, expert systems etc.). The following may serve as a means of achieving balances supply and demand in public transportation: monitoring, telemetric and telecommunication systems. These systems include: GPS (Global Positioning System), GSM (Global System for Mobile Communications), wireless networks and CCTV (Closed-Circuit Television). A solution implementing intelligent demand monitoring in railway transportation was presented in issue 3/2012 of LogForum [Celiński and Sierpiński 2013]. The right and legitimate implementation of the abovementioned technology may permit:

- design of dynamic timetables, updated based on observed demand;
- design of dynamic access points to public transportation lines (variable spatial distribution of access points, virtualization of access points);
- design of dynamic public transportation routes based on road networks (means of transportation with their own transportation roads or tractions are less susceptible in this case: railway transportation, trams);
- optimized capacity of means of transportation based on demand characteristics.

From this angle, the suggested technology should be used to obtain maximum precision in identifying time and spatial parameters of demand for public transportation. This also applies to identifying the nature of demand (type and direction structure) [Celiński and Sierpiński 2013].

The article outlines chosen aspects pertaining to the description of supply and demand in such a system, as well as a model and chosen scenarios. An important premise for implementing such a system is the sustainable development policy in the field of transportation [White Paper 2001, White Paper 2011].

DEMAND AS WIDE TRANSPORTATION SYSTEM CUSTOMERS EXPECTATIONS

What parameters characterize present-day demand for public transportation? We can willfully state that there are various parameters while they are all characterized by an observable increase in dynamics. This dynamics is increasing at a more and more intense pace, which is an unfavorable phenomenon [Karoń et al. 2009, Pawlak 2012]. A change in the professional profile of almost all age groups has been observed [Celiński and Sierpiński 2012]. It is becoming the norm to have two, at times three, sources of income. The flexibility and scope of business hours is also changing, regulated by new employment regulations [Directive 2003/88/EC, Wratny 2010]. The first aspect leads to lack of spatial uniformity of travel distribution, the second to lack of time uniformity. The way people spend their leisure time is also changing. From the point of view of traffic organizers, the significance of the distinction between obligatory and facultative travels is decreasing. The first are no longer a dominating and "easy" element when shaping communication order in urban areas. This is the result of substantial defragmentation. The entire "view" of public transportation is additionally complicated by a series of other, unfavorable, phenomena: suburbanization, seasonal work, spatial fluctuations and fragmentation of business entities, telecommuting, etc. As the demand for public transportation is changing spatially and temporally, to an extent that has not been observed within the last century, we may formulate the following question: are hitherto forms of satisfying demand justified? According to the authors of this article, the answer is: no. The description of demand for public transportation should no longer be limited solely to characteristics of increased travel to and from home, often determined for a couple of years at a time. Demand for public transportation should be presented in the form of spatial 3D functions, described within a transportation network. For simplification, the description of demand contained in the article is expressed in figures. Furthermore, these functions should not be described discretely - limited solely to geometric parameters of transportation networks. Demand for public transportation services should be observed, to the extent possible, along the entire transportation network area. It is possible to adjust supply to meet demand in a flexible manner, based on observations of the values of 3D functions expressing demand for transportation. This can be carried out not only by changing timetables, but also the routes of urban public transportation lines. The basic problem is determining (simplifying) the discretization of 3D functions expressing the characteristics of demand for public transportation. It is obvious that a continual description is not necessary in this case. It is possible to define a certain increase (Δl) for both dimensions (length and width) of area S occupied by the transportation system, with the principle of approximating values of the demand for public transportation function. For determined delimitation parameters of area S, it is possible to define certain decision criteria. As an example, in the case of bus lines, distances should not be greater than the distance of road sections (or group of sections), due to the economic aspect of breaking and accelerating between two stops (greater fuel use). This is a typical economic limitation, imposed on public transportation. Losses linked with traction characteristics of vehicles should define the smallest possible interval in this scope. The same goes for railway traction (although in this case there are greater infrastructure-related limitations). This function can be expressed with the support of matrix A (square or rectangular):

$$PTZ_c = A = [a_{ij}] \tag{1}$$

where:

PTZ_c - total size of demand for public transportation, expressed by matrix *A*,

a_{ij} - element *ij* of matrix *A*, describing the value of demand for public transportation in the spatial regime containing *ij* coordinates for the network area of the transportation network. Delimitation of the transportation network's area into its width (x) and length (y) with the value Δl creates a spatial regime matrix with *i x j* dimensions. The division can also take under consideration divisions that are not uniform $\Delta l_x \neq \Delta l_y$, in extreme cases a division based on the area of asymmetric figures. In the case of demand measurements based on the characteristics of cellular networks, the matrix can be described as the area of circles representing BTS (Base Transceiver Station) range. Dimensions of *i* and *j* are, accordingly, the number of spatial regimes describing the analyzed area using vertical and horizontal coordinate descriptors ($W_x^{a_{ij}}$ and $W_y^{a_{ij}}$, accordingly - or: longitude and latitude).
The *ij* parameters indicate the spatial regime of the area; descriptors their geographical dimensions. The dimensions of matrix *A* are directly linked with the assumed manner for calculating area width and length of the transportation network $\Delta l_x = W_x^{a_{ij}} - W_x^{a_{i+1j+1}}$, accordingly: $\Delta l_y = W_y^{a_{ij}} - W_y^{a_{i+1j+1}}$. The values of Δl_x and, accordingly, Δl_y may be different, depending on the uniformity of the transportation network. *A* type of matrix can be used, despite its discrete nature, to describe the area of the transportation network in its constant form.

To do so, for any three nonlinear "points" (a_{ij}) describing demand in the analyzed area, and described coordinates, e.g.: $P_1^{a_{ij}}(x_{1,}y_1,z_1), P_2^{a_{i+1j+1}}(x_{2,}y_2,z_2), P_3^{a_{i+1j-1}}(x_{3,}y_3,z_3)$ (e.g. centers of spatial regime areas), an $\Re^3$ surface can be formed: $Ax+By+Cz+D=0$. Intermediate points, describing demand between the elements of matrix A, can be approximated to values described with such a surface. Due to the fact that the above description may differ as a result of: means of transportation, motivation, equation (1) can be expressed as:

$$PTZ^* = A^* = [a_{ij}^*] \qquad (2)$$

where:

(*) signifies the value of demand for public transportation expressed by matrix A* in relation to: travel motives, means of transportation, etc. In this sense $PTZ_c = \sum_* PTZ^* w^*$, where (*) signifies shares of percentages of individual travel motives or means of transportation for observed trips within a transportation network. As an example, if a public transportation vehicle is a bus, matrix A should be based on Δl resulting from existing tracts or spatial distribution of the bus stop network. In the case of the dynamic approach - resulting from planned or potential network of such objects. When it is possible to identify motives for travel, the value of Δl should be the result of the distribution of infrastructure linked with the motive. Travel motives can be identified based on GSM networks described in the publications [Sierpiński and Celiński 2012]. When considering the fact that observations of demand parameters can be realized in Δt, demand can be described as: $PTZ_c = A = [a_{ij}]\Delta t$. The value of Δt is linked directly with the possibilities of the technology used to monitor the demand for public transportation services within a given population.

SUPPLY AS LIMITED SYSTEM RESOURCES

A transportation carrier/operator's limited services possibilities are always a critical element. This is a result of limited resources, mainly the number of vehicles at a carrier's disposal. The prices of means of transportation, as well as access to public transportation infrastructure (fees, licenses, taxes, etc.) are systematically increasing. In the presence of decreasing demand for public transportation, despite sustainable development policies, the right management of limited resources gains even greater significance than it ever has before [White Paper 2011]. In practice this signifies the necessity to implement the only rational solution - adjustment of supply to demand to the maximum extent. Often public transportation operators are comprised of entities called to life by local authorities. Keeping in mind the currently observable financial situation of local authorities, the possibility of offering sustainable supply is additionally curbed, even given such policies. On the other hand, supply is also limited as a result of increased road congestion. Solutions that prioritize public transportation (on the infrastructural, organization and traffic steering levels), are rather unpopular. These solutions furthermore have other shortcomings on levels not discussed in this article. Carriers also have limited staff (drivers, mechanics) as a result of substantial migration within these professional groups in Poland.

In contrast to demand for public transportation, which can be substantially described as a spatial distribution of lodged requests, supply should be described in the form of modified equation (1), where the interval between regimes/regime central points that describe supply is expressed as follows:

$$\Delta l_{x,y} = W_{x,y}^{a_{kl}} - W_{x,y}^{a_{k+1k+1}} = \mathrm{const} \rightarrow 0 \qquad (3)$$

Delimitation of the transportation network in this case aspires toward a continuous distribution, along with the technological progress of monitoring systems. In practice the interval (Δl) described by equation (3) should stem directly from the interval between possible "windows of data transfer" linked with the technological possibilities of communication/identification of vehicle location within the transportation network. In the case of GPS, precision in practice is a few dozen meters [Borriello et al. 2005]. In the case of GSM, precision is limited in the simplest cases by the cellular sector's area of operation [Rashid et al. 2005, Tarumi et al. 2004]. This interval should make it possible: for public transportation vehicles to stop on demand, alter their routes, give vehicles the possibility to refuel when necessary, change drivers, etc. An additional parameter describing supply in the system should be vehicle capacity and technical possibilities (e.g. low-floor vehicle, bike rack, etc.):

$$PDTZ_c = A^{'} /_{B,C,D...} = [a^{'}_{kl} /_{B_{kl}}, _{C_{kl}}, _{D_{kl}} ....] \quad (3)$$

where:
$PDTZ_c$ - total size of public transportation vehicle expressed by matrix A which defines the location of vehicles within the analyzed area, with conditions expressed by matrixes B (capacity); C (technical parameters), D (passengers on board), etc.

A fundamental difference between the matrixes describing supply and demand (A' and A, accordingly) in the system is their size ($ij \neq kl$). Along with an increase in the precision of demand measurements, in order to balance the dynamics of changes in matrix dimensions expressed by (1), the values *ij* and (2) *kl* should become similar.

OPERATING SCENARIOS FOR TRANSPORTATION OPERATORS

Previous sections proposed a description of public transportation demand/supply distribution using two matrixes (1) and (3). Matrix A or A' contains values for supply or demand within a given (different) spatial regime. The supply matrix will generally be determined with greater precision than the demand matrix, as a result of the size of the population and used identification techniques. If the dimensions of the demand matrix *ij* are a multiple of the supply matrix kl, the latter may be aggregated in order to resize *kl* to *ij*. In this case demand in a certain transportation network location (*ij=n*kl*) can be directly compared with supply (comparison within two equivalent spatial regimes). A simple balance of supply with demand within a given transportation network can be conducted this way, in every spatial regime:

$$\sum_{ij} ([a_{ij}] \quad -[a^{'}_{ij}]) \cong 0 \qquad (4)$$

where:

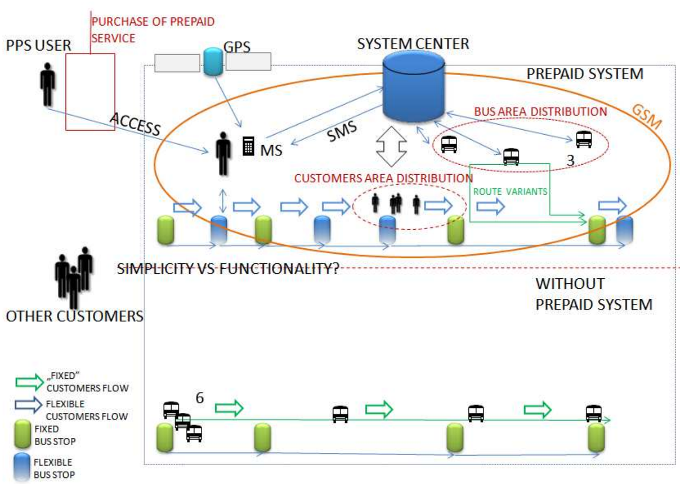
$a^{'}_{ij}$ - demand in *n kl* spatial regimes aggregated to the dimensions of regime *ij*.

Optimization of the transportation system in this aspect will entail finding the minimal value of the equation (4). In practice, even given considerable dynamics of system data updates, there will always be an observable error: $\zeta_{ij} = ([a_{ij}] \quad -[a^{'}_{ij}])$, linked with the aggregation of the demand matrix, due mainly to: determining motivation, localizing vehicles and public transportation clients, assessment of vehicle parameters (fuel reserves, number of passengers on board, etc.).

The suggested model offers a few operating scenarios for public transportation operators. These scenarios, when implemented, should lead to optimization of values expressed by equation (4). It is assumed that, based on the proposed dynamic solution, the public transportation system can also be implemented based on scenarios without predefined timetables. The entire system operates similarly to the principles of "Just in time". Whenever demand changes, it is immediately satisfied by updated supply. The first activity undertaken to meet this activity can be variation of vehicle travel speeds. If greater demand appears at "location" a_{ij}, vehicles at "locations" $a^{'}_{i(+1,-1)\,j(+1,-1)...itd.}$ increase their speeds, if possible, to permissible limits in order to satisfy a need for services as quickly as possible. If this is not possible (road congestion), all neighboring locations with the possibility of route variants are analyzed. The vehicle intended to "balance demand" should have appropriate parameters, depending on the number of passengers on board and its technical parameters. Another variant (scenario) of this type is flexibility (virtualization) of public transportation access points. Paradoxically, this approach might be problematic, especially in the case of railroads, where location and construction of stops require specific technical conditions. In the case of busses it is possible to place numerous access points along roads. Assuming the high dynamics of the suggested system, including shorter waiting periods, access points would not require the installation of bus shelter. Access points could be marked by a single vertical sign with communication module. In the case of serial production it would be possible to saturate the entire transportation network with stops of this kind. In the case of two-way communication between carrier and client, it would be possible to "virtualize" the distribution of access points. This approach would increase accessibility to transportation in an unprecedented way. This system has yet another benefit - if demand in a certain area falls (for certain periods/days), courses could be cancelled from the route of rerouted. This would lead to significant savings and optimal management of public transportation fleets. Yet another important feature of the system is minimization of duplicating services along the same points, as a result of the suggested dynamic demand monitoring technique. If demand drops in "location" a_{ij}, vehicle routes can be altered and vehicles can be rerouted to neighboring locations (algorithm for finding the shortest path within a network) in order to minimize a carrier's operating costs. Hence the benefit of the proposed system is an increase of communication availability in an urban area. Virtual (variant) stop locations can be implemented as part of the system.

CRITICAL REMARKS ABOUT MONITORING SYSTEMS

The proposed concept is based on the possibilities of localizing the distribution of supply and demand throughout the transportation network. Supply does not pose greater technical difficulties as it is limited in relation to demand. GPS technology is already being utilized to monitor public transportation (various examples throughout the world). It may be, however, problematic to add additional functions to the system, such as: dynamically determining vehicles' technical parameters, capacity, etc. Modern fleets fulfill these technical requirements [websites: ENTE, ALSTOM and PESA]. Especially rolling stock has good systems for calculating capacity [websites: ENTE, ALSTOM and PESA].



Source: Author's research

Fig. 1. Prepaid system compatible with proposed concept
Rys. 1. System pre-paid spójny z proponowaną koncepcją

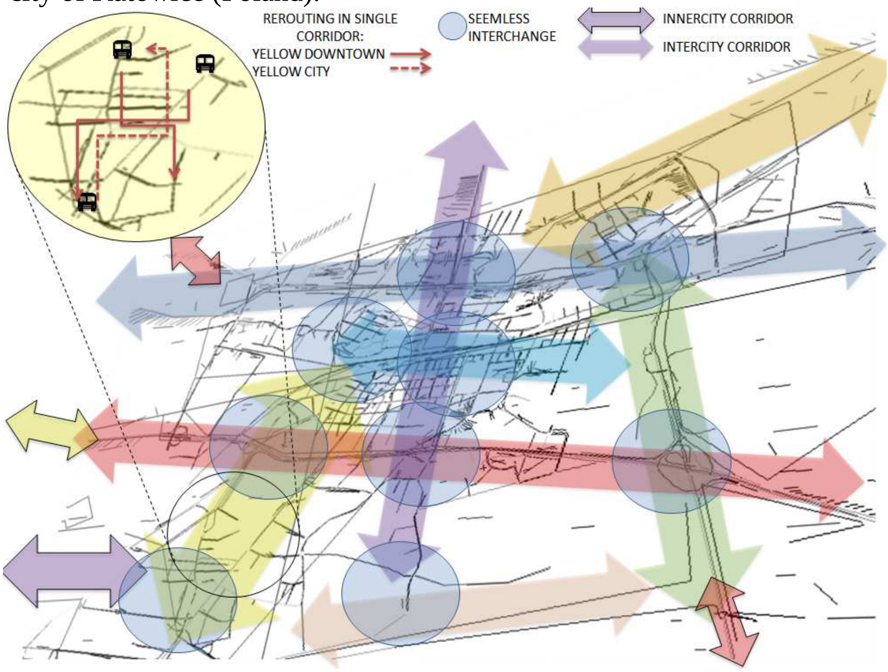
Determining time and spatial distribution is considerably more problematic. Researchers have on numerous occasions suggested utilizing cellular phone networks to do so [almost all publications quoted by this article]. This can be obtained with or without the collaboration of existing GSM network providers. The latter might require constructing a special telemetric system. Measuring the signal does not mean decoding it - only confirming the presence of a user in a given spatial regime.

A prepaid network based on precise GPS technology in combination with the functionality of a cellular phone network would be the simplest means of implementing the system. Users (ultimately all those using public transportation) could be located in urban terrain via GPS while the functionality of the solution could be integrated with GSM in the form of text message services. This system would work best if services were provided by many providers at the same time. Technical support would not pose a problem. In Poland in 2013 the number of MS (Mobile Station) subscribers and pre-paid users exceeded 54.9 million [Central Statistical Office 2013] (total Polish population less then 37 million).

Figure 1 shows a prepaid system for identifying demand for public transportation based on GPS technology and GSM systems. The main benefits of the system are an improved balance of demand and supply as well as increased accessibility to the network. Difficulties include system implementation and social acceptance. This pertains mainly to a conflict on the simplicity/functionality axis. Benefits are the outcome of: dynamic variation of public transportation routes and flexibility linked with the localization of a greater amount of access points and adjusting fleet size to existing needs.

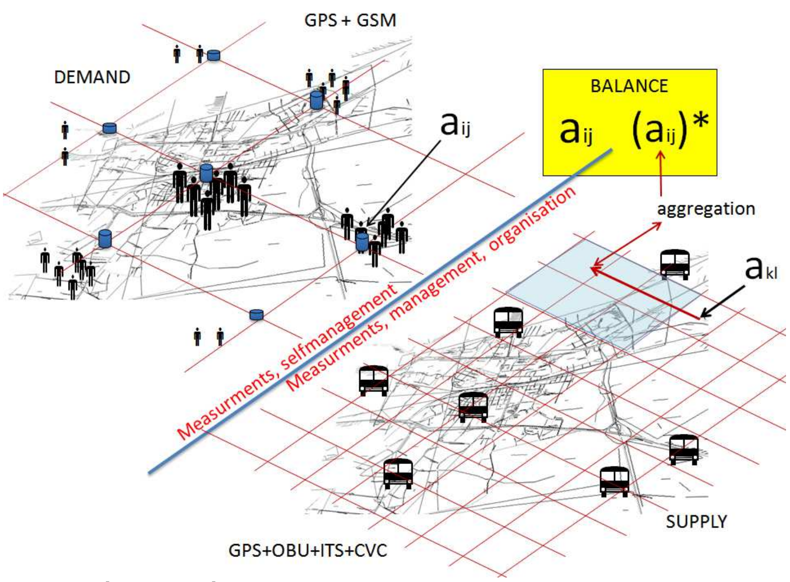
MODEL CONCEPT - WHERE DO YOU WANT TO GO TODAY?

When choosing a means of transportation, a client considers various criteria. We will be overlooking the aspect of a choosing directly between public and individual transportation, which boils down to owning a passenger car and, at times, traffic conditions or fuel prices. The client mainly considers: service realization time, service reliability, service accessibility and safety of services [Sierpiński 2011]. The proposed system places an emphasis on three of the aforementioned aspects: service realization time, service reliability and on increasing the accessibility of services. Decreasing service realization time is, in this case, directly linked with the system's basic objective: prompt balance of dynamically identified demand (fig. 3). This is possible via rerouting and virtualization of network accessibility points. Shorter service realization periods, including waiting time, are possible via a simplification of access points (bus stops), and in practice: in increasing their number. This is possible thanks to a simplified infrastructure (no roofed structures, no bays). Structures are not necessary due to shorter waiting periods on stops; bays are not necessary due to shorter boarding times. A significant problem for the model is posed by formalizing route variant procedures based on time and spatial parameters of identified demand. Balancing supply and demand in the system is possible mainly by creating route variants to spatial regimes where a greater demand for public transportation services is lodged. The manner in which the system functions is not simple or clear from the point of view of the user (even when disregarding the aspect of virtualizing access points). The system should maintain an organization structure that allows for information clarity while simultaneously maintaining high service frequency. Functionality can be implemented based on predefined transportation corridors located throughout the city. A commuting client is not "forced" to use a fixed line number when using the system. He or she must only know which corridors to take to reach a destination and in which direction. Every vehicle operating within the system would only be marked with the corridor's color and direction. The concept of a road network divided into corridors is illustrated based on the city of Katowice (Poland).



Source: Author's research

Fig. 2. Dynamic rerouting in proposed concept.
Rys. 2. Dynamiczne zmiany tras w proponowanej koncepcji



Source: Author's research

Fig. 3. Balance of supply and demand in proposed concept (OBU-OnBoard Unit, CVC- central vehicle computer, ITS- intelligent transport system)).
Rys. 3. bilansowanie popytu I podaży w proponowanej koncepcji (OBU-OnBoard Unit, CVC- centralny komputer samochodowy, ITS- inteligentny system transportowy)).

Figure 2 shows the road system in Katowice divided into eight inner-city transportation corridors, marked in different colors. Each corridor is marked with its own color and contains a description of direction. The illustration shows direction as downtown and city, depending on the vehicle's path in relation to the city's center. The upper right hand corner of Figure 2 contains example of route variants for one corridor. Instead of several independent lines operating within a single corridor, there is only one line and its routes depend on demand lodged in the system. The width of the corridor makes it possible for a client to access a line of a certain color, choose the correct direction, arrive at his or her destination within a distance proportionate to the width of the corridor (on Figure 2 this distance is up to a few hundred meters, 500-900). The system considerably simplifies the organization of public transportation within a given city. The eight corridors shown on Figure 2 replace a few hundred lines organized by multiple regional public transportation carriers. If the solution was implemented, then - in the case of the yellow corridor and given the current distribution - a few dozen buses could be used to prepare route variants. The difference is that, in contrast to fixed lines, the variants would be adjusted to meet lodged demand within a given transportation corridor.

A detailed description of organization structure and rerouting algorithms goes beyond the framework of this article.

DISCUSSION AND CONCLUSIONS

The model outlined at a glance in the article comprises a new approach to managing public transportation fleets. It places greater emphasis on the needs of passengers (including potential passengers), and simultaneously takes under consideration ways to optimize the use of fleets owned by public transportation companies. Full integration may enable, inter alia, planning dynamic timetables based on observed demand, and even the design of dynamic access points to public transportation lines. Routing along public transportation corridors, without lines in the classic sense, should enable fleets to bypass road congestion (as they could, to an extent, avoid congested routes). Another benefit of the system is the increase of transportation availability in urban areas.

In method proposed in the article, fleet management system assumes the use of transport corridors describing the area of the city. The idea is reasonable in the case where the width of the corridors are not too large (approx: 2x500 meters from the axis of the corridor - 5 minutes walking an average speed of 1.66 m/s). Too large width of corridors demonstrated in Figure 2 significantly increase the arrive at and leaving times people residing (or working, studying etc.) in their area.

This approach forces the use of a large number of closing to each other corridors in a limited area. This narrows down their use for close city centers, densely populated suburban areas or corridors organized within the urban main roads. Low population density, particularly heterogeneous in suburban areas, complicated variants of the routes of public transport vehicles in such cases. In these cases appear to be reasonable traditional timetables and organization of public transport. In these cases, should also expect significant instability in the qualitative and quantitative parameters for passenger traffic. This requires further work, especially micro-simulation modeling to accurately identify and examine the proposed method.

Subsequent research should focus on so-called rerouting based on dynamic measurements of the characteristics of the transportation system.

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DYNAMICZNE ZARZĄDZANIE FLOTĄ TRANSPORTU ZBIOROWEGO

STRESZCZENIE. **Wstęp:** Artykuł prezentuje koncepcję zarządzania flotą transportu zbiorowego w aspekcie dynamicznym. Współcześnie istnieje wiele możliwości technicznych identyfikacji popytu w sieci transportowej. Można również wskazać zasadne podstawy szacowania i sterowania podażą. Artykuł ten jest opisem ogólnej koncepcji systemu zarządzania flotą transportu zbiorowego w oparciu o bilansowanie popytu i podaży.
Metody: W prezentowanej metodzie wykorzystywany jest opis macierzowy popytu na transport w oparciu o dane z systemów telemetrycznych i telekomunikacyjnych. Skupiono się głównie na ogólnej koncepcji pomijając sposób pozyskiwania danych opisany w innych opracowaniach autorów.
Cele: Wynikiem działania przedmiotowego modelu jest budowa systemu zarządzania flotą w czasie rzeczywistym. System taki ma również zapewniać optymalne wykorzystanie ilostanu środków transportu pozostającego w gestii przewoźników funkcjonujących na rynku usług transportowych.
Wnioski: Prezentowana koncepcja umożliwia inne spojrzenie na problem zarządzania flotą transportu zbiorowego. Projekt w przypadku wdrożenia powinien pozwolić m. in. na projektowanie dynamicznych rozkładów jazdy, aktualizowanych na bazie obserwacji popytu, a nawet projektowanie dynamicznego rozkładu punktów dostępu do linii transportu zbiorowego. W dalszych pracach należy zwrócić uwagę na problem tzw. reroutingu tras pojazdów transportu zbiorowego na podstawie dynamicznych pomiarów charakterystyki systemu transportowego..

Słowa kluczowe: tranport, zarządzanie flotą transportową, model zarządzania.

DYNAMISCHE FUHRPARK-VERWALTUNG IM MASSENVERKEHR

ZUSAMMENFASSUNG. Einleitung: Der Beitrag stellt ein Konzept für Management einer Massen-Transportflotte in dynamischer Hinsicht dar. Heutzutage bestehen zahlreiche Möglichkeiten für technische Identifikation der Nachfrage in Transportnetzen. Man kann natürlich auch begründete Grundlagen der Schätzung und Steuerung des Angebotes vorweisen. Der vorliegende Beitrag beschreibt die allgemeine Idee eines Systems für Management einer Flotte im Gruppentransport anhand einer Nachfrage- und Angebotsbilanzierung.
Methode: Die vorgestellte Methode nutzt die Matrixbeschreibung der Transportnachfrage anhand der mit Hilfe von telemetrischen und telekommunikativen Systemen generierten Angaben. Der Fokus richtet sich auf die allgemeine Idee. Die Art der Gewinnung von Angaben wird jedoch außer Acht gelassen, da sie von anderen Autoren bereits beschrieben wurde.
Ziele: Das Ergebnis des gegenständlichen Modells ist die Ausgestaltung eines Managementsystems für Transportflotten in der Echtzeit. Dieses System soll auch eine optimale Nutzung des Bestandes von Transportmitteln, der den auf dem Markt tätigen Transportunternehmen zur Verfügung steht, gewährleisten.
Fazit: Die vorgestellte Idee ermöglicht es, das Problem des Managements von Transportflotten für den Gruppentransport aus einer anderen Perspektive zu betrachten. Das Projekt sollte im Falle seiner Einführung u.a. das Entwerfen von dynamischen Fahrplänen, die anhand von Nachfrageanalysen aktualisiert werden, und von dynamischen Plänen der Zugangspunkte zu Gruppentransportstrecken ermöglichen. In der weiteren Bearbeitung sollte man sich mit dem Problem des sog. Rerouting von Gruppentransportmitteln anhand dynamischer Messungen von Kennlinien und -ziffern eines Transportsystems beschäftigen.

Codewörter: Transport, Fuhrpark-Verwaltung, Modell des Managements.

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RISK ASSESSMENT AND MANAGEMENT LOGISTICS CHAINS

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ABSTRACT. Background: In the context of economic globalization and increasing complexity of economic relations enterprises need methods and techniques to improve and sustain their position on the global market. Integration processes offer business new opportunities, but at the same time present new challenges for the management, including the key objectives of the risk management.
Method: On the basis of analysis tools known from the pertinent literature (Supply Chain Management and Supply Chain Risk Management methods, methods of probability theory, methods of risk management, methods of statistics) the authors of this paper proposed their own risk assessment method and the method of management of logistics chains. The proposed tool is a specific hybrid of solutions known from the literature.
Results: The presented method has been successfully used within the frames of economic-mathematical model of industrial enterprises. Indicators of supply chain risks, including risks caused by supplier are considered in this paper. Authors formed a method of optimizing the level of supply chain risk in the integration with suppliers and customers.
Conclusion: Every organization, which starting the process of integration with supplier and customers, needs to use tools, methodologies and techniques for identification of "weak links" in the supply chain. The proposed method allows to fix risk origin places in various links of the supply chain and to identify "weak links" of a logistic chain that may occur in the future. The method is a useful tool for managing not only risks and risk situations, but also to improve the efficiency of current assets management by providing the ability to optimize the level of risk in the current assets management of the industrial enterprise.

Key words: risk management, supply chain risks, optimization of risks, integration risks.

INTRODUCTION

The paper is devoted to the risk assessment and management of the industrial supply chain. The authors considered indicators of supply chain risks, including risks caused by supplier. Authors formed a method of optimizing the level of the supply chain risk in the integration with suppliers and customers.

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In the context of economic globalization and increasing complexity of economic relations enterprises need methods and techniques to improve and sustain their position on the global market. Integration processes offer business new opportunities, but at the same time present new challenges for the management, including the key objectives of the risk management.

BRIEF METHOD OF ASSESSMENT AND MANAGEMENT LOGISTICS CHAINS

In our view, the integration is a process of creation and the involvement of individual

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parts into a whole, taking into account the ability of their devices to achieve new qualitative state and acquire new capabilities. But the result of such a state can be achieved not only through the integration process, but also in the so-called quasi-integration. Analysis of the literature showed that the consensus on the concept of quasi-integration does not exist. In this regard, we consider it reasonable to offer own definition of "quasi-integration", based on the interpretation of the term by Sheresheva [2010]. The quasi-integration is an association of economic subjects, based on the stable and long-term relationship between them and the management mechanism of their joint activities through transparency, financing (including long-term lending, investment lending, leasing), insurance and other tools to control the behavior of subjects other than legally issued change of ownership [Butrin and Vikulov 2012].

Butrin A. [2012] in his work "Methodical bases chain costs management in integrated enterprise" notes that the participation in the integration process provides participants with the following features:
- higher access to different types of resources (material, financial, labor),
- the opportunity to operate on a broader integration space,
- to create efficiencies,
- to create privileged conditions for integrating subjects and protect them from the competition of other non-interest in the structure of grace,
- an agreed solution.

Modern integration processes were reflected in the risk management. Today, risk management in some industries is carried out on the level of the whole company, and begins to go beyond a single enterprise, taking the form of an integrated process, accompanying the transition of companies to the concept of supply chain management (SCM). In this regard, we note the emergence of scientific papers on supply chain risk management (SCRM). This concept covers all aspects of the activity and serves as a strategically tool of risk management in the integration process [Tsaplin 2011, Vikulov 2011].

In recent years, many papers covering this field have been published by Russian scientists. This work can be structured in the following areas: risk management in integrated structures, strategic risk management, development of risk management system at the enterprise, risk management of certain areas of the company.

The main weaknesses of the current stage of risk management are as folllows:
- lack of theoretical and methodological framework for identifying risks and losses of their intensification,
- no methodology of risk management in the context of growing integration in the industry,
- local management of interacting participants functional without including risk component. It does not permit to achieve the desired synergies and reduces efficiency,
- the pricing based on the classical approach, does not fully take into account the risk of losses in the logistics chain.

Accordingly, the actual tasks are:
- disclosure of organizational and economic nature of the risks and characteristics of industrial enterprises in the context of integration with suppliers and customers,
- development of risk optimization method in industrial enterprises current assets management,
- development of economic and mathematical model for determining the optimal level of risk in logistic chain.

We consider the developed method of risk management in current assets management of industrial enterprises in the context of integration. In contrast to existing methods, authors propose method, firstly, based on fixing of sources of risk at their location in the circulation of current assets, which eliminates duplication, secondly, considering various schemes of logistic chain, taking into account the specifics of interaction with contractors, each of which has its influence on the occurrence and size of the risk, and thirdly, based on the intersystem approach and aims to choose the optimal parameters of current assets with the risk component in the quasi-integration.

We offer the following composition of the risks listed in Table 1, in order to fix the source of the risk at their location in the supply chain. It corresponds to the placement of the main sources of risk in the various links of the supply chain [Butrin and Vikulov 2012].

This approach to the risk classification allows to fix the places of risks appearing in specific links of supply chain and identify "weak links" of the supply chain that may occur in the future, in contrast to most existing approaches, where the "weak links" are already determined after the fact. The systematic picture of the potential "weak links" in the chain is a useful management tool not only for the risks and risk situations management, but also for improving of the overall efficiency of management company.

Table 1. The composition of the various risks in the of logistic chain links
Tabela 1. Poszczególne ryzyka w obrębie ogniw łańcucha logistycznego

Group of risks	Composition of risks
Risks associated with supplier	Risk of "care" supplier
	Risk of penalties to the supplier for violations of contract
	Risk of violating the delivery schedule resources
	Risk of buying poor quality resources
	Risk of non-delivery / short delivery resources
	Risk of changes in resource prices
	Risk of leaving the consumer reasons associated with supplier
Risks of the "Procurement"	Risk of failure in transport
	Risk of damage or loss transported values
	Risk of leaving the consumer for reasons, that have arisen in «Procurement»
Risks of the "Warehousing, storage, internal transportation resources"	Risk of improper storage resources
	Risk of loss of resources for internal transport
Risks of the "Production"	Risk of rhythm disorders of manufacturing
	Risk of producing unwanted products (overproduction)
	Risk of downtime production capacity for technical reasons
	Risk of failure in IT-systems of production management
	Risk of downtime for other reasons
	Risk of increase the marriage finished products
	The risk of poor control quality of products
	Risk of environmental losses
Risks of the "Warehousing, storage, internal transportation products"	Risk of improper storage products
	Risk of loss of products for internal transport
Risks of the "Sales and Marketing"	Risk of changes in the planned volume of sales
	Risk of failure of networking sales
	Risks choosing the wrong promotion strategy
	Risk of reduce market prices for finished products
Risks of the "Transportation of finished products"	Risk of failure in transport
	Risk of damage or loss transported values
Risk of the “Finance”	Risk of loss due to the binding of the capital in the functional "Procurement"
	Risk of loss due to the binding of the capital in the form of stock
	Risk of loss due to the binding of capital in the form accounts receivable from buyers
Risks associated with the buyer	Risk of bad debt
	Risk of "care" buyer
	Risk of losses (gains) of default by the buyer

We have to go through several steps in order to solve the optimization problem of finding of the optimal value of the delay (timing) flows.

In the first stage it is necessary to accumulate all the necessary statistical and operational information in order to determine the magnitude of the losses and the probability of their occurrence. This bank of information is easier to form than in the disintegration as under the conditions of quasi-integration in the presence of open information space and its transparency, it is entirely possible to do.

Table 2. The formula for calculating the integral components of the expectation of losses
Tabela 2. Wzór wyliczania składowych przewidywanych strat

$Integr.R= R(S)+R(P)+R(SR)+R(PR)+R(FS)+R(M)+R(D)+R(F)+R(C)$
$R(S)=\min(B_{zp}*Q_{neposp.res}/N_{racx}*T_{proizw}*(1+TAX_{ss})+T_{zap}*MR_{sztr.pr.post.}*P_{realiz}*Q_{neport.res}/N_{rash};\ R_{utz}*P_{zakyp}*Q_{nepost}*R_{srocz}+(P_{dr.post}-P_{zakup})*Q_{nepost})*P(S_1)+(MR_{szt.prosr.opl}*C_{neopl}*(T_{oc}-T_{octsr.})+(Q_{post}-Q_{swob})*P_{zakup}*MR_{szt.prosr.prin}*\frac{(Q_{treb.res.}-Q_{swob})}{V_{wysw}})*P(S_2)+\min(B_{zp}*Q_{nepost.resc}/N_{rash}*T_{proizw}*(1+TAX_{ss})++T_{zap}*MR_{sztr.pr.port.}*P_{realiz}*Q_{nesw.post.res}/N_{rash}-T_{zap}*R_{sztr.pr.rost.}*P_{zakup}*Q_{nesw.post.res.};\ R_{utz}*P_{zakup}*Q_{nesw.post.res}*R_{srocz}+(P_{drp.post}-P_{zakup})*Q_{nesw.post.res}-T_{zap}*R_{sztr.pr.post.}*P_{zakup}*Q_{nesw.post.res.})*P(S_3)+\min(B_{zp}*Q_{nepost.res}/N_{rash}*T_{proizw}*(1+TAX_{ss})+T_{zap}*MR_{sztr.pr.post.}*P_{realiz}*Q_{nekacz.res}/N_{rash}+\min(R_{utz}*P_{zakup}*Q_{nekacz.res};\ (P_{zakup}-P_{zakup.g.})*Q_{nekacz.res})-R_{sztr.nekacz.}*P_{zakup}*Q_{nekacz.res.};\ R_{utz}*P_{zakup}*Q_{nekacz.res}*R_{srocz}+(P_{dr.post}-P_{zakup})*Q_{nekacz.res}+\min(R_{utz}*P_{zakup}*Q_{nekacz.res};\ (P_{zakup}-P_{zakup.g.})*Q_{nekacz.res})-R_{sztr.nekacz.}*P_{zakup}*Q_{nekacz.res.})*P(S_4)+\min(B_{zp}*Q_{nepost.res}/N_{rash}*T_{proizw}*(1+TAX_{ss})+T_{zap}*MR_{sztr.pr.post.}*P_{realiz}*Q_{nekomp.post.res}/N_{rash}-T_{zap}*R_{sztr.pr.}*P_{zakup}*Q_{nekomp.post.res};\ R_{utz}*P_{zakup}*Q_{nekomp.post.res}*R_{srocz}+(P_{dr.post}-P_{zakup})*Q_{nekommp.post.res}-T_{zap}*R_{sztr.pr.}*P_{zakup}*Q_{nekomp.post.res})*P(S_5)+(P_{now}-P_{zakup})*Q_{post}*P(S_6)+(P_{realiz}-PC_{plan})*Q_{nepost.res}/N_{rash}*P(S_{71})+(P_{realiz}-PC_{plan})*Q_{nesw.post.res}/N_{rash}*P(S_{72})+(P_{realiz}-PC_{plan})*Q_{nekomp.post.res}/N_{rash}*P(S_{73})$
$R(P)=\min(B_{zp}*Q_{nenpost.res}/N_{rash}*T_{proizw}*(1+TAX_{ss})+T_{zap}*MR_{sztr.pr.post.}*P_{realiz}*Q_{nesw.post.res.tr}/N_{rash}-T_{zap}*R_{sztr.pr.post.}*P_{zakup}*Q_{nesw.post.res.tr};\ R_{utz}*P_{zakup}*Q_{nesw.post.res.tr}*R_{srocz}+(P_{dr.post}-P_{zakup})*Q_{nesw.post.res.tr,}-T_{zap}*R_{sztr.pr.post.}*P_{zakup}*Q_{nesw.post.res.tr})*P(P_1)+\min(B_{zp}*Q_{nepost.res}/N_{rash}*T_{proizw}*(1+TAX_{ss})+T_{zap}*MR_{sztr.pr.post.}*P_{realiz}*Q_{powrerzd.res.tr.}/N_{rash}+P_{zakup}*Q_{powrerzd.res.tr.}-R_{sztr.pow.post.tr}*P_{zakup}*Q_{powrerzd.res.tr.};\ R_{utz}*P_{zakup}*Q_{powrerzd.res.tr.}*R_{srocz}+(P_{dr.post}-P_{zakup})*Q_{powrerzd.res.tr.}+P_{zakup}*Q_{powrerzd.res.tr.}-R_{sztr.pow.post.tr}*P_{zakup}*Q_{powrerzd.res.tr.})*P(P_2)+(P_{realiz}-PC_{plan})*Q_{powrerzd.res.tr.}/N_{rash}*P(P_{31})+(P_{realiz}-PC_{plan})*Q_{nesw.post.res.tr}/N_{rash}*P(P_{32})$
$R(SR)=(B_{zp}*Q_{nepost.res}/N_{rash}*T_{proizw}*(1+TAX_{ss})+R_{utz}*P_{zakup}*Q_{nekacz.hr.res.}*R_{srocz}+T_{zap}*MR_{sztr.pr.post.}*P_{realiz}*Q_{nekacz.hr.res.}/N_{rash}+P_{zakup}*Q_{n.h.res})*P(SR_1)+(B_{zp}*Q_{nepost.res}/N_{rash}*T_{proizw}*(1+TAX_{ss})+R_{utr}*P_{zakup}*Q_{nakcz.tran.res.}*R_{srocz}+T_{zap}*MR_{sztr.pr.post.}*P_{realiz}*Q_{nekacz.tran.res.}/N_{rash}+P_{zakup}*Q_{nekacz.tran.res.})*P(SR_2)$
$R(PR)=\min(B_{zp}*Q_{nepost.res}/N_{rash}*T_{proizw}*(1+TAX_{ss})+R_{utz}*P_{zakup}*Q_{nekomp.post.res.}*R_{srocz};\ B_{zp}*Q_{nepost.res}/N_{rash}*T_{proizw}*(1+TAX_{ss})+T_{zap}*MR_{sztr.pr.post.}*P_{realiz}*Q_{nekomp.post.res.}/N_{rash})*P(PR_1)++(T_{hran}*C_{hran.}*Q_{perreproizw}+K_{obescen}*P_{realiz}*Q_{pereproizw})*P(PR_2)+\min(2*B_{zp}*T_{prost}(1+TAX_{ss})+T_{zap}*MR_{sztr.pr.post.}*P_{realiz}*Q_{prost}+\text{З}_{priob.zap.cz.};\ 2*B_{zp}*T_{prost}(1+TAX_{ss})+\text{З}_{serw.obsl}+\text{З}_{priob.zap.cz.})*P(PR_3)+\min(B_{zp}*T_{prost}(1+TAX_{ss});\ T_{zap}*MR_{sztr.pr.post.}*P_{realiz}*Q_{prost})*P(PR_4)+\min(B_{zp}*T_{prost}(1+TAX_{ss});\ T_{zap}*MR_{sztr.pr.post.}*P_{realiz}*Q_{prost})*P(PR_5)+(B_{zp}*(Q_{braka}+Q_{braka.obor.}+Q_{braka.t.pr.})*T_{proizw}++B_{zp}*(Q_{braka}+Q_{braka.obor.}+Q_{braka.t.pr.})*T_{proizw}*TAX_{ss}+T_{zap}*MR_{sztr.pr.post.}*P_{realiz}*(Q_{braka}+Q_{braka.obor.}+Q_{braka.t.pr.}))*(P(PR_{63})+P(PR_{64})+P(PR_{65}))+CC_{plan}*Q_{braka.}*P(PR_{63})+CC_{plan}*Q_{braka.oobor.}*P(PR_{64})+CC_{plan}*Q_{braka.t.pr.}*P(PR_{65})+(R_{utz.p.}+MR_{sztr.nekacz.})*P_{realiz}*Q_{nekcz.post}/N_{rash}*P(PR_7)+\text{З}_{ekol.}*P(PR_8)$
$R(FS)=(T_{zap}*MR_{sztr.pr.post.}*P_{realiz}*Q_{nekacz.hr.gp.}+CC_{plan}*Q_{n.h.gp})*P(FS_1)+T_{zap}*MR_{sztr.pr.post.}*P_{realiz}*Q_{nekacz.tran.gp.}*P(FS_2)$
$R(M)=(P_{real}-CC_{plan})*(Q_{plan}-Q_{fakt})*P(M_1)+(\text{З}_{form}-(P_{real}-CC_{plan})*Q_{fakt})*P(M_2)++(\text{З}_{prog}-(P_{real}-CC_{plan})*Q_{fakt})*P(M_3)+(P_{now}-P_{real})*Q_{fakt}*P(M_4),$
$R(D)=(T_{zap}*MR_{sztr.pr.post.}*P_{realiz}*Q_{nesw.post.gp.tr.}+T_{zap}*R_{sztr.pr.post.}*P_{realiz}*Q_{nesw.post.gp.tr.})*P(D_1)++(T_{zap}*MR_{sztr.pr.post.}*P_{realiz}*Q_{powrerzd.gp.tr.}+CC_{plan}*Q_{powrerzd.gp.tr.}-R_{sztr.pow.post.tr}*P_{real}*Q_{powrerzd.res.tr.})*P(D_2),$
$R(F)=\text{ДЗ}_{post}*R_{god}*t_{zap}^{post}/365*P(F_1)+(P_{zakup}*Q_{res}*R_{god}*(t_{hr.res}+t_{proizw}+t_{hr.gp}+t_{oc})/365++P_{real}*Q_{gp}*R_{god}*(t_{hr.gp}+t_{oc})/365)*P(F_2)+(P_{real}*Q_{gp}-P_{real}*Q_{gp}/(1+R_{alt}*t_{zap}^{pok}/365))*P(F_3)$
$R(C)=P_{real}*Q_{gp}*s*P(C_1)+l*L_u*H_{pr}*P(C_2)+P_{real}*Q_{nepr.gp}*MR_{sztr.nepr}*t_{nepr.}*P(C_{31})++P_{real}*Q_{gp}*MR_{sztr.prosr}*t_{prosr.}*P(C_{32})$
where B_{zp} - rate for an additional charge of basic salary, $Q_{nepost.res}$ – quantity of undelivered resources, N_{rsah} – flow rate of the resource per unit of production, T_{proizw} – time per unit of output, TAX_{ss} – fixed rate of social security contributions, R_{utz} – share of transport costs in the total amount of the purchase of resources, P_{zakup} –cost of purchased resources, Q_{nepost} – quantity of undelivered resources, R_{srocz} – increased rate for urgency, $P_{dr.post}$ –cost of resources from another supplier, T_{zap} - duration of the delay of delivery, due to the delay in the search for raw materials (days), $MR_{sztr.pr.post.}$ - value of the contract penalty for each day of delay in the form of interest rate, P_{realiz} - price of product, C_{neopl} – amount of non-payment, T_{oc} - quantity of days equal to the difference between the operating cycle (from the receipt of raw materials to the receipt of the money from customers for manufactured product), Q_{post} –volume of purchased resources, Q_{swob} – free storage space, $Q_{reb.res}$ – quantity of required resources, P_{zakup} –cost of purchased resources, $MR_{szt.prosp.prin.}$ - amount of the fine in the form of interest per day of delay in taking delivery, V_{wysw} - average (speed) of the release of a warehouse for storage which can be time-ship their power to all of the resources could be taken, $Q_{nesw.post.res}$ – quantity of untimely set of resources, $Q_{nekacz.res}$ – quantity assigned resources inadequate quality, $P_{zakup.g.}$ – price of the resource, taking into account the discount, $R_{sztr.nekacz.}$ –value of the fine supplier under the contract for the supply of low-quality resources, $Q_{nekomp.post.res}$ – quantity of undelivered resources, PC_{plan} – planned the cost price of products, $Q_{powrerzd.res.tr.}$– quantity of damaged / lost resources, transportation company, $R_{sztr.pow.post.tr}$ –value of the fine (sum insured) for damage resources transportation company under contract as a percentage rate of the value of goods, $Q_{nekacz.tran.res.}$ – quantity of improperly transported in resource production and unsuitable for the production, T_{hran} – time of storage, $C_{hran.}$ - cost of storage per unit per day, $Q_{pereproizw}$ - quantity of over-produced products, $K_{обесцен}$ – rate of depreciation of products on the market, $T_{прост}$ – downtime due to technical reasons, $Q_{прост.}$ –quantity of units that may make during the down time, $\text{З}_{serw.obsl}$ – maintenance costs, $\text{З}_{priob.zap.cz.}$ – cost of spare parts, $Q_{braka.}$ – quantity of defective products because of the low skilled personnel, $Q_{braka.obor.}$ – quantity of defective products due to poor condition of the equipment, $Q_{braka.t.pr.}$ – quantity of defective products associated with the process, T_{proizw} – time per unit of output, CC_{plan} – cost of routine, $R_{utr.p.}$ - specific transport costs per 1 ruble of sales of inadequate quality, $\text{З}_{ekol.}$ – cost of the environment, $Q_{nekacz.tran.gp.}$ – quantity of improperly transported in the production of finished products, and unsuitable for implementation, Q_{plan} – planned sales, Q_{fakt} – actual sales, З_{form} – cost of creation / organization of the sales network, З_{prod} – cost of product promotion, P_{now} – new price realization, $Q_{powrerzd.gp.tr.}$– amount of damaged / lost finished goods transport company, $R_{sztr.pow.post.tr}$ – value of the fine (sum insured) for damage to the transport company resources under the agreement as a percentage rate of the value of goods, ДЗ_{post} – advanced payment provider for raw materials, R_{god} – annual interest rate on the loan for financing, P_{zakup}- cost resources, P_{real} – cost of the finished product, Q_{gp} – quantity of stocks of finished products, Q_{res} – quantity of resource stocks, R_{god} – annual interest rate on the loan for financing, $t_{hr.res}$ – time of storage resources, t_{proizw} – production time, $t_{hr.gp}$ – time of storage of finished products, t_{oc} – value of the operating cycle, Q_{gp} – quantity of finished products, R_{alt} – alternative rate investment of resources, t_{zap}^{pok} –duration of the period of collection of receivables, S –proportion of bad debts (debt to the value of the delay of more than 2 months) in the structure of receivables, l –average cost of shipment per customer, L_u – quantity of buyers once freed, shih unserviced for the analyzed period, H_{pr} – rate of profit enterprises, $t_{zap.pok}$ – lag time of shipment of products buyers, $Q_{nepr.gp}$ – quantity of delayed introduction of products, $MR_{sztr.nepr}$ – value of fines for non-timely, $t_{nepr.}$ – duration of the breach, $MR_{sztr.prosr}$ – size of the penalty for late payment, $t_{prosr.}$ – duration of the breach of the obligation to pay

In the second stage, we calculate and group losses in the supply chain that are possible when operating the focus of each of the types of risks identified in Table 1.

In the third stage, we calculate the probability of loss, based on the availability of statistical information.

In the fourth stage, we calculate the intermediate indicators of the expectation of losses for each type of risk by the equations given in Table 2.

The fundamental equation (1) of calculation of these indicators, which is the sum of the product of the probability of loss is shown below.

$$R(N)= \Sigma \ N_i*P(N_i), \qquad (1)$$

where R(N) is the mathematical expectation of loss of the circuit of specific stage of current assets, N is group of risk type, N_i is loss value of specific type of risk, $P(N_i)$ is probability of loss of specific type of risk.

In the fifth stage, we calculate to the integral expectation of loss of focus company, which is calculated as the sum of pairwise products of the value of losses in each of the links in the supply chain for their probability. It is as follows:

$$Integr.R=R(S)+R(P)+R(SR)+R(PR)+R(FS)+R(M)+R(D)+R(F)+R(C), \qquad (2)$$

where:

Integr.R - integral expectation of losses on all stages,
(S) - expectation losses caused supplier,
R(P) - the expectation stage loss "Supply",
R (SR) - expectation loss in " Warehousing, storage and internal transport resources",
R(PR) - the expectation of loss under "Production",
R(FS) - the expectation of losses in the process of "Warehousing, storage and internal transportation of finished products",
R(M) - the expectation of the loss of the "Sales. Sale. Marketing",
R(D) - the expectation of losses on the stage of "The transportation of finished products",
R(F) - the expectation of loss of the "Financing",
R(C) - the expectation of losses caused by the buyer.

In the sixth stage, we define the values $t_{del}^{supp}, t_{del}^{cons}$ that provide the minimum value of the integral of the expectation of losses.

Table 3. The sample values in the search area in the short term decisions
Tabela 3. Wartości próbek uzyskanych w badanych obszarze dotyczące decyzji krótkoterminowych

Duration of the period of repayment of the debt, days	Duration of the period of collection of accounts receivable, days	The expectation of losses in the stages of the current assets circuit, rubles.									Integr.R, rubles.	K_{eff}
		S	P	SR	PR	FS	M	D	F	C		
-5	10	12760.24	2247.78	71.44	4348.31	105.78	15349.12	-998.76	6597.71	35.42	40517.04	0.842
-5	11	12784.00	2247.78	71.44	4348.31	105.78	15349.12	-998.76	6655.21	35.42	40598.30	0.841
-5	12	12807.76	2247.78	71.44	4348.31	105.78	15349.12	-998.76	6712.67	35.42	40679.52	0.839
-5	13	12831.52	2247.78	71.44	4348.31	105.78	15349.12	-998.76	6770.10	35.42	40760.71	0.837
-5	14	12855.28	2247.78	71.44	4348.31	105.78	15349.12	-998.76	6827.49	35.42	40841.87	0.836
-5	15	12879.04	2247.78	71.44	4348.31	105.78	15349.12	-998.76	6884.86	35.42	40922.99	0.834
-4	10	12736.48	2247.78	71.44	4348.31	105.78	15349.12	-998.76	34444.53	35.42	68340.11	0.499
-4	11	12760.24	2247.78	71.44	4348.31	105.78	15349.12	-998.76	36823.91	35.42	70743.24	0.483
-4	12	12784.00	2247.78	71.44	4348.31	105.78	15349.12	-998.76	39133.68	35.42	73076.77	0.467
-4	13	12807.76	2247.78	71.44	4348.31	105.78	15349.12	-998.76	41376.86	35.42	75343.71	0.453
-4	14	12831.52	2247.78	71.44	4348.31	105.78	15349.12	-998.76	43556.29	35.42	77546.90	0.440
-4	15	12855.28	2247.78	71.44	4348.31	105.78	15349.12	-998.76	45674.65	35.42	79689.02	0.428
-3	10	12712.72	2247.78	71.44	4348.31	105.78	15349.12	-998.76	177932.03	35.42	211803.84	0.161
-3	11	12736.48	2247.78	71.44	4348.31	105.78	15349.12	-998.76	179330.53	35.42	213226.10	0.160
-3	12	12760.24	2247.78	71.44	4348.31	105.78	15349.12	-998.76	180513.44	35.42	214432.77	0.159
-3	13	12784.00	2247.78	71.44	4348.31	105.78	15349.12	-998.76	181527.05	35.42	215470.15	0.158
-3	14	12807.76	2247.78	71.44	4348.31	105.78	15349.12	-998.76	182405.28	35.42	216372.13	0.158
-3	15	12831.52	2247.78	71.44	4348.31	105.78	15349.12	-998.76	183173.55	35.42	217164.16	0.157

For example, consider the distribution of the integral of the expectation of losses in a manufacturing enterprise JSC "Clean Ural", which are engaged in the production of detergents and is closely associated with its suppliers and customers. The selection of calculations results in performed expectation of losses on the basis of statistical and expert enterprise data presented in Table 3.

Thus, we see that the best solution to optimize the level of risk is the duration of the period of repayment of the debt equal to -5 days, and the period of collection of receivables is 10 days. Under these conditions, the interaction in quasi-integration: supplier of material resources and the buyer of finished products manufacturer is to reach lower values of the expectation of losses up to 40,517.04 rubles, which will reduce the rate to 83.55% from the current one. In this case, the data values can be effectively achieved in the short term, as the decision has been selected, subject to certain limits.

CONCLUSIONS

The proposed method allows us to fix risk origin places in various links of the supply chain and to identify "weak links" of logistic chain that may occur in the future. The method is a useful tool for managing not only risks and risk situations, but also as a tool to improve the efficiency of current assets management by providing the ability to optimize the level of risk in the industrial enterprise current assets management.

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ZARZĄDZANIE RYZYKIEM I ŁAŃCUCHAMI DOSTAW

STRESZCZENIE. Wstęp: Wobec narastającej globalizacji gospodarki oraz wzrostu złożoności i kompleksowości wzajemnych powiązań gospodarczych przedsiębiorstw, konieczne jest wypracowanie nowych metod i technik w celu poprawy i utrzymania pozycji rynkowej. Procesy integracji stwarzają nowe możliwości, ale jednocześnie stwarzają nowe wyzwania dla zarządzających, w tym również w obrębie zarządzania ryzykiem.

Metody: Na podstawie analizy znanych narzędzi (zarządzania łańcuchem dostaw, zarządzania ryzykiem w obrębie łańcucha dostaw, zastosowanie teorii prawdopodobieństwa, metod zarządzania ryzykiem oraz metod statystycznych) autorzy zaproponowali nową metodę zarządzania ryzykiem oraz metodę zarządzania łańcuchem dostaw. Zaproponowane narzędzie jest specyficznym hybrydowym rozwiązaniem stworzonym na podstawie narzędzi dostępnych w literaturze.

Wyniki: Prezentowana metoda została z powodzeniem zastosowana w ramach ekonomiczno-matematycznych modeli przedsiębiorstwa przemysłowego. Uwzględniono wskaźniki związane z ryzykiem łańcucha dostaw, w tym powodowane przez dostawcę. Autorzy sformułowali metodę optymalizacji poziomu ryzyka łańcucha dostaw we współpracy z dostawcami i klientami.

Wnioski: Każda organizacji, która rozpoczyna proces integracji z dostawami i klientami, potrzebuje narzędzi, metodologii oraz technik do identyfikacji "słabych ogniw" w obrębie łańcucha dostaw. Zaproponowana metoda pozwala na opanowanie ryzyka w różnych miejscach łańcucha dostaw oraz zidentyfikowanie zagrożeń, które mogą się pojawić w przyszłości. Metoda ta jest dobra nie tylko do zarządzania ryzykiem, ale również dla poprawy efektywności obecnych metod zarządzania poprzez optymalizację poziomu ryzyka w przedsiębiorstwie.

Słowa kluczowe: zarządzanie ryzykiem, ryzyka łańcucha dostaw, optymalizacja ryzyka, integracja ryzyka.

MANAGEMENT VON RISIKEN UND LIEFERKETTEN

ZUSAMMENFASSUNG. Einleitung: Angesichts der wachsenden Globalisierung der Wirtschaft und der Zunahme von Kompliziertheit und Komplexität der gegenseitigen wirtschaftlichen Zusammenhänge zwischen Unternehmen ist es unentbehrlich, neue Methoden und Techniken zwecks der Verbesserung und der Aufrechterhaltung der Marktpositionen auszuarbeiten. Die Integrationsprozesse schaffen einerseits neue Möglichkeiten, andererseits generieren für die Manager neue Herausforderungen, darunter auch im Bereich des Managements von Risiken.

Methoden: Auf Grund der Analyse der bekannten Tools (Management der Lieferkette, Management des Risikos innerhalb der Lieferkette, Anwendung von Wahrscheinlichkeitstheorie, von Methoden des Risk Managenment und von statistischen Methoden) haben die Autoren eine neue Methode des Managements von Risiken und Lieferketten vorgeschlagen. Das vorgeschlagene Instrument ist eine spezifische Hybriden-Lösung, die anhand der in der Literatur vorhandenen Werkzeuge geschaffen wurde.

Ergebnisse: Die präsentierte Methode wurde mit Erfolg im Bereich der ökonomisch-mathematischen Modelle eines Industrieunternehmens in Anspruch genommen. Dabei hat man die mit dem Risiko der Lieferkette, darunter dem vom Lieferanten verursachten Risiko, verbundenen Indikatoren berücksichtigt. Die Autoren haben danach die Methode für die Optimalisierung des Niveaus des Lieferkette-Risikos im Rahmen einer Kooperation zwischen den Lieferanten und Kunden formuliert.

Fazit: Jede Wirtschaftsorganisation, die den Integrationsprozess mit den Lieferanten und Kunden anbahnt, bedarf der Werkzeuge, Methodologie und Techniken für die Ermittlung von "schwachen Gliedern" innerhalb der Lieferkette. Die vorgeschlagene Methode erlaubt eine weitgehende Beherrschung des Risikos an verschiedenen Stellen der Lieferkette sowie eine Ermittlung von Gefahren, die in Zukunft auftauchen können. Die Methode ist brauchbar nicht nur für das Risiko-Management, sondern auch für die Verbesserung der Effektivität der gegenwärtigen Verwaltungsmethoden durch Optimalisierung des Niveaus des Lieferkette-Risikos im Unternehmen.

Codewörter: Risk Management, Risiken der Lieferkette, Optimalisierung des Risikos, Integration des Risikos.

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INNOVATIVE APPROACH TO COLLABORATION IN JOINT ORGANIZATION OF TRANSPORT PROCESSES

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ABSTRACT. Background: The paper presents an innovative approach to the collaboration in joint transport processes within existing supply chains which has been implementing by member companies of ECR Poland. Current approach results in inefficient use of resources due to mainly horizontal cooperation between individual service users and service providers. This effect has been demonstrated by research conducted by the author as well as by the European Environmental Agency.

Methods: The aim of this paper is to present how design thinking approach allows creation of new transport business model and communication platform.

Results: Created solution allowing simultaneous vertical and horizontal co-operation of independent companies involved in the organization of transport processes. The result of such cooperation is the elimination of identified inefficiencies through sustainable use of available resources.

Conclusions: The work is summarized by the results of the implementation of presented solutions within the group of companies operating in the FMCG sector in Poland. Companies were able to reduce their transport costs, increase load factor, reduce empty runs as well as reduce congestion on roads where they operate.

Key words: design thinking, innovation, virtual collaboration, sharing supply chains, communication platforms, load factor, empty runs.

INTRODUCTION

The European economy has been experiencing some radical changes in the last few years. The analysis of the data of the European Statistical Office shows a 5% increase in the sales and turnover in wholesale and retail trade in European Union states [Golinska, Hajdul 2012]. The effects of the global economic recession appeared in 2009, causing the slowdown of the economic progress. Still, companies have remained active and have been adjusting their strategies to the changing market conditions [Śliwczyński, Hajdul, Golińska 2012]. Mergers of companies take place, new process management concepts are introduced. At the same time, competition gets stiffer and consumers' expectations grow. It should be also noted that regardless of the economic growth rate, the transportation of goods by road increased in the last four years. As an example, on the basis of the latest data made available by the Main Statistical Office (GUS), the share of road transportation in goods shipping in Poland was 84.4% in tons, and 70.4% in ton-kilometers, [McKinnon 2010].

These changes forced companies who not only wish to survive, but also to develop and bring the expected profits, to introduce changes to their operation. Hence, it was necessary to search sets of activities, most often completed in sequences, that would allow making a product or providing a service

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whose value is specified and acceptable to the customer.

What is more, due to the economic crisis and dynamic changes on the business market most of the producers work on the reduce to the minimum margin. Their aim is to be competitive and offer as good price of their products as it is possible. However, the price of the finished product offered by manufacturing or distribution companies depends on the level of incurred fixed and variable costs. It is even more important to rationalize the cost of logistics, with special emphasis on the cost of flow of goods, since this will allow offering end customers a lower price for the final product, and thus contributing to the competitiveness of enterprise.

Based on the overview presented above, it is clear that new approach to organisation of transport processes is one of the key elements to which more and more companies started to pay attention and try to optimize it to increase their competitiveness.

Therefore, the paper's objective is to present a how design thinking approach to innovation allows creation and implementation of new business model for collaboration in transport. The implementation has been carrying out within members of ECR Poland.

ECR Poland, member of ECR Europe - a non-profit association focused on optimising value chains in order to deliver better value for consumers/shoppers. ECR Mission is working together to fulfil consumer/shopper needs - better, faster and at less cost in a sustainable way. ECR Poland gathers large, medium and small companies representing:

- retailers and wholesalers,
- manufacturers (mostly supplying all Europe)
- service providers (including logistics and IT services).

CURRENT WAY OF TRANSPORT PROCESSES ORGANIZATION

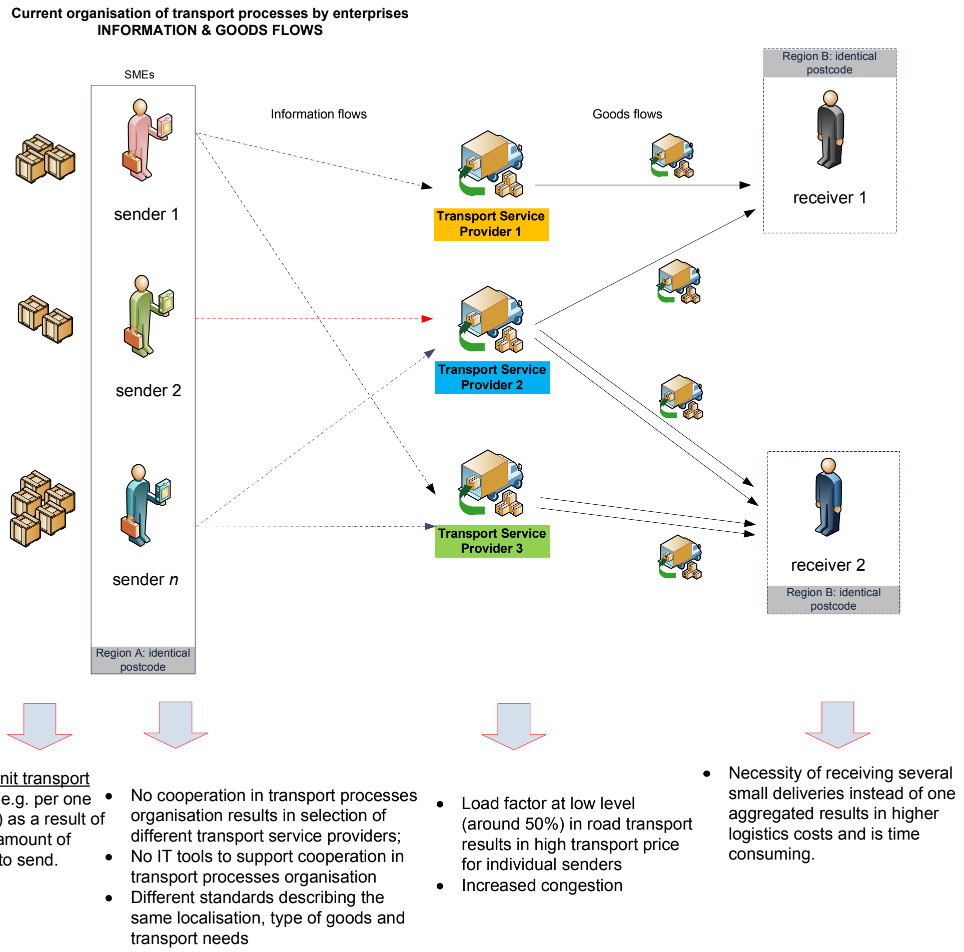
The effects of the currently applied approach to transport organization within existing supply chains lead to heavier traffic, reduced travel safety and increased emission of harmful substances. The growing congestion lowers the average technical speed of vehicles, ultimately increasing delivery time and possibly impacting customer dissatisfaction, which may even cause a part of orders to be cancelled. Hence, in the long run the companies unwittingly work towards worse financial results and reduced competitiveness [Golinska, Hajdul 2011].

The above situation is confirmed by the research of the European Environment Agency. The research shows that the utilization of the available load capacity of transportation means is poor across UE states. In case of the most popular type of transportation, namely road transportation, the average utilization of the available load capacity of trucks for delivery or distribution purposes is at 54% [European Environmental Agency 2010]. Naturally, the situation varies among specific countries.

This results were confirmed by research conducted by the European Statistical Office and Professor Alan McKinnon of the Heriot-Watt University. According to their analyses the EU average percentage share of empty runs, as a total number of covered kilometers, for road transportation is at 25% [McKinnon 2010]. Unfortunately, it often happens that truck owners cannot find return loads and their truck come back empty or only carrying minor loads.

The analysis of presented results leads to a conclusion that transportation resources are used uneconomically, simply speaking are wasted [Hajdul 2010]. These activities not only apply to improper use of the available resources, but also confirm that possibilities of completing given actions with reduced outlays are either omitted or intentionally ignored [Hajdul, Golińska 2012].

Taking into consideration presented above information, together with 30 production companies from ECR Poland a detailed measurement was carried out. The aim of this action was to identify what was the load factor (utilisation of the truck space) while cooperation with small and medium transport companies (partial and FTL transports described in previous chapter). The utilization of the available load capacity of trucks for delivery or distribution purposes was at 57% [Hajdul, Golińska 2012].



Source: Own study

Fig. 1. Selected weaknesses of traditional way of organizing transport process by selected members of ECR Poland
Rys. 1. Wybrane słabe strony tradycyjnego podejścia do organizacji przewozów w firmach należących do ECR Polska

DESIGN THINKING APPROACH TO INNOVATION

There are a variety of ways to define the main goals of each company. While it is true the firm is generally dedicated to maximising the investment return on the cash and other assets contributed to the enterprise, it is perhaps more useful to develop a definition of the output from the form's business activities that is more closely aligned to the actual uses of the firm's resources. A term that has become quite popular in last years is innovation, which has been defined as the search for, and the discovery, development, improvement, adoption and commercialisation of, new processes, new products, and new organisational structures and procedures. The search for innovation is very complex and costly, and involves a good deal of uncertainty, risk taking, ideation, designing and redesigning, experimenting and testing [Bigliardi, Dormio 2009].

On the other hand competitiveness at the company level depends crucially on the speed with which new products can be brought to the market place and new cost saving innovations can be made. Similarly, the creation of wealth and employment depends to a very large extent on the speed with which scientific and technological breakthroughs are converted into practical and attractive solution. Innovation - the ability to reap the rewards of scientific achievement - requires much more than the ability to turn a new idea into a working product.

Efficient flows of technology are not enough - ready supplies of finance and of business skills are also needed. There must be accessible protection for intellectual property, and adequate incentives for entrepreneurial drive. In short, what is needed is a dynamic, self-sustaining culture of innovation. Thanks to a culture of innovation the small and medium-sized enterprises (SMEs) have proved themselves to be the engines of economic growth, and the principle sources of new employment and in many fields provide the channels along which new technologies develop. As a consequence, the economic growth widely relies on the existence of SMEs that innovate themselves and are also ready to cooperate with each other. Innovation is increasingly likely to come from outside of the individual firm or even from another institutional sphere such as the university where the focus of attention is on original path breaking developments, whether in science or technology. Moreover, it can be expected that discontinuous innovations, which originate in a company, are more likely to be utilized in a different environment where the blinders of current taken for granted practices or commitment to existing technologies and products are less likely to have effect. As innovation moves outside of a single organization, lateral relationships across boundaries, rather than hierarchical bureaucratic structures, become more important. To both analyse these developments and guide their future development, a new model of the cooperation among companies in organization of their processes is needed [Rothwell, Zegveld 1983].

In order to be precise term innovation should be precisely defined. On the one hand we have the most popular European approach defined in so called Oslo Manual and on the other hand we can describe innovation through the concept of design thinking.

According to the Oslo Manual innovation can be new technology, product, process and new or improved way of organization. The term - product is used to cover both goods and services. Innovation can be understood not only as new product or process but also as significant technological improvement of product or process. Novelty for innovation in that meaning is that it is new at least for the company. Power of innovation can be measured by degree of this novelty, so it can be new for company, branch, whole region or country or in the best case new in the world. Moreover - when we are considering organizational change in can be treated as innovation (according to Oslo Manual) if there is measurable change in output (such as for example increased productivity). Innovation requires improvement in performance of the service or in the way in which it is delivered. Such improvement is measured by costs savings of companies reorganizing transport processes by using tool designed by Institute of Logistics and Warehousing [Eurostat 2005].

Source: own study

Fig. 2. Design thinking approach to innovation
Rys. 2. Zastosowanie myślenia projektowego w tworzeniu innowacji

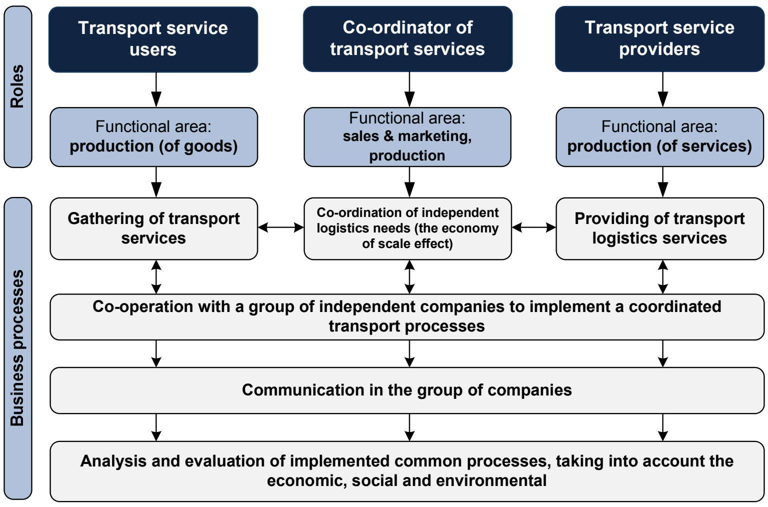
In design thinking methodology, which were used in project of reorganization of transport processes, three main components build real and valuable innovation. These three elements are: business viability, technological feasibility and human values [Plattner, Meinel, Leifer 2011]. This approach is presented on Figure 2.

All three above mentioned components of the innovation understood according to design thinking methodology are very well represented in the project of reorganization of transport processes. The first element - business viability was verified in the series of pilot cases performed with testing companies at the very early stage of implementation. Optimization of transport processes leads to significant savings for companies and as the result financial benefits become crucial advantage for each involved business entity. The second element - technological feasibility is assured thanks to well design software allowing group of companies for common reorganization of their transport processes. And last but not least - the third element - human values - behind each piece of software are always people operating it and making their decisions. Involvement of this end users in whole processes of creation of the solution and through testing and redesign of its functionality led to the innovation which well fit needs of companies and employed there specialists working in reorganization and optimization of transport processes.

PRACTICAL IMPLEMENTATION OF THE COLLABORATION MODEL IN MEMBERS OF ECR POLSKA

The idea of developing new business model for joint transport processes organisation within member companies of ECR Poland began in 2010. The whole 2010 was spent on the development of theoretical model and discussion among production companies about way of possible cooperation.

The created by the Institute of Logistics and Warehousing reference model for the coordination of transport processes in companies defines the roles of individual links, dependences between such links and also between the companies and the region where they operate. Fig. 11 presents the developed reference model.



Source: Hajdul Golińska 2012

Fig. 3. Reference model allowing collaboration in joint organization of transports
Rys. 3. Model referencyjny umożliwiający współpracę w organizacji procesów transportowych

In the developed reference model, the companies cooperate for the purpose of completion of defined business processes. These processes are completed in specified functional areas present in each company. The cooperation between individual firms in the model is both vertical and horizontal. In practice this means that first, vertical cooperation takes place within objects fulfilling the same role in the model.

Based on that steps which allow implementation of the solution were carried out:

- cost and value analyses for transport users, as well as service providers,

- development of practical web-accessible tool (T-Scale) enabling automated information exchange between involved parties within the whole supply chain in order to start vertical cooperation between companies to reduce transport cost,
- guidelines on information sharing based on the unified communication standards,
- some possible pre-defined scenarios, based on:
  - product categories,
  - current distribution network set-up,
  - geographies,
  - scale economies,
- guidelines on ordering processes optimisation within the supply chains,
- other changes in transport processes organisation to present operations that are envisaged,
- key performance indicators.

Developed T-Scale platform plays the crucial part in the virtual collaboration in transport organisation within the supply chains. T-Scale allows real time exchange of information among companies participating in the realization of transportation processes. It enables to form temporary cooperation network (virtual supply chains). There are four key roles applied:

- The transport users define transportation needs.
- The transport service providers offer their services.
- The planning of deliveries and generating of consolidated transportation orders are made by the transportation coordinator, who also acts as an intermediary between group of independent producers and carriers.
- 4th party role responsible for auditing of all companies, verifying if the agreed conditions for cooperation are obeyed and providing technical solutions. The Institute of Logistics and Warehousing acts as technical and content-wise coordinator. The Institute oversees the technical aspect of operation of the platform. Moreover, ILiM carries out monthly impartial audits of effectiveness of planning of transportation and ensures stability and safety of the solution.

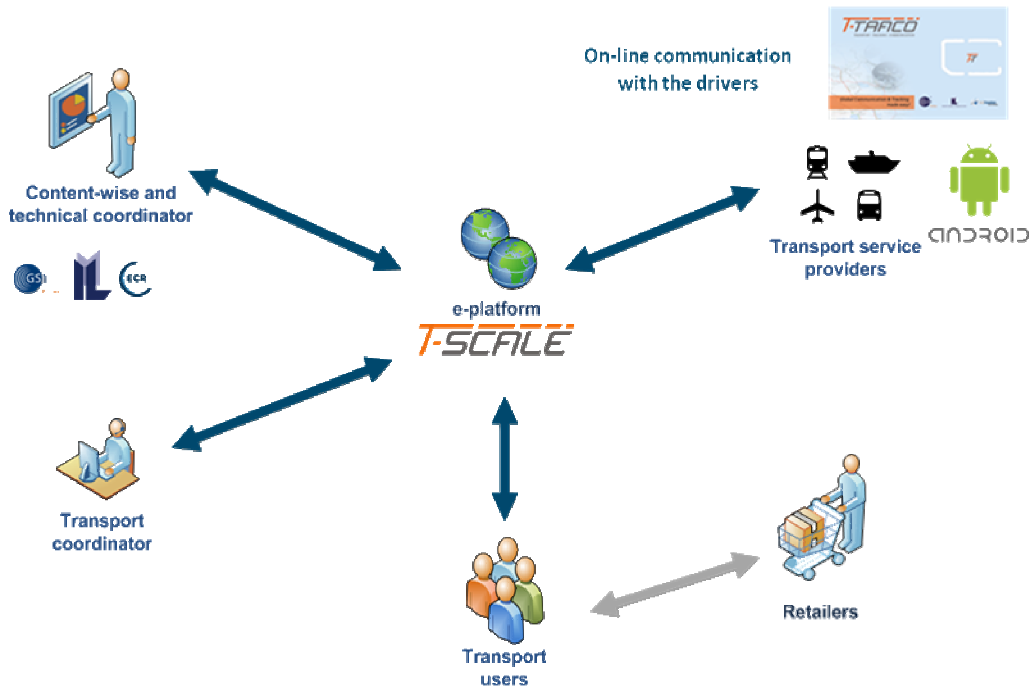
The principal advantage of the discussed solution (T-Scale platform) is the complete coordination of cooperation among different companies involved in the common transport planning and scheduling process in order to use the available transportation resources in a balanced manner. Furthermore, T-Scale is based on agreed global communication standards.

The following transport communication standards (GS1 standards for transport and logistics) were selected and agreed to be used in the new business model for joint transport processes organisation:

- Global Location Number (GLN) - is the GS1 ID Key used to identify locations and legal entities. Using a GLN rather than a proprietary internal numbering system for locations gives a company significant advantages, because it provides a standardised way to uniquely identify entities and locations throughout the supply chain [GS1 2010].
- Serial Shipping Container Code (SSCC) - the GS1 ID Key used to identify individual logistic units. A logistic unit is defined in T-Scale as combination of units put together on a truck/container, where the specific unit load needs to be managed through the supply chain [GS1 2010].
- format for naming point of origin and destination,
- type of products groups and its transport susceptibility,
- type of transport units and its equipment,
- transport request,
- transport order,
- transport service description [Pedersen, Paganelli, Knoors 2010],
- format of the transport pricelists,
- common process for placing of the transport requests and orders,
- common process for sharing of the savings in the transport costs.

The T-Scale platform improves communication between virtual supply chain participants for purposes of joint organization of deliveries, which translates to a number of benefits from the cooperation between companies, such as:

- optimization of transportation costs due to the achieved scale effect,
- improved availability of cargo space,
- better utilization of the load capacity of trucks,
- elimination of "empty runs",
- reduction of road traffic intensity.



Source: own study

Fig. 4. Roles on the T-Scale platform
Rys. 4. Role na platformie T-Scale

On the selected seventeen routes which belong to ten producers, T-Scale in June 2012, was able to significantly improve effectiveness and efficiency of the transport processes. At the beginning of the pilot implementation the following options for collaboration were defined:

- First option: Cooperation within FTL transports in order to find partner which allows two or more producers to close the whole route (e.g. from point A to point B and from point B to point A). Therefore, total transport rate is going to be calculated on the basis of the number of run kilometres. It means production company is paying for transporting the route from point A to point B and from B to A.
- Second option: Cooperation within joint organisation of partial transports (above 10 pallets) and LTL in order to increase utilisation of truck and reduction of transport unit costs.

To sum up, sharing of resources and cooperation in transport organisation according to agreed communication standards is of multi-dimensional nature. It positively impacts both companies that use transport services and the ones that provide such services. However, it is still a challenge to change companies' attitude and approach with respect to the business processes organisation and being more open for cooperation in the field of logistics. Moreover, presented case concerns only road transport cooperation, there is a great challenge to implement similar business model for intermodal transport, where more actors are involved in the process.

Table 1. Results of the T-Scale operations in June 2012
Tabela 1. Rezultaty współpracy na platformie T-Scale z czerwca 2012

Parameter	Without T-Scale and communication standards	With T-Scale and communication standards
Pallets carried out [pcs]	18202	18202
Total number of transport routes [pcs]	821	649
Total number of kilometres [km]	198682	157058
Total transport costs [euro]	168880	119757
Total savings in transport costs [euro]	-	49123
Average savings in transport costs per company [%]	-	15%
Average share of empty runs in total number of kilometres [%]	data not available	7,7%

CONCLUSIONS

Collaboration in joint cooperation of transports is of multi-dimensional nature. It impacts both companies that use transport services and the ones that provide such services. Furthermore, these companies are closely connected to the environment in which they operate. In many cases the main objectives of companies and the society are not identical. The proposed solution makes it possible to organize logistics process while taking into account economic, social and environmental aspects.

Additionally, the positive reception of the solution by the leading manufacturers and distributors in Poland allows to hope that the solution will soon be accepted and employed in business activity.

This hope is also fortified with the growing awareness the companies have of their impact on the environment. It can now be observed that companies exhibiting advanced social awareness often shape their activities not only with their own strategies in mind, but also taking into account the objectives and values of the society. Corporate social responsibility is a method of creating generally understood benefits, both for companies, as profits, and for its environment. Hence, one can say that a company following the principle of sustainable development can achieve a balance between its profitability and effectiveness, and social interests.

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INNOWACYJNE PODEJŚCIE DO WSPÓŁPRACY FIRM WE WSPÓLNEJ ORGANIZACJI PROCESÓW TRANSPORTOWYCH

STRESZCZENIE. **Wstęp:** Artykuł prezentuje innowacyjne podejście do współpracy niezależnych firm produkcyjnych we wspólnej organizacji procesów transportowych w istniejących łańcuchów dostaw. Praca prezentuje rezultaty osiągnięte przez firmy produkcyjne należące do ECR Polska. Przesłanką do podjęcia współpracy pomiędzy firmami była potrzeba poszukiwania nowych modeli organizacji procesów transportowych celem poprawy ich skuteczności i efektywności. Aktualne podejście do organizacji przewozów charakteryzuje się nieefektywnym wykorzystaniem zasobów. Wynika to głównie z faktu współpracy poziomek między poszczególnych usługodawcami i usługobiorcami. Potwierdziły to nadania potwierdzone przez autorów, a także przez Europejską Agencję Ochrony Środowiska.

Metody: Celem pracy jest przedstawienie sposobu wykorzystania metody "design thinking" do stworzenia nowego modelu współpracy niezależnych firm z wykorzystaniem innowacyjnej platformy komunikacyjnej.

Wyniki: Stworzone, w ramach przeprowadzonych przez autorów prac badawczych, rozwiązanie umożliwia jednoczesną pionową i poziomą współpracę niezależnych firm zlecających usługi transportowe jak i firm zajmujących się organizacją procesów transportowych. Efektem tej współpracy jest wyeliminowanie zidentyfikowanych wad istniejących rozwiązań poprzez zrównoważone wykorzystanie dostępnych zasobów.

Wnioski: W podsumowaniu autorzy prezentują wyniki pilotażowego wdrożenia opisanego rozwiązania przez firmy w sektorze FMCG w Polsce. Firmy były w stanie zredukować koszty transportu, zwiększyć współczynnik wykorzystania pojazdów, zredukować puste przebiegi, a także zredukować kongestię w regionie, w którym prowadzą działalność.

Słowa kluczowe: design thinking, innowacja, wirtualna współpraca, współdzielenie łańcuchów dostaw, platformy komunikacyjne, współczynnik wypełnienia pojazdu, puste przebiegi.

INNOVATIVES HERANGEHEN AN DIE ZUSAMMENARBEIT DER FIRMEN INNERHALB DER GEMEINSAMEN ORGANISATION VON TRANSPORTPROZESSEN

ZUSAMMENFASSUNG. Einleitung: Der Artikel präsentiert ein innovatives Herangehen an die Kooperation von unabhängigen Produktionsfirmen bei der gemeinsamen Organisation von Transportprozessen innerhalb der bestehenden Lieferketten. Die Arbeit stellt die Ergebnisse der der Organisation ECR Polska angehörenden Produktionsfirmen dar. Der Ansporn zur Aufnahme der Zusammenarbeit zwischen den betreffenden Firmen ergab sich aus dem Bedürfnis, neue Modelle für die Organisation von Transportprozessen zwecks der Verbesserung deren Wirksamkeit und Effektivität zu finden. Das gegenwärtige Herangehen an die Lösung der Problemstellungen bei der Organisation von Beförderungsprozessen charakterisiert sich durch eine uneffektive Inanspruchnahme von Beständen. Dies resultiert hauptsächlich aus der Tatsache einer horizontalen (waagrechten) Kooperation zwischen den einzelnen Dienstleistern und Dienstleistungsnehmern, was die von den Autoren und der Europäischen Agentur für Umweltschutz durchgeführten Forschungen bestätigt haben.

Methoden: Das Ziel der Arbeit ist es, die Art und Weise der Inanspruchnahme der Methode "design thinking" für die Schöpfung eines neuen Modells für die Kooperation der unabhängigen Firmen mit Anwendung einer innovativen Kommunikationsplattform darzustellen.
Ergebnisse: Die im Rahmen der von den Autoren durchgeführten Forschungsarbeiten ausgearbeitete Lösung ermöglicht gleichzeitige, vertikale und horizontale Zusammenarbeit zwischen den betreffenden unabhängigen Firmen, die die Transport-Dienstleistungen in Auftrag geben oder die Organisation von Transportprozessen in Auftrag nehmen. Das Resultat solch einer Kooperation ist die Eliminierung der ermittelten Nachteile innerhalb der bestehenden Lösungen durch eine ausgewogene Inanspruchnahme von den zur Verfügung stehenden Beständen.
Fazit: In der Abrundung des Beitrags präsentieren die Autoren die Ergebnisse einer einleitenden Einführung der beschriebenen Lösung in ausgewählten polnischen Unternehmen aus dem FMCG-Sektor. Die besagten Firmen waren gegebenenfalls imstande, die Transportkosten zu reduzieren, den Koeffizient der Inanspruchnahme von Transportfahrzeugen zu erhöhen, Leerfahrten zu reduzieren, sowie den lokalen Verkehr in der Region der Ausübung deren Transport-Aktivitäten zu vermindern.

Codewörter: design thinking, Innovation, virtuelle Kooperation, gegenseitige Teilung von Lieferketten, Kommunikationsplattformen, Koeffizient der Auffüllung des Fahrzeugs, Leerfahrten

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AN EOQ MODEL FOR WEIBULL DETERIORATING ITEM WITH RAMP TYPE DEMAND AND SALVAGE VALUE UNDER TRADE CREDIT SYSTEM

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ABSTRACT. Background: In the present competitive business scenario researchers have developed various inventory models for deteriorating items considering various practical situations for better inventory control. Permissible delay in payments with various demands and deteriorations is considerably a new concept introduced in developing various inventory models. These models are very useful for both the consumers and the manufacturer.

Methods: In the present work an inventory model has been developed for a three parameter Weibull deteriorating item with ramp type demand and salvage value under trade credit system. Here we have considered a single item for developing the model.

Results and conclusion: Optimal order quantity, optimal cycle time and total variable cost during a cycle have been derived for the proposed inventory model. The results obtained in this paper have been illustrated with the help of numerical examples and sensitivity analysis.

Key words: EOQ, Weibull deterioration, ramp type demand, salvage value, trade credit.

INTRODUCTION

In the traditional EOQ inventory model, the purchaser pays for his items as soon as the items are received. However in real competitive business world, the supplier may allow a credit period to encourage the customers to buy in bulk. It is also named as permissible delay in payments. Delay in payments to the supplier is an alternative way of price discount. Hence paying later in directly, reduces the purchase cost which attracts the customers to enhance their ordering quantity. Generally retailers are encouraged towards bulk purchasing due to the trade credit given by suppliers. No interest is charged if the account is settled within the credit period. However if the payment is not settled during the period, then interest is charged. Salvage value is the estimated resale value of an asset at the end of its useful life. Researchers are being engaged in developing various inventory models taking various practical situations.

Abad et.al [2003] developed an inventory model of joint approach for setting unit price and the length of the credit period for a seller when end demand is price sensitive. Similarly Ordering policies of deteriorating items under permissible delay in payments studied by Aggarwal [1995]. Chang C.T, [2004] invented an EOQ model with deteriorating items under inflation when supplier credits linked to order quantity. Chung, K. J. [2009] developed an ordering policy with allowable shortage and permissible delay in payments. Huang, Y.F, [2003] studied an inventory model for optimal retailer's ordering policies in the EOQ model under trade credit financing. Hwang, H. and

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Shinn, S. W., [1997] proposed a model for retailer's pricing and lot-sizing policy for exponentially deteriorating products under the condition of permissible delay in payments. Jamal, A. M. M., Sarker, B. R., and Wang, S., [1997] studied an ordering policy for deteriorating items with allowable shortages and permissible delay in payment. Meher M.K., Panda G.Ch., Sahu S.K., [2012], have studied an inventory model with Weibull deterioration rate under the delay in payment in demand declining market. Shah, Nita H. and Raykundaliya, Nidhi, [2010], proposed a model of retailers pricing and ordering strategy for Weibull distribution deterioration under trade credit in declining market. Tripathy C.K. and Pradhan L.M., [2010], [2011] and [2012] have developed some EOQ and EPQ models considering various aspects like trade credit, permissible delay in payments, salvage value and price discount under different situations. Tripathy C. K., and Mishra U. [2011] studied an EOQ model with time dependent Weibull deterioration and ramp type demand for constant deterioration.

In the present paper an economic ordered quantity model has been developed considering three parameter Weibull deterioration where salvage value is considered but shortages are not allowed. Here the demand is assumed to be ramp type demand and holding cost is constant. In section 2 assumptions and notations required for the development of the model have been given. The optimum cycle time, optimal ordered quantity and total average cost of the model have been derived in the Section 3. Illustrative numerical examples, sensitivity analysis and conclusion have been given in section 4, 5 and 6 respectively..

BASIC ASSUMPTIONS AND NOTATIONS

The following are the assumptions required for developing the model:

1. The model deals with a single item.
2. Replenishment rate is infinite.
3. Lead time is zero and shortages are not allowed.
4. Ramp-type demand rate

   $f(t) = D_0\left[t-(t-\mu)H(t-\mu)\right]$, $D_0 > 0$,

   Here $H(t-\mu)$ is a Heaviside's unit function which is defined as follows:

   $$H(t-\mu) = \begin{cases} 1 & t > \mu \\ 0 & t \le \mu \end{cases}$$

5. Unit cost of generated sales revenue is deposited in an interest bearing account at the time of fixed period μ .To meet the day-to-day expenses of the system, the difference between sales price and unit cost is retained. At the end of the credit period the account is settled and interest charges are payable on the account in stock.
6. Deterioration rate is a three parameter Weibull function.
7. The salvage value aC (where $0 \le a < 1$) is associated to deteriorated units during the cycle time.

The notations that are employed here:

- *A*: ordering cost per order.
- *a:* constant or a real number, where $0 \le a < 1$.
- *C*: Purchase cost per unit.
- *P*: Unit selling price P>C
- *h:* Inventory holding cost per unit per unit time excluding interest charges.
- θ: Weibull three parameter deterioration rate (unit/unit time), $\theta = \alpha\beta(t-\gamma)^{\beta-1}$, where $0 < \alpha < 1$, $\beta > 0$, and $0 < \gamma$, where α is called scale parameter, β is called shape parameter and γ is called the location parameter.
- *T:* The length of cycle time.
- *D(T)* It is the Number of units that deteriorate during one cycle.
- I_c Interest charged per unit in stock per annum by the supplier to the retailer.
- I_e Interest earned per unit per annum. (I_c>I_e).
- μ: Permissible delay period for settling accounts in time units.
- $\phi_1(T)$: Total average cost per time unit when $\mu < T$.
- $\phi_2(T)$: Total average cost per time unit when $\mu > T$.

MATHEMATICAL MODEL

For developing mathematical model we consider two cases as follows.

Case 1 When $\mu < T$

Let $I(t)$ denote the on hand inventory of the system at any time t $(0 \le t \le T)$. Let the initial inventory be Q. Depletion due to demand and deterioration occur simultaneously. In this case the permissible delay period for settling accounts is less than the total cycle time of the system. The differential equation that describes the instantaneous state of $I(t)$ in the interval $0 \le t \le T$ is given by

$$\frac{dI(t)}{dt} + \theta\, I(t) = -D_0\, t \quad , \qquad 0 \le t \le \mu \qquad (1)$$

$$\frac{dI(t)}{dt} + \theta\, I(t) = -D_0\, \mu \quad , \qquad \mu \le t \le T \qquad (2)$$

Where $\theta = \alpha\beta(t-\gamma)^{\beta-1}$, $0 < \alpha < 1$, $\beta > 0$ and $0 < \gamma$ called the scale, shape and location parameter respectively.
Here the boundary conditions are

$$I(0) = Q \text{ and } I(T) = 0 \qquad (3)$$

Where Q is the inventory order quantity.

Equation (1) is a linear differential equation. Its integrating factor is given by

$$= e^{\int \alpha\,\beta\,(t-\gamma)^{\beta-1}\,dt} = e^{\alpha\,(t-\gamma)^{\beta}} .$$

Hence the solution of equation (1) can be written as

$$I(t)\, e^{\alpha(t-\gamma)^{\beta}} = \int -D_0\, t\, e^{\alpha(t-\gamma)^{\beta}}\, dt + c ,$$

where c is the constant of integration.

Since α is very small, neglecting the terms involving second and higher powers α of from the series expansion of the exponential function and then integrating we get

$$I(t)\, e^{\alpha(t-\gamma)^{\beta}} = \int -D_0\, t\left[1 + \alpha(t-\gamma)^{\beta}\right] dt + c$$

$$\Rightarrow I(t)\, e^{\alpha(t-\gamma)^{\beta}} = -D_0\left\{\frac{t^2}{2} + \frac{\alpha t\,(t-\gamma)^{\beta+1}}{(\beta+1)} - \frac{\alpha(t-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}\right\} + c$$

Using the given boundary condition $I(0) = Q$ in the above we get the required solution of equation (1) as

$$I(t)\, e^{\alpha(t-\gamma)^{\beta}} = -D_0\left\{\frac{t^2}{2} + \frac{\alpha t\,(t-\gamma)^{\beta+1}}{(\beta+1)} - \frac{\alpha(t-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}\right\} + Q + Q\alpha(-\gamma)^{\beta} - \frac{D_0\alpha(-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}$$

$$\Rightarrow I(t) = e^{-\alpha(t-\gamma)^{\beta}}\left[-D_0\left\{\frac{t^2}{2} + \frac{\alpha t\,(t-\gamma)^{\beta+1}}{(\beta+1)} - \frac{\alpha(t-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}\right\} + Q + Q\alpha(-\gamma)^{\beta} - \frac{D_0\alpha(-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}\right]$$

Since $0 < \alpha <$,1so taking the first two terms from the series expansion of the exponential function and multiplying we get,

$$\Rightarrow I(t) = \left[1 - \alpha(t-\gamma)^{\beta}\right]\left[-D_0\left\{\frac{t^2}{2} + \frac{\alpha t\,(t-\gamma)^{\beta+1}}{(\beta+1)} - \frac{\alpha(t-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}\right\} + Q + Q\alpha(-\gamma)^{\beta} - \frac{D_0\alpha(-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}\right]$$

Again neglecting the terms involving second and higher powers of α the above equation can be written as

$$I(t) = \frac{-D_0 t^2}{2} - \frac{D_0\alpha t\,(t-\gamma)^{\beta+1}}{(\beta+1)} + \frac{D_0\alpha(t-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} + Q + Q\alpha(-\gamma)^{\beta}$$
$$- \frac{D_0\alpha\,(-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} + \frac{D_0 t^2\alpha(t-\gamma)^{\beta}}{2} - Q\alpha(t-\gamma)^{\beta}, \qquad 0 \le t \le \mu \qquad (4)$$

Similarly using the condition $I(T)=0$ and solving the equation (2) we can find

$$I(t)=D_0\mu(T-t)+\frac{D_0\mu\alpha\,(T-\gamma)^{\beta+1}}{(\beta+1)}-\frac{D_0\mu\alpha\,(t-\gamma)^{\beta+1}}{(\beta+1)}-D_0\mu\alpha(t-\gamma)^{\beta}(T-t),\quad \mu\le t\le T \tag{5}$$

Similarly using the condition $I(T)=0$ and solving the equation (2) we can find

$$I(t)=D_0\mu(T-t)+\frac{D_0\mu\alpha\,(T-\gamma)^{\beta+1}}{(\beta+1)}-\frac{D_0\mu\alpha\,(t-\gamma)^{\beta+1}}{(\beta+1)}-D_0\mu\alpha(t-\gamma)^{\beta}(T-t),\quad \mu\le t\le T \tag{5}$$

Substituting $t=\mu$ in equation (4) and (5) and then equating both the equation we get

$$\begin{aligned}\Rightarrow &\frac{-D_0\mu^2}{2}-\frac{D_0\alpha\,\mu(\mu-\gamma)^{\beta+1}}{(\beta+1)}+\frac{D_0\alpha(\mu-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}+Q+Q\alpha(-\gamma)^{\beta}\\ &-\frac{D_0\alpha\,(-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}+\frac{D_0\mu^2\alpha(\mu-\gamma)^{\beta}}{2}-Q\alpha(\mu-\gamma)^{\beta}=D_0\mu(T-\mu)+\frac{D_0\mu\alpha\,(T-\gamma)^{\beta+1}}{(\beta+1)}\\ &\qquad-\frac{D_0\mu\alpha\,(\mu-\gamma)^{\beta+1}}{(\beta+1)}-D_0\mu\alpha(\mu-\gamma)^{\beta}(T-\mu)\end{aligned}$$

$$\begin{aligned}\Rightarrow Q\left[1+\alpha(-\gamma)^{\beta}-\alpha(\mu-\gamma)^{\beta}\right]&=D_0\mu T-\frac{D_0\mu^2}{2}+\frac{D_0\mu^2\alpha\,(\mu-\gamma)^{\beta}}{2}+\frac{D_0\alpha\,\mu(T-\gamma)^{\beta+1}}{(\beta+1)}\\ &\quad-D_0\mu T\alpha(\mu-\gamma)^{\beta}-\frac{D_0\alpha(\mu-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}+\frac{D_0\alpha(-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}\end{aligned}$$

$$\begin{aligned}\Rightarrow Q=\left[1+\left\{\alpha(-\gamma)^{\beta}-\alpha(\mu-\gamma)^{\beta}\right\}\right]^{-1}&\left[D_0\mu T-\frac{D_0\mu^2}{2}+\frac{D_0\mu^2\alpha\,(\mu-\gamma)^{\beta}}{2}+\frac{D_0\alpha\,\mu(T-\gamma)^{\beta+1}}{(\beta+1)}\right.\\ &\left.-D_0\mu T\alpha(\mu-\gamma)^{\beta}-\frac{D_0\alpha(\mu-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}+\frac{D_0\alpha(-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}\right]\end{aligned}$$

Now using the series expansion formula $(1+x)^{-1}=1-x+x^2-x^3+.....$ and neglecting the terms involving second and higher powers of α (i.e. taking the first two terms of the series) the above equation can be written as

$$\begin{aligned}\Rightarrow Q=\left[1-\alpha(-\gamma)^{\beta}+\alpha(\mu-\gamma)^{\beta}\right]&\left[D_0\mu T-\frac{D_0\mu^2}{2}+\frac{D_0\mu^2\alpha\,(\mu-\gamma)^{\beta}}{2}+\frac{D_0\alpha\,\mu(T-\gamma)^{\beta+1}}{(\beta+1)}\right.\\ &\left.-D_0\mu T\alpha(\mu-\gamma)^{\beta}-\frac{D_0\alpha(\mu-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}+\frac{D_0\alpha(-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}\right]\end{aligned}$$

Now multiplying the above two brackets and neglecting the terms involving second and higher powers of α (since α is very small) the above equation can be written as

$$\begin{aligned}Q=D_0\mu T-\frac{D_0\mu^2}{2}+\frac{D_0\mu\alpha\,(T-\gamma)^{\beta+1}}{(\beta+1)}-\frac{D_0\alpha\,(\mu-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}\\ +\frac{D_0\alpha\,(-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}-D_0\mu\alpha\,T(-\gamma)^{\beta}+\frac{D_0\mu^2\alpha(-\gamma)^{\beta}}{2}\end{aligned} \tag{6}$$

Now the number of units that deteriorate during one cycle is given by

$$D(T) = Q - \left[\int_0^{\mu} D_0 t \; dt + \int_{\mu}^{T} D_0 \mu \; dt\right]$$
$$= Q - \left[\frac{D_0\mu^2}{2} + D_0\mu T - D_0\mu^2\right] = Q - D_0\mu T + \frac{D_0\mu^2}{2}$$

Using the value of Q from equation (6) the above equation becomes

$$D(T) = \frac{D_0\mu\alpha\,(T-\gamma)^{\beta+1}}{(\beta+1)} - \frac{D_0\alpha\,(\mu-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} + \frac{D_0\alpha\,(-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} - D_0\mu\alpha\, T(-\gamma)^{\beta} + \frac{D_0\mu^2\alpha(-\gamma)^{\beta}}{2}$$

Hence cost due to deterioration during one cycle is given by

$$CD(T) = \frac{CD_0\mu\alpha\,(T-\gamma)^{\beta+1}}{(\beta+1)} - \frac{CD_0\alpha\,(\mu-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} + \frac{CD_0\alpha\,(-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}$$
$$-CD_0\mu\alpha\, T(-\gamma)^{\beta} + \frac{CD_0\mu^2\alpha(-\gamma)^{\beta}}{2}, \qquad (7)$$

Now the salvage value of deteriorated units is given by

$$SV = a\,CD(T) = \frac{a\,CD_0\mu\alpha\,(T-\gamma)^{\beta+1}}{(\beta+1)} - \frac{a\,CD_0\alpha\,(\mu-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} + \frac{aCD_0\alpha\,(-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}$$
$$-aCD_0\mu\alpha\, T(-\gamma)^{\beta} + \frac{aCD_0\mu^2\alpha(-\gamma)^{\beta}}{2} \qquad (8)$$

Putting the value of Q from equation (6) in the equation (4) we get

$$I(t) = \frac{-D_0t^2}{2} - \frac{D_0\alpha t\,(t-\gamma)^{\beta+1}}{(\beta+1)} + \frac{D_0\alpha(t-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} + \frac{D_0\alpha t^2\,(t-\gamma)^{\beta}}{2} + D_0\mu T - \frac{D_0\mu^2}{2}$$
$$+\frac{D_0\alpha\mu(T-\gamma)^{\beta+1}}{(\beta+1)} - \frac{D_0\alpha(\mu-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} - D_0\mu T\,\alpha(t-\gamma)^{\beta} + \frac{D_0\mu^2\alpha(t-\gamma)^{\beta}}{2}, \quad 0 \le t \le \mu \qquad (9)$$

Total inventory holding cost per cycle is

$$IHC = h\int_0^T I(t)dt = h\left[\int_0^{\mu} I(t)dt + \int_{\mu}^{T} I(t)dt\right]$$

Using the value of $I(t)$ from equation (9) and (5) in the above equation and then integrating we get,

$$IHC = h\left[\frac{-D_0\mu^3}{6} - \frac{D_0\alpha\mu\,(\mu-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} + \frac{3D_0\alpha\,(\mu-\gamma)^{\beta+3}}{(\beta+1)(\beta+2)(\beta+3)} - \frac{3D_0\alpha(-\gamma)^{\beta+3}}{(\beta+1)(\beta+2)(\beta+3)}\right.$$
$$\left.+\frac{D_0\alpha\mu T(-\gamma)^{\beta+1}}{(\beta+1)} - \frac{D_0\mu^2\alpha(-\gamma)^{\beta+1}}{2(\beta+1)} + \frac{D_0T^2}{2} + \frac{D_0\mu\alpha T(T-\gamma)^{\beta+1}}{(\beta+1)} - \frac{2D_0\alpha\mu\,(T-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}\right] \qquad (10)$$

Ordering cost per cycle is, $OC = A$ (11)

Total interest earned during one cycle time is

$$IE_1 = PI_e \int_0^{\mu} D_0 t \; dt = \frac{PI_e D_0 \mu^2}{2}, \tag{12}$$

Total interest paid during one cycle time is

$$\begin{aligned} IC_1 &= CI_c \int_{\mu}^{T} I(t) dt \\ &= CI_c \Bigg[\frac{D_0 \mu T^2}{2} - \frac{2D_0 \alpha\mu (T-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} + \frac{D_0 \mu\alpha T (T-\gamma)^{\beta+1}}{(\beta+1)} - D_0 \mu^2 T + \frac{D_0 \mu^3}{2} \\ &+ \frac{2D_0 \alpha\mu (\mu-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} + \frac{D_0 \mu\alpha T (\mu-\gamma)^{\beta+1}}{(\beta+1)} - \frac{D_0 \mu^2 \alpha \left\{ (T-\gamma)^{\beta+1} + (\mu-\gamma)^{\beta+1} \right\}}{(\beta+1)} \Bigg] \end{aligned} \tag{13}$$

Therefore the total average cost per unit time is

$$\begin{aligned} \phi_1(T) &= \frac{1}{T}\left[OC + IHC + CD + IC_1 - IE_1 - SV \right] \\ &= \frac{A}{T} + \frac{h}{T}\left[\frac{-D_0\mu^3}{6} - \frac{D_0\alpha\mu(\mu-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} + \frac{3D_0\alpha\left\{ (\mu-\gamma)^{\beta+3} - (-\gamma)^{\beta+3} \right\}}{(\beta+1)(\beta+2)(\beta+3)} \right] \\ &\quad + \frac{D_0\alpha\mu h(-\gamma)^{\beta+1}}{(\beta+1)} - \frac{D_0\mu^2\alpha h(-\gamma)^{\beta+1}}{2(\beta+1)T} + \frac{D_0\mu T h}{2} + \frac{D_0\mu\alpha h(T-\gamma)^{\beta+1}}{(\beta+1)} \\ &\quad - \frac{2D_0\alpha\mu h(T-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)T} + \frac{CD_0\mu\alpha(1-a)(T-\gamma)^{\beta+1}}{(\beta+1)T} - CD_0\mu\alpha(1-a)(-\gamma)^{\beta} \\ &\quad - \frac{CD_0\alpha(1-a)\left\{ (\mu-\gamma)^{\beta+2} - (-\gamma)^{\beta+2} \right\}}{(\beta+1)(\beta+2)T} + \frac{CD_0\mu^2\alpha(1-a)(-\gamma)^{\beta}}{2T} \\ &+ CI_c\Bigg[\frac{D_0\mu T}{2} - \frac{2D_0\alpha\mu(T-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)T} + \frac{D_0\mu\alpha(T-\gamma)^{\beta+1}}{(\beta+1)} - D_0\mu^2 + \frac{D_0\mu^3}{2T} + \frac{2D_0\alpha\mu(\mu-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)T} \\ &- \frac{D_0\mu^2\alpha\left\{ (T-\gamma)^{\beta+1} - (\mu-\gamma)^{\beta+1} \right\}}{(\beta+1)T} + \frac{D_0\mu\alpha(\mu-\gamma)^{\beta+1}}{(\beta+1)} \Bigg] - \frac{PI_e D_0\mu^2}{2T} \end{aligned} \tag{14}$$

The necessary condition for the total average cost to be minimized is $\frac{\partial \phi_1}{\partial T} = 0$

$$\begin{aligned} &\Rightarrow \frac{-A}{T^2} - \frac{h}{T^2}\left[\frac{-D_0\mu^3}{6} - \frac{D_0\alpha\mu(\mu-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} + \frac{3D_0\alpha\left\{ (\mu-\gamma)^{\beta+3} - (-\gamma)^{\beta+3} \right\}}{(\beta+1)(\beta+2)(\beta+3)} \right] \\ &+ \frac{D_0\mu^2\alpha h(-\gamma)^{\beta+1}}{2(\beta+1)T^2} + \frac{D_0\mu h}{2} + D_0\mu\alpha h(T-\gamma)^{\beta} - \\ &\frac{2D_0\alpha\mu h}{(\beta+1)(\beta+2)T^2}\left\{ T(\beta+2)(T-\gamma)^{\beta+1} - (T-\gamma)^{\beta+2} \right\} \\ &+ \frac{CD_0\mu\alpha(1-a)}{(\beta+1)T^2}\left\{ T(\beta+1)(T-\gamma)^{\beta} - (T-\gamma)^{\beta+1} \right\} + \frac{CD_0\alpha(1-a)}{(\beta+1)(\beta+2)T^2}\left\{ (\mu-\gamma)^{\beta+2} - (-\gamma)^{\beta+2} \right\} \\ &- \frac{CD_0\mu^2\alpha(1-a)(-\gamma)^{\beta}}{2T^2} + CI_c\Bigg[\frac{D_0\mu}{2} - \frac{2D_0\alpha\mu h}{(\beta+1)(\beta+2)T^2}\left\{ T(\beta+2)(T-\gamma)^{\beta+1} - (T-\gamma)^{\beta+2} \right\} \\ &+ D_0\mu\alpha(T-\gamma)^{\beta} - \frac{D_0\mu^3}{2T^2} - \frac{2D_0\alpha\mu(\mu-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)T^2} - \frac{D_0\mu^2\alpha}{(\beta+1)T^2}\left\{ T(\beta+1)(T-\gamma)^{\beta} - (T-\gamma)^{\beta+1} \right\} \\ &+ \frac{D_0\mu^2\alpha(\mu-\gamma)^{\beta+1}}{(\beta+1)T^2} \Bigg] + \frac{PI_e D_0\mu^2}{2T^2} = 0 \end{aligned} \tag{15}$$

The value of T found from equation (15) will minimize the average total variable cost if the second order derivative is positive.

Case 2 When μ > T

Let $I(t)$ denote the on hand inventory of the system at any time t $(0 \le t \le T)$. Let the initial inventory be Q. Depletion due to demand and deterioration occur simultaneously. In this case the permissible delay period for settling accounts is greater than the total cycle time of the system. Hence there is no interest charged during the cycle. The differential equation that describes the instantaneous state of $I(t)$ in the interval $0 \le t \le T$ is given by

$$\frac{dI(t)}{dt} + \theta I(t) = -D_0 t \quad , \qquad 0 \le t \le T \tag{16}$$

Using the given boundary condition $I(0) = Q$ the solution of equation (1) is obtained as

$$\begin{aligned} I(t) = & \frac{-D_0 t^2}{2} - \frac{D_0 \alpha t\,(t-\gamma)^{\beta+1}}{(\beta+1)} + \frac{D_0 \alpha (t-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} + Q + Q\alpha(-\gamma)^{\beta} \\ & - \frac{D_0 \alpha\,(-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} + \frac{D_0 t^2 \alpha (t-\gamma)^{\beta}}{2} - Q\alpha(t-\gamma)^{\beta}, \quad 0 \le t \le T \end{aligned} \tag{17}$$

Now using the condition $I(T) = 0$, in equation (17) the value of Q can be found as

$$Q = \frac{D_0 T^2}{2} + \frac{D_0 \alpha T\,(T-\gamma)^{\beta+1}}{(\beta+1)} + \frac{D_0 \alpha (-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} - \frac{D_0 \alpha (T-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} - \frac{\alpha(-\gamma)^{\beta} D_0 T^2}{2} \tag{18}$$

Using this value of Q in equation (17) we get

$$\begin{aligned} I(t) = & \frac{-D_0 t^2}{2} - \frac{D_0 \alpha t\,(t-\gamma)^{\beta+1}}{(\beta+1)} + \frac{D_0 \alpha (t-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} + \frac{D_0 t^2 \alpha (t-\gamma)^{\beta}}{2} \\ & + \frac{D_0 T^2}{2} + \frac{D_0 \alpha T\,(T-\gamma)^{\beta+1}}{(\beta+1)} - \frac{D_0 \alpha (T-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} - \frac{D_0 T^2 \alpha (t-\gamma)^{\beta}}{2}, \ 0 \le t \le T \end{aligned} \tag{19}$$

Now the number of units that deteriorate during one cycle is given by

$$\begin{aligned} D(T) &= Q - \int_0^T D_0 t\,dt = Q - \frac{D_0 T^2}{2} \\ &= \frac{D_0 \alpha T\,(T-\gamma)^{\beta+1}}{(\beta+1)} + \frac{D_0 \alpha (-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} - \frac{D_0 \alpha (T-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} - \frac{D_0 T^2 \alpha (-\gamma)^{\beta}}{2} \end{aligned} \tag{20}$$

Hence cost due to deterioration during one cycle is given by

$$CD(T) = \frac{C D_0 \alpha T\,(T-\gamma)^{\beta+1}}{(\beta+1)} + \frac{C D_0 \alpha (-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} - \frac{C D_0 \alpha (T-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} - \frac{C D_0 T^2 \alpha (-\gamma)^{\beta}}{2} \tag{21}$$

Now the salvage value of deteriorated units is given by

$$SV = a\,CD(T)$$

$$= \frac{aCD_0\alpha T\ (T-\gamma)^{\beta+1}}{(\beta+1)} + \frac{aCD_0\alpha(-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} - \frac{aCD_0\alpha(T-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} - \frac{aCD_0T^2\alpha(-\gamma)^{\beta}}{2} \qquad (22)$$

Total inventory holding cost per cycle is

$$IHC = h\int_0^T I(t)dt$$

Using the value of $I(t)$ from equation (19) and then integrating we get,

$$IHC = h\left[\frac{D_0T^3}{3} - \frac{3D_0\alpha T\ (T-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} + \frac{3D_0\alpha\left\{(T-\gamma)^{\beta+3}-(-\gamma)^{\beta+3}\right\}}{(\beta+1)(\beta+2)(\beta+3)} + \frac{D_0\alpha T^2}{(\beta+1)}\left\{(T-\gamma)^{\beta+1} + \frac{(-\gamma)^{\beta+1}}{2}\right\}\right] \qquad (23)$$

Ordering cost per cycle is, $OC = A$ (24)

Total interest earned during one cycle time is

$$IE_2 = PI_e\int_0^T D_0t\ dt + PI_eD_0T(\mu - T) = PI_eD_0T\left(\mu - \frac{T}{2}\right), \qquad (25)$$

Total interest paid during one cycle time is $IC_2 = 0$ (26)

Therefore the total average cost per unit time is

$$\phi_2(T) = \frac{1}{T}\left[OC + IHC + CD - SV + IC_2 - IE_2\right]$$

$$\Rightarrow \phi_2(T) = \frac{1}{T}\left[OC + IHC + (1-a)CD - IE_2\right]$$

$$= \frac{A}{T} + \frac{hD_0T^2}{3} - \frac{3hD_0\alpha\ (T-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} + \frac{3hD_0\alpha\left\{(T-\gamma)^{\beta+3}-(-\gamma)^{\beta+3}\right\}}{(\beta+1)(\beta+2)(\beta+3)T}$$

$$+ \frac{hD_0\alpha T}{2(\beta+1)}\left\{2(T-\gamma)^{\beta+1} + (-\gamma)^{\beta+1}\right\}$$

$$+ (1-a)CD_0\alpha\left\{\frac{(T-\gamma)^{\beta+1}}{(\beta+1)} - \frac{T(-\gamma)^{\beta}}{2} - \frac{(T-\gamma)^{\beta+2}-(-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)T}\right\} - PI_eD_0\left(\mu - \frac{T}{2}\right) \qquad (27)$$

The necessary condition for the total average cost to be minimized is $\frac{\partial\phi_2}{\partial T} = 0$ (28)

The value of T found from equation (28) will minimize the average total variable cost $\phi_2(T)$ if the second order derivative is positive.

To illustrate these we have given a numerical example and a sensitivity analysis in the following section.

NUMERICAL EXAMPLE

Case 1 When μ < T

Let us consider an inventory system with the following parametric values in their proper units.

$[A, C, h, P, I_c, I_e, a, D_0, \mu, \alpha, \beta, \gamma]$

$= [500, 10, 5,\ 100,\ 0.16, 0.12,\ 0.4, 20, 0.2, 0.4, 4, 0.6]$

Using these values in equation (15) we get, T=2.25362. For this value of T the second order derivative found to be 275.674 which is greater than zero. So this value of T will minimize the total variable cost. Putting the optimum values of T in equation (6) and (14) we get, Q=121359 and φ_1=276.624 and respectively.

Case 2 When μ > T

Let us consider an inventory system with the following parametric values in their proper units.

$$[A, C, h, P, \ I_e, a, \ \mu, D_0, \alpha, \beta, \gamma]$$
$$= [2000, 10, 4, \ 50, 0.24, \ 0.4, 5, 16, 0.6, 4, 0.4].$$

Using these values in equation (28) we get T=1.82892. For this value of T the second order derivative found to be 1990,33>0. So this value of T will minimize the total variable cost. Putting the optimum values of T in equation (18) and (27) we get, Q=55.5447 and φ_2=493.388 respectively

SENSITIVITY ANALYSIS

For study of sensitivity analysis change in one parameter is considered at a time keeping the other parameters unchanged. The original values of all the parameters for sensitivity analysis have been taken from the example given in section 3 above. Sensitivity analysis is performed by changing the values of all the parameters from -50% to +50%, one by one in the model which are given in the following tables. Table 1 is for Case 1 and Table 2 is for Case 2.

Table 1. When μ < T
Tabela 1. Sytuacja gdy μ < T

Parameter	% change	T	ϕ_1	Q
D_o	-50	2.51187	242.767	8.66642
	-25	2.35809	261.635	10.4626
	0	2.25362	276.624	12.1359
	25	2.17487	289.355	13.7258
	50	2.11181	300.585	15.2529
μ	-50	2.50997	243.814	8.73996
	-25	2.35739	262.386	10.5255
	0	2.25362	276.624	12.1359
	25	2.17511	288.136	13.6092
	50	2.11187	297.666	14.9648
α	-50	2.47713	257.628	12.9967
	-25	2.34356	268.562	12.501
	0	2.25362	276.624	12.1359
	25	2.18654	283.029	11.8403
	50	2.13344	288.347	11.5881
β	-50	2.91949	242.541	16.3787
	-25	2.4794	267.726	15.3033
	0	2.25362	276.624	12.1359
	25	2.11761	287.111	11.5743
	50	2.02787	292.023	10.3358
γ	-50	2.05037	306.614	13.0341
	-25	2.15079	291.113	12.6249
	0	2.25362	276.624	12.1359
	25	2.35877	262.516	11.3801
	50	2.46628	248.029	10.1079

Table 2. When μ > T
Tabela 2. Sytuacja gdy μ > T

Parameter	% change	T	ϕ_2	Q
D_o	-50	2.0411	760.96	36.6079
	-25	1.91591	636.841	40.8599

	0	1.82892	493.388	44.5447
	25	1.76213	338.419	47.8517
	50	1.7078	175.639	50.8782
α	-50	1.98051	420.623	47.3964
	-25	1.89091	461.847	45.6981
	0	1.82892	493.388	44.5447
	25	1.78185	519.144	43.6759
	50	1.7441	541.013	42.9815
β	-50	2.1036	417.688	58.5671
	-25	1.93201	470.805	52.4949
	0	1.82892	493.388	44.5447
	25	1.75678	515.921	40.4415
	50	1.70531	530.929	36.8627
γ	-50	1.71723	576.435	46.1735
	-25	1.77252	533.552	45.3117
	0	1.82892	493.388	44.5447
	25	1.88653	455.204	43.697
	50	1.94556	418.04	42.519

From the table 1 given below we can conclude the following:

The optimal time T increases as γ increases but it decreases as D_o, μ, α, β increases. Again the optimal ordered quantity Q per cycle increases as D_o, μ increases but it decreases as α, β, γ increases. The total average cost ϕ_1 of the system increases as D_o, μ, α, β increases but it decreases as γ increases.

From the table 2 given below we can conclude the following:

The optimal time T increases as γ increases but it decreases as D_o, α, β increases. Again the optimal ordered quantity Q per cycle increases as D_o increases but it decreases as α, β, γ increases. The total average cost ϕ_2 of the system increases as α, β increases but it decreases as γ and D_o increases.

CONCLUSIONS

In the present paper an economic ordered quantity model has been developed for an item considering three parameter Weibull deterioration, ramp type demand, salvage value and permissible delay in payments. The optimal cycle time, optimal ordered quantity per cycle and total optimal cost has been derived for the model. Sensitivity analysis shows how the different parameters affect the optimal cycle time, ordered quantity per cycle and total optimal cost. In both the cases of the present model it can be concluded that to minimise the total cost, it is required to minimize the value of the location parameter whereas we need to maximise the value of scale parameter, shape parameter and the constant coefficient D_o present in the ramp type demand function.

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MODEL EOQ DLA ASORTYMENTÓW ULEGAJĄCYCH NISZCZENIU WEDŁUG SCHEMATU WEIBULLA ZE SPADAJĄCYM POPYTEM I WARTOŚCIĄ REZYDUALNĄ DLA SYSTEMU KREDYTU KUPIECKIEGO

STRESZCZENIE. **Wstęp:** Środowisko rynkowe, na którym działają obecnie firmy charakteryzuje się duża konkurencyjnością i właśnie dla takiego rynku zostały opracowane różne modelu zarządzania zapasem dla asortymentów ulegających zniszczeniu. Opcja opóźnionej płatności w takich modelach jest nowo pojawiającym się elementem. Modele tego typu są bardzo praktyczne w zastosowaniu zarówno dla konsumentów jak i dla wytwórcy.
Metody: W prezentowanej pracy został przedstawiony opracowany model uwzględniający trójparametrowy system dla asortymentów podlegających niszczeniu Weibulla, charakteryzujący się spadającym popytem oraz uwzględniający oferowany kredyt kupiecki. Metoda została zaprezentowana dla jednego artykułu.
Wyniki i wnioski: Optymalna wielkość zamówienia, optymalny czas cyklu zamówienia oraz całkowite koszty zmienne w trakcie trwania cyklu zostały wyliczone dla proponowanego modelu zarządzania zapasem. Otrzymane wyniki zostały dodatkowo zaprezentowane w formie przykładu liczbowego oraz analizy wrażliwości..

Słowa kluczowe: EOQ, obniżenie wartości według schematu Weibulla, popyt spadający, wartość rezydualna, kredyt kupiecki.

DAS EOQ-MODELL FÜR DIE EINEM VERDERB UNTERLIEGENDEN SORTIMENTE NACH DEM WEIBULL-MODELL MIT SINKENDER NACHFRAGE UND RESIDUELLEM WERT FÜR DAS KAUFMANNSKREDIT-SYSTEM

ZUSAMMENFASSUNG. Einleitung: Das Umfeld des Marktes, auf dem gegenwärtig Firmen und Unternehmen aktiv sind, charakterisiert ein großer Wettbewerb und daher gerade für einen solchen Markt wurden unterschiedliche Modelle für Vorratshaltung der einem Verderb unterliegenden Sortimente ausgearbeitet. Das Verfahren einer verzogenen Zahlung stellt bei solchen Modellen ein neues Element dar. Die betreffenden Modelle sind in der Anwendung sowohl für die Verbraucher als auch für die Produzenten sehr brauchbar.

Methoden: Im Rahmen der vorliegenden Arbeit wurde ein konzipiertes Modell, welches das Dreiparameter-System für die dem Verderb nach dem Weibull-Modell unterliegenden Sortimente berücksichtigt, dargestellt. Das Weibull-Modell charakterisiert sich durch eine sinkende Nachfrage und nimmt den angebotenen Kaufmannskredit in Anspruch. Diese Methode wurde anhand nur eines Sortiment-Artikels präsentiert.

Ergebnisse und Fazit: Für das vorgeschlagene Modell der Vorratshaltung wurden die optimale Größe der Bestellung, die optimale Zeit des Bestellungszyklus und die variablen Gesamtkosten innerhalb eines Zyklus berechnet. Die ermittelten Ergebnisse wurden anhand eines zahlmäßigen Beispiels und in Form einer Empfindlichkeitsanalyse dargestellt..

Codewörter: EOQ, Wertsenkung nach dem Weibull-Modells, sinkende Nachfrage, residueller Wert, Kaufmannskredit

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MODEL OF INVENTORY REPLENISHMENT IN PERIODIC REVIEW ACCOUNTING FOR THE OCCURRENCE OF SHORTAGES

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ABSTRACT. Background: Despite the development of alternative concepts of goods flow management, the inventory management under conditions of random variations of demand is still an important issue, both from the point of view of inventory keeping and replenishment costs and the service level measured as the level of inventory availability. There is a number of inventory replenishment systems used in these conditions, but they are mostly developments of two basic systems: reorder point-based and periodic review-based. The paper deals with the latter system. Numerous researches indicate the need to improve the classical models describing that system, the reason being mainly the necessity to adapt the model better to the actual conditions. This allows a correct selection of parameters that control the used inventory replenishment system and - as a result - to obtain expected economic effects.

Methods: This research aimed at building a model of the periodic review system to reflect the relations (observed during simulation tests) between the volume of inventory shortages and the degree of accounting for so-called deferred demand, and the service level expressed as the probability of satisfying the demand in the review and the inventory replenishment cycle. The following model building and testing method has been applied: numerical simulation of inventory replenishment - detailed analysis of simulation results - construction of the model taking into account the regularities observed during the simulations - determination of principles of solving the system of relations creating the model - verification of the results obtained from the model using the results from simulation.

Results: Presented are selected results of calculations based on classical formulas and using the developed model, which describe the relations between the service level and the parameters controlling the discussed inventory replenishment system. The results are compared to the simulation results which are treated as reference. Determined are the relative errors of calculations based on formulas and the model. It is determined that the results obtained from the model have a significantly better fit.

Conclusions: The model presented in the paper should be a starting point for further works with the purpose to account for other phenomena observed during the simulation of inventory replenishment. This will allow a more accurate determination of the controlling parameters of the tested system, and also using the results to build similar models for other inventory replenishment systems used in practice.

Key words: inventory management, periodic review, inventory shortages, modelling, simulation.

INTRODUCTION

Apart from the reorder point-based system, the periodic review system is one of two basic inventory replenishment systems. It is based on inventory review at a regular time interval and ordering varying quantities of goods, depending on the level available during the review. Terminology in this paper is based on the terminology of European Logistics Associations [ELA, 1994], where this system is designated as ST (ST system - an ordering system with variable order quantities and fixed order moments "T". If the economic stock is smaller than "S", procurement order is placed

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for a quantity such that the economic stock becomes equal to the level "S").

The ST system in its classic form is used in practice, although its modifications are also widely used - e.g. the sS system [Krzyżaniak, Fechner 2013]. Similarly to other inventory replenishment systems, the ST system is still the subject of much research aiming at optimized adaptation of the ST system model solutions to the real conditions where they are applied. One of the most important issues is optimal defining of the random variability of demand, and also of the random changes of the system time parameters, particularly the replenishment lead time [e.g. Diane, Bischak, Silver, Blackburn. 2013]. Very often the description of the demand distribution by means of one of theoretical distributions (e.g. normal distribution, the most popular is case of FMCG) is not sufficiently accurate. There are other approaches in the literature, e.g. description of the random variability of demand based on the fuzzy set theory [Dey, Chakrabotry, 2009].

Correct evaluation of random changes of demand and of the consequences of random delivery delays has a key importance for estimating the expected frequency and volume of shortages which directly affects the service level. Determination of the shortage volume is also the subject of a lot of papers, both empirical and theoretical [e.g. Lavin 2012, Johansen, Hill, 2000]. The research is based on building and using mathematical models, and also on simulation [e.g. Drake, Marley, 2010].

The research, the results of which are presented in this paper, was based on a complex mathematical model, verified on the basis of results of simulation of inventory replenishment in the ST periodic review system. The main purpose of the research was to determine and describe the model interaction between the expected shortage volume and service level understood as the probability that the whole demand is satisfied in a given cycle, taking into account the deferred demand (backorders).

FEATURES OF THE ST SYSTEM

Determining the controlling parameters:

- determination of the required service level (POP),
- calculation of the demand distribution in a unit of time (only random changes),
- determination of the replenishment lead time LT
- determination of the review cycle time T (it can depend on the volume of an economic order or result from the arrangements with the supplier),
- calculation of the S level, according to the formulas (3) or (6).

Stock replenishment procedure according to the determined parameters - at a specific moment in time determined by the used cycle:

- the available stock (economic stock) S_e is calculated

$$S_e = S_w + S_o + S_{er} - S_b \qquad (1)$$

where:
S_w stock physically available in the warehouse (on-hand),
S_o orders placed, but not yet implemented,
S_{er} stock en route,
S_b stock already booked.

- A procurement order is placed for the volume:

$$q = S - S_e \qquad (2)$$

These ST system rules are shown in figure 1.

In the classical approach, the relation between the parameter S (also called the maximum stock level) and the service level is as follows:

$$S = D * (LT + T) + SS \qquad (3)$$

where:
D - mean demand in a unit of time used (e.g. day, week)

T - review interval (time between two successive reviews (orders)),
LT - replenishment cycle time - time between the review and delivery of goods.

SS - safety stock, expressed as:

$$SS = \omega * \sigma_{(D\text{-}LT,T)} \qquad (4)$$

where:
ω - safety factor, which depends on the applied service level and the type of the demand frequency occurrence distribution,

$\sigma_{(D\text{-}LT,T)}$ - standard deviation of demand in the time equal to the sum of review interval and inventory replenishment time.

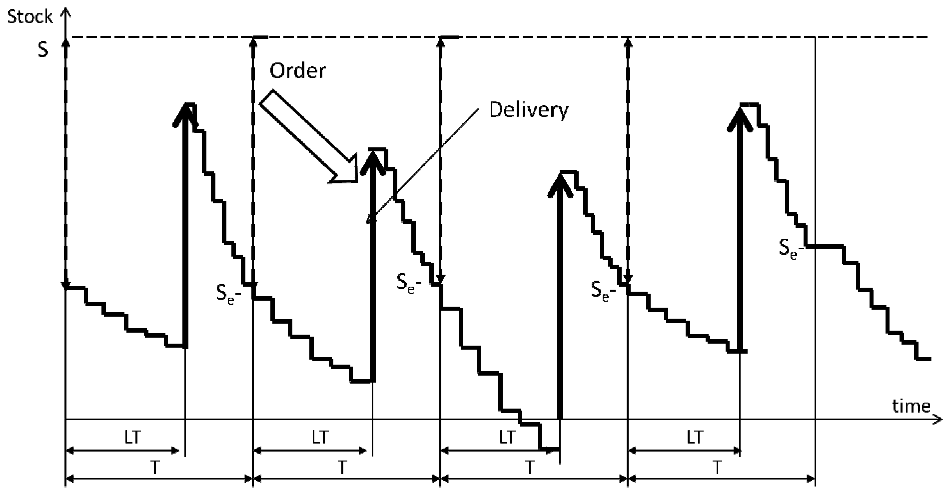

Fig. 1. Inventory replenishment in the periodic review (ST system)
Rys. 1. Ilustracja zasady realizacji odnawiania zapasu w przeglądzie okresowym (system ST)

In a general case (random variation of demand and inventory replenishment time), the following formula applies:

$$SS = \omega \cdot \sqrt{\sigma_D^2 \cdot (LT + T) + \sigma_{LT}^2 \cdot D^2} \qquad (5)$$

where:
σ_D – standard deviation of demand in a unit of time used (the same as for D)
σ_{LT} – standard deviation of replenishment lead time.

Obviously, the calculations of both deviations must concern the exclusively random changes. It is assumed that the review interval T does not change. In this paper it is also assumed that the replenishment lead time LT is constant (i.e. it is assumed that $\sigma_{LT} \approx 0$). With these assumptions, the relation (1) will be expressed as:

$$S = D \cdot (LT + T) + \omega \cdot \sigma_D \sqrt{LT + T} \qquad (6)$$

An additional assumption has been made for the type of distribution of demand D – a normal distribution has been used, typical for fast moving goods.

Another important issue affecting the practical use of relation (4) is correct definition of the service level. A classical probabilistic definition has been used here which defines the service level as a probability that no shortage in the inventory will occur in the review interval time and inventory replenishment time (LT + T). This probability will be represented by αSL [Tempelmeier H. 2000].

In case of normal distribution the relation between the probability of demand satisfaction and the safety factor is as follows:

$$\propto SL = \int_{-\infty}^{\omega} \frac{1}{\sqrt{2 \cdot \pi}} \cdot e^{-\frac{z^2}{2}} dz = \Phi(\omega) \qquad (7)$$

Normal distribution is a good indicator of the demand variation for fast moving goods and that is why is has been used here. In reality, the lower limit of integration in the formula (7) should equal 0 (negative demand is excluded), but for fast moving goods with relatively high mean demand it can be assumed that:

$$\int_0^{\omega} \frac{1}{\sqrt{2\cdot\pi}}\cdot e^{-\frac{z^2}{2}}dz \approx \int_{-\infty}^{\omega} \frac{1}{\sqrt{2\cdot\pi}}\cdot e^{-\frac{z^2}{2}}dz \qquad (8)$$

The formula (4) can be rearranged in order to calculate the expected service level depending on the assumed maximum stock level S:

$$\alpha SL = \Phi[\omega] = \Phi\left[\frac{S - D\cdot(LT+T)}{\sigma_D\cdot\sqrt{LT+T}}\right] \qquad (9)$$

This relation is shown in figure 2.

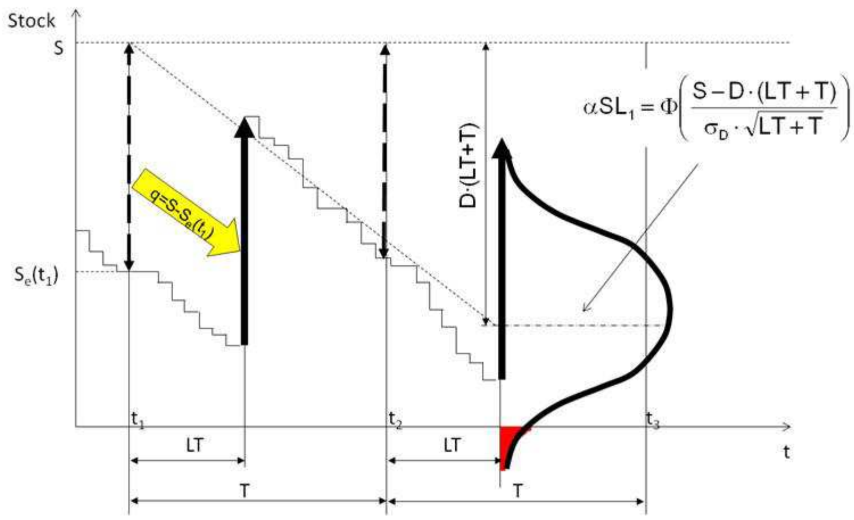

Fig. 2. Determination of service level in the ST system
Rys. 2. Ilustracja zasady wyznaczania poziomu obsługi w systemie ST

The formulas (6) and (9) usually work well in practice, but conformity of actual results to calculations largely depends on to what extent the distribution of frequency of actual demand conforms to the type of distribution used. The discrepancies are very often significant, which is a result of not only eliminating the "non-random" demand from the analysed data (the effects of promotions, seasonality, or other causes of periodic variations), but also - simply - of a complex nature of real phenomena.

The simulation tests based on the model distribution of demand have shown some discrepancies between the obtained service levels and the results calculated according to the formula (9). The discrepancies concern particularly the cases where the service level is lower. One can say that from the practical point of view this issue is not significant. On the other hand, building a correct model which results conform to the simulation in the entire tested range is important also from the point of view of building correct analytical models of other inventory replenishment systems (e.g. the Ss system - Fechner, Krzyżaniak 2013).

SCOPE OF SIMULATION TESTS USED TO BUILD AND VERIFY THE MODEL

The simulation tests used a proprietary tool developed as an Excel application which allows to simulate the most important inventory replenishment systems for chosen distributions of demand occurrence frequency.

The main source of data for the inventory replenishment simulation is generating the random demand variations for a given unit of time (here 1 day has been used). The normal distribution has been used, with the following parameters: mean D = 50.2 units, standard deviation σ_D=7.25 units. Typical variation of generated demand and corresponding distribution are shown in figure 3.

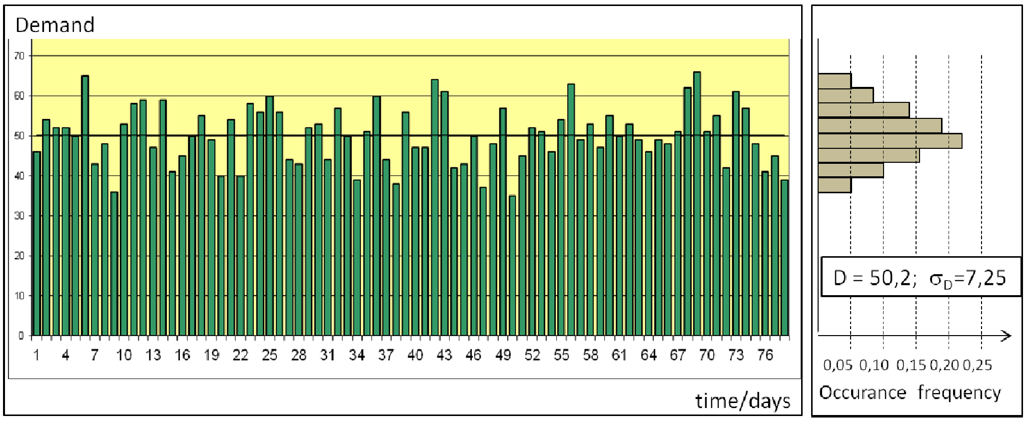

Fig. 3. An example of demand variation generated to be used in the inventory replenishment simulation
Rys. 3. Przykładowy przebieg zmian popytu generowany do wykorzystania do symulacji odnawiania zapasu

The conformity of the distribution of the generated demand with normal distribution was checked using the Kolmogorov-Smirnov test (e.g. Benjamin J. R, Cornell C. A., 1977) which is usually applied to test the null hypothesis that the distribution of a variable (empirical data) is close to the normal distribution. In this case the Kolmogorov-Smirnov test was applied to the data from the generator. For the selected sample of 78 days the conformity to the normal distribution at the significance level of α=0.05 was received.

Detailed analyses of the simulation results leading to the construction of the model have been performed for the parameter sets presented in table 1. The Smax - Smin ranges have been selected to ensure approximately comparable intervals of achieved service level.

A simulation result example is presented in figure 4.

Table 1. Range of data used in the model simulation and verification
Tabela 1. Zakres danych wykorzystanych w symulacji i weryfikacji modelu

Variant		1	2	3	4	5	6
Review interval T		8	7	6	5	6	6
Replenishment lead time LT		1	2	3	4	1	5
Variation range of parameter S	S max	505	505	505	505	400	615
	S min	410	410	410	410	305	520

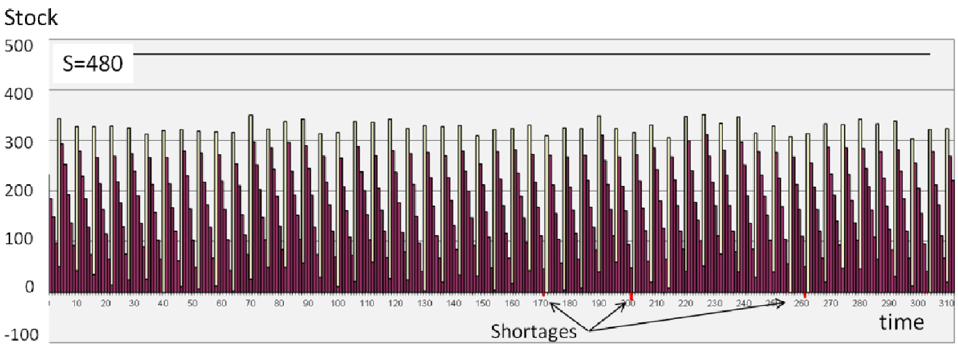

Fig. 4. Graphical representation of simulation results
Rys. 4. Przykład graficznej ilustracji wyników otrzymywanych drogą symulacji

During the analysis the following values were distinguished:

- Number (per cent) of cycles with shortages,
- Number (per cent) of cycles with shortages occurring after the cycles without shortages,
- Number (per cent) of cycles with shortages occurring after the cycles with shortages,
- Mean demand in the (LT+T) cycle for cycles with shortages,
- Mean demand in the (LT+T) cycle for cycles without shortages,
- Mean shortage volume per one cycle (sh),
- Mean shortage volume per one cycle with shortages (sh').

ST SYSTEM MODEL ACCOUNTING FOR INVENTORY SHORTAGES AND LOST SALES

The analyses of the above-mentioned values have indicated the need to include in the analytical model the phenomenon of reduced shortage risk in the cycle occurring after the cycle with shortages. This is a consequence of two phenomena:

1. Virtual shift of the S level in case of lost unsatisfied demand, that is when the unsatisfied demand in cycle "i" (as a result of shortage) is not "deferred" and does not increase the demand in cycle "i+1".
2. Variation of the actual demand in the (LT + T) cycle, depending on whether the observed cycle occurs after the cycle with shortages or after the cycle without shortages.

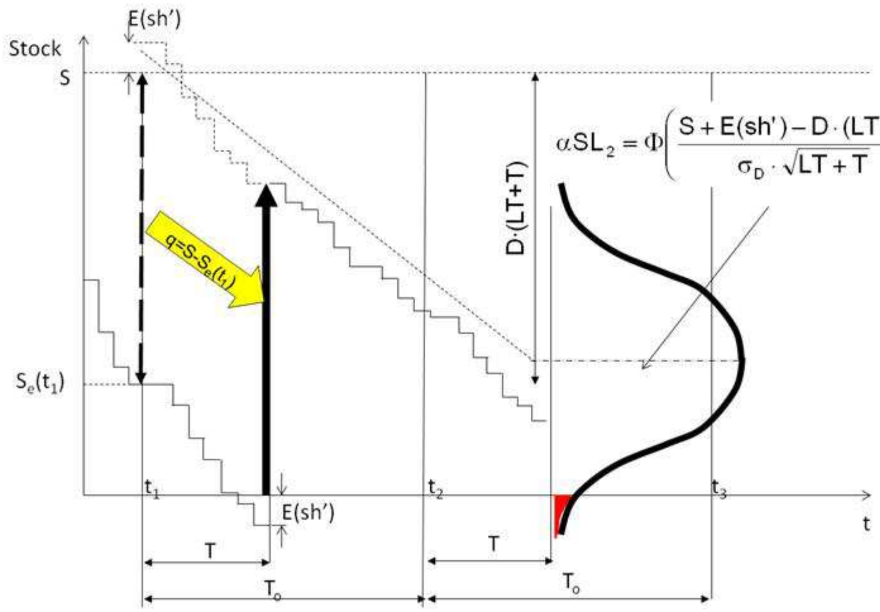

Fig. 5. Impact of the lost demand effect on the probability of shortage occurrence in the next cycle - formula (9), assuming r=0
Rys. 5. Wpływ efektu popytu traconego na prawdopodobieństwo wystąpienia braku w następnym cyklu - formuła (9), z przyjęciem r=0

This paper focuses on the first case. The following discussion concerns its impact on reduced risk of shortage occurrence in the next cycle.

1. If no shortage occurred in the previous cycle, the expected service level is:

$$\propto SL_1 = \Phi[\omega_1] = \Phi\left[\frac{S - D\cdot(LT+T)}{\sigma_D \cdot \sqrt{LT+T}}\right]$$
(10)

which conforms to the formula (9), as shown in figure 2.

2. If shortage occurred in the previous cycle, the expected service level is:

$$\propto SL_2 = \Phi[\omega_2] = \Phi\left[\frac{S + E(sh')\cdot(1-r) - D\cdot(LT+T)}{\sigma_D \cdot \sqrt{LT+T}}\right]$$
(11)

where E(sh') is an expected shortage volume in case of absence of shortage, and r is the degree to which the unsatisfied demand manifests itself in the next cycles (deferred demand). Assumption that r=0 means the total loss of unsatisfied demand in cycle "i", whereas assumption that r=1 means that the unsatisfied demand is fully shifted to the cycle "i+1".

Both these cases are shown in figures 5 and 6, where figure 5 illustrates the total loss of unsatisfied demand (r=0), and the figure 6 illustrates the total shift of unsatisfied demand to the later cycles (r=1). It can be seen that the second case corresponds the situation shown in figure 2. However, one should keep in mind that the loss of unsatisfied demand happens very often, particularly in the retail trade. Thus, accounting for this phenomenon should be considered important.

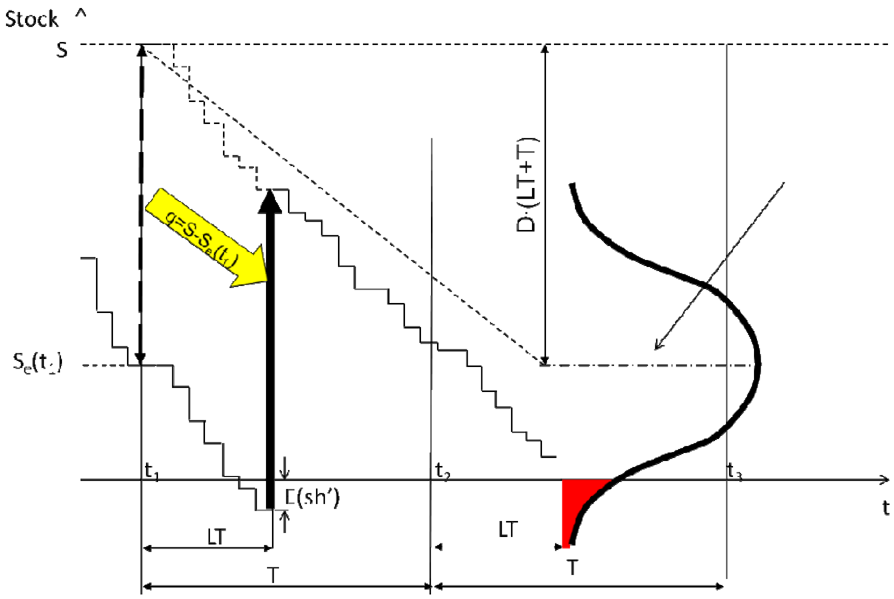

Fig. 6. Impact of the effect of lost demand shift to the next cycle on the probability of shortage occurrence in the next cycle - formula (9), assuming r=1
Rys. 6. Wpływ efektu przenoszenia straconego popytu na kolejny cykl, na prawdopodobieństwo wystąpienia braku w następnym cyklu - formuła (9), z przyjęciem r=1

Generally, the following formula is suggested to calculate the expected shortage volume in the cycle with shortage:

$$E(sh') = \propto SL \cdot E(sh'_1) + (1 - \propto SL)\cdot E(sh'_2)$$
(12)

where:

$$E(sh'_1) = \frac{E(sh_1)}{1-\propto SL_1}; \qquad E(sh'_2) = \frac{E(sh_2)}{1-\propto SL_2}$$
(13)

and $E(sh_1)$ and $E(sh_2)$ are expected numbers of shortages referenced to any cycle, respectively for case 1 (cycle after the cycle without shortages) and case 2 (cycle after the cycle with shortages). They are calculated according to the following formulas:

$$E(sh_1) = I(\omega_1) \cdot \sigma_D \cdot \sqrt{LT+T};$$
$$E(sh_2) = I(\omega_2) \cdot \sigma_D \cdot \sqrt{LT+T} \qquad (14)$$

where:

$I(\omega)$ - standardized number of units of shortage: $I(\omega) = \int_{z=\omega}^{\infty} (z-\omega) \cdot f(z)dz$

$\sigma_D \cdot \sqrt{LT+T}$ - standard deviation of demand in the review interval and inventory replenishment cycle.

Taking all above-mentioned formulas (10) - (14), the expected service level αSL is calculated as follows:

$$\propto SL = \propto SL \cdot \propto SL_1 + (1-\propto SL) \cdot \propto SL_2$$
(15)

The formulas (10) - (15) are interdependent, as shown in figure 7. Hence, the solution of this system of equations requires an iterative approach.

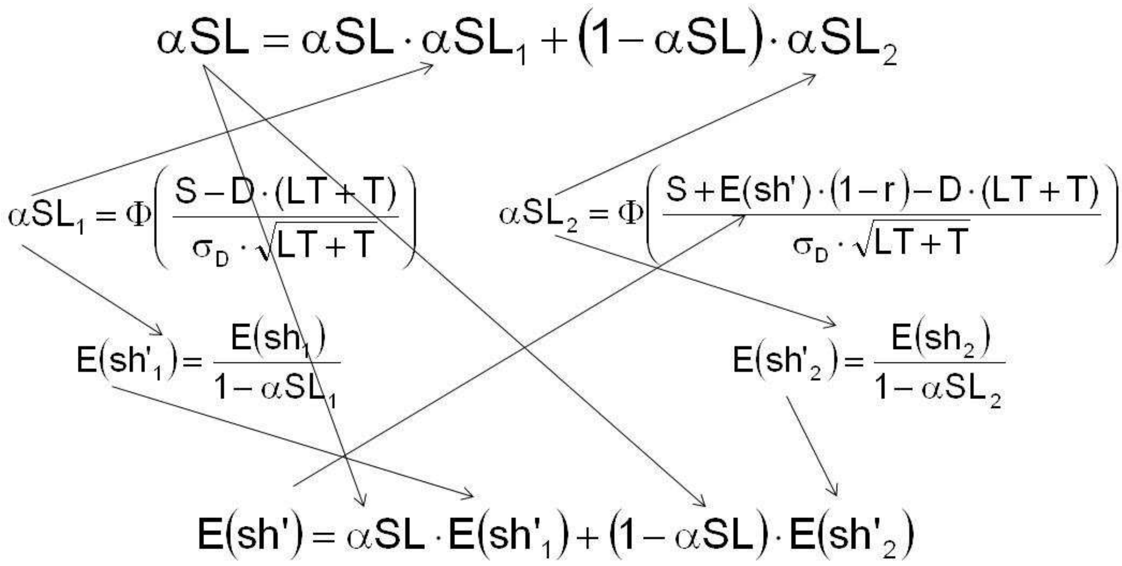

Fig. 7. Interdependencies between the equations included in the model
Rys. 7. Ilustracja wzajemnych zależności pomiędzy równaniami wchodzącymi w skład opracowanego modelu

RESULTS OF MODEL QUALITY TESTS

The presentation of the model quality test results has been limited to the comparison of the αSL obtained from the simulation (as a reference curve) to the values obtained from the classical formula (9) and from the model.

Figure 8 shows the αSL =f(S) curve for variant 3 (table 1). It can be seen that at the 80-85% level the differences between the simulation results and the calculations based on the classical formula (9) become significant.

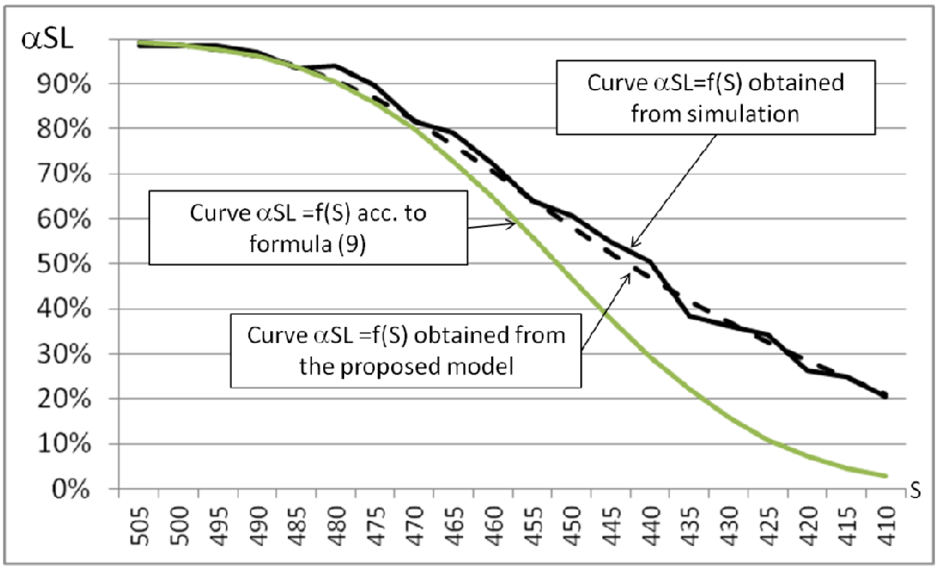

Fig. 8. Comparison of SL=f(S) curves obtained from simulation (reference), from classical formula (9), and from the presented model. The curves are determined for T = 6 days, LT = 3 days

Rys. 8. Porównanie przebiegu zależności SL =f(S) otrzymanych drogą symulacji (jako przebieg odniesienia), otrzymany w oparciu o klasyczny wzór (9) oraz w wyniku zastosowania przedstawionego modelu. Przebiegi wyznaczono dla T = 6 dni, LT = 3 dni.

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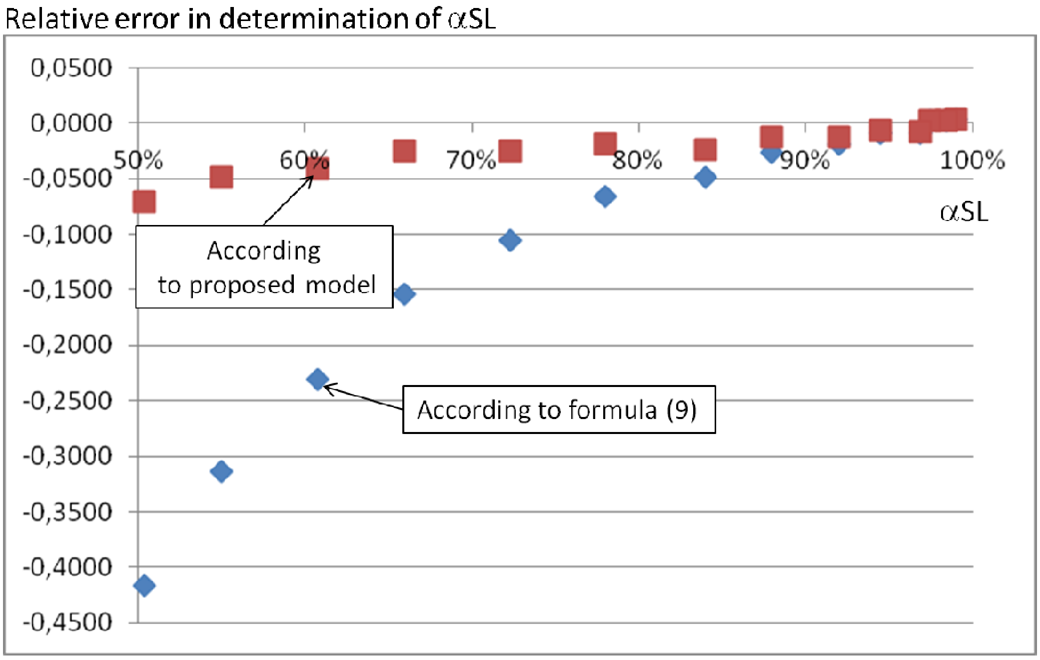

Fig. 9. Relative error in determination of the service level SL obtained from simulation (reference), from classical formula (9), and from the proposed model. The curves are determined for T = 6 days, LT = 3 days.
Rys. 9. Błąd względny wyników obliczenia poziomu obsługi SL otrzymanych drogą symulacji (przebieg odniesienia), otrzymany w oparciu o klasyczny wzór (9) oraz w wyniku zastosowania proponowanego modelu. Przebiegi wyznaczono dla T = 6 dni, LT = 3 dni

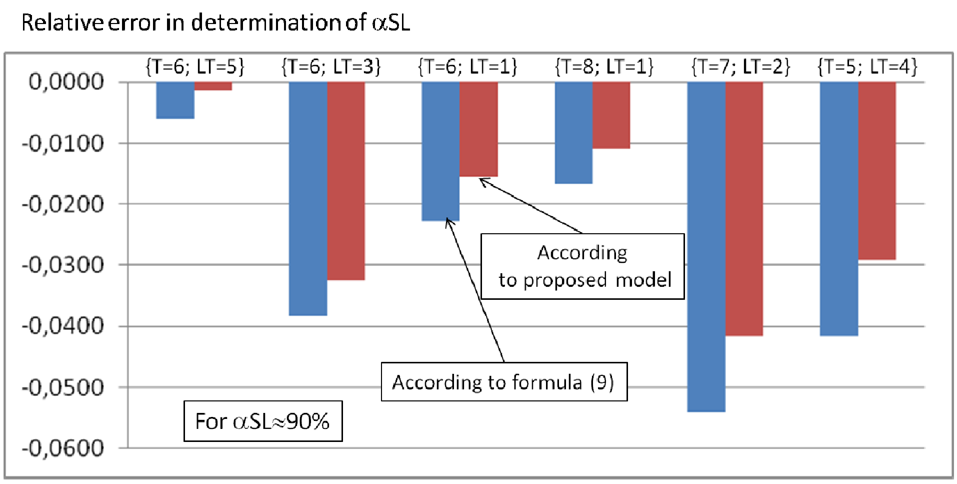

Fig. 10. Relative error in determination of the service level SL obtained from classical formula (9) and from the proposed model in comparison to the simulation results, determined for the chosen variants (table 1), at the simulation-obtained service level SL equal to about 90%.
Rys. 10. Błąd względny wyników obliczenia poziomu obsługi SL otrzymanych w oparciu o klasyczny wzór (9) oraz w wyniku zastosowania proponowanego modelu, w odniesieniu do wyników otrzymanych drogą symulacji, wyznaczony dla przyjętych wariantów (tabela 1), przy poziomie obsługi SL otrzymanym drogą symulacji równym ok. 90%

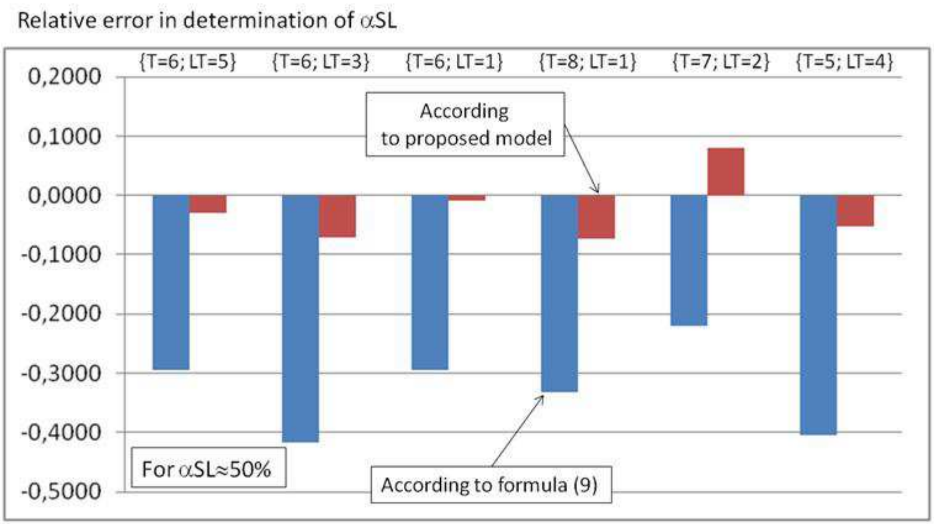

Fig. 11. Relative error in determination of the service level SL obtained from classical formula (9) and from the proposed model in comparison to the simulation results, determined for the chosen variant (table 1), at the simulation-obtained service level SL equal to about 50%

Rys. 11. Błąd względny wyników obliczenia poziomu obsługi SL otrzymanych w oparciu o klasyczny wzór (9) oraz w wyniku zastosowania proponowanego modelu, w odniesieniu do wyników otrzymanych drogą symulacji, wyznaczony dla przyjętych wariantów (tabela 1), przy poziomie obsługi SL otrzymanym drogą symulacji równym ok. 50%

Figure 9 presents relative errors in estimating the service level using formula (9) and the model in comparison to the values obtained from simulation. It can be seen that even for the 50% service level (not used in practice) the relative error for the results obtained from the model is small, which indicates its significantly better fit than of classical formula (9).

Figures 10 and 11 present on the other hand the identically defined errors for all six tested variants shown in table 1, at two chosen service levels: αSL = 90% and αSL = 50%. Here we can see (fig. 10), more clearly than in fig. 8 and 9, the better conformity of the presented model to the simulation results (reference), also at αSL =90%. We can also see that for the tested cases the value of errors does not depend on the interrelations between LT and T.

CONCLUSIONS

The presented model is a much more accurate tool to describe the relations (observed during the simulation) between the service level and the parameters controlling the periodic review- based inventory replenishment system. Although in case of the service levels used in practice (above 90%) the differences in accuracy are not significant, yet the possibility of describing the relations between the used service level and the system parameters is important also from the point of view of improved modelling of other inventory replenishment systems.

Other phenomena observed during the simulations which can affect the model accuracy (particularly the variation of actual demand depending on whether the observed cycle occurs after the cycle with shortages or after the cycle without shortages) require further development of the model.

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MODEL ODNAWIANIA ZAPASÓW W PRZEGLĄDZIE OKRESOWYM UWZGLĘDNIAJĄCY WYSTĘPOWANIE BRAKÓW

STRESZCZENIE. **Wstęp**: Zarządzanie zapasami w warunkach losowych zmian popytu jest wciąż - mimo rozwoju alternatywnych koncepcji zarządzania przepływem dóbr - ważnym zagadnieniem zarówno z punktu widzenia kosztów utrzymania i uzupełniania zapasów, jak i poziomu obsługi mierzonego poziomem dostępności zapasu. Istnieje szereg systemów uzupełniania zapasu w takich warunkach, przy czym stanowią one najczęściej rozwinięcie dwóch podstawowych: systemu opartego na punkcie ponownego zamówienia oraz opartego na przeglądzie okresowym. Artykuł odnosi się do drugiego z nich. Liczne badania wskazują konieczność udoskonalania klasycznych modeli opisujących ten system. Wynika to przede wszystkim z potrzeby lepszego dopasowania modelu do warunków rzeczywistych. To pozwala na poprawny dobór parametrów sterujących przyjętym systemem odnawiania zapasu i - tym samym - osiągania oczekiwanych efektów ekonomicznych.
Metody: Przedmiotem prezentowanych badań było stworzenie modelu systemu przeglądu okresowego odzwierciedlającego obserwowane w trakcie badań symulacyjnych zależności pomiędzy wielkością występujących braków w zapasie i stopnia uwzględnienia tzw. popytu odłożonego, a poziomem obsługi przyjętym jako prawdopodobieństwo obsłużenia popytu w cyklu przeglądu i uzupełnienia zapasu. Przyjęto następującą metodę budowy i weryfikacji modelu: symulacja numeryczna odnawiania zapasu - szczegółowa analiza wyników symulacji - budowa modelu uwzględniającego prawidłowości zaobserwowane podczas symulacji - określenie zasad rozwiązania układu zależności tworzących model - weryfikacja wyników uzyskiwanych na podstawie modelu z wynikami symulacji.
Wyniki: Przedstawiono wybrane wyniki obliczeń opartych na klasycznych formułach i przy wykorzystaniu opracowanego modelu, opisujących zależności pomiędzy poziomem obsługi a parametrami sterującymi odnawianiem zapasu w omawianym systemie. Porównano je z wynikami symulacji traktowanych jako referencyjne. Wyznaczono

błędy względne obliczeń opartych na formułach i modelu. Stwierdzono znacząco lepsze dopasowanie wyników uzyskiwanych przy zastosowaniu modelu.
Wnioski: Przedstawiony w artykule model powinien stanowić punkt wyjścia do dalszych prac mających na celu uwzględnienie innych zjawisk obserwowanych w trakcie symulacji odnawiania zapasu. Pozwoli to na bardziej dokładne wyznaczanie parametrów sterujących badanego systemu, ale także na wykorzystanie wyników prac do budowy podobnych modeli dla innych, stosowanych w praktyce, systemów odnawiania zapasów..

Słowa kluczowe: zarządzanie zapasami, przegląd okresowy, braki w zapasie, modelowanie, symulacja

MODELL ZUR ERNEUERUNG DER VORRÄTE BEI PERIODISCHER ÜBERPRÜFUNG UND BERÜCKSICHTIGUNG DES VORKOMMENS VON VORRATSMÄNGELN

ZUSAMMENFASSUNG. Einleitung: Das Vorratsmanagement bei zufälligen Änderungen der Nachfrage ist immer noch - trotz der Entwicklung alternativer Konzepte zum Management des Güterflusses - eine Frage, die sowohl im Hinblick auf die Kosten für die Vorratshaltung und -ergänzung als auch das Bedienungsniveau, das durch das Niveau der Verfügbarkeit der Vorräte gemessen wird, sehr wichtig. Es besteht eine Reihe von Systemen zur Ergänzung der Vorräte unter derartigen Bedingungen, wobei sie meistens eine Entwicklung der zwei grundlegenden Systeme sind: ein System, das auf dem Nachbestellpunkt basiert, und ein System, das auf der periodischen Überprüfung basiert. Der Artikel betrifft das zweite System. Zahlreiche Untersuchungen weisen auf die Notwendigkeit hin, die klassischen Modelle, die dieses System beschreiben, weiter zu entwickeln. Dies ergibt sich vor allem aus dem Bedürfnis, das Modell an die tatsächlichen Bedingungen besser anzupassen. Es ermöglicht eine richtige Auswahl der Parameter, die das angenommene System zur Erneuerung des Vorrats steuern, und somit die gewünschten wirtschaftlichen Effekte zu erzielen.
Methoden: Gegenstand der präsentierten Untersuchungen war die Erarbeitung eines Modells für ein System zur periodischen Überprüfung, das die während der Simulationsuntersuchungen beobachteten Wechselbeziehungen zwischen der Größe der Vorratsmängel und dem Grad der Berücksichtigung der sog. aufgeschobenen Nachfrage einerseits und dem Bedienungsniveau andererseits, das als Wahrscheinlichkeit der Bedienung der Nachfrage im Zyklus der Überprüfung und Ergänzung der Vorräte angenommen wird, widerspiegelt. Man hat folgende Methode zum Aufbau und zur Prüfung des Modells angenommen: nummerische Simulation der Erneuerung der Vorräte - detaillierte Analyse der Ergebnisse der Simulation - Aufbau eines Modells, das die Regelmäßigkeiten berücksichtigt, die während der Simulation beobachtet wurden - Bestimmung der Grundsätze für die Auflösung des Systems der Regelmäßigkeiten, die das Modell bilden - Vergleich der aufgrund des Modells erzielten Ergebnisse mit den Ergebnissen der Simulation.
Ergebnisse: Es wurden ausgewählte Ergebnisse der auf den klassischen Formeln basierenden Kalkulationen sowie unter Anwendung des entwickelten Modells dargestellt, die die Wechselbeziehungen zwischen dem Bedienungsniveau und den Parametern, die die Erneuerung der Vorräte in dem zur Analyse stehenden System steuern, beschreiben. Sie wurden mit den Ergebnissen der Simulation verglichen, die als Referenzergebnisse gelten. Es wurden die relativen Fehler der Kalkulationen bestimmt, die auf den Formeln und dem Modell basieren. Es wurde eine wesentlich bessere Anpassung der Ergebnisse festgestellt, die unter Anwendung des Modells erzielt werden.
Fazit: Das in dem Artikel präsentierte Modell soll als Ausgangspunkt für weitere Arbeiten gelten, deren Ziel es ist, andere Erscheinungen zu berücksichtigen, die während der Simulation der Erneuerung der Vorräte beobachtet wurden. Dies ermöglicht, die steuernden Parameter des zur Analyse stehenden Systems genau zu bestimmen und die Ergebnisse der Arbeiten zum Aufbau ähnlicher Modelle für andere, in der Praxis anwendbare Systeme zur Erneuerung der Vorräte zu verwenden.

Codewörter: Vorratsmanagement, periodische Überprüfung, Vorratsmängel, Modellierung, Simulation

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A REBA-BASED ANALYSIS OF PACKERS WORKLOAD: A CASE STUDY

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ABSTRACT. Background: One of the elements of a logistics system is the subsystem of production, which is a system composed of physical elements such as machinery, tools and (most importantly) people. In addition, system-dependent human operators are particularly prone to problems related to discomfort, which can affect production quality and increase training costs and absenteeism. The aim of this study was to assess the workload and risk of musculoskeletal discomfort (MSD's) in the process of order fulfillment for the position of packer and to conduct an analysis of risk factors.

Methods: The Rapid Entire Body Assessment (REBA) evaluation method was used. Activities related to the fulfillment of an order were assessed for three workstations.

Results: Five postures qualified for action category (AC) 2, seven postures for AC 3 and one posture for AC 4. The main factors affecting the risk of a negative assessment of posture were keeping the back bent and twisted, keeping the arms raised above the trunk, working in a standing position and the weight of packaged carton.

Conclusions: Packers working on research positions face a high level of exposure to the risk of MSD's, therefore corrective actions should be carried out as soon as possible. Ergonomic intervention should be linked to redesigning workstations and methods of working. After making changes to the research workstations, re-evaluation using the REBA method is recommended to verify the effectiveness of the changes.

Key words: REBA, workload, ergonomics, risk, MSD's.

INTRODUCTION

One of the elements of logistics systems is the subsystem of production [Słowiński 2008] and the basic elements (resources) of each work process comprise of people, means of labor and objects of labor [Słowiński 2008]. Production systems are defined as a complex system of physical items such as machinery, tools and (most importantly) people. Employees in manufacturing systems are "internal consumers" and the system must be designed to meet their needs. At the same time, production systems must produce goods that meet the needs of "external consumers". In terms of health and safety, the production system is designed to meet the needs of both internal and external consumers [Black 2007]. In addition, production systems dependent on a human operator are particularly prone to problems related to discomfort, which can affect production quality and increase the cost of training and absence from work [Kasvi et al. 2000].

Work performed by people is accompanied by physical activity, which can cause the appearance of musculoskeletal discomfort (MSD's) among workers [Vieira, Kumar 2004]. Studies have shown that the position of the employee whilst working, range of motion, force, repetition and duration must be taken into account when categorizing the level of physical activity [Kumar 1994]. The body and movements of the operator during operation

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are important variables that must be taken into account in safety at work because they are the two most important factors in determining the workload on the employee. The position of an employee at work is affected by factors such as job done, nature of work, tools used, tool design and the anthropometric characteristics of workers [Vieira, Kumar 2004, Westgaard, Winkel 1997].

Research techniques proposed to estimate the level of discomfort and the posture's workload associated with the worker's adoption of different positions during labor can be divided into observational and device-based techniques. In the case of observation techniques, angular deviation of body sections from the neutral position is obtained by visual observation. However, for techniques based on instruments, continuous position monitoring is conducted by devices connected to the worker. Due to the lack of integration in the labor process, low cost and ease of use, observational techniques are more widely used in industry [Genaidy et al. 1994].

Observational methods used to assess postural worker load include, amongst others the Ovako Working posture Analysis System (OWAS) [Karhu et al. 1977, Kivi and Mattila 1991], Rapid Upper Limb Assessment (RULA) [McAtamney, Corlett 1993] and Rapid Entire Body Assessment (REBA) [Hignett, McAtamney 2000]. They have been developed for different purposes and are therefore used under different workplace conditions [Kilbom 1994]. Each technique has its own approach to system operator classification, which differs from other techniques. Variance may arise in the final result for operator load, depending on the technique used.

The publication of several scientific studies has shown the usefulness in assessing operator position while working in different environments such as warehouses [Torres, Vina 2012], construction [Kivi, Mattila 1991, Li, Lee 1999], agriculture [Gangopadhyay et al. 2006], forestry [Calvo 2009], supermarkets [Carrasco et al. 1995, Coyle 2005, Ryan 1989], the poultry industry [Scott, Lambe 1996], operation and maintenance of ships [Joode et al., 1997], beverage distribution centers [Wright, Haslam 1999], metal processing [Gonzalez et al. 2003], wood [Jones, 2007], stone carving [Mukhopadhyay, Srivastava 2010)], truck drivers [Massaccesi et al. 2003], fish processing [Quansah 2005], cleaners in an office environment [Kumar 1994], computer operators [Pillastrini et al. 2007, Shuval, Donchin 2005], firefighters and emergency medical technicians [Gentzler, Stader 2010], in the steel industry, electronics, automotive and chemical industries [Kee, Karwowski 2007, Kee et al. 2011, Lasota 2013a, Lasota 2013b, Muthukumar et al. 2012, Sesek et al. 2004, Wang et al. 2012], appliance manufacturers, plastics and composites manufacturers [Chiasson et al. 2012], etc. The approach has also been used in redesign and simulation in areas such as design and modeling using a digital human model [Lamkull et al. 2009, Minami et al. 2009], virtual modeling [Hirose et al. 1995], job design [Cimino et al. 2009, Hallbeck et al. 2010], design of assembly systems [Battinii et al. 2011], etc.

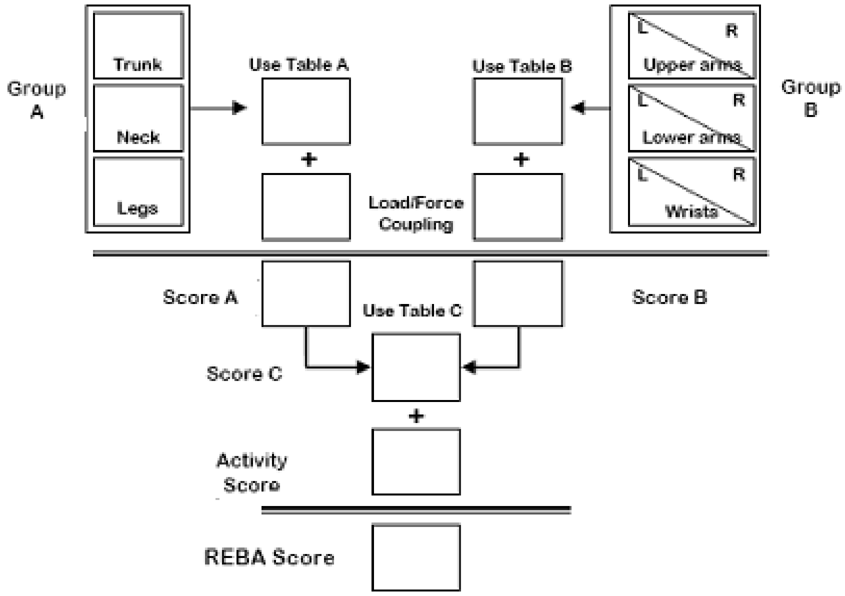
The aim of this study was to assess the workload and the risk of MSD's in the process of order fulfillment for the packer position and to conduct an analysis of risk factors using the REBA method.

METHODS AND MATERIALS

REBA method

The REBA method was developed in 2000 [Hignett, McAtamney 2000) and distributed in many countries. It is designed to assess the risk exposure associated with MSD's based on the posture of the operator at work. The method comprehensively considers the issue based on the observation of techniques used in performing the work activities. It takes into account the body postures taken by the employee during physical work, distinguishing the following segments: trunk, neck, legs, upper arms, lower arms and wrists. Also included are load/force required, hand-object coupling used and an activity score (static postures held repetition, large rapid changes in postures, or unstable base). The basis of the assessment of the degree of exposure is the aggregate position of the body and the rest of the REBA score gives scores divided by body group; score A is established by Neck, Trunk and Leg Analysis, score B is established by

Arm and Wrist Analysis, score C is given by score A and score B combined and the final score is then created from score C with adjustment according to Figure 1.



Source: Hignett i McAtamney 2000

Fig. 1. Reba score system
Rys. 1. Ocena metodą Reba

Based on the resulting final score, the risk of exposure to MSD's, Action Categories (AC) required for the improvement of working conditions on the assessed position can be classified. The authors singled out the following action categories:

- AC 0: negligible exposure, corrective actions are not required;
- AC 1: low exposure levels, corrective action may be required;
- AC 2: medium level of exposure, corrective actions are required;
- AC 3: high level of exposure, corrective action required soon;
- AC 4: very high exposure levels, corrective action required immediately.

Assessment system

The study was conducted in a company that sells books in a chain of stores and via the Internet. Some positions were in their main warehouse where the goods were prepared for subsequent purchase in stores, and also for orders made via the internet or directly at the store. Process analysis was conducted for subsequent order fulfillment actions consisting of:

- order picking,
- carton sealing,
- sorting parcels.

These positions were located on a conveyor belt. The work takes place in a standing position, from Monday to Saturday in three shifts of 8 hours working time.

RESULTS AND DISCUSSION

In the position of Order Picker (Table 1) five operator body postures were observed. In the case of the operation of collecting the carton and depositing the order ready for wrapping and taping, the risk of exposure to MSD's was high - AC 3 - which requires ergonomic correction soon. The high level was due to the need to maintain a stable upright posture while working, tilt the body, especially for the collection of the carton from the floor, and a high involvement of the upper limbs in the performance of the task. For other activities, the risk of MSD's is classified as medium, AC 2, and in the case of collection of the order - from the left side of the body - is low, AC 1. The most vulnerable segments of the body to injuries arising were the thorax, which was usually tilted heavily forward, or twisted to the side; legs - due to the standing nature of the work; arms - most were at a greater distance from the axis of the body, elevated at the shoulder joint, and frequently bent and twisted wrists.

Table 1. Position: Order fulfillment
Tabela 1. Stanowisko kompletowania zamówień

No	Activity	Score							AC	
		A	B		C		Final			
			L	R	L	R	L	R	L	R
1	Obtaining ist of ordered products	4	1	5	3	5	3	5	1	2
2	Obtaining carton	7	4	4	8	8	8	8	3	3
3	Order completion	4	3	6	4	6	4	6	2	2
4	Packing order to carton	3	4	4	3	3	4	4	2	2
5	Placing carton to conveyor belt	6	7	7	9	9	9	9	3	3

L - left upper limb R - right upper limb

Table 2. Position: Carton Sealing
Tabela 2. Stanowisko zaklejania kartonów

No	Activity	Score							AC	
		A	B		C		Final			
			L	R	L	R	L	R	L	R
1	Obtaining the carton from the conveyor belt	6	7	7	9	9	10	10	3	3
2	Sealing the carton	6	4	7	7	9	8	10	3	3
3	Labeling the carton with delivery number	5	1	6	4	7	5	8	2	3
4	Returning the carton to the conveyor belt	6	7	7	9	9	10	10	3	3

L - left upper limb R - right upper limb

Table 3. Position: Package Sorting
Tabela 3. Stanowisko sortowania paczek

No	Activity	Score							AC	
		A	B		C		Final			
			L	R	L	R	L	R	L	R
1	Obtaining the package from the conveyor belt	6	7	7	9	9	10	10	3	3
2	Scanning the delivery number	3	2	6	3	5	4	6	2	2
3	Visual inspection of the delivery region	4	6	6	6	6	7	7	2	2
4	Loading the package to the appropriate pallet	8	8	8	10	10	11	11	4	4

L - left upper limb R - right upper limb

In the position of Order Carton Sealing (Table 2), four working positions were rated. Only when applying the postage label the left side of the body was exposed to a medium risk of MSD's, which qualified for AC 2. In other cases, the risk level was high - AC 3 - which requires correction of the position soon. In the case of obtaining the package for taping and applying the tape, the worker often lifted heavy packages, comprising of the ordered items. This required rapid large-range changes in position, significant tilting and twisting of the torso to one side, and a strong involvement of shoulders, elbows and wrists in the work. The largest load during the entire task appeared in the neck - bent forward at over 20° and twisted at the sealing of the carton; torso - due to the inclined posture of the worker in the upper extremities - in particular the arms (raised at the shoulder joint) and the wrist slightly deflected but also twisted.

In the position of Sorting Packages (Table 3) there were also four operator working positions. During the task the operator was exposed to different - often consecutive -

loads from medium AC 2 (when scanning the number of origin and conducting a visual inspection of the dispatch region), along with high AC 3 (while getting the packed, taped carton) to very high AC 4 (while placing the carton with the order to the appropriate pallet). During the task, the most vulnerable areas of the body were the trunk - leaning even more than 60° or twisted; the lower limbs - due to the standing nature of the work as well as the need for significant bending of the knees (over 60°) while putting cardboard on pallets; the upper limbs - particularly arms which are constantly raised.

The level of exposure of the left and right sides of the body can be considered as similar in the studied positions. Only in the position of the Order Picker, when retrieving the list of ordered products, was it noted that the right side of the body is subject to a higher load than the left, which is due to the fact that the employee obtains the list items with the right limb. The position of Carton Sealing exposes the upper right limb to a more vulnerable position than the left while applying the number, which results in different levels of exposure.

Considering the right side of the body allows the level of exposure to MSD's to be more correctly described. It was observed that of the entire 13 postures taken by employees at three job positions, none of them has a low or neglible risk of MSD's. Five postures were characterized by a medium level of exposure, AC 2 - hence ergonomic intervention may be required. In the case of seven activities, the level of exposure is high, AC 3 - corrective intervention is required soon. However, in one case, the risk was very high - AC 4 - immediate intervention is required.

The greatest workload appears in all positions when obtaining and depositing the carton with the order - this was a result of the high frequency of performance of these tasks (repetitive work), increased weight of the package, poorer ability to grasp the subject and the need for rapid large-range changes in position when removing and putting the carton on the conveyor belt. The risk of symptoms from the musculoskeletal system at the assessed positions primarily manifests itself within:

– trunk - significantly inclined, and in addition sometimes twisted to the side during all tasks performed by the employees for the majority of working time;
– lower limbs - associated with standing work on the assessed positions;
– arms - raised above 45° for a substantial proportion of working time - caused by the necessity of continuous lifting, carrying and depositing of cartons and their sealing, labeling and scanning;
– forearms - as in the case of the arms, the employee spends most of the working time performing tasks involving very heavy use of the upper limbs;
– wrists - though usually not too strongly bent, a majority of the work forces the worker to twist them.

CONCLUSIONS AND RECOMMENDATIONS

An important element in production systems, in addition to the physical components, is the human factor that affects performance, cost and quality (Istota inżynierii produkcji 2012). Improving the production system can not only cover the technical sphere, but also the realm associated with the environment and ergonomics. The aim of this study was to assess the level of exposure to MSD's in the process of order fulfillment using the REBA method.

Of all the respondents assessed, the following action categories were assigned:
– AC 2 - five activities,
– AC 3 - seven activities,
– AC 4 - one activity.

The main factors affecting the risk of a negative assessment of posture were:
– keeping the back bent and twisted;
– maintaining a significant deviation of the arms from the body;
– working in a standing position;
– the weight of the packaged carton.

Work at the assessed positions is associated with a significant risk of MSD's, therefore

corrective actions should be carried out soon. Ergonomic intervention should be related to:
- reorganization of workstations,
- redesign of working methods.

After making changes on the assessed position, re-evaluation with the REBA method is recommended to verify the effectiveness of the changes.

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ANALIZA OBCIĄŻENIA PAKOWACZY METODĄ REBA: STUDIUM PRZYPADKU

STRESZCZENIE. **Wstęp**: Jednym z elementów systemu logistycznego jest podsystem produkcji, który jest układem złożonym z elementów fizycznych takich jak: maszyny i urządzenia, narzędzia pracy, i (co najważniejsze) ludzi. Ponadto systemy zależne od człowieka-operatora są szczególnie podatne na problemy związane z: uciążliwościami, zapewnieniem produkcji, jakości i ze wzrostem kosztów szkolenia i nieobecności w pracy. Celem pracy była ocena obciążenia i ryzyka wystąpienia mięśniowo-szkieletowego dyskomfortu (MSDs) w procesie realizacji zamówień na stanowiskach pakowacza, analiza czynników ryzyka.

Metody: Do oceny zastosowano metodę Rapid Entire Body Assessment (REBA). Oceniono czynności związane z realizacją zamówienia na trzech stanowiskach.

Wyniki: Żadną z występujących czynności nie zakwalifikowano do AC 0 i AC 1; do AC 2 zakwalifikowano 5 czynności, AC 3 - 7 czynności, AC 4 - 1 czynność. Głównymi czynnikami ryzyka wpływającymi na negatywną ocenę pozycji podczas pracy były: utrzymywanie pleców pochylonych i skręconych, utrzymywanie ramienia odchylonych od tułowia, praca w pozycji stojącej, oraz ciężar zapakowanego kartonu.

Wnioski: Pakowacze pracujący na badanych stanowiskach w znacznym stopniu narażenie są na ryzyko MSDs, stąd działania korekcyjne powinny być przeprowadzone najszybciej jak to możliwe. Interwencja ergonomiczna powinna być związana z: przeprojektowaniem stanowisk oraz metod pracy. Po dokonaniu zmian na badanych stanowiskach zaleca się ponowną ocenę metodą REBA w celu weryfikacji skuteczności wprowadzonych zmian..

Słowa kluczowe: metoda REBA, obciążenie pracą, ergonomia, ryzyko, MSDs

ANALYSE DER BELASTUNG VON PACKERN MIT ANWENDUNG DER REBA-METHODE: EINE FALLSTUDIE

ZUSAMMENFASSUNG. Einleitung: Einer der Bestandteile eines Logistiksystems ist das Subsystem der Produktion, welches aus physischen Elementen besteht, wie: Maschinen und Geräte, Arbeitswerkzeuge, und (am wichtigsten) aus Menschen. Darüber hinaus sind die vom Menschen-Operateur abhängigen Systeme besonders anfällig für Probleme, die mit Beschwerlichkeiten, Sicherstellung der Produktion und Qualität sowie mit steigenden Schulungskosten und Abwesenheit in der Arbeit verbunden sind. Das Ziel der Arbeit war die Bewertung der Belastung und des Risikos von Muskel-Skelett-Krankheiten (MSDs) beim Prozess der Umsetzung von Bestellungen an den Arbeitsstellen der Packer, ferner die Analyse der Risikofaktoren.

Material und Methoden: Zur Bewertung dieser Faktoren wurde die Methode Rapid Entire Body Assessment (REBA) angewendet. Bewertet wurden Tätigkeiten bei der Umsetzung der Bestellungen an drei Arbeitsstellen.

Ergebnisse: Keine der Tätigkeiten wurde eingestuft als AC 0 und AC 1; als AC 2 wurden 5 Tätigkeiten eingestuft, AC 3 - 7 Tätigkeiten, AC 4 - 1 Tätigkeit. Die häufigsten Risikofaktoren, die die negative Bewertung der Haltung während der Arbeit beeinflussten, waren: gebeugter und gekrümmter Rücken, andauernde Entfernung der Arme vom Rumpf, Arbeit im Stehen und das Gewicht des gepackten Kartons.

Fazit: Die an den untersuchten Arbeitsstellen arbeitenden Packer sind weitgehend dem Risiko von Muskel-Skelett-Krankheiten ausgesetzt. Die ergonomische Intervention sollte die Umgestaltung der Arbeitsstellen und der Arbeitsmethoden umfassen. Nachdem die Veränderungen an den untersuchten Stellen vorgenommen worden sind, wird eine erneute Untersuchung nach REBA empfohlen, um die Effektivität der vorgenommenen Änderungen zu verifizieren.

Codewörter: REBA-Methode, Arbeitsbelastung, Ergonomie, Risiko, Muskel-Skelett-Krankheiten, MSDs.

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ORGANIZATION OF WASHING AND DISINFECTION DURING THE PRODUCTION PROCESS IN MEAT INDUSTRY

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ABSTRACT. Background: Washing and disinfection in the food industry are major operations, affecting safety and stability of final products and therefore they are critical point of the production process. The proper organization of this part of the process ensures significantly the efficiency of the whole process.

Methods: The paper presents the process of washing and disinfection as well as control methods to assess their efficiency in meat processing plants. Their properties and application of washing and washing and disinfecting agents were characterized. Requirements imposed on washing and disinfecting agents used in the food industry are reported.

Conclusions: It is essential to have knowledge on problems related to organization and optimization of cleaning process in order to properly organize the whole production processes in meat industry.

Key words: washing, disinfection, washing agents, disinfectants, washing methods, disinfection methods, organization of production process.

INTRODUCTION

Washing and disinfection of both machines and equipment, and production facilities is essential for effective prevention of health hazards related with food. This process ensures hygienic production conditions and clean, pleasant and safe working conditions. It is connected with removal of food potentially attracting rodents and other pests, it prevents breakdowns and has a positive effect on potential customers. Left production residue provides a substrate for the development of microorganisms, but it may also become a source of biological infestation and contamination with toxic or harmful substances, formed as a result of degradation of this residue (oxidation, hydrolysis, pyrolysis). For this reason washing and disinfection processes in food industry plants aim at the maintenance of an appropriate hygienic status, both in technological equipment and production facilities. Cleanliness and hygiene have to be maintained in food production within the Good Hygienic Practice (GHP), which is the foundation for the principles of the HACCP system. Systematic, thoroughly performed washing and disinfection processes using effective agents, techniques and equipment have a significant effect on food safety.

WASHING, DISINFECTION - DEFINITIONS, OBJECTIVES, LEGAL ASPECT

Washing is a procedure consisting in thorough removal of soiling from surfaces subjected to this process, typically using physical agents such as e.g. brushing, rinsing, high pressure, low pressure, use of chemicals e.g. organic acids [Kołożyn-Krajewska 2001,

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Özbay and Demirer 2007, Fryer and Asteriadou 2009, Diakun and Mierzejewska 2012, Diakun 2013, Koo et al. 2013].

Disinfection consists in selective elimination of undesirable microorganisms causing spoilage of food products or disturbing the appropriate course of the technological process, first of all pathogens, dangerous for human and animal health. Disinfection destroys microorganisms thanks to its effect on the structure or metabolism of microorganisms [Kołożyn-Krajewska 2001, Olesiak and Stępniak 2012]. Washing and disinfection of machines and equipment aim at the establishment of an adequate standard of production hygiene, and thus providing appropriate quality of products. Effectiveness of disinfection depends on such factors as duration of the process and concentration of the disinfectant [Lewicki 2005, 2006, Olesiak and Stępniak 2012]. These parameters are provided on labels by producers of biocides. Offered high quality disinfectants and washing and disinfecting agents are most frequently based on several active substances. Effectiveness of these substances is defined using the degree of reduction of microbial contamination and the bactericidal and fungicidal effect is specified according to the standards PN-EN 13697, PN-EN 1276 and PN-EN 1650. Disinfection effectiveness is confirmed when the microbial count is reduced, depending on the standard by 99.9% (3 log reduction) up to 99.999% (5 log reduction) [Sienkiewicz 2013].

Effectiveness of washing and disinfection in meat industry plants may also be assessed based on the Polish Standard PN-A-82055-19 - Meat and processed meat products. Microbiological analyses. Determination of microbial contamination of surfaces of equipment, furnishings, facilities as well as packaging and workers' hands [Boliński and Bolińska 2003].

The Ordinance of the Minister of Health of 19 December 2002 on hygienic and sanitary requirements in processing plants and requirements concerning hygiene in production and turnover of items and products to be used with these items is the essential legal act binding for food producers and distributors as well as inspection agencies, which specifically requires the application of washing and disinfection procedures in the food industry. This act regulates principles of washing and disinfection and it refers to the problem of disinfectants and effectiveness of the above mentioned procedures.

The Act of 25 August 2006 on food and nutrition safety [the Journal of Law Dziennik Ustaw Dz.U. 06.171.1225 2006) is the primary legal act concerning food. It specifies health requirements for food and requirements concerning principles of hygiene, and it regulates issues connected with official food control.

Specific veterinary conditions required in meat processing of slaughter animals and storage of processed meat products are provided by the Ordinance of the Minister of Agriculture and Rural Development of 18 March 2004 [the Journal of Law Dziennik Ustaw Dz.U.04.50.489].

Since 1 January 2006 uniform food regulations have been binding in all EU member countries, constituting the so-called Hygiene Package and comprising four Resolutions establishing principles of foodstuff hygiene, as well as principles of activities of respective authorities supervising operators of the food sector.

STAGES OF WASHING AND DISINFECTION

The process of washing and disinfection in meat processing plants is performed in the night, i.e. between the last and the first shifts. In turn, individual machines of the production line (grinders, cutters), some elements of equipment in contact with the product (the rail belt) and auxiliary implements (knives, containers) should be cleaned more frequently. This may be caused by a change in the production profile, e.g. the type of meat being cut or upon the completion of production of a given batch.

Primary stages of washing and disinfection:

1. Preparation or preliminary rinsing - to remove bigger fragments of the product from surfaces, as well as some residue loosely attached to the surface. The primary aim of the operation is to provide appropriate conditions for washing, reduce to the minimum the dilution of washing liquids and limit the participation of washing agents in reactions with product components. In this process, lasting for only several seconds, approx. 30% residue is removed.
2. Washing procedure - removal of soiling and residue left after the production process from machine and equipment surfaces. It is important to perform it thoroughly, as it may have a tremendous effect on potential secondary contamination.
3. Rinsing - to remove residue of previously applied chemicals and preparation of residue surface for contact with the next working substances, tearing off of a dirt layer, revealing microorganisms (biofilm)
4. Disinfection - penetration to biofilm and inactivation of microorganisms. Disinfection may be performed only on thoroughly washed surfaces, using preparations based on various types of active substances, of which each has its own limitations and advantages. It is not recommended to apply universal washing and disinfecting preparations, which - while reducing the time of the whole process - markedly lower its effectiveness,
5. Final rinsing - it has to be performed using drinking water, the quality of this water determines the possibility of secondary contamination of washed and properly disinfected surfaces [Kołożyn-Krajewska 2001, Lewicki 2005, 2006, Piepiórka et al. 2009, Piepiórka and Wlazło 2010]

DIVISION OF WASHING METHODS

Washing techniques and methods may be classified in several ways, e.g. depending on:

- the type of washed objects (raw materials - soft, hard; packaging - direct, indirect; surfaces - facilities, equipment; equipment - non-disassembled, disassembled; installations; equipment and technological tools)
- character of the effect of washing agents (mechanical, chemical, temperature, time)
- manner of effect on washed surface (hydro-mechanical, manual, with a considerable effect of chemicals - diagram 1)
- organisation (the type of washed objects - single, flow, mass, and control - by an operator, automatic, computer-controlled)
- type of equipment (washing in pools, chamber washers, tunnel washers, CIP - Cleaning In Place - in the closed or open systems, COP - Cleaning Out of Place - mechanically assisted or manual) [Diakun 2013]

Manual washing should be applied sporadically and only in those cases, when mechanical washing does not yield required results. It may be used for small machines and equipment, which incorporation in the mechanical washing system is impossible or non-viable economically. In most cases it consists in the disassembly of equipment, mechanical removal of product residue and soiling, rinsing of washed parts and their assembly. In the course of washing mechanical brushes or pressure installations applying foam or gel may be used. The possibility of visual assessment of performed work guarantees that it was properly performed. However, this method requires considerable input of human labour as well as consumption of water and chemicals and due to the subjective evaluation of the performed washing operation, it also requires a well-organised control of production hygiene [Piepiórka-Stepuk 2011, Diakun 2013].

Mechanical washing may be performed in the manual or automatic control system. In most cases washing is performed by spraying with water or its solutions with chemicals and rinsing with water. Thus the action on the washed surface may be defined as hydromechanical [Diakun 2013].

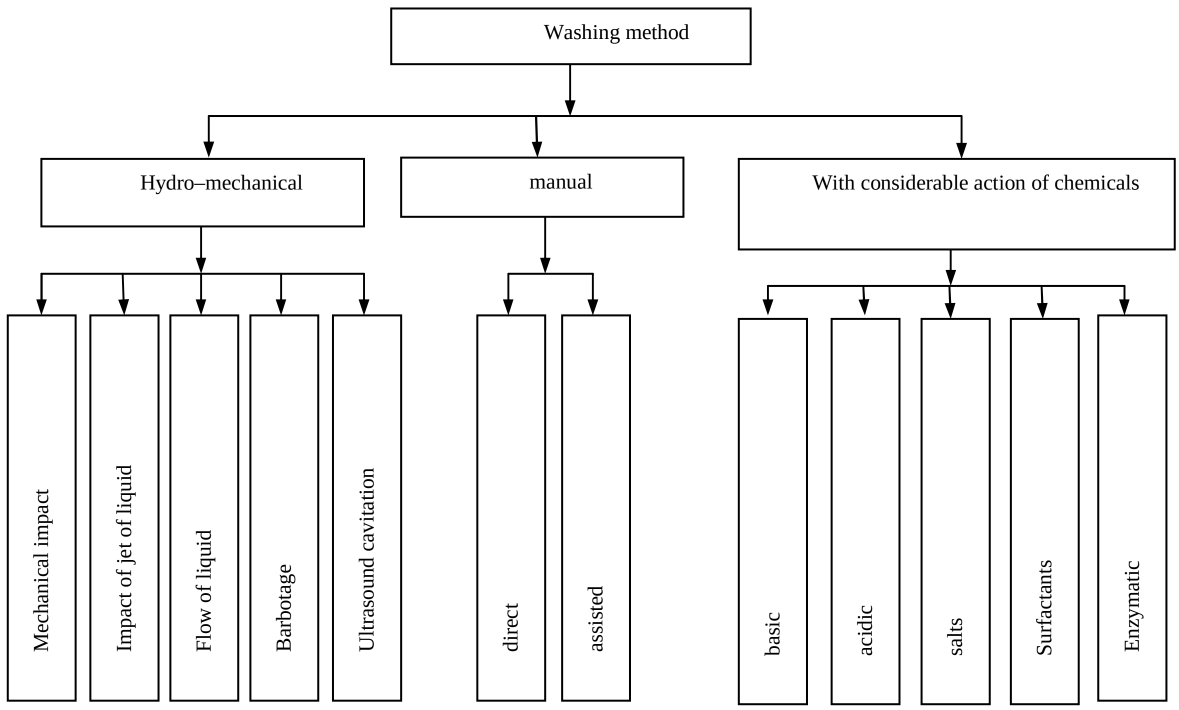
Washing in an open system is used in the case of highly soiled surfaces and production lines organised so that it is impossible to wash them using a central washing station. In this system the washing solutions are used only once and upon the completion of the washing process they are discharged to the sewage system. When the detergency of the solution is not completely depleted in the process, the solution is collected in a tank and used in preliminary rinsing in the next washing cycle [Lewicki 2005].

Washing in the closed cycle (CIP - Cleaning In Place) facilitates repeated use of washing agents. Washing in the CIP system is performed with no installation disassembly (the installation is closed), thus it is difficult to verify washing quality. In order to provide effective washing and guarantee surface cleanliness after this process a significant role is played by washing factors, i.e. duration of the washing process, temperature of the washing liquid, washing chemicals and their concentration, mechanical energy expressed as the action of the liquid on walls of washed elements and local shear stresses [Lelievre 2002, Lewicki 2005, Bremer et al. 2006, Blel et al. 2007, Piepiórka and Diakun 2007, Diakun 2011, Piepiórka-Stepuk and Diakun 2012, Srey et al. 2013]. For example, dirt may be removed from tanks thanks to:

- free flow of the liquid over the wall (e.g. when washing tanks previously holding fruit juice immediately after they have been emptied)

or

- the impact of the jet of the liquid flowing out of the nozzle with high velocity (when contamination is difficult to remove, e.g. in a tank previously holding fat).



Source: Diakun 2013

Fig. 1. Classification of washing methods in terms of the manner of action on washed surface
Rys. 1. Klasyfikacja metod mycia ze względu na sposób oddziaływania na mytą powierzchnię

The washing process with a repeated use of washing solutions and following a present programme has to be extremely thoroughly controlled. Each washing process had to make the surfaces reach a specific cleanliness status defined physically, chemically and microbiologically.

The course of the washing process in the CIP system is controlled using programmers or microprocessors. In programming devices the sequence of actions and their parameters are found in the memory of the module, while the display presents the flow chart and the currently performed action [Piepiórka and Diakun 2007, Diakun 2011, Srey et al. 2013].

Dry washing is limited to precipitation, suction, brushing and wiping off the contaminants. Dry washing generally precedes wet washing.

Wet washing is a complex process, consisting in preliminary rinsing, main washing - mechanically assisted and/or with elevated temperature, rinsing in order to remove the washing agent. The applied medium is water or water solutions of washing agents.

Washing using the jet of washing liquid is divided into: normal washing (low pressure - pressure up to 25 bars) and high pressure - run at a pressure from 25 to 120 bars. High pressure facilitates removal of contaminants. Moreover, in the case of this method we need to ensure that no mechanical damage, secondary infestation or aerosols are formed. Water bubbles transport microorganisms, which after some time are deposited and contaminate equipment. However, a much better solution is to combine low pressure rinsing with foam generated by the system e.g. to wash external surfaces [Piepiórka et al. 2009].

Such washing methods as foaming, spraying and gelling are mainly used in the meat industry. These washing methods are frequently used to wash walls, installations and their direct environment. Other special washing methods involve steam up to 140°C, gases, i.e. oxygen, or mechanical systems (scrubbing systems).

WASHING AND DISINFECTING AGENTS AND THEIR CHARACTERISTICS

Many chemicals certified by the National Institute of Hygiene for washing and disinfection of surfaces in contact with food are commercially available. However, these agents need to be selected according to needs, considering the type and amount of contaminants and the specific load of organic substances. Unfortunately, there are no universal washing agents. Alkaline or neutral agents are sufficient to eliminate loads of organic substances, while acid agents are required to remove salt and calcium residue. However, while using acid washing agents we need to consider their effect on production equipment. Corrosive substances may within a short time destroy the plant equipment. It is also important for those preparations to be relatively cheap. The new Regulation of the European Parliament and the Council (EU) (no. 528/2012 of 22 May 2012 - the Official Journal of the European Union L 2012.167.1) concerning the making available on the market and use of biocidal products entered into force on 1 September 2013. This Regulation (BPR, Regulation (EU) no. 528/2012) pertains to the introduction to turnover and application of biocidal products, which are used to protect humans, animals, materials or products against harmful organisms such as pests or bacteria thanks to the use of active substances contained in the biocidal product.

Post-production contamination varies in character and constitutes a mixture of organic and mineral compounds. In order to provide surfaces which are physically and microbiologically clean we need to use substances of various chemical character or their mixtures. When applying disinfecting preparations we need first to identify the proliferating microflora. The mechanism of disinfectant action is connected with the disturbed function of the cytoplasmic membrane, protein denaturation, degradation of nucleic acids, oxidation of sulfhydryl groups in protein structures or formation of stable bonds with other compounds [Piepiórka 2008, Kozirόg 2012]. However, serious problems may arise in the case of rough or scratched surfaces or when washing and disinfection processes are performed inappropriately. In such a case on these surfaces biofilms may be formed, i.e. complex microbial structures, surrounded by a layer of mucus, showing adhesion to biotic and abiotic surfaces. In food industry biofilm infestation of food products and surfaces in contact with food may cause food spoilage and consumer infections [Piepiórka 2008, Shi and Zhu 2009, Simoes et al. 2010, Kołwzan 2011, Myszka and Czaczyk 2011, Kozirόg 2012, Dzwolak 2013, Srey et al. 2013]. Bacterial cells under the protective biofilm layer are over 1000 times more resistant to the action of disinfecting agents than cells in the planktonic state. They may be resistant to the action of such agents as bases, iodophors, phenols and quaternary ammonium compounds. To reduce or eliminate biofilms from working surfaces the most frequently used procedures include:

- physical processes - mechanical action (scrubbing, scraping), thermal processes (hot water, hot air), high pressure washing, pulsation laser rays, UV radiation, pulsed electric field, ultrasound, radiation processing
- chemical processes - electrolised oxidation water (EO), ozone (gas and ozonated water), ethylenediaminetetraacetic acid (EDTA), peracetic acid, sodium oxochlorate, peroxides (hydorgen peroxide, potassium tetraoxomanganate), chelating compounds
- biological processes - antagonistic bacteria, bacteriophages, bacteriocins (nisin, etc.), enzymes (α-amylase, glucoamylase and cellulases) [Piepiórka 2008, Simoes et al. 2010, Dzwolak 2013, Srey et al. 2013]

In practice disinfection is most frequently performed by a chemical method using chemicals. Since washing agents often exhibit bactericidal action, the washing process itself destroys most microflora found on washed surfaces. Obviously also those microorganisms, which survived the washing process, need to be destroyed. For this purpose substances belonging to different chemical groups are applied. The most important include:

- chlorine compounds. These are sodium oxochlorate, oxochloric acid, sodium oxochlorate and chloramines. These compounds are characterised by good water solubility, they are stable at room temperature and exhibit low sensitivity to light. They have a relatively wide spectrum of action against microorganisms. Upon contact with microbial cells they released ionised oxygen, which denatures proteins and destroy structures of cytoplasmic membrane and deactivates enzymes containing the -SH group. Water applied in disinfection leads to cell death. Sodium oxochlorate is used most often. It has strong oxidising properties, but its high chemical activity leads to corrosity in equipment made from metal. It also exhibits an irritant action towards the respiratory tract. Concentration of active chlorine in an alkaline solution should range from 150 to 200 ppm, while in an acid medium as little as 80 - 100 ppm is sufficient in an acid environment [Piepiórka 2008, Sienkiewicz 2012, Srey et al. 2013].
- Chlorine dioxide is effective in the control of bacteria and viruses. In the first place it destroys the cell membrane and next the nucleus of bacteria. It is used in the disinfection of surfaces in contact with food, in indoor and outdoor washers, in washing systems, in rinsing, in treatment of drinking and processing water, in washing and disinfection of meat, poultry carcasses, vegetables, fruit and in fish processing [Anonymous 2006].
- Quaternary ammonium compounds (QAC), i.e. cationic surfactants. These compounds exhibit very good microbial effectiveness, good water solubility and low toxicity. They alter permeability of cell walls and membranes in microorganisms, reduce surface tension, act within a broad range of pH values, exhibit good wettability and do not case corrosion. They are stable both as working solutions and in the concentrated form. Their activity decreases considerably in the presence in the medium of such contaminants as proteins, fats, milk and soap [Sienkiewicz 2012].
- Peroxide compounds. This group comprises such compounds as hydrogen peroxide, peracetic acid and potassium persulfate. This major property is connected with their effectiveness against both vegetative and sporulating forms. They act not only against bacteria, but also viruses, Koch's bacilli and fungi. Their other advantage is related with the fact that microorganisms do not acquire immunity against them. Microbial cells do not develop resistance mechanisms towards their action. These substances are not corrosive to steel or aluminium, they are readily leached and are biodegradable. Products of their degradation do not pose a hazard in relation to food products.
- Peracetic acid is used most often, acting against vegetative and sporulating forms,

both against fungi and viruses. Its action consists in:

- Oxidation of -SH groups of proteins to disulfate bridges

- Oxidation of double bonds found in the cell membranes [Olesiak and Stępniak 2012].

Mechanism of destruction of microorganisms consists in the release of active oxygen, which destroys both proteins and fats or nucleic acids [Olesiak and Stępniak 2012, Sienkiewicz 2013, Srey et al. 2013]. Peracetic acid is composed of acetic acid, oxygen, water and it may be used in the food industry, even under conditions when rinsing after disinfection is impossible. It has weak foaming properties. It is one of the most effective active substances in the control of biofilms. Another advantage is also connected with its complete biodegradability and good activity at low temperatures [Piepiórka 2008, Olesiak and Stępniak 2012, Sienkiewicz 2013, Srey et al. 2013].

- Ozone has strong oxidising properties, resulting from the high redox potential. Thus susceptibility to the action of ozone is observed in gram-positive and gram-negative bacteria, viruses, yeasts, spores and vegetative cells. It degrades more rapidly in water than in oxygen or air. Most metals are susceptible to the action of ozone. It does not cause the formation or increased resistance of microorganisms. It may be used to wash plastic containers used in storage and transport of meat [Krosowiak et al. 2007, Pascual et al. 2007, Li et al. 2011, Srey et al. 2013]
- Alcohols. Disinfecting agents are produced mainly on the basis of ethanol and propanol. The greatest activity is observed at a concentration of 50 - 70%. When applying them we may eliminate the stage of rinsing of disinfected facilities with water. They cause first of all protein denaturation and lipid dissolution.
- Aldehydes. The most frequently used include formaldehyde and glutaraldehyde. Due to their toxicity they are not used for surfaces, which are in contact with food [Olesiak and Stępniak 2012].

Disinfection may be also performed using physical factors. It consists in the use of heat energy and the mechanical action of a jet of liquid. In a limited number of cases ultraviolet radiation is used to sterilise surfaces.

Sterilisation of equipment using heat is performed mainly using saturated steam at a temperature of 120°C and lasting for 10-15 minutes. In specific cases hot air is used. Then the process lasts for 60 minutes at a temperature of 160°C. The use of high temperatures is applied e.g. to sterilise knives, saws or axes. Disadvantages of the thermal method include its high energy and time consumption [Piepiórka and Wlazło 2010].

UV radiation has found more extensive applications and is used for general disinfection of tables, tanks, tools, walls, ceilings and air in production facilities. Biocidal properties are found for radiation with a wavelength of 240-280 nm. It acts on vegetative and sporulating forms of bacteria. Vegetative forms of microorganisms from the log growth phase are most sensitive to ultraviolet radiation. Effectiveness of UV radiation depends on the radiation dose, the physiological phase of the microorganism and on conditions found immediately after irradiation [Piepiórka and Wlazło 2010, Omyliński 2013].

Mechanical action of a jet of liquid consists in targeting a jet of pure fresh water under high pressure onto the cleaned surface. Most typically two ranges of water pressure are applied when cleaning with this method:

- Cleaning with a jet of water under high pressure (68 MPa - 170 MPa)
- Cleaning with a jet of water under very high pressure (over 170 MPa).

Disinfection using ultrasound depends on the intensity of ultrasounds, including the generation of cavitation and on the temperature of the liquid and the chemical structure of the washing solution. Good results are obtained using ultrasound with a frequency of 20 - 150 Hz [Piepiórka and Wlazło 2010, Srey et al. 2013].

STUDIES ON THE EFFECTIVENESS OF WASHING AND DISINFECTION

Washing and disinfection of machines, equipment, production facilities, warehouses as well as changing rooms, corridors and toilets for employees aims at providing adequate hygiene in meat processing plants, which is essential to ensure safety of the final product. Effectiveness of washing and disinfection is influenced by the duration of the washing cycle, temperature, conductivity, pH of washing agents, flow velocity, pressure, etc. Despite thorough control of these parameters and repeatability of washing processes it is not certain whether the cleaned surface is clean. Thus it has to be verified whether machines, equipment and production facilities have been properly washed and whether they will not constitute a source of contamination for the final product. This may be ensured thanks to the application of the following methods:

- Visual assessment of cleanliness of facilities and equipment; it is a qualitative and subjective evaluation
- optical (turbidimetric) method consisting in the measurement of the degree of turbidity of the washing solution
- electrical method, which consists in the measurement of electric conductivity of the flowing liquid
- microbiological methods consisting in:
  - collection of smears (from production surfaces, hands), preparation of cultures and verification of counts of growing colonies
  - assessment of air purity using spontaneous particle sedimentation
  - outwashing of microorganisms from tanks, pipes - the method is based on the flushing with a specific amount of sterile liquid, from which quantitative cultures are next prepared on general or selective media
  - preparation of agar blots - the assay consists in blotting surfaces of tested materials on solidified medium and incubation of cultures under adequate conditions. Results are given per unit area of the surfaces [Lewicki 2005, 2006, Piepiórka 2009, Palka 2009].
- determination of ATP concentration - determination of the level of adenosinetriphosphate by bioluminescence. This method uses the common presence of ATP in all plant and animal cells as well as microorganisms. The presence of ATP in samples collected in order to asses the cleanliness status in a processing plant indicates the existence of organic contamination - plant and animal residue as well as microorganisms. Testing results from the ATP method are obtained within approx. a quarter of an hour [Szczawiński and Szczawińska 2002, Lewicki 2006]

CONCLUDING REMARKS

The washing and disinfection process, extremely important for the maintenance of high production hygiene, in itself may constitute a specific hazard for the quality of the final product. Poorly washed surfaces constitute a source of chemical and microbiological contamination of the material, while leaking valves or a too short rinsing process may lead to contamination with washing and disinfecting agents. However, it needs to be stressed that the currently applied design solutions as well as washing agents ensure high effectiveness and safety of the washing and disinfection process. If in the production process food is contaminated as a result of the applied washing process, it is a result of simple negligence and a lack of maintenance of machines and equipment. Due to the rare, but still occurring failure of equipment, as well as wear and tear of specific structural elements, the washing and disinfection process should be treated as a critical control point in food safety and quality assurance systems

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ORGANIZACJA MYCIA I DEZYNFEKCJI W TRAKCIE PROCESU PRODUKCYJNEGO W PRZEMYŚLE MIĘSNYM

STRESZCZENIE. **Wstęp:** Mycie i dezynfekcja w przemyśle spożywczym są jednymi z ważniejszych operacji, które mają wpływ na bezpieczeństwo i trwałość gotowych produktów, dlatego też stanowią punkty krytyczne procesu produkcji.
Metody: W pracy przedstawiono proces mycia i dezynfekcji oraz metody kontroli oceny ich skuteczności działania w zakładach przemysłu mięsnego. Scharakteryzowano właściwości oraz zastosowanie środków myjących i myjąco - dezynfekujących. Podano wymagania stawiane środkom myjącym i dezynfekującym stosowanym w przemyśle spożywczym.
Wnioski: Znajomość tych zagadnień jest istotna dla prawidłowej organizacji oraz optymalizacji całości procesu produkcyjnego w przemyśle mięsnym.

Słowa kluczowe: mycie, dezynfekcja, środki myjące, środki dezynfekujące, metody mycia, metody dezynfekcji, organizacja procesu produkcyjnego.

ORGANISATION DES WASCH- UND DESINFEKTIONSPROZESSES IN DER FLEISCHVERARBEITENDEN INDUSTRIE

ZUSAMMENFASSUNG. Einleitung: Waschen und Desinfektion stellen in der fleischverarbeitenden Industrie die wichtigsten, die Qualitätssicherung und Lebensdauer von Fertigprodukten beeinflussenden Operationen innerhalb des Produktionsprozesses dar. Daher machen sie kritische Punkte innerhalb des betreffenden Produktionsprozesses aus.
Methoden: Im Rahmen der vorliegenden Arbeit wurden die Prozesse des Waschens und der Desinfektion sowie die Methoden der Kontrolle deren Wirksamkeit in Unternehmen der fleischverarbeitenden Industrie dargestellt. Dabei wurden Eigenschaften und die Anwendung von Wasch- und Wasch- und Desinfektionsmitteln charakterisiert. Es wurden die an die in der fleischverarbeitenden Industrie angewendeten Wasch- und Desinfektionsmittel gestellten Anforderungen angegeben.
Ergebnisse: Kenntnis dieser Problemstellungen ist unentbehrlich für die richtige Organisation und die Optimierung des gesamten Produktionsprozesses in Unternehmen der fleischverarbeitenden Industrie.

Codewörter: Waschen, Desinfektion, Waschmittel, Desinfektionsmittel, Waschmethoden, Desinfektionsmethoden, Organisation des Produktionsprozesses

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E-SHOPS AS A CONDITION FOR THE EVOLUTION OF THE TRADE

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ABSTRACT. Background: The paper discusses the dynamic development of a new form of sales, which is e-commerce. There are following sources of competitive advantages of a company: sales technology, methods of services and the logistics of goods.

Methods: The results of questionnaire researches conducted in 2012 based on the sample of 607 e-shops were used to present the development of the e-commerce in Poland in last years.

Results and conclusions: The e-commerce does not develop in Poland at present in a previous rate. The slower rate of the growth of the number of newly opened e-shops is the result of the economic crisis, weaker absorption capacity of the market and growing competition among e-retailers. The processes, which occur in the trade sector, are of evolutionary nature and are the results of adaptation activities to the turbulent market environment.

Key words: distribution, e-shops, e-trade, e-commerce, e-logistics.

INTRODUCTION

The aim of this paper was to analyze the influence of the Internet and other modern telecommunication technologies on the evolution of the trade, where the structural changes occur systematically. They are caused by the globalization processes as well as very rapid and dynamic development of new IT-technologies. The Internet changes the traditional balance of forces in distributional channels for the benefit of the customer due to the fact, that it provides quick access to information and enables to make optimal purchase decisions. After a period of the expansion of shopping malls and large stores (like hypermarkets, supermarkets and discounts), at present there is a time of e-commerce. However in last few years, the e-commerce does not develop as quickly as before. A slower rate of growth of the number of new e-shops is the consequence of the economic crisis, lower absorption capacity of the market and the intensifying competition among e-retailers.

FACTORS DETERMINING THE COMPETITIVENESS OF TRADE ENTERPRISES

Taking into account the realities of today's market, the companies operating in the trade sector, try to obtain the privileged position on the market and to discount its effects on the relationships with suppliers, customers, competitors and other market participants. The competitive advantage is usually not very stable, due to the fact, that if such advantage is ease to obtain than other competitors will surely try to copy such success strategy for themselves. The following points influence and determine the attractiveness of the market offer of the company and its competiveness:

– the potential of the company (tangible and intangible assets),

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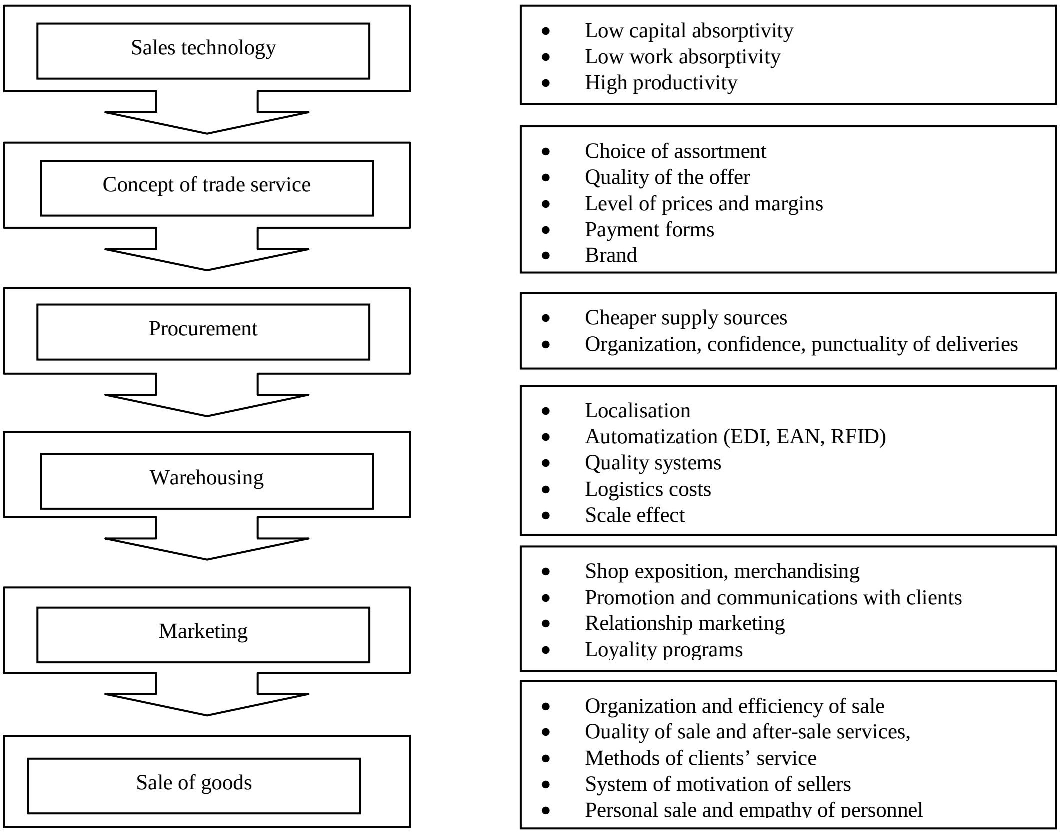
- competitive advantage (the ability to impose the conditions of the competition),
- instruments of the competitiveness (tools and methods to achieve objectives),
- the competitive position (the position gained during the fight with competitors).

The final result of such a competition (the ability of the company to maintain the advantage position for longer period) depends on many factors. The most important ones are: available resources, the height of entry barriers, motivation and the degree of the aggressiveness of the competition fight. Only a comprehensive analysis and diagnosis of the sources of competitive advantage and taking into account this knowledge during the process of designing the sales strategy as well as its consistent implementation allows gaining the market success (the stable development of the company in a changing competitive environment can be considered to be such success). The potential sources of the competitive advantage of a retailer are presented at the Figure 1. These sources should be used during the process of the creation of the added value offered to clients.



Source: Ciechomski 2010

Fig. 1. Sources of the competitive advantage of the retailers in the sales process
Rys. 1. Źródła przewagi konkurencyjnej detalisty w procesie sprzedaży

One of the conditions for the achievement of the market success by a company is to create and offer the appropriate added value to clients [Pisz, Sęk, Zielecki, 2013]. This value is cumulated in the supply chain and is expressed by the amount, which the buyers are willing to pay for a good or a service. The model created by M.Porter displays several basic operations (input logistics, production, output logistics, marketing and sale, service) as well as auxiliary ones (personnel management, implementation of innovations, development of technical infrastructure of a company). The implementation of these operations enables cheaper and faster achieving of a privileged market position by a given company. The important advantage of this model is a comprehensive look at the process of creating of a competitive advantage. It is essential to remember, that the weakest link of the entire chain determines its strength. Sometimes it is the logistics of goods movement, which is inadequate to the needs and requirements of the market.

The logistics covers the area of an economic knowledge, which investigates the processes of flow of goods and information both in micro- and macroeconomical scale. The logistics consists in the management of processes of physical flow of goods (raw materials, semi-finished goods, finished goods) within a company as well as between companies. Apart from the physical flow, the flow of information is also an essential part of the logistics. The area of the logistics covers the localization of points of sales, warehouses, logistics centers as well as stocks management, transport management, sales and client service. The main area of logistics management of the company covers the demand forecasting, processing of orders, warehouse management, inventory management, procurement, service of returns and packaging, handling, internal and external transport and the flow and storage of information [Wieczerzycki 2012]. The main feature of modern logistics is the system approach to the logistics of a company, which implies the need of the integration of material, financial and information flows as well as treating the logistics as an important tool of the competition fight on the market. There is no doubt, that the logistics of a company can decide or at least influence the success or failure on the market, where there is a permanent surplus of the supply over the demand.

In recent years, the systems of automatical identification, electronic data interchange, satellite communication and new methods of transport management develop in a very dynamic way. At present, RFID seems to be the most developing technique of the automatic identification [Długosz 2009]. It is used on large scale by the logistics centers of retail chains. The suppliers of goods to such chains as American Wal-Mart or German Metro Group are obliged to attach RFID codes to pallets, containers or other collective packaging.

The very important and still developing tool for improving of a competitive position of the company is the management of experiences of clients and relationships with them. It consists of all interactions between a client and a supplier [Brdulak 2012]. The management of client's experiences covers monitoring, measuring of the level of clients' satisfaction and the discrepancy between the obtained and expected quality. The interactive attitudes and a systematic collection of feedbacks are necessary to keep existing customers. Undoubtedly, Internet and other modern communication solutions facilitate these activities significantly. However, the technological applications do not prejudge the success of a company. The conditions, much more important in this area are: organizational culture of a company, management of the knowledge and the internal consistency of the implemented activities.

E-LOGISTICS AND E-COMMERCE AS MODERN DIRECTIONS OF THE DEVELOPMENT OF THE DISTRIBUTION OF GOODS

The phenomenon of Internet is unquestionable and unprecedented. The development of network applications is equally important to quantitative development of the network (measured by growing number of users and computers) [Ciesielski 2011]. Previously, Internet was regarded as a platform to exchange information between users, but currently it becomes to be a basic platform to support business processes of a company. This technology gives a lot of opportunities in such areas like: collection of data, communication and cooperation with clients.

It can be expected in near future, that:

- the reach of the network, the quality of the signal and the speed of the transfer will increase,
- higher number of mobile phones and other mobile devices will enable to use mobile Internet in efficient and convenient way,
- intelligent software will be used to detect the type of a device and to adapt the traditional or mobile version of website,
- screens of mobile phones and i-Pods, browsers, navigational systems, the content

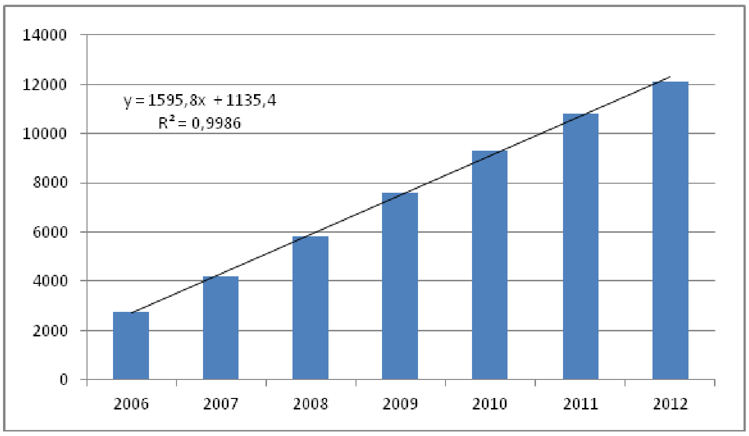
of mobile websites (graphics and sound) will be adjusted technologically to the needs and preferences of users,
- promotional communication will be more and more personalized.

The further dynamic development of e-logistics can be expected. Its essence is the use of IT and telecommunication technology in the management of logistics processes in such areas as:
- marketing communication (information about company's offer or promotion),
- agreeing the terms of the cooperation and other negotiations with business partners,
- placing and executing of orders, payments,
- support for transport activities, ability of Internet verification of the progress of the order fulfillment,
- maintain the relationships with clients.

From technical point of view, e-logistics consists on the fulfillment most of orders by the use of computer network platforms:
- by Internet, e.g. to search for new suppliers or customers, promoted goods, etc,
- by Intranet, e.g., to manage the logistics of a company and to keep contact with its workers,
- by Extranet, e.g. for an automation and an effective cooperation with business partners within the supply chain [Skowron-Grabowska 2010].

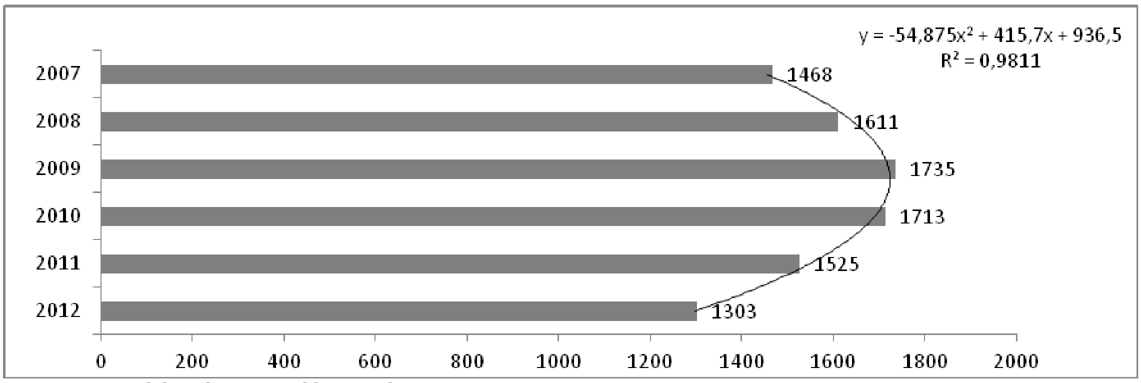
Internet revolutionizes many areas of the social and economic life. Besides the e-logistics, the dynamic development of e-commerce can be observed. One of used measure of the role of e-commerce is the share of electronic sales in the total turnover of companies. This rate in 2011 for Poland was only 11% and for entire European Union was equal to 14% [Feldy 2012]. These data confirm the relatively small delay of Polish electronic trade in the relation to European one. But the indicator showing the share of expenses in e-shops for Polish households is already much worse in such comparison. This indicator for Poland was only 3,1% in year 2011, while at the same time in other European countries was three times higher (United Kingdom 12,0%, Germany 9,0%, Switzerland 8,7%).

7% share of e-commerce in total retail trade in Poland is estimated to be reached only in 2015 [Cimochowski, Huten-Czapski, Rał, Sass 2011]. Our country distinguishes only with regards to the dynamics of the increase of the value of the e-commerce market, which was equal to 33,5% during the period of 2010-11 and was the highest one in Central and Eastern Europe. The growth rate is estimated to be 20-25% in the coming years, which is one of many negative consequences of the economic slowdown. Figures 2 and 3 present the number of e-shops in Poland in years 2006-12 as well as date illustrating a decrease of the dynamic of this process after 2009 year.



Source: own work based on www.sklepy24.pl

Fig. 2. Number of e-shops in Poland in 2006-2012
Rys. 2. Liczba e-sklepów w Polsce w latach 2006-2012



Source: own work based on www.sklepy24.pl

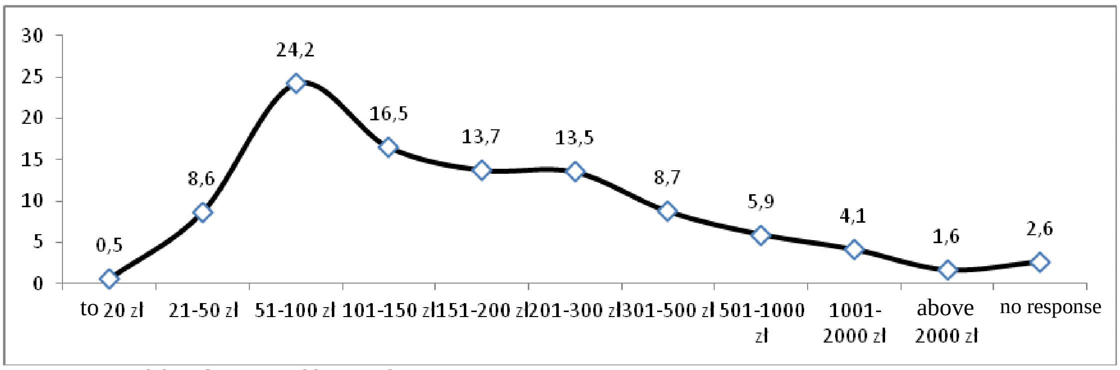
Fig. 3. The number of e-shops opened in Poland in years 2007-2012
Rys. 3. Liczba e-sklepów otwieranych w Polsce w latach 2007-2012

The growing atomization of the e-commerce results in the aggressive competition among companies, which use this type of trade channel. The decreasing (for last three years) number of new Internet shops shows the gradual saturation of the market. The most important reasons to start on-line sale are:

- growing interest of clients in this type of shopping,
- ability to gain new clients from remote localizations,
- the desire to create an alternative distribution channel,
- the need to keep up with the activities of competitors,
- reduction of sales costs comparing to the traditional trade,
- lack of the adequate rooms and infrastructure, necessary to run a traditional shop.

The majority of trade companies (84%) uses electronic sales to diversify distribution channels and treats the e-commerce as an additional, even experimental, channel of the market. Only 16% of retailers, operating in Internet, sell their goods only via the Internet and does not possess a traditional shop. Some of owners of e-shops take part in Internet auctions (68%), conduct their activities in the form of wholesale (45%) and mail-order (12% sales [Szymański 2010].

Most of e-commerce companies are small ones (up to 5 workers), which in order to reduce their costs, have the storage area lower than 50 m^2 or even arrange the shipment of goods directly from the producer to an e-customer. Two-thirds of companies have only one website, 21% of them two electronic shops and 13% of them have three and more e-shops. The cart value in e-shops usually is a little more than 260 PLN, but only every second seller is able to go beyond the limit of 150 PLN.



Source: own work based on www.sklepy24.pl

Fig. 4. The percentage structure of e-shops in regard to the average cart value
Rys. 4. Struktura procentowa sklepów internetowych według przeciętnej wartości koszyka

More than half of the e-shops realizes less than 100 orders per months, which shows the fragmentation of the e-commerce market. The average margin for Polish e-shops is 21,7%, but most of small retailers do not execute margins higher than 20%. The highest margins are used by e-shops offer gifts (26%) and clothes (25,8%) and the lowest margins are used for computers (10,2%) and household and electronic devices (13,5%).

CONCLUSIONS

The dynamic development of the Internet changes the traditional role and the negotiation strength of individual participants of distribution channels. It has undoubtedly a positive influence on the clients' position in their relationships with suppliers of goods and services. It provides an express access to vast information resources and therefore enables to make rational purchasing decisions. The scale and the dynamics of the development of browsers and websites offering price comparison services proves the big and important role of the information function of Internet for creating behaviours patterns of customers. However in last three years, the e-commerce does not develop in Poland in similar previous very fast rate. The slower rate of the growth of the number of newly opened e-shops is the result of the economic crisis, weaker absorption capacity of the market and growing competition among e-retailers.

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E-SKLEPY JAKO PRZESŁANKA EWOLUCJI SEKTORA HANDLU

STRESZCZENIE. **Wstęp:** W artykule podjęto zagadnienie dynamicznego rozwoju nowej formy sprzedaży, jaką jest handel internetowy. Do potencjalnych źródeł przewagi konkurencyjnej przedsiębiorstw handlowych należą: technologia sprzedaży, metody obsługi klientów oraz logistyka towarów stanowiących przedmiot obrotu.
Metody: Dla przedstawienia rozwoju sprzedaży internetowej w Polsce w ostatnich latach wykorzystano wybrane wyniki obszernych badań ankietowych zrealizowanych w 2012 roku na próbie 607 e-sklepów.
Wyniki i wnioski: E-handel nie rozwija się obecnie w Polsce we wcześniejszym tempie. Wolniejsza dynamika przyrostu liczby nowo otwieranych e-sklepów jest pochodną kryzysu gospodarczego, słabszej chłonności rynku i zaostrzającej się rywalizacji pomiędzy e-detalistami. Procesy dokonujące się w handlu detalicznym i hurtowym mają charakter ewolucyjny i są rezultatem działań przystosowawczych przedsiębiorstw handlowych do turbulentnego otoczenia rynkowego.

Słowa kluczowe: dystrybucja, e-sklepy, e-handel, e-commerce, e-logistyka

E-LÄDEN ALS PRÄMISSE DER EVOLUTION DES HANDELS

ZUSAMMENFASSUNG. Einleitung: Im Beitrag wurde die Frage der dynamischen Entwicklung einer neuen Verkaufsform, nämlich des Internet-Handels, aufgegriffen. Zu den potenzialen Quellen der Wettbewerbsfähigkeit von Handelsunternehmen gehören: Verkaufstechnologie, Methoden des Kundenservices und Logistik der Waren, die Objekte des Warenumschlags sind.
Methoden: Für die Darstellung der Entwicklung des Internet-Handels in den letzten Jahren in Polen wurden ausgewählte Ergebnisse der umfangreichen, im Jahre 2012 in 607 E-Läden durchgeführten Umfrage-Untersuchungen in Anspruch genommen.
Ergebnisse und Fazit: Der E-Handel entwickelt sich gegenwärtig in Polen nicht im früher notierten Tempo. Die langsamere Entwicklungsdynamik bei der Anzahl von neu betätigten E-Läden ist auf die Wirtschaftskrise, schwächere Nachfrage des Marktes und den immer schärfer werdenden Konkurrenzkampf zwischen den E-Einzelhändlern zurückzuführen. Die sich innerhalb des Klein- und Großhandels vollziehenden Prozesse haben einen evolutionären Charakter und sind das Ergebnis der von Handelsunternehmen unternommenen Aktivitäten hinsichtlich der Anpassung an das turbulente Marktumfeld.

Codewörter: Distribution, E-Läden, E-Handel, E-Commerce, E-Logistik

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COMPETITIVE BEHAVIOUR IN SUPPLY CHAINS

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ABSTRACT. Background: The article deals with the results of literature and empirical research into competitiveness and behaviour of entities in supply chains.

Methods: A research hypothesis has been formulated that both partnership as well as dominance relations occur between enterprises functioning as suppliers-consignees. In order to verify the hypothesis a survey was completed in 2012. It encompassed 116 enterprises (manufacturers - 33, service providers - 32 and sellers - 24 as well as enterprises selling goods and providing services - 27) of which 54 were large, 26 medium and 36 were small enterprises. Competitive behaviour in supply chains has been identified and analysed. Furthermore, the authors intended to identify, reveal and examine possible interdependences between competitive behaviour and behaviour typical of supply chain strategies.

Results and conclusions: The analysis of survey results revealed a tendency to preserve equilibrium between a chain leader and dependent enterprises. It may be easily justified in practice as on the one hand there is a need to keep the supply chain competitive and on the other hand to avoid the interruptions, which could occur as a result of elimination of dependent enterprises.

Key words: competitive behaviour, competitiveness, supply chains, supply chain strategy, bargaining power, bargaining position, leader.

INTRODUCTION

In accordance with the emergent approach [Cyrson 2011] it is assumed that supply chain strategies are a result of the behaviour of individual entity components of such chains. Obviously, the supply chain strategy is shaped under the influence of supply and demand as well as competition present in a given sector. However, the relationships between suppliers and consumers are also of some significance. In particular one must account for the usage of control measures and power by the supply chain leader. Reflections on participants' behaviour are a part of the analysis of supply chain strategies described in pertinent literature and are treated as one of the determinants of their formation. As such behaviour is collectively called competitive, the issue in question is discussed from the perspective of the concepts of competitiveness and competitive position, so the article deals with the results of literature and empirical research into competitiveness and behaviour of entities in supply chains. A research hypothesis has been formulated that both partnership as well as dominance relations occur between enterprises functioning as suppliers-consignees and even negative behaviour could be positive but in the widest perspective - perspective of supply chains.

COMPETITIVENESS AND COMPETITIVE POSITION

Definitions of competitiveness, which are to be found in pertinent literature, may be divided into two groups. One group contains definitions in accordance with which competitiveness is perceived as a feature of

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enterprises expressed in terms of their capacity to achieve aims to a greater extent than rivals or as a result obtained in the wake of the achievement of those aims [Porter 2008]. The second group is composed of definitions focusing on the result of market behaviour of enterprises, which make them more attractive. The latter approach has been adopted in the research project intended to describe supply chain strategies by identifying and analysing enterprise behaviour.

The terms 'competitive position' and 'strategic position' are commonly used [Urbanowska-Sojkin, Banaszyk 2007]. The term competitive position refers to the role of the enterprise and its development opportunities in relation to its competitors. The position of the enterprise may be perceived from two perspectives - as a better or worse position in comparison with its competitors, which is assessed for instance through the share that a given enterprise has in a specific market or as a competitive position held in a given supply chain. The position of an enterprise in a complex supply chain (supply network) may be determined on the basis of the analysis of individual supply chains of which it is composed in reference to the so-called 'profit zone' - a large share in the market (...) a burden rather than an advantage and in fact it is of no significance. What is significant is where one can gain profit in one's own industry [Slywotzky, Morrison, Andelman 2002]. Enterprises may take a more or less advantageous location in a supply chain and due to that obtain better or worse financial results. Cox [2004] argues similarly that an organisation will dominate the supply chain in order to acquire value from such dominance and hold such a position, which shall not be exploited by other supply chain participants. Empirical analysis reveals that many enterprises take advantage of their size and power in supply chains to force other participants into co-operative behaviour [Webster, Breen, Chatziaslan 2005].

COMPETITIVE BEHAVIOUR IN SUPPLY CHAINS

Behaviour, which one may observe in supply chains, is a mixture of competitiveness (competitive contest, negotiation contest and bargaining contest), co-operation and control. What differentiates such behaviour from traditional competitive behaviour is the taking advantage of relationships between enterprises operating in a supply chain as suppliers-consumers, where both partnership and dominance are present. Therefore, the authors find it necessary to review the nomenclature used with reference to supply chains as it would be more accurate to talk about bargaining behaviour or negotiation behaviour than competitive behaviour in supply chains. Competitive behaviour would then refer to horizontal relations and negotiation behaviour to vertical ones.

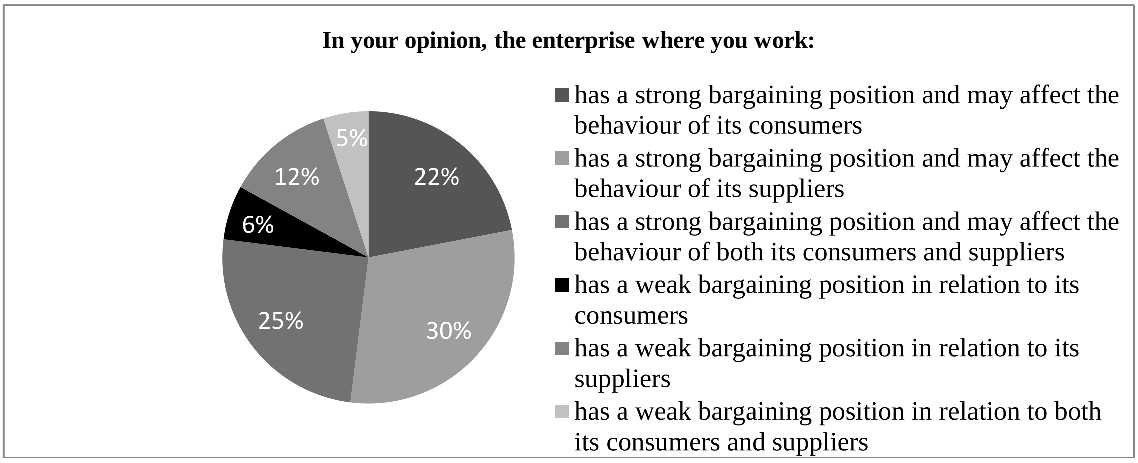
It is commonly accepted that the behaviour of entities operating in the market is connected with the choice of form of operation implemented to attain intended goals, which affect the behaviour of other market entities. Competitive behaviour of enterprises is based on their strategies as they are focused on competing by making strategic choices, which are called competitive strategies. Numerous typologies of competitive strategic behaviour of enterprises have been described in pertinent literature so far based on various criteria. The most common criteria adopted are the mode of operation and the aim intended to be attained by the enterprise due to such operations.

This paper mainly presents the results of the surveys carried out among 116 enterprises active in the region of the western Poland, in 2012. The majority of enterprises are manufacturers - 33, followed by service providers - 32 and 24 traders (including distributors - 12 and wholesalers, retailers, intermediaries - 4 of each group respectively) as well as enterprises trading and providing services - 27. Among the surveyed enterprises, there were 54 large, 26 medium and 36 small ones, according to Annex I to Commission Regulation (EC) No 800/2008 of 6 August 2008.

It has been initially assumed in the research that bargaining behaviour results from the power of the position held by an enterprise and hence the first question directly connected with the topic of the research referred to the perceived position of a given enterprise in a supply chain. The answers provided are presented in chart 1.

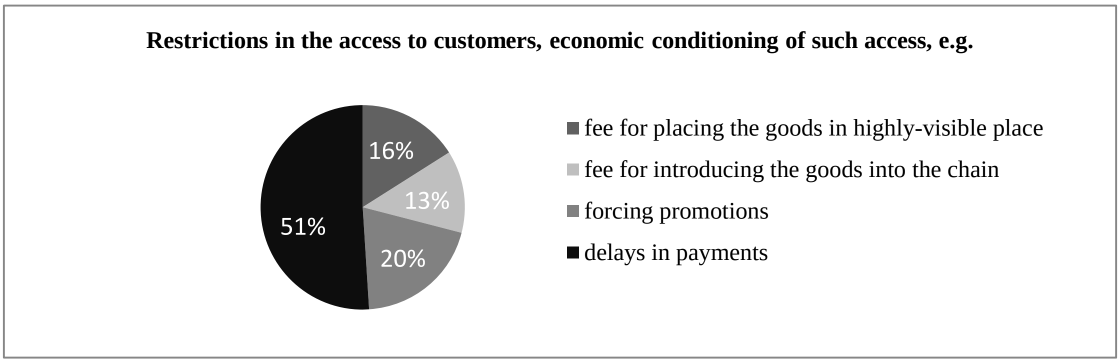
The majority of surveyed persons (77%) represented enterprises having a strong bargaining position. The researchers tried to establish on the basis of the next part of the survey whether it resulted from the size of the enterprise, but the answers were inconclusive and it proved to be impossible to draw unambiguous conclusions.

The next issue to determine was the demonstration whether some behaviour described in pertinent literature in fact occurs in real life. Among other objectives the authors wanted to determine whether access to consumers was limited, and if so by what type of behaviour. The distribution of listed behaviour types is presented in chart 2.



Source: research carried out by the authors of the paper

Fig. 1. Bargaining position of an enterprise in supply chains
Rys. 1. Pozycja przetargowa przedsiębiorstwa w łańcuchu dostaw



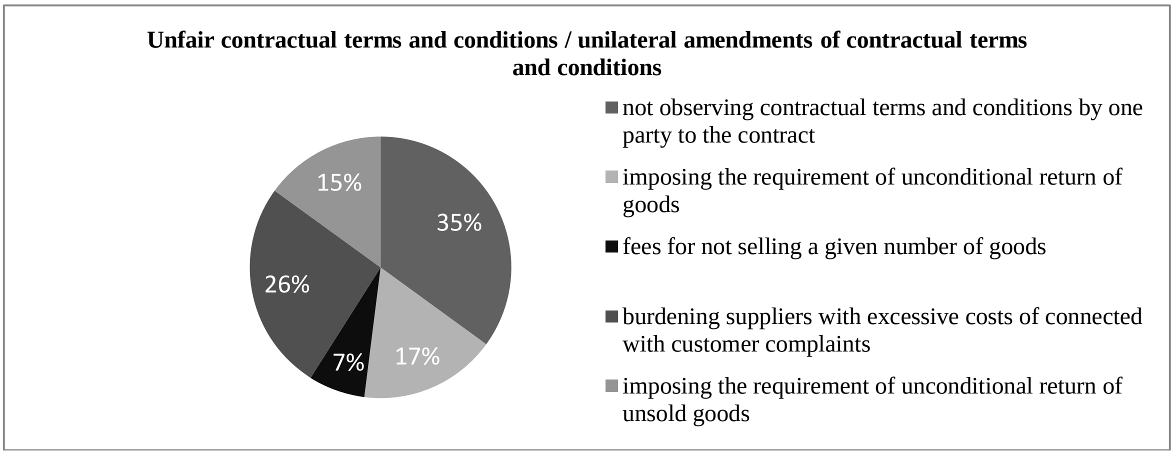
Source: research carried out by the authors of the paper

Fig. 2. Behaviour limiting access to consumers
Rys. 2. Ograniczenia dostępu do klientów

The behaviour connected with imposing contractual terms and conditions or not observing them was also identified. Usually it is typical of enterprises with greater bargaining power. Although such behaviour is not in compliance with legal provisions it is still indicated by the survey respondents as applied by their enterprises and it may be implied that it constitutes a strategy of enterprise operation in supply chains. Chart 3 presents the distribution of behaviour in this category.

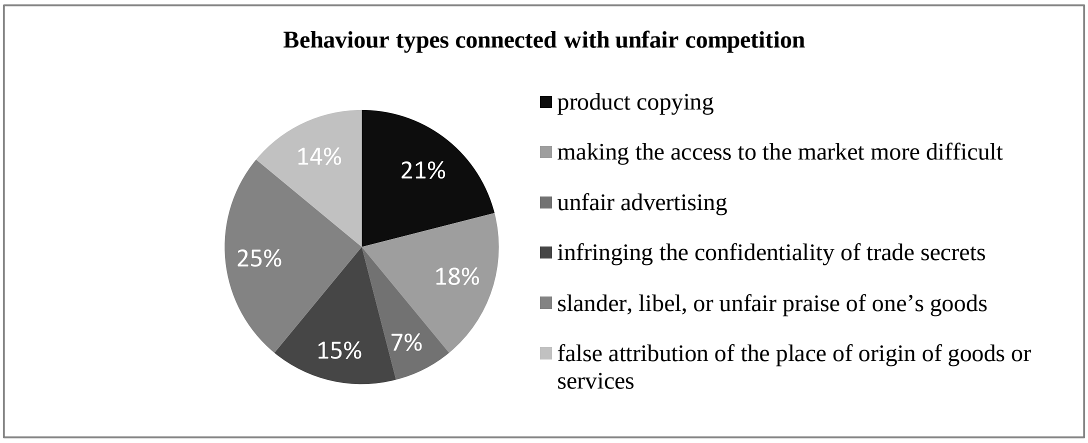
Apart from the behaviour forms identified on the basis of literature analysis and those listed in the survey, the respondents had a chance to provide information on behaviour experienced or observed by them in their work. The following unfair contractual terms and conditions have been enumerated: forcing to bear the costs of damage occurring in intermediary warehouse leased by the consumer, minimum supplies to central warehouses, failure to process an order when its size is not compliant with logistic minimum, failure to observe the terms of payment, terminating the contract despite the fact that the enterprise observes its terms and conditions and performs its obligations.

The next behaviour group included unfair competition. It has been presented in chart 4. The answers provided created almost an exhaustive list as only in one case an additional possibility was indicated being an attempt to bribe someone.



Source: research carried out by the authors of the paper

Fig. 3. Behaviour in supplier-consumer relations of an enterprise - contract terms and conditions
Rys. 3. Zachowania w relacjach dostawca-klient - warunki umów



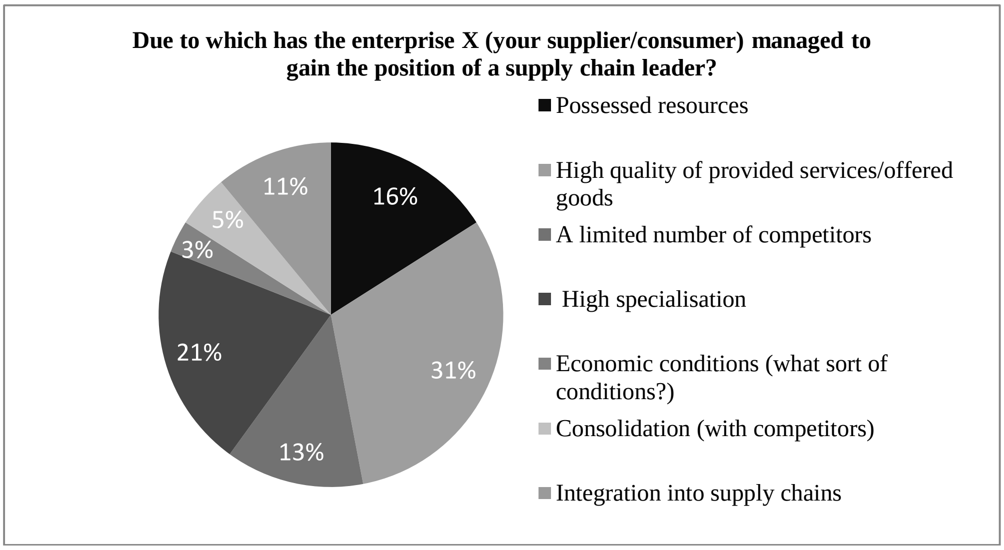
Source: research carried out by the authors of the paper

Fig. 4. Behaviour types in supplier-consumer relations of an enterprise - unfair competition
Rys. 4. Zachowania w relacjach dostawca-klient - zachowania nie-fair

Analysing the existing legal limitations, which may affect the behaviour of enterprises in supplier-consumer relations, one should account for such action or inaction as: not adjusting the infrastructure for supplies to shops and markets, manufacturing identical products as the original ones with the change of one letter or number in the product name, "placing" specific products in the project (here: construction project) and impossibility of substituting a cheaper counterpart, determining the terms and conditions for orders, system limitations such as TS 16949, the necessity to observe a specification for bids for tenders, excise taxes and exchange rates. It should be stated here that legal limitations usually result from the nature of the conducted business activity and restrictions applicable to a specific sector.

Apart from the already described negative forms of behaviour, the survey also included questions on additional advantages emerging due to co-operation in supply chains. The respondents enumerated the following examples: lower prices in the case of scheduling in a longer span of time, permanent orders, loyalty programmes, possibility of increasing prices depending on the demand, decreasing transportation costs, taking advantage of the effect of scale in order to decrease the costs of purchases of materials, possibility of negotiating prices particularly in the periods of achieving the so-called "targets", better opportunities of manufacturing on order.

The next part of the research was to enable identification of actions integrating suppliers with consumers. The distribution of answers was almost balanced - 48% of respondents indicated the advantages resulting from implementing new technologies and 52% of respondents indicated the common creation of new products and working together on their promotion. The respondents also provided some other ideas. Among behaviour integrating entities in supply chains the surveyed respondents listed: preparing common quality standards, strengthening collective packaging, decreasing the number of items in a collective package, common work conditions, timely transfer of information, timely deliveries, manufacturing under one's own brand name, offering a wider product mix, introducing new makes. So the scope of such integrating action refers to both operational actions and strategic co-operation.



Source: research carried out by the authors of the paper

Fig. 5. Determinants serving the purpose of attaining the position of a leader in a supply chain
Rys. 5. Czynniki określające uzyskanie pozycji lidera w łańcuchu dostaw

The survey also contained a question concerning potential determinants helping attain the position of a supply chain leader. It has been assumed that the answers should be provided by respondents representing enterprises, which are supply chain leaders. The number of answers was as great as the percentage of enterprises, which had a strong bargaining power in relations with their suppliers or consumers. The distribution of given answers is presented in chart 5. The analysis of answers gives justification for the claim that the position of an enterprise in a supply chain first and foremost results from the level of specialisation and high quality of services or goods.

Gaining the position of a leader is also possible due to: good infrastructure and geographical location of an enterprise, foreign capital, regionalisation, merging a few departments and providing comprehensive service (through consolidation) as well as using state-of-the-art machinery.

In the opinion of 46% of respondents there is a possibility of changing the position in a supply chain but 54% consider it to be impossible. As the opinions for and against were almost balanced it is worth analysing the grounds given by the surveyed group. The juxtaposition of arguments for and against the possibilities of changing the position of an enterprise in a supply chain has been provided in Table 1. The majority of actions enabling a change of the role of an enterprise in a supply chain refer to quality, qualifications, introducing new products, innovation, that is to say actions which make an enterprise more competitive as well as horizontal integration intended to increase one's own impact on suppliers or consumers. Only one answer referred to external factors - market surroundings. Consequently, enterprises consider it possible to change their role in supply chains by increasing their competitive potential. The listed forms of behaviour are almost the same as the already mentioned determinants of attaining the position of a supply chain leader.

Table 1. Behaviours enabling and disabling change the distribution of forces in supply chains
Tabela 1. Zachowania umożliwiające i uniemożliwiające zmiany dystrybucji sil w łańcuchach dostaw

FOR	AGAINST
Co-operation, Improving the quality of deliveries, timely deliveries, lower prices, better transportation fleet, Improving employee qualifications or employing specialists, Decreasing the number of competitors that is to say inviting them to co-operate, Investing in innovative technologies, which increase the quality of provided services, Implementing new products, which are not offered by competitors, Market conditions must change, Time, information transfer, keeping to the deadlines, Signing contracts with exclusivity clause, Reducing the quality of manufactured goods, Increasing prices of manufactured goods, Supply chain price and quality competition, Honest, reliable approach to business, employing specialists	The impact of competition, Consumers are magnates of the automotive sector on the market (VW, Porsche, BMW) and they set the rules of the game, Keeping one's position, maintaining quality, Enterprise has its own fleet of vehicles and suppliers, there is no point in improving anything, Everything operates correctly, everyone co-operates properly, speedily and reliably, There are not many opportunities in forwarding, Being dependent on the supplier, Excessive share of large enterprises on the market

Source: research carried out by the authors of the paper

The failure to change the position in a supply chain, in turn, resulted from two main types of behaviour:
- an enterprise had a well-established position and it aimed to maintain the status quo,
- consumers or suppliers were the leaders.

In the latter case it has been stressed that the movement of power is impossible due to the strong position of a leader - both in competition and in bargaining and the fact that the enterprise is dependent on the leader.

CONCLUDING REMARKS

Having analysed pertinent literature and the results of the survey, the authors identified the following types of behaviour:
- positive ones including loyalty programmes, decreasing costs of logistic operations,
- negative ones including limiting access to consumers, imposing or not observing contract terms and conditions, unfair competition, taking advantage of loopholes,

- determining possibility of attaining the position of a supply chain leader and
- making it possible to change the position in a supply chain.

On the basis of more extensive analysis (carried out in the framework of the research project) which in this article were presented selectively, the following conclusions have been drawn. Supply chain strategies are intended to make them flexible, agile, lean, reactive and are developed due to the integration of suppliers and consumers. If that is the case, then the overriding aim of co-operating entities is to gain competitive advantage for the whole supply chain. Such advantage may be achieved by implementing all identified positive behaviour forms.

Negative behaviour, however, is controversial. It is due to the fact that it may be analysed from three perspectives: (i) the supply chain perspective, (ii) dominant entity perspective, and (iii) economic network perspective.

It is most important for a supply chain to attain competitive advantage. This purpose may be accomplished by both positive and negative behaviour as far as either enables fulfilment of the intended strategic aim of the whole supply chain. Thus, negative behaviour may serve the purpose of increasing supply chain competitiveness. Additionally, if supply chains compete with one another, the profitability of individual enterprises is irrelevant and what really counts is the profitability of the whole supply chain and the value delivered by those operating within it.

The position held may be essential for entities, which form a supply chain. They may become leaders, which will give them the possibility to dominate other entities and impose central strategy on them by among others measures resorting to negative behaviours. However, an enterprise may become a leader if it first manages to gain advantage over its competitors, mainly due to high quality of provided services and offered goods and then it may also become responsible for a supply chain strategy. On the other hand, enterprises, which are not supply chain leaders, often have no influence on the price margins or terms and conditions of co-operation. However, they may profit from becoming participants in a given supply chain as despite a rigorous approach of the leading enterprise, it brings financial profits and competitive advantage. Co-operation in supplier-consumer relations is usually established between selected, best enterprises or enterprises that are co-dependent, which finally affects positively the competitiveness of the whole supply chain.

As far as economic networks are concerned, one should consider negative behaviour as a factor, which may disturb the balance of power in a network and result in economic problems. For instance, the European Commission ordered conduct of research on the issue in question and in 2008 it was announced that the strategy of concentration and globalisation especially in retail led to the imbalance of bargaining power between entities in the food supply chain, which negatively affected its competitiveness due to the fact that smaller but resilient entities might be forced to carry out less profitable business.

Therefore, both positive and negative behaviour occurs in supply chains but what is most important is to maintain balance between the leader and dependent entities in order to make the supply chain competitive and at the same time do not lead to the failure of such supply chain by eliminating dependent entities.

It should be stressed that the results of the survey are of regional scope and the research should be carried out in other regions too to confirm a wider applicability of observed trends. Taking into consideration the number of entities operating in the region of Wielkopolska in Poland in 2011 (The data provided by the Main Statistics Office (GUS) in Poland concerning business entities in specific branches and places of main activities in 2011, as of 2012, December 17], the sample of 150 surveyed entities ensures confidence in findings of nearly 80%, with the maximum statistical error of 5% [naukowiec.org/dobor]. The situation will change slightly if we are to generalize the results for all entities operating in Poland, that is to say the number of 74 870 entities. In order to maintain the same criteria as far as the level of confidence and error are concerned, the surveyed sample should amount to 157 entities. However, there is no denying that in order to be 99.9% certain of the representativeness of the results obtained, the surveyed sample should amount to over 1000 entities in Poland, which would significantly exceed the scope of the research carried out within the project.

SUMMARY

The article deals with the results of literature and empirical research into competitiveness and behaviour of entities in supply chains. A research hypothesis has been formulated that both partnership as well as dominance relations occur between enterprises functioning as suppliers-consignees. In order to verify the hypothesis a survey was completed in 2012. It encompassed 116 enterprises (manufacturers - 33, service providers - 32 and sellers - 24 as well as enterprises selling goods and providing services - 27) of which 54 were large, 26 medium and 36 were small enterprises. Competitive behaviour in supply chains has been identified and analysed. Furthermore, the authors intended to identify, reveal and examine possible interdependences between competitive behaviour and behaviour typical of supply chain strategies. The analysis of survey results revealed a tendency to preserve equilibrium between a chain leader and dependent enterprises. It may be easily justified in practice as on the one hand there is a need to keep the supply chain competitive and on the other hand to avoid the interruptions, which could occur as a result of elimination of dependent enterprises.

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ZACHOWANIA KONKURENCYJNE W SIECIACH DOSTAW

STRESZCZENIE. **Wstęp:** W artykule dokonano oceny konkurencyjności i zachowań podmiotów w sieciach dostaw na podstawie przeprowadzonych badań literaturowych i empirycznych.

Metody: Postawiono hipotezę badawczą: w relacjach pomiędzy przedsiębiorstwami w układzie dostawca-odbiorca występuje zarówno partnerstwo, jak i dominacja. W celu zweryfikowania hipotezy w 2012 roku przeprowadzono badania ankietowe, które objęły 116 przedsiębiorstw (firmy produkcyjne - 29%, usługowe - 28% oraz firmy handlowe). Badanie przeprowadzono w 54 firmach dużych, 26 średnich i 36 małych. Zidentyfikowano i przeanalizowano zachowania konkurencyjne w sieciach dostaw. Ponadto celem tych badań było wykazanie i rozpoznanie ewentualnych zależności między zachowaniami konkurencyjnymi a zachowaniami występującymi w strategiach sieci dostaw.

Wyniki i wnioski: Analiza ankiet wykazała tendencję zmierzającą do zachowywania równowagi między liderem a podmiotami zależnymi w sieci. Znajduje to uzasadnienie praktyczne, gdyż istnieje konieczność utrzymania konkurencyjność sieci dostaw przy jednoczesnym uniknięciu jej załamania, które mogłoby nastąpić w wyniku wyeliminowania podmiotów zależnych..

Słowa kluczowe: zachowania konkurencyjne, konkurencyjność, sieci dostaw, strategie sieci dostaw, siła przetargowa, lider

KONKURRENZVERHALTEN INNERHALB VON LIEFERNETZEN

ZUSAMMENFASSUNG. Einleitung: Im vorliegenden Beitrag wurde auf Grund der durchgeführten empirischen und Literaturrecherchen eine Beurteilung der Konkurrenzfähigkeit und des Verhaltens von Lieferanten in den Liefernetzen ausgeführt.
Methoden: Dabei stellte man eine Forschungshypothese auf: innerhalb der Zusammenhänge zwischen den Unternehmen im Verhältnis Lieferer-Abnehmer treten sowohl Partnerschaft als auch Domination auf. Zwecks der Verifizierung der Forschungshypothese führte man 2012 Umfragen durch, die 116 Unternehmen (Produktionsfirmen - 29%, Dienstleistungsfirmen - 28% und Handelsfirmen) umfassten. Die Untersuchungen wurden in 54 großen, 26 mittelgroßen und 36 kleinen Unternehmen durchgeführt. Es wurden dabei Konkurrenzverhalten innerhalb von Liefernetzen ermittelt und analysiert. Darüber hinaus war es das Ziel dieser Forschungen, eventuelle Zusammenhänge zwischen den Konkurrenzverhalten und den in den Strategien von Liefernetzen auftretenden Verhalten aufzuzeigen und zu identifizieren.
Ergebnisse und Fazit: Die Analyse der Fragebögen zeigte eine auf die Aufrechterhaltung des Gleichgewichtes zwischen dem Leader und den Subjekten innerhalb des Netzes hinzielende Tendenz auf. Dies findet eine praktische Begründung, denn es besteht die Notwendigkeit der Aufrechterhaltung der Konkurrenzfähigkeit des Liefernetzes bei gleichzeitiger Meidung dessen Zusammenbruches, der in Folge der Ausscheidung von abhängigen Subjekten auftreten könnte.

Codewörter: Konkurrenzverhalten, Konkurrenzfähigkeit, Lieferketten, Lieferketten-Strategie, Umfrage-Analyse, Fragebögen, Leader.

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MATRIX LOGISTICS INDICATORS ASSESSMENT OF DISTRIBUTED TRANSPORT HUB

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ABSTRACT. Background: The paper is devoted to the distributed transport hub substantiation and assessment. The paper was an example of the technique and form an array of logistical factors as variables that determine this condition. Experience in organizing multimodal transport showed that the "bottleneck" of transport logistics are items of cargo handling ports, terminals, freight stations and warehouses. At the core of the solution of these problems is the problem of estimating the variables determine the Multi-purpose Hubs.

The aim is to develop a method of forming the system of logistical multiplying factors determine the role of each of the types in the technologiacal process of distributed Multi-purpose Hubs.

Methods: The assessment model for the formation of Distributed Transport Units can be based on formal methods to predict the behavior of complex systems engineering complexes. Then one of the approaches to the solution of the problem may be the matrix method of technological factors.

Results and conclusions: The proposed methodology of the selection and validation of logistic coefficients has the practical importance in the models development for assessing the condition and behavior of Distributed Transport.

Key words: transport, multimodal, freight unit, cargo flow, the transport hub, the matrix.

INTRODUCTION

Experience in organizing multimodal transport showed that the "bottleneck" of transport logistics are items of cargo handling ports, terminals, freight stations and warehouses. Development of the infrastructure of these elements of the Unified Transport System (UTS) has resulted in the late 20th century to the formation of Multi-purpose Hubs (TH) at the points of traffic concentration and crossing. They have concentrated the main problems of the common methodology for organizing, modeling and management processes of formation of freight transport processes.

At the core of the solution of these problems is the problem of estimating the variables Determine the TH (DTH). The establish data system assessments to select the basic characteristics of TH behavior, which changes relatively slowly or may be taken as constant. As such values are logistical factors.

The aim is to develop a method of forming the system of logistical multiplying factors determine the role of each of the types in the technologiacal process of distributed TH.

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CHARACTERISTICS OF DISTRIBUTED TRANSPORT HUB

A marked increase in the last decade the movement of goods and cargo capacity resulted in a number of regions need to decompose the handling of certain types of transport on specialized sites that meet their specific : marinas, road and rail terminals, airports . This is the case with the ever - increasing direct reloading (transfer) from one truck to the other units . The unit loads in such variants belong to one and the same mode of transport, but have a higher (lower) load : the car - car, plane - aircraft, ship - to-ship , the vagon - the vagon) . This position is due not only to the requirements of the logistics, but also saving the cost of transporting cargo unit with the same mode of transport. But yet we have the organization of traditional logistics plan on multimodal principle, which includes several types of cargo units . Thus , TH becomes distributed over a large enough area of the complex handling centers. Together, they form a Distributed TH (DTH) . The main feature of the DTH is a need to organize their own logistics, when inside it, is additional transport work . Thus in the DTH formed procedure that meets the economic category of producer-consumer . Each cargo unit formally was " made " as a delivery unit to DTH by one transport mode for its further use "consumer" - by another transport mode.

In the elementary case the price of shipping cargo unit expressed the sum of the costs of the scheme "producer goods - the price of transportation in the DTH (**Д$_1$**) - the price of goods in the process of DTH (**П**) - the price of delivery to the consumer [Ariefiew 2007a].

$$(Д_2):\ Д_1+Д_2+П = S$$

In the multi-modal version of this scheme is much more complicated. The constant shifting of cargo nomenclature, the technology of its processing, the fluctuations of supply and demand in the goods market, over time, lead to the transformation of the state of the DTH. It is possible to characterize the position of the DTH as a dynamic system.

If we exclude from consideration the specific transport continuous wave (hydraulic and pneumatic systems), the transport in the conventional representation - a system of discrete steps. As part of this system the DTH is also an object of discrete steps. Units workload are similar: ton, packaging, pallet, container, etc. The same provision applies to the internal rolling stock TH, directly performing the movement: by cargo capacity (cubic meters, liters, tons) or technological characteristics of internal communications (axle load, sediment size).

Based on the theory of logistics, we note that the cargo can be stationary and non-stationary random [Ariefiew 2011]. This provision applies to the DTH.

Stationary traffic flows are formed on the basis of established contractual obligations times on a particular type of cargo or a regular route of a particular mode of transport. Such systems are primarily all continuous and regular flow of cargo routes converge at a node. Their load is previously known for considerable periods of time (up to decades). An example would be any line of ferry traffic, complex construction, energy securing of the regions, etc. Logistic schemes of this type of DTH standardized and are long-term nature. Indicators of his condition take the form of constants and coefficients are classified. [Grzybowski 2012]

Unsteady flows generated by the movement of certain goods in the small group (limited) period of time. These streams are most common in the implementation of seasonal produce, delivery and navigation system, etc. Unsteady TH oriented organization of logistics schemes for navigation (temporary) traffic switching from one mode to another.

Current changing needs of the regions and territories, new technologies, fluctuations in demand and supply of output in the non-stationary RTS mode. The random component of the nodes in some areas is 40%-70%. [Grzybowski 2012, Strategia rozwoju 2010]. These random streams appear constantly when in need of low-slot goods in the conveying and sorting of goods in transport hubs multi-purpose, off-schedule delivery of materials and equipment. However, the experience and the calculations have shown that up to 90% of the cargo are a type of stationary. Even casual flows in statistical estimates at short intervals of time (a week, ten days) reducible to conventionally fixed at the current logistics organization of TH.

DTH is a ground complex. Moving goods between its elements (terminals, warehouses, wharves, warehouses, site) is their means of three kinds: material handling equipment (conveyors, trailers, cranes, manipulators), wagons, cars (Figure 1). They close the multimodal process of individual routes into a unified Transport System.

The system analysis provided above and the characteristic to the TH allow to pass to a choice and justification of the variables characterizing its condition, as ITS element.

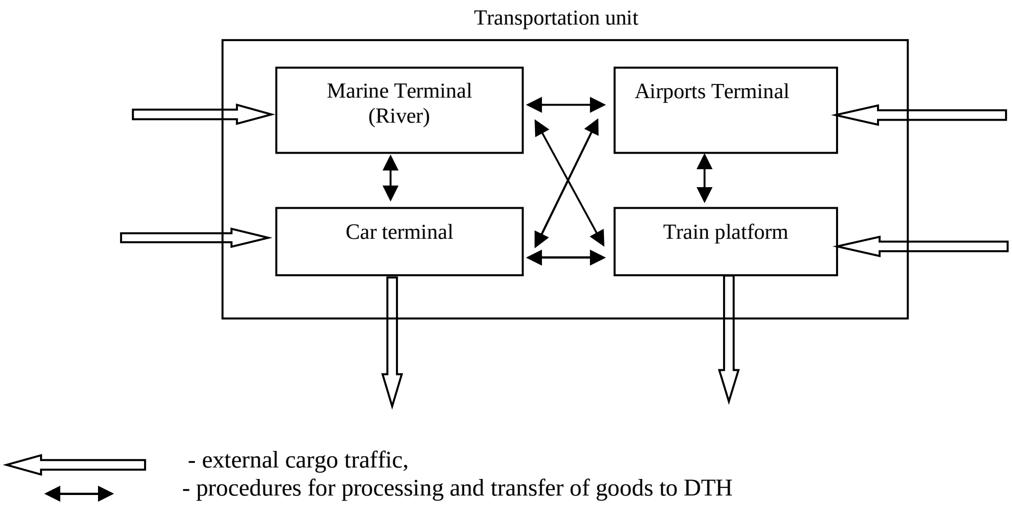

Fig. 1. The scheme of interaction of elements of integrated DTH
Rys. 1. Schemat interackji pomiędzy elementami zintegrowanego DTH

THE CHOICE OF INDICATORS AND THE CHARACTERISTICS OF THE STATE OF DTH

The choice of variables that provide a methodology for assessing the state of the DTH is based on the assertion that it is a type of cond stationary systems. Consequently, the assessment model for the formation of RTC can be based on formal methods to predict the behavior of complex systems engineering complexes.

Then one of the approaches to the solution of the problem may be the matrix method of technological factors [Arefyev 2011]. The following is a technique which allows an example of costs of cargo handling characterize and assess the state of the DTH as a logistics facility. Indicators of this feature are represented by two groups:

The first group of these indicators are the variables in physical units (kilometers, ton, volumes, tactical and technical data load units). Since the main operational work in the distribution of traffic TH falls on the traditional transport, the total transport of products in it will be a vector X with component

$$X_1\ X_2\ X_3\ ...\ X_N .$$

These indicators meet the volume of each type of transport in particular. The task is greatly simplified, since it is known that

$$N = 3.$$

The second variable that determines the state of the DTH is the speed of product delivery I. This figure is traditional and needs no comment. It should only be noted that for stationary traffic flow time can be selected from the conditions of ease of analysis and simulation of decision-making procedures: the hour, decade, month, year, etc.

Characteristics of transport work to the DTH are three factors:

- price of cargo unit delivery
  S [PLN]/[cargo unit],
- costs of the transport infrastructure development, necessary for the further increases in the unit capacity
  L - [PLN] / ([cargo unit] / [year]^2),
- cost of cargo unit delivery
  R - [PLN] / ([cargo unit] / [year].

Types of expenses form own matrix and their sum defines cost of goods delivery R_i as a whole.

Thus, the N columns of the table with the list handling costs for each internal transport costs will be the matrix. It is clear that the manufacturer of a particular DTHwork input allows other manufacturers to continue similar work according to accepted logistics scheme.

Consequently, the cost is a square matrix of NxN. Its elements are defined as technological factors at the DTH [Ariefiew 2010]

$$A_0 = \{a_{ij}\}.$$

THE COEFFICIENT MATRIX HANDLING COSTS AT THE DTH

The elements of the rows of costs form part of the cargo going to other modes of transport. The sum of all elements of the first N rows of A_x has a unit. The sum of elements N + 1 is P_z. Cost-effective work is $P_z \leq 1$. The model is $R_{nt} \geq 0$. When there is no load, then P = 1. Profitability is equal to zero. There is a record of the matrices A_x and $A_ή$

$$A_x = S_c^{-1} A_ή$$

We can write the matrix of alternating one another. This will be the product of two matrices. In Table 1 is the relationship.

Table 1. Matrix of technological factors of DTH
Tabela 1. Macierz czynników technologicznych DTH

n	The matrix of the estimated	The matrix of known				
		Matrix of factors A	Matrix of cost A_s	Matrix of relative costs A_1	Matrix of flows $A_П$	Matrix of Relative odds A_x
N	1	2	3	4	5	6
1	$A=\{a_{1j}\}$	E	$S^{-1}A_s$	$S^{-1}A_1S$	$S_c^{-1} A_П S^{-1} S$	$S^{-1} S_cA_x S_c^{-1} S$
2	$SAS=\{S_1a_{1j}\}$	SA	E	A_1S	$A_П S_c^{-1} S$	$S_cA_x S_c^{-1} S$
3	$A_t=\{S_1/S_ja_j\}$	$S{\cdot}A{\cdot}S^{-1}$	A_sS^{-1}	E	$A_П S_c^{-1}$	$S_cA_x S_c^{-1}$
4	$A_П=\{ S_1/X_1a_{1j} \}$	$S{\cdot}A{\cdot} S^{-1}S_c$	$A_sS^{-1}S_c$	A_1S_c	E	S_cA_x
5	$A_x=\{X_j/ X_1a_{1j} \}$	S_c^{-1}	$S_c^{-1}A_sS^{-1}S$	$S_c^{-1}A_1S_c$	$S_c^{-1} A_П$	E

Source: author's research

As an example, we construct a costs matrix of handling at the RTU as the ratio of the technological coefficients of the transport process work presented as $A_0 = \{a_{ij}\}$. The elements of this matrix a_{ij} are specific quantitative requirements for the work done by the *i*-th mode of transport. They need to work on the next work cycle (map routing) mode of transport *j*.

The matrix consists of 3 sectors: loading and unloading equipment, cars (structures), cars. Each of them delivers transport units for determined time in a certain place. If it is the main cargo unit. that transport unit goes from the TH (the mooring, the terminal, a platform). In case of freight processing in knot, transport unit arrives on sorting or storage (a warehouse, the bunker, a platform). In the second case there is verified the further movement of freight in compliance with the external logistic scheme (Table 2).

In the *i*-th row of the matrix indicates the types of transport as cargo deliverymen, and *j*-th column, they also act as the successors of the process (consumers). For example, the element a11 = 0,25 characterizes the running costs of the group's own vehicles RTU (per year). The rest of the entries a22 and a33 show the cost *i*-th group in the interest of work in the *j*-th groups. Thus, the element a12 = 0,4 determines the cost of the conveyor, which are necessary for operation of the train (in a year), a21 - the costs of the railway to ensure the operation of the conveyor (yearly) etc.

By analogy with the above methods any of the DTH coefficient matrix can be constructed and reasonably predict his fortune according to any of the selected system performance.

Table 2. Matrix of technological coefficients of DTH
Tabela 2. Macierz współczynników technologicznych DTH

N п/п	i / j	Conveyor	Wagon (set)	Car
1	Conveyor	a11 = 0,25	a12 = 0,75	a13 = 0,0
2	Wagon (set)	a21 = 0,6	a22 = 0,15	a23 = 0,25
3	Car	a31 = 0,15	a32 = 0,1	a33 = 0,75

Source: author's research

CONCLUSIONS

The proposed methodology of the selection and validation of logistic coefficients has the practical importance in the models development for assessing the condition and behavior of Distributed Transport Hab (DTH). Presented in a matrix form of all parameters of DTH such model is a part of the management system and forecasting multimodal freigh.

The coefficient matrix of the logistics process shows the inner structure of DTH.

It fixes the state of DTH at this time. The procedure for forecasting the DTH through the data matrix is the next stage of the procedure. It is associated with the characteristic of the processes, that go in the elements of the DTH. These elements are a means of transport, works in this DTH.

This model should get a differential equations. The equations show the dynamics of process change. This direction is creation of mathematical technique assessments DTH. The model must be built based on a matrix of technological coefficients.

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MACIERZ WSPÓŁCZYNNIKÓW LOGISTYCZNYCH CENTRUM LOGISTYCZNEGO

STRESZCZENIE. **Wstęp:** Opracowanie poświęcone jest uzasadnieniu i ocenie stanu Węzłów Transportowych typu rozstawionego. Przedstawiona jest metodyka i przykład kształtowania macierzy wskaźników logistycznych i zmiennych określających ten stan. Doświadczenie organizacji przewozów multimodalnych wykazuje, że w logistyce transportowej "wąskie gardło" stanowią punkty obróbki ładunku: porty, terminały, stacje przeładunkowe i magazyny. U podstaw rozwiązania tych zadań leżą problemy oceny zmiennych określających stan Węzła Transportowego jako całości.
Celem opracowania jest sporządzenie metodyki kształtowania wskaźników logistycznych określających rolę każdego poszczególnego rodzaju transportu w procesie działalności Rozstawionego Węzła Transportowego.
Metody: model oceny dla kształtowania rozstawionych jednostek transportowych może opierać się na formalnych metodach prognozowania zachowania się złożonych systemów i kompleksów logistycznych. Wtedy jednym z podejść do rozwiązania problemu może być przedstawiona w tym opracowaniu macierzowa metoda równowagi czynników technologicznych współdziałania rodzajów transportu w Węźle Transportowym.
Wyniki i wnioski: przedstawiona w niniejszym opracowaniu metodyka wyboru i uzasadnienia wskaźników logistycznych ma znaczenie praktyczne przy sporządzaniu modelu oceny stanu i zachowania się Rozstawionych Węzłów Transportowych. Takiego rodzaju model przedstawiona w macierzowej postaci równowagi zgodnie ze wszystkimi wskaźnikami działalności Rozstawionego Węzła Transportowego stanowi element systemu prognozowania i podjęcia decyzji w zakresie zarządzania potokami ładunkowymi typu multimodalnego.

Słowa kluczowe: transport, multimodalność, jednostka ładunkowa, potok ładunkowy, węzeł transportowy, macierz.

MATRIX FÜR LOGISTISCHE KOEFFIZIENTEN DES LOGISTIK-ZENTRUMS

ZUSAMMENFASSUNG. Einleitung: Der Abhandlung liegt eine Begründung und Beurteilung des Zustandes von Transport-Knotenpunkten gestaffelten Typs zugrunde. Es wurden die Methodik und ein Beispiel für die Ausgestaltung der Matrix von logistischen Kennziffern und Variablen, die den Zustand bestimmen, dargestellt. Die Erfahrung in der Organisation von multimodalen Transporten zeigt, dass es innerhalb der Transport-Logistik die Bearbeitungspunkte von Ladungen: Häfen, Terminale, Verladungsstationen und Läger die "Engpässe" ausmachen. Grundlage für die Lösung solcher Aufgaben bilden Fragestellungen bei der Beurteilung von den Variablen, die den Zustand des Transport-Knotenpunktes als Ganzes bestimmen.
Das Ziel der Bearbeitung war es, eine Methodik für die Ausgestaltung der logistischen Kennziffern, die die Rolle jeder einzelnen Transportart im Prozess der Betätigung des gestaffelten Transport-Knotenpunktes bestimmen, zu erstellen.
Methoden: Das Modell für die Ausgestaltung von gestaffelten Transport-Einheiten kann auf formelle Methoden für die Prognostizierung des Verhaltens von komplexen Systemen und logistischen Zentren gestützt werden. Gegebenenfalls kann als eines der möglichen Herangehen an die Lösung des Problems die in der vorliegenden Abhandlung projizierte Matrix-Methode des Gleichgewichtes von technologischen Faktoren beim Zusammenwirken von unterschiedlichen Transportarten innerhalb des Transport-Knotenpunktes angewendet werden.
Ergebnisse und Fazit: Die im Rahmen der vorliegenden Bearbeitung dargestellte Methodik für die Auswahl und Begründung von logistischen Kennziffern besitzt eine praktische Bedeutung bei der Erstellung des Modells für die Beurteilung des Zustandes und des Verhaltens von gestaffelten Transport-Knotenpunkten. Solch ein Modell, das in der Gestalt einer Matrix des Gleichgewichtes, gemäß allen Kennziffern der Funktionsausübung des gestaffelten Transport-Knotenpunktes dargestellt wird, macht ein Element des Prognostizierungssystems und der Entscheidung im Rahmen des Managements von multimodalen Ladungsflüssen aus..

Codewörter: Transport, Multimodalität, Ladungseinheit, Ladungsfluss, Transport-Knotenpunkt, Matrix.

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BARRIERS LIMITING THE DEVELOPMENT OF INTERMODAL TRANSPORT IN POLAND - THE PERSPECTIVE OF BUSINESSES AND PUBLIC ADMINISTRATION

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ABSTRACT. Background: The purpose of this article is to identify the barriers resulting in poor use of intermodal transport in Poland and to indicate the actions currently taken by public administration and businesses to change this unfavourable situation, such as creation of the Intermodal Transport Council at the Ministry of Transport, Construction and Maritime Economy or the planned creation of Polish Intermodal Transport Cluster.

Methods: The article focuses on an expert analysis of the barriers limiting the development of intermodal transport in Poland. The author presents the results of selected research projects implemented by him and financed from the funds of the European Union, and the outcomes of initiatives undertaken at the level of the European Union and of Polish government administration.

Conclusions: The barriers limiting the development of intermodal transport in Poland presented in the article and the identified activities which are to change this unfavourable situation show how to cope with the challenges connected with the continuously growing volume of freight transport in Poland in a way that is economically viable and responsible towards the environment, the climate and man.

Key words: Intermodal transport, barriers to intermodal transport, FLAVIA project, EMPIRIC project.

INTRODUCTION

Intermodal transport is a complex transport process where freight is moved by vehicles representing various modes of transport [Mindur, 2002]. The businesses' main reason to use it is the fact that intermodal transport enables them to take advantage of an optimum set of the service and cost features characterising particular means of transport [Coyle, Bardi, Langley Jr., 2002].

Since Poland is situated in the centre of Europe and the main transport corridors run across its territory, it can use practically all modes of transport for intermodal carriage, i.e. road transport, rail transport, sea transport and inland waterway transport. Unfortunately, despite many attempts to develop intermodal transport, its share in Poland remains very low - for instance the share of intermodal transport in rail transport at the end of 2011, estimated based on data from the Office for Rail Transportation (UTK), calculated by freight weight, was 2.2% [Hajdul, 2012]. Combined with the continuous growth of trade (domestic transport, export, import, transit), these results in a situation where a growing number of transport routes, especially in road transport, reach their maximum capacity and it is becoming increasingly difficult or practically

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impossible to organise transport processes efficiently and effectively.

BARRIERS TO THE USE OF INTERMODAL TRANSPORT IN POLAND

The research work undertaken by the employees of the Institute of Logistics and Warehousing (ILiM) and performed within the described initiatives shows that the issues of intermodal transport development in Poland are very complex and require multifaceted consideration. There are a number of legal, administrative & organisational, economic & financial, technical & technological barriers which hinder any greater use of intermodal transport [Mindur, Krzyżaniak, 2011].

Economic & financial barriers

The use of intermodal transport is limited mostly for economic reasons - intermodal transport is too expensive. This results from too high fees for access to railway infrastructure for intermodal operators.

The transport financing system is another obstacle to the development of rail transport in Poland. While road carriers are exempt from the majority of charges, referred to as external costs, and the road network maintenance, modernisation and development costs are borne by the State, railway carriers must incur the railway network maintenance and development costs. Modernisation of railway infrastructure is covered by the network manager (PKP PLK S.A.) from the fees collected from railway carriers for access to the network [Jeleń, Foltyński, Guszczak, 2011].

Technical & technological barriers

The other barriers include lack of tools for effective implementation of the national Transport Development Strategy for Poland, adopted on 22 January 2013 by the Council of Ministers, and inadequate quality of transport services, reflected for instance in low commercial speed of rail transport. According to the data of the Office for Rail Transportation (UTK), the average commercial speed of freight trains in Poland in 2012 was about 29 km/h.

Table 1. Average commercial speed of freight trains in Poland in 2012 by railway carrier
Tabela 1. Średnia prędkość pociągów towarowych przewoźników kolejowych w Polsce w 2012

Name of carrier	Average speed [km/h]
CTL Express	42
CTL Logistics	23
DB Schenker Rail Polska	24
Lotos Kolej	34
Majkoltrans	80
PKP Cargo*	35
PKP LHS	40
Rail Polska	18
STK	25

Source: Office for Rail Transportation (UTK)

For comparison, the average commercial speed in rail transport in other European countries is as follows:
- Hungary - 32 km/h,
- France - 64 km/h,
- Sweden - 65 km/h,
- Germany - 71 km/h.

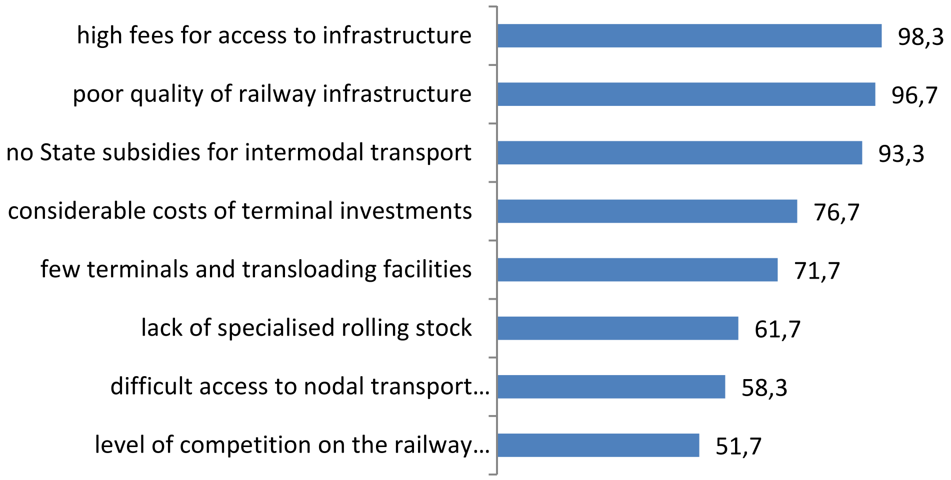
The most important qualitative parameter in intermodal transport is the commercial speed between the dispatch site (for instance a sea port) and the collection site (for instance an inland container terminal). Railway travel time must be competitive with road travel time. To make intermodal transport more competitive with long-distance road transport, railway infrastructure manager must improve the condition of linear infrastructure and change the rules governing the assignment of train routes within annual train schedules, making intermodal transport a bigger priority.

Legal, administrative & organisational

Legal, administrative & organisational barriers are as follow:
- lack of legal regulations governing the operation of the intermodal transport organizer,
- no permanent dialogue between the representatives of the public administration and business.
- lack of logistics centers causing reduction of the cargo - difficulties in intermodal block trains building up,

- lack of uniform and comprehensive information system in the whole intermodal transport chain,
- lack of comprehensive and effective instruments promoting the intermodal transport within the framework the national transport policy, in particular the lack of financial support,
- lack of a coherent long-term transport (intermodal) policy, taking into account the needs of the country and the transit location of Poland on the map of Europe.

The significance of those barriers is also confirmed by the results of surveys conducted by the Office for Rail Transportation (UTK) among railway carriers. They believe high fees for access to the infrastructure and poor quality of services reflected in low commercial speed to be the biggest barriers to the development of intermodal transport in Poland. Results of the surveys are shown in the chart 1.



Source: Office for Rail Transportation (UTK)

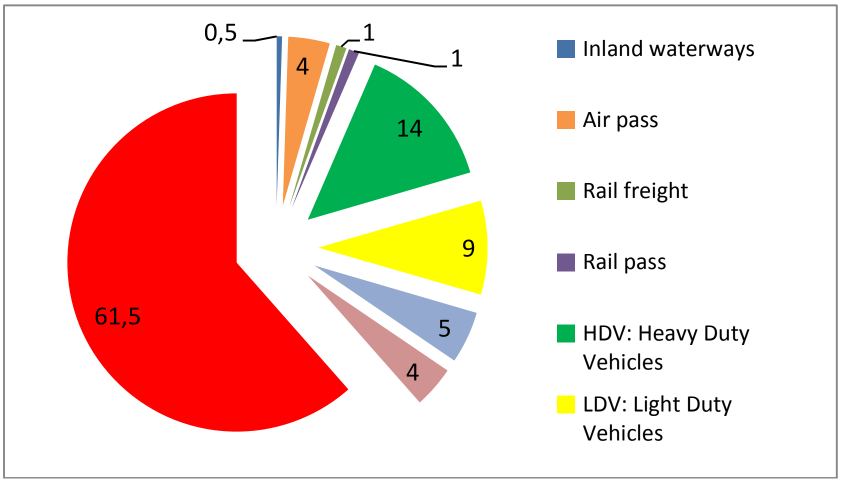
Fig. 1. Barriers to the development of the intermodal transport market (percentage of respondents)
Rys. 1. Bariery rozwoju rynku transportu intermodalnego (odsetek odpowiedzi)

WHITE PAPER - CHALLENGES

In March 2011, the European Commission published a White Paper (Brussels, 28.3.2011, COM 2011, 144 final) regarding transport. Known as the "Roadmap to a Single European Transport Area - Towards a competitive and resource efficient transport system," it is a strategic document. The White Paper offers evaluation of the transport policy in the recent years and research results regarding long-term challenges; it also permits identifying the objectives for the upcoming 40 years - until 2050, and it defines specific framework conditions for transportation policy activities for the upcoming 10 years.

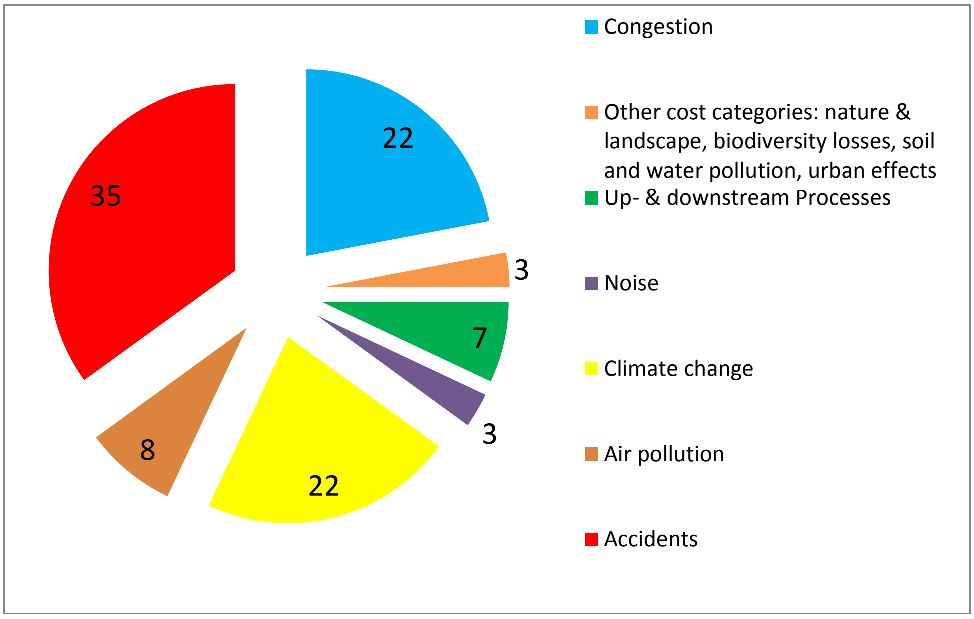
To achieve a 60% reduction in pollutant emissions from transport in the face of the society's growing need for mobility, the White Paper defines the criteria for both transportation policy and progress evaluation. According to them, 30% of long-distance road freight (over 300 km) should shift to rail by 2030, and more than 50% by 2050.

A study focusing on external cost of transport conducted in 2011 jointly by CE Delft, INFRAS and Fraunhofer ISI [External cost of transport in Europe, 2011] shows that external costs are much higher for road transport than for rail transport.



Source: External Costs of Transport in Europe, Update Study for 2008, CE Delft, INFRAS, Fraunhofer ISI, Delft, November 2011

Fig. 2. Total external costs of transport by transport mode
Rys. 2. Całkowite koszty zewnętrzne transportu wg typów transportu



Source: External Costs of Transport in Europe, Update Study for 2008, CE Delft, INFRAS, Fraunhofer ISI, Delft, November 2011

Fig. 3. Total external costs of transport by externality
Rys. 3. Całkowite koszty zewnętrzne transportu w stosunku do ich wpływu na otoczenie

Among the means of road transport, the biggest share in external costs of transport belongs to cars (61,5%), which are followed by heavy duty vehicles (14%), light duty vehicles (9%), motorcycles and mopeds (5%) and buses and coaches (4%). Then comes air transport, the share of which in external costs of transport is 4% (only internal EU flights were taken into account). The share of rail transport is just above 1%, and of inland waterway transport - only 0.3%. Sea transport was not considered in the study.

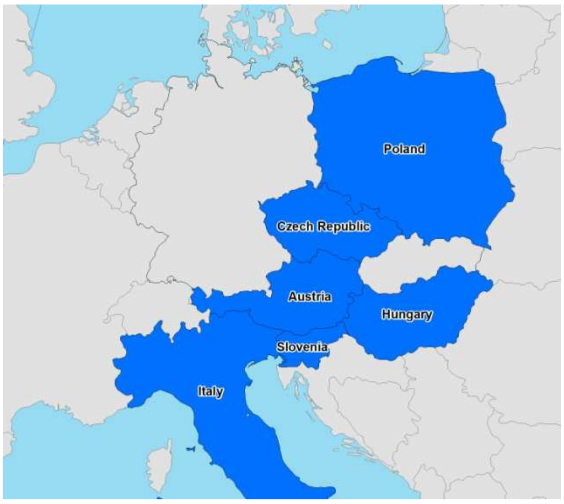
With a share of 35%, accidents dominate in external costs. Congestion and climate change constitute 22% each. The lowest external costs of transport (3%) are related to the noise emitted by vehicles during carriage.

In connection with those ambitious challenges which arise from the White Paper and which are to help reduce environmental pollution, the European Commission decided to support initiatives promoting intermodal transport as it entails the lowest external costs and may be a real alternative to road transport. This support is found for instance in the financial aid provided via the Marco Polo II programme (for more visit www.ec.europa.eu/marcopolo), addressed to companies offering new or significantly modified services in terms of the way of transporting freight - a shift from congested roads to more environmentally friendly modes of transport, such as rail, sea and inland waterway transport.

Another tool of support for intermodal transport is to subsidise research projects which aim to identify and eliminate the barriers and bottlenecks limiting the use of that mode of transport. Via the Interreg Central Europe financial programme (for more visit www.central2013.eu), the European Commission supported EMPIRIC and FLAVIA - two international research projects in which the Institute of Logistics and Warehousing (ILiM) is directly involved.

THE EMPIRIC CORRIDOR PROJECT

The growing demand for transport services, especially at the Baltic Sea, keeps increasing the significance of the 2nd transport corridor, known as the Baltic-Adriatic corridor, running from the north to the south. Unfortunately, the still poorly developed transport infrastructure permits using mainly road transport, which affects the natural environment. This encouraged the partners from the countries situated at the Baltic-Adriatic corridor (Poland, the Czech Republic, Austria, Hungary, Slovenia, Italy) to create a consortium within the EMPIRIC project (Enhancing Multimodal Platforms, Inland waterways and Railways services Integration in Central Europe). The project is to provide transport operators and logistics service providers with the instruments and the framework conditions to support the process of activating and improving multimodal connections integrating the ports of the northern Adriatic with Central Europe. The project is to help prepare investments, define the joint tools increasing the appeal of multimodal transport, and improve the infrastructure connecting those regions. Due to the size of the area, local approach is inadequate so ensure a satisfactory solution, which is why the project adopts a transnational approach, integrating representatives of the countries of the Baltic-Adriatic corridor. The following figure shows the EMPIRIC transport corridor.



Source: ILiM own source

Fig. 4. EMPIRIC transport corridor
Rys. 4. Korytarz transportowy EMPIRIC

The main objective behind the EMPIRIC project is to ensure appropriate conditions for new multimodal services provided within the Baltic-Adriatic corridor and for the related investments so that multimodal transport, especially rail and inland waterway transport, can become a more appealing solution. Other objectives include improving the technological and political instruments which enable transport operators and logistics service providers to develop effective and sustainable transport solutions and supporting the connections between economically viable multimodal services, provided especially between NAPA (North Adriatic Ports) and the regions of Central Europe. It is also important for the partners to prepare initial conditions for the infrastructural investments to be used for new, alternative services provided within multimodal platforms and to evaluate the economic, social and environmental effects of such investments.

The creation of strong structural foundations of economic growth includes an efficient transport system. From the point of view of Poland's development objectives, it is important that the transport not only stops being a barrier hindering economic development of the country but also becomes an element significantly contributing to its development, which can be achieved by building adequate infrastructure and providing high quality services on a free, competitive and indiscriminative market.

With European assistance, building a network of motorways and express roads and modernizing the most important railway lines is a feasible task. Modernization of the basic transport network and providing for high quality transport services so that transport contributes adequately to economic development is the most essential task for the upcoming years until 2025. An efficient transport system will contribute to the improvement of standards of living, improved accessibility to built-up areas, and an increase in foreign investment in Poland. At the same time, the increasing demand for transport posed by the economy will be subject to 'control' in accordance with the principle of sustainable development. By the year 2025, the transport system of Poland will meet all the requirements that the transport system of highly developed countries and it will be able to meet Polish and international transport users' expectations in terms of mobility and high quality transport services in line with environmental standards. Implementation of the various transport Policies and incentives requires further actions in order to create specific documents to develop each separate objective.

The most important transport policy in Poland is the National Transport Policy (NTP) 2006 -2025 which is a concise document of 34 pages which was produced by the Ministry of Infrastructure and approved by the Council of Ministers on 29th June 2005. It is currently the key long-term strategy document in the transport sector in Poland.

The following table shows the incentive policies to multimodal transport mapped by the Empiric project in Poland. The policies below are still active but not mapped as active policies for multimodal transport, not being specifically devoted to it.

Table 2. Incentive policies to multimodal transport in Poland mapped by the Empiric project
Tabela 2. Zachęty dla rozwoju transportu multimodalnego w Polsce zmapowane w projekcie Empiric

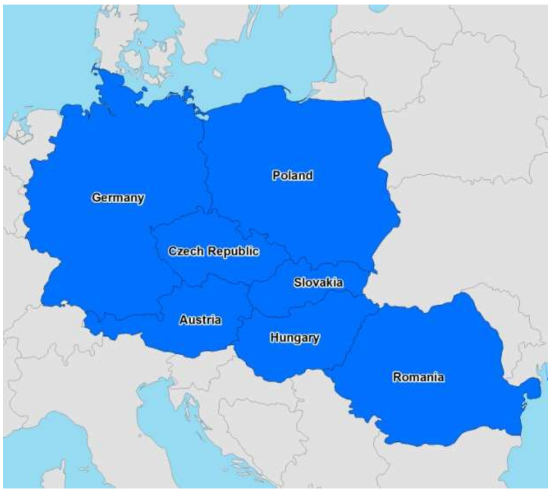
Title	Funding type	Main objective
National Transport Policy 2006 – 2025	Key long term strategy	Key long term strategy document in the sector in Poland
Exemption from real estate and transport taxes	Tax incentives	Originators of new jobs can be totally or partially exempted from real estate tax
Support for employers under the Labour Found	Support for employers	Entrepreneurs who satisfy specific criteria can apply for financial assistance from the Labour Fund
Special Economic Zones	Establish of Special Economic Zones	Accelerate economic growth of the country's regions, make use of post-industrial property and infrastructure e.g. construction of highway, modernization of the railway track or intermodal terminal

Source: EMPIRIC project, Actions to promote multimodal transport in Central Europe, Policies analysis and companies needs

THE FLAVIA CORRIDOR PROJECT

FLAVIA (Freight and Logistics Advancement in Central/South-East Europe - Validation of trade and transport processes, Implementation of improvement actions, Application of co-coordinated structures) is another project addressing the issues of intermodal transport.

The FLAVIA international project is a contribution to the improvement of logistics in Central and South-Eastern Europe. Due to the validation of mechanisms and of transport and commercial processes, the project presents assumptions for the improvement and consolidation of international cooperation conditions. 14 partners from 7 European countries - Germany, Poland, the Czech Republic, Slovakia, Austria, Hungary, Romania - participate in the project by creating the FLAVIA corridor. The following figure shows the FLAVIA transport corridor.



Source: ILiM own source

Fig. 4. FLAVIA transport corridor
Rys. 4. Korytarz transportowy FLAVIA

The project supports intermodal cooperation and joint development of a logistics corridor between Central and South-Eastern Europe. Strengthening intermodal transport between the regions of the corridor helps improve the integration of markets within the European internal market. To ensure the competitiveness of the regions participating in the project, assumptions related to Green Logistics and to shift of freight transport from roads to green modes of transport, such as railway and inland waterways, have also been studied.

Intermodal transport in the FLAVIA corridor has a high potential to develop new trade and transport routes. But, to ensure efficient trade and transport relations in future the transport chains within the region have to be extended and developed. This concerns the establishment of reliable transport services to enhance the accessibility as well as the construction of an integrated transport network that enables multimodal logistics approaches. This requires a number of measures to overcome the barriers identified in the FLAVIA project.

Infrastructural, technical, organizational and administrative measures are as follow:

- Terminals within the FLAVIA corridor have to expand their handling area.
- Modernization of existing multimodal infrastructure for overcoming cross-border problems.
- Capacity of rail infrastructure is assessed as a high obstacle because in many countries the infrastructure does not reflect the needs of the transport market actors. Hence - usage of multimodal transports could have only supportive role in organization of overall transportation solution. Therefore, the extension of the rail capacity should be moved in the focus of national transport plans.
- The rail management systems within the FLAVIA corridor is far away from completion by the different national systems and built in the short and medium run a barrier for intermodal transport. This situation should be changed by a consecutive harmonisation.
- Waiting times due to inefficient organisational processes should be reduced for freight trains at borders within the FLAVIA corridor and on the external borders. The main obstacles at the borders like inefficient cross border processes, heterogeneous licence and legislation within each country as well as interoperability issues should be addressed by bi- and multilateral negotiations and agreements.
- Concerning the requirements of the market players, the costs of rail innovations are perceived as high. This probably is one of the major barriers to the successful adoption

of the innovations in the rail transhipment market. In this market, costs are very important and cannot always be recovered through charging higher prices. For intermodal freight transport necessary innovations should be supported by national and international research and implementation funds.

- Licensing time and responsibilities as a major problem, policy stakeholders should start to create a common licence and legislation level within the FLAVIA corridor as well as the EU. A lot of license and legislation still differ within each FLAVIA country and result in a lot of additional administrative and operative work which makes rail and intermodal transport unattractive.
- The implementation of obligatory safety and security standards within intermodal supply chains (storage, transport process, turnover process, loading unit, wagons etc.) will increase the reliability of this mean of transport drastically [Guszczak, Jeleń, 2013].

INTERMODAL TRANSPORT COUNCIL

The need to intensify intermodal transport development activities was noticed at the national level as well - on 11 December 2012 Sławomir Nowak, the Minister of Transport, Construction and Maritime Economy, established the Intermodal Transport Council [Journal of Laws of 11 December 2012, item 84]. As an auxiliary body, the Council focuses on improving the conditions for the functioning of intermodal transport in Poland by initiating activities to eliminate the existing barriers - both legal and organisational ones - inhibiting the development of this mode of transport. The tasks of the Council will include indentifying the solutions necessary to ensure the development of intermodal transport.

The following organisations supported the creation of the Intermodal Transport Council and became its members: PKP S.A., Instytut Kolejnictwa (Railway Institute), PKP Polskie Linie Kolejowe S.A., PKP Cargo S.A., Civil Affairs Institute (INSPRO) in Łódź, PCC Intermodal S.A., Polzug Intermodal Polska Sp. z o.o., Federation of Independent Rail Operators (ZNPK), Overland Transport Chamber of Commerce (IGTL), Institute of Logistics and Warehousing (ILiM), Polish Chamber of Commerce (KIG) and Polish International Freight Forwarders Association (PISiL).

One of the first tasks of the Council members is to prepare recommendations for amendment of the regulations regarding the methodology for calculating the fees for access to railway infrastructure for intermodal transport.

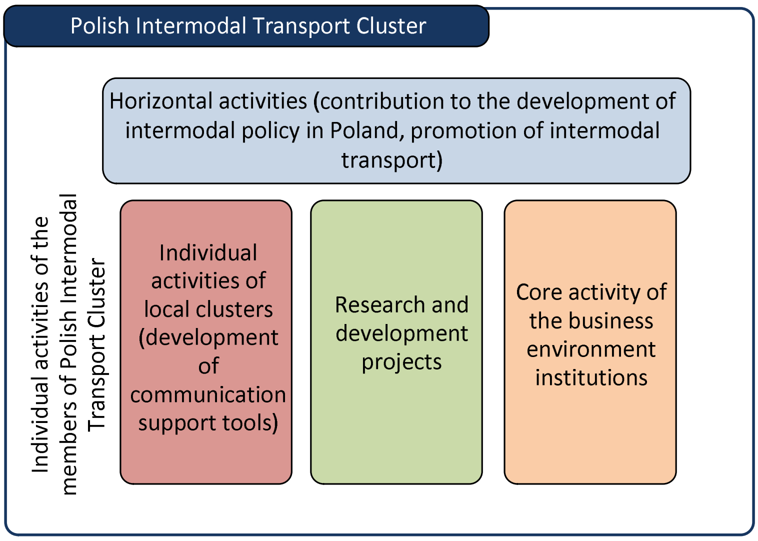
POLISH INTERMODAL TRANSPORT CLUSTER

Entrepreneurs are not indifferent to the development of intermodal transport in Poland, seeing it as an opportunity to increase the efficiency of their logistics chains. They take the steps to integrate the hitherto dispersed actions into one cluster initiative. Coordination of individual initiatives seems necessary since it will permit, via to economies of scale, to eliminate the basic barriers limiting further development of intermodal transport in Poland more effectively and efficiently. Such cluster activities have been initiated by the Institute of Logistics and Warehousing (ILiM), which - as a leading European research unit - together with representatives of selected companies (manufacturing, commercial, service companies) intends to create Polish Intermodal Transport Cluster with the main task of intensifying the actions supporting the development of intermodal transport in Poland. The notion behind the works performed within the cluster is shown in Figure 6.

Cluster activities are generally related to the following areas:

- Cooperation with national and regional authorities, to develop effective transport and infrastructure policies and strategies,
- Facilitate public participation in development policy and strategy building process,

- Providing expertise and assistance in the field of sustainable transport planning and development,
- Promotion and dissemination of innovative technologies and tools in intermodal transport,
- Research and dissemination of knowledge about planning and development of integrated, multimodal transport systems.



Source: Compilation of the Institute of Logistics and Warehousing (ILiM)

Fig. 6. Activities undertaken within Polish Intermodal Transport Cluster
Rys. 6. Aktywności podejmowane przez Polski Klaster Transportu Intermodalnego

CONCLUSIONS

The progressing European integration and globalisation processes have been continuously increasing the distance that freight has to travel. And this is where a special advantage of rail freight transport can be found. Other trends, such as the systematically growing volume of container cargo transhipped in Polish sea ports (in 2012 it grew by almost 23% TEUs when compared to 2011 [Namiary na Morze i Handel, 2013]), development of the infrastructure of container terminals or the increasing significance of energy efficiency of particular modes of transport (the system advantage of rail transport) open new possibilities for intermodal transport as well. Additionally, intermodal transport has become more competitive and more customer-oriented due to the opening of the market, competition growth, and the resultant variety of services offered.

The barriers limiting the development of intermodal transport in Poland presented in the article and the identified activities which are to change this unfavourable situation show how to cope with the challenges connected with the continuously growing volume of freight transport in Poland in a way that is economically viable and responsible towards the environment, the climate and people.

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BARIERY OGRANICZAJĄCE ROZWÓJ TRANSPORTU INTERMODALNEGO W POLSCE Z PERSPEKTYWY ADMINISTRACJI PUBLICZNEJ ORAZ ŚRODOWISKA BIZNESOWEGO

STRESZCZENIE. **Wstęp:** Celem niniejszego artykułu jest identyfikacja barier wpływających na niskie wykorzystanie transportu intermodalnego w Polsce, a także wskazanie obecnie podejmowanych na gruncie administracji publicznej oraz przedsiębiorstw działań mających na celu zmianę niekorzystnej sytuacji, np. powstanie Rady ds. transportu intermodalnego działającej przy Ministrze Transportu, Budownictwa i Gospodarki Morskiej, planowane utworzenie Polskiego Klastra Transportu Intermodalnego.
Metody: Prezentowany artykuł koncentruje się na eksperckiej analizie barier ograniczających rozwój przewozów intermodalnych w Polsce. Autor przedstawił wyniki wybranych projektów badawczych finansowanych ze środków Unii Europejskiej, których był realizatorem, inicjatyw podejmowanych na poziomie Unii Europejskiej oraz administracji rządowej w Polsce.
Wnioski: Przedstawione w niniejszym artykule bariery ograniczające rozwój przewozów intermodalnych w Polsce oraz wskazane działania mające na celu odwrócenie tej niekorzystnej sytuacji, pokazują jak można podołać wyzwaniom związanym ze stale rosnącym wolumenem transportu towarowego w Polsce w sposób ekonomicznie opłacalny oraz odpowiedzialny wobec środowiska, klimatu i człowieka.

Słowa kluczowe: transport intermodalny, bariery w transporcie intermodalnym, projekt FLAVIA, projekt EMPIRIC.

DIE DIE ENTWICKLUNG DES INTERMODALEN TRANSPORTS IN POLEN EINSCHRÄNKENDEN BARRIEREN AUS DER PERSPEKTIVE DES ÖFFENTLICHEN VERWALTUNGSWESENS UND DER BUSINESS-KREISE

ZUSAMMENFASSUNG. Einleitung: Das Ziel des folgenden Artikels ist es, die Hindernisse zu erforschen, die sich auf die geringe Ausnutzung des intermodalen Verkehrs in Polen auswirken und die derzeit durch die öffentliche Verwaltung und Unternehmen getroffenen Maßnahmen zur Veränderung dieser negativen Erscheinung, z. B. Gründung eines Rates für intermodalen Verkehr beim Ministerium für Transport, Bauwesen und Seewirtschaft oder die geplante Eröffnung des Polnischen Clusters für intermodalen Verkehr, zu bestimmen.

Methoden: Der vorliegende Artikel konzentriert sich auf einer Expertenanalyse in Bezug auf die Hindernisse, die die Entwicklung des intermodalen Verkehrs in Polen hemmen. Der Autor präsentierte die Ergebnisse ausgewählter Forschungsprojekte, die aus den Mitteln der Europäischen Union gefördert wurden und an deren Realisierung der Autor selbst arbeitete, sowie bestimmter Initiativen auf der Ebene der Europäischen Union und der Regierungsverwaltung in Polen.
Fazit: Die in dem vorliegenden Artikel erläuterten Hindernisse bei der Entwicklung des intermodalen Verkehrs in Polen und die hier genannten Maßnahmen zur Veränderung dieser negativen Erscheinung zeigen, wie man den Herausforderungen im Zusammenhang mit dem permanent steigenden Warentransportvolumen in Polen auf eine vom Standpunkt der Wirtschaft her rentable und der Umwelt, dem Klima und dem Menschen gegenüber verantwortungsbewusste Art gerecht werden kann.

Codewörter: der intermodale Transport, Einschränkungen innerhalb des intermodalen Transportes, das FLAVIA-Projekt, das EMPIRIC-Projekt.

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ALTERNATIVE CONNECTION BETWEEN TERRITORY OF POLAND AND FAR / MIDDLE EAST COUNTRIES FOR CONTAINERS TRANSPORT

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ABSTRACT. Background: The new cyclical service, available on the Polish market, related to the railway connection between Port of Koper and the terminal in Silesia, enables delivery of containers, skipping the Polish and German ports. To "the opening" of a direct connection with the Adriatic Sea arises dilemma that requires the identification of sustainability of the containers' transport to the Polish territories in economical and ecological terms. The key to this problem is a solution of the equation with several unknowns, which include the cost and time of transport, sea freight operator procedures, infrastructure constraints and the interests of local and regional communities. The analysis of the impact area of rail connection Koper - Slawkow was carried within Empiric project. The assumptions and results are described below.

Material and methods: Based on the experience of the Slawkow-Koper link's operator and analysis of distances, cost, duration of containers transport, the research has been conducted, intended to estimate the area of influence of ports, located on the shores of the four seas surrounding area of Central Europe: Adriatic, Baltic, Black and North, with particular reference to the Port of Koper. The research used publicly available information, calculators, and disseminated investment plans.

Results: Analysis of factors possible to calculate, especially the cost of containers' transport, by adopted assumptions, the study allowed to estimate the theoretical impact area of the Port of Koper. The area covers a large part of Poland, south from the line Szczecin-Brest. Besides aspect of cost impact area has been expanded due to different rail-gauge along the eastern Polish border. Also the environmental aspects indicate south direction of transport containers, as beneficial to the natural environment. As the factors reducing the development of the connections financial policies of the sea freight operators and infrastructure limitations of the northern Adriatic ports were indicated.

Conclusions: Based on the results of the research it is clear that a "southern" connection of the Polish territory with the Far East in the case of container transport is a viable and beneficial option, with exception of the interests of the communities related to the Polish ports. It is only a matter of time, related to planned deadlines of upgrading of Adriatic ports, that southern direction of transport will become the direction successfully competing with the 'traditional' ones. An important factor will be the change of sea freight operators' attitude and pricing policies.

Key words: containers transport, transport of containers.

In the 2011 year company called Baltic Rail started periodic connection between the Port of Koper (Slovenia) and intermodal terminal located in Dąbrowa Górnicza (South of Poland). This way Poland has been opened to the Adriatic Sea by direct intermodal link. Terminal in Dąbrowa Górnicza was the regional node - gate for national market. In the near future the importance of terminal can grow, because of plans of Baltic Rail concerning expansion of Koper connection further into the North and East of Europe. This step finally will initiate direct connection which joints Adriatic and Baltic Seas with periodic and stable link. The initiative of single

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company has initiated the issue of the impact areas of alternative ports.

The impact area of ports in Poland in case of containers transport was subject of some studies. As example the presentation in scope w TransBaltic project [Andrzejewski 2012] which specifies Koper as alternative port for part of Poland - the rail connection with Koper is indicated as an option for transport of containerized goods from Far East to south voivodeships, for 20 feet containers mainly. Another example is the MDS Transmodal Limited study [MDS Transmodal Limited] indicating Poland as biggest potential market for North Adriatic ports.

The mentioned study estimates the share of containers, transported via Suez to / from Poland, as nearly 70% of whole containers turnover in TEU (2010), which creates huge potential for considered connection. Additionally when compare transport via Koper and "north" ports to the Upper Silesia the reduction of power consumption and emissions of dangerous substances (between the others CO2 and NOx) values is estimated on the level of 25%.

Potential volume of connection stream, expected cost and emission reductions are reasons, justified interest in considered redirection of the containers' flow on the European part of line Far East - Poland.

POTENTIAL IMPACT AREA OF REPRESENTATIVE PORTS

The potential of the Koper-Sławków connection (after relocating the connected terminal in 2012) as regional node and its influence on region was the subject of the impact analysis on a macro-regional level in the frames of the EMPIRIC project (Enhancing Multimodal Platforms, Inland Waterways and Railways Integration in Central Europe, the project is implemented through the priority 2 of CENTRAL EUROPE Programme "Improving accessibility to, and within, Central Europe" and is co-financed by the European Regional Development Fund, EMPIRIC is led by the Venice Port Authority / Italy and the project consortium consists of 12 partners including Institute of Logistics and Warehousing / ILiM from Poland), which has been developed to support the start-up and improvement of multimodal connections from/to North Adriatic Ports with Central Europe hinterland. One of the more significant results of the study was the definition of impact areas of the four seas "surrounding" the area of Poland.

The ports of Baltic and North Seas are closest to the area of Poland. Does it means that they are the best solutions in case of shipment from all over the world? When consider the sea freight from America or West Europe there is no discussion - ports of North Germany and Benelux, with feeders (or direct) connection with polish ports are the only reasonable solution. But one look on the map of Europe creates doubts - what about freight from Far East, what about Mediterranean Sea? Should ships to/from that direction go as usual around the whole West Europe? Why? Let's consider the freights from countries of Southern and Eastern Asia only.

IDENTIFICATION OF FACTORS AFFECTING THE AREA OF THE CONNECTION'S INFLUENCE

To determine the impact areas of sea surrounding area of Poland the two most important factors very identified. First one is the cost of transport, second one the time of transit, both considering from the place of shipment (countries of Southern and Eastern Asia) to the end customer.

The main assumption is no difference of other features of transports via different sea or direction, like safety or additional cost of, for example, handling.

The potential impact area of the connection has been determined on the basis of:

- identification of major streams of goods in intermodal transport for the connection;
- financial efficiency of freight using the subject connection as compared with alternative routes and methods of freight organisation;

– time efficiency of freight.

The above factors are fundamental criteria in the decision-making process related to delivery or shipment of goods. Other factors, including local interests or politics, are less significant. Some entrepreneurs agree to additional costs or the extension of transit time, provided that freight is carried out by domestic partners. The so-called "local patriotism" is also reflected in the operation of political organisations and local government bodies, promoting preferential treatment of local or domestic entrepreneurs.

IDENTIFICATION OF SIGNIFICANT LIMITATIONS

There are a number of practical limitations that affect the shape of the impact area. Major limitations include:

- comparable rates for freight of 1 TEU from China to any European port, regardless the freight distance, other factors related to business policies of ship-owners, forwarders and carriers,
- limitations of the ports related to the shallow water passage, which requires earlier partial unloading of containers in neighbouring ports or involves feeder transport, resulting in an overall extension of freight duration;
- throughput of rail lines,
- price competition.

In the long run, however, such limitations can be mitigated. For instance the Ministry of Economic Development and Technology of Slovenia will spend 15.7 million Euros (including cohesion fund subsidies) on dredging the water-way in the Port of Koper (from 11.4 to 15 m), thus enabling access to the port to ships with a larger draught. This shall improve navigational safety and increase the competitiveness and appeal of the Port of Koper. The project shall be completed by April 2015. Similarly in the long term a possible increase in the stream of cargo via the ports of southern Europe and competition on freight market shall enforce the diversification of rates for freight.

The cargo capacity of trains in terms of the stream transshipped is not the limitation. According to Market study on the potential cargo capacity of the North Adriatic ports system in the container sector [MDS Transmodal Limited]: The RailNetEurope corridors provide a nearly-complete core hinterland rail network for NAPA (North Adriatic Ports Association). At the same time the study indicates bottlenecks, influencing the further development of rail links for freight from the Far East, to eliminate in long term.

It should be stressed that the impact area has been determined with the assumption that above limitations will be mitigated in the near future.

Another limitation is the change in wheel gauge at the border of the westernmost countries of the former Soviet Union. The change significantly hinders transport across historic borders and affects the impact areas of ports.

Additional limitation, which has to be considered, is geographical considerations, e.g. location of mountain ranges, rivers and the temporary freezing of seas. However, the discussed impact area is so saturated with transport infrastructure (the land part) that such limitations have no substantial effect on the impact area.

THE DETERMINATION OF THE CONNECTION'S EXPECTED IMPACT AREA

For the purpose of the analysis, instance ports were selected, as representative of particular sea:

- Koper (the Adriatic Sea),
- Odessa (the Black Sea),
- Hamburg (the North Sea),
- Gdańsk (the Baltic Sea).

Considering freight from any direction and distance / time of transport to / from nearest considered port, excluding limiting factors (such as differences in wheel gauge in the East and in the West), a division of the Baltic -

Adriatic corridor on the impact areas of individual ports is shown in Figure 1.

Borders of the impact areas run along the western, southern and south-eastern borders of Poland. The impact area of the port of Gdańsk, apart from whole Poland, includes the small north-western part of Ukraine, almost the whole territory of Belarus (except its south-eastern part) and obviously, Lithuania, Latvia and Estonia and the Kaliningrad Region; it cannot be assumed, however, that the latter regions shall be serviced by Gdańsk.

A hypothetical division between the Hamburg and Koper impact areas runs along the Prague-Nurnberg line and between the Koper and Odessa impact areas - along the western border of Ukraine and Romania.

Source: ILiM own study based on maps.google.pl

Fig. 1. Estimated impact area of ports (freight from undetermined directions)
Rys. 1. Szacowany obszar oddziaływania portów (fracht z nieokreślonych kierunków)

Table 1. Distances and freight transit times from Shanghai to considered ports
Tabela 1. Dystanse i czas frachtu z Szanghaju do rozważanych portów

Port		Distance *[Nm]*		Estimated duration of freight *[days]*	
shipment	Collection		*Difference Shanghai-Koper*		*Difference Shanghai-Koper*
Shanghai	Koper	8,439	-	24,1	-
	Odessa	8,288	*- 151*	24,7	*0.5*
	Hamburg	10,657	*2,218*	31,7	*7.6*
	Gdańsk	10,998	*2,559*	32,8	*8.6*

Source: www.searates.com

The situation is different when we consider only the stream of goods delivered to Europe from the Middle and Far East. In this case, the difference in distance of freight between the ports in Koper and in Gdańsk is as much as 2 550 nautical miles. Distances and theoretical transit times (not resulting from freight timetable and possible stops in intermediate ports) are shown in Table 1.

Considering the values in the above table and the average speed in rail freight in transit and target countries, the delivery to Hamburg or Gdańsk via Koper (by sea to Koper and further on by rail) is on average shorter by a couple of days, as compared with the direct sea freight (assuming transshipment in all ports takes the same amount of time).

The impact areas of ports being considered, taking into account only the transit time from Shanghai, are shown in Figure 2. Due to the slightly shorter transit time to Koper, the division line Koper-Odessa was moved to the east. Assuming that recipients/senders value delivery time the most, the area of Europe subject to discussion can be divided into only two impact areas: the Adriatic Sea ports and Black Sea ports. The interesting thing is that the border between the two impact areas separates areas with various wheel gauge (except Romania), and thus limitation due to changing wheel gauge does not apply here.

Source: ILiM own study based on maps.google.pl

Fig. 2. Estimated impact areas of the ports in relation to the time of TEU delivery to the customer (Far Eastern freight)

Rys. 2. Szacunkowe obszary wpływu portów w relacji do czasu dostawy TEU do klienta (fracht z Dalekiego Wschodu)

Source: ILiM own study based on maps.google.pl

Fig. 3. Estimated impact areas of the ports in relation to the cost of TEU delivery to the customer (Far Eastern freight)
Rys. 3. Szacunkowy obszary wpływu portów w relacji do kosztu dostawy TEU do klienta (fracht z Dalekiego Wschodu)

However, in the case of freight from the Far East, a reduction in transit time by ca. one week is not always a decisive factor. This is in contrast to overall costs of freight, where the cost factor is always the most crucial.

The following assumptions concerning the costs of TEU freight were assumed in order to determine the impact areas of ports:

- sea freight: 0.48 EUR/km,
- rail freight: 0.55 EUR/km,

Average rail freight rates were determined based on suppliers' price lists for the last two years (2011-2012). Distances of sea freight were taken from the global shipping costs calculator.

Costs relating to road transport (terminal-customer and customer-terminal) were omitted since the distance from the terminal to the end customer is independent from the port of transshipment.

Under such assumptions, without considering additional limitations, impact areas of selected ports are as shown in Figure 3.

Considering the transport costs (and time of delivery), the impact area of Koper and Odessa extend significantly to the north. The central part of Poland can be equally well serviced by Koper and by Odessa. The analysis proves that in both cases this is a cheaper and faster solution than the use of Baltic ports or Hamburg. Only the areas of northern Poland and northern Germany strongly "gravitate" towards the Baltic Sea and the North Sea ports.

When consider the Polish territory only, thanks to differences in wheel gauge, the impact area should be extended by the area of eastern Poland. Finally Figure 4 shows economically justified and delivery-time efficient impact area of the Adriatic Sea, represented by Port of Koper. The area covers bigger part of Poland, southern from the line Szczecin-Brest, including cities like Warszawa, Poznań, Łódź, Kraków and whole Silesia.

Source: ILiM own study based on maps.google.pl

Fig. 4. Estimated impact area of the Port of Koper in Poland (freight from the Far East)
Rys. 4. Szacunkowy obszar wpływu portu w Koprze (transport z Dalekiego Wschodu)

After expected development of ports in the Szczecin region the division line will be moved in its west part insignificant to the north, but it will not have considerable influence on the result of research.

Finally when consider time and cost of delivery of containers from the Middle and Far East with described assumptions the significant part of Poland should be server by north ports of Adriatic Sea. The influence of port Gdańsk and in the future port in the Szczecin region will be limited to the voivodeships with direct access to the sea.

CONCLUSIONS

Concluding the area of Poland in bigger part should be server, when considering containers transport form Far East, by ports located in the north part of the Adriatic Sea. The determined potential impact area covers most area of Poland despite the publications connected with NAPA indicated only the closest countries (geographical hinterlands [MDS Transmodal Limited]) as potential market for mentioned ports. The limitations of the development of south direction transport are technical parameters of the ports in mentioned area and policies of the ship or freight operators, which do not differentiate rates of the shipments of TEU from the East to particular port in Europe.

The growth of the flow volume, development of ports and transport infrastructure should lead to change of the rules and further development of the connection. As example can be indicated the Korean car factories, located in Slovakia, which are served from south direction. It is worth to indicate, that distance between polish border and Kia factory in Żylina, is less than 50 km.

South link expansion may not gain social acceptance, especially of entities interested in the development of Polish sea ports. However, the anticipated reduction in emissions and energy consumption fully justifies promoting of the link.

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ALTERNATYWNE POŁĄCZENIE TRANSPORTU KONTENERÓW POMIĘDZY TERYTORIUM POLSKI ORAZ KRAJAMI DALEKIEGO / ŚRODKOWEGO WSCHODU

STRESZCZENIE. **Wstęp:** Nowa dostępna na polskim rynku cykliczna usługa, związana z kolejowym połączeniem portu w Koprze z terminalem na Śląsku, umożliwia dostarczenie kontenerów z pominięciem polskich i niemieckich portów. Wobec otwarcia bezpośredniego połączenia z Morzem Adriatyckim powstaje dylemat, wymagający identyfikacji zrównoważonego w sensie ekonomicznym i ekologicznym kierunku transportu kontenerów na tereny Polski. Klucz do tego problemu to rozwiązanie równania z kilkoma niewiadomymi, do których należy zaliczyć koszt i czas transportu, procedury operatorów frachtów morskich, ograniczenia infrastruktury, a także interesy lokalnych i regionalnych społeczności. W ramach realizacji projektu Empiric przeprowadzona została analiza wpływu kolejowego połączenie Koper - Sławków, której założenia i wyniki zostały opisane poniżej.
Metody: Na podstawie doświadczenie operatora połączenia Koper-Sławków oraz analizy dystansów, kosztów, czasu trwania frachtów i transportu kolejowego kontenerów, powstało badanie, mająca na celu oszacowanie obszaru wpływu poszczególnych portów, zlokalizowanych u wybrzeży czterech mórz, otaczających obszar środkowej Europy: Adriatyckiego, Bałtyckiego, Czarnego i Północnego, ze szczególnym uwzględnieniem Portu Koper. Do badań wykorzystane zostały ogólnodostępne informacje, kalkulatory oraz upowszechniony plany inwestycyjne.
Wyniki: Analiza czynników możliwych do kalkulowania, zwłaszcza kosztu transportu kontenerów, przy przyjętych założeniach, pozwoliła oszacować teoretyczny obszar wpływu Portu Koper, który obejmuje znaczną część naszego kraju, na południe od linii Szczecin- Brześć. Poza aspektem kosztowym obszar oddziaływania został poszerzony w związku z różnicą rozstawu torów wzdłuż wschodniej granicy Polski. Także aspekty ekologiczne wskazują na południowy kierunek transportu kontenerów, jako korzystniejszy dla środowiska naturalnego.
Jako czynniki ograniczające rozwój połączenia należy wskazać politykę finansową operatorów frachtu morskiego oraz ograniczenia infrastruktury portów północnego Adriatyku.
Wnioski: Na podstawie wyników badań należy stwierdzić, że "południowe" połączenie terenu Polski z Dalekim Wschodem w przypadku transportu kontenerów jest rozwiązaniem opłacalnym i korzystnym, z zastrzeżeniem interesów społeczności związanych z polskimi portami bałtyckimi. Jest tylko kwestią czasu, związanego z planowanymi terminami modernizacji portów adriatyckich, żeby południowy kierunek transportu stał się kierunkiem z powodzeniem konkurującym z "tradycyjnymi" kierunkami. Istotnym czynnikiem będzie zmiana stanowiska (i cenników) operatorów frachtów morskich.

Słowa kluczowe: transport kontenerów.

ALTERNATIVE VERBINDUNG FÜR DEN CONTAINERVERKEHR ZWISCHEN POLEN UND DEN LÄNDERN DES FERNEN / NAHEN OSTENS

ZUSAMMENFASSUNG. Einleitung: Die auf dem polnischen Markt neue, zyklische, im Zusammenhang mit der Eisenbahn-Verbindung zwischen dem Hafen in Koper (SLO) und dem Terminal in Schlesien (PL) in Betrieb genommene Dienstleistung ermöglicht die Beförderung von Containern ohne die Inanspruchnahme der polnischen und deutschen Häfen. Angesichts der Eröffnung einer direkten Anbindung an die Adria entsteht ein Dilemma, das die Ermittlung des im wirtschaftlichen und ökologischen Sinne nachhaltigen Container-Transports in Richtung Polen erforderlich macht. Der Schlüssel zur Lösung dieses Problems ist eine Lösung der Gleichung mit mehreren Unbekannten, zu denen man die Kosten und die Zeit des Transportes, Prozeduren von Seefracht-Operateuren, Einschränkungen seitens der Infrastruktur und die Interessen der lokalen und regionalen Gemeinschaften zählen muss. Im Rahmen der Ausführung des Projektes Empiric wurde eine empirische Analyse der Auswirkungen der Bahnverbindung Koper - Slawkow durchgeführt; deren Annahmen und Ergebnisse werden im Folgenden beschrieben.

Methoden: Auf Grund der Erfahrung des Betreibers der Bahnverbindung Koper - Slawkow und der Analyse von Entfernungen, Kosten und Dauer des Fracht- und Container-Transportes auf Schiene entstand eine Studie, der die Einschätzung von Auswirkungen der an vier Meeren (an der Adria, an der Ostsee, am Schwarzen Meer und an der Nordsee) im mitteleuropäischen Raum lokalisierten Seehäfen, unter der besonderen Berücksichtigung des Hafens von Koper, zugrunde lag. Für die Zwecke der Untersuchungen wurden allgemein zugängliche Informationen, Kalkulatoren und bekanntgemachte Investitionspläne in Anspruch genommen.

Ergebnisse: Die Analyse der kalkulierbaren Einflussfaktoren, insbesondere der Kosten des Container-Transportes, erlaubte bei festgelegten Annahmen, den theoretischen Einflussbereich des Seehafens von Koper einzuschätzen. Der Bereich umfasst den bedeutenden, südlich der Linie Szczecin-Brest gelegenen Landesteil Polens. Abgesehen vom Kosten-Aspekt wurde der Einflussbereich dieses Hafens im Zusammenhang mit dem Unterschied der Gleis-Breite der polnischen Ostgrenze entlang ausgebreitet. Die ökologischen Aspekte weisen auch auf die südlich orientierte Richtung der Container-Beförderung als die vorteilhaftere für die Umwelt hin. Als die die Entwicklung dieser Verbindung einschränkenden Einflussfaktoren muss man die Finanzpolitik der Seefracht-Betreiber sowie vorhandene Einschränkungen der Infrastruktur der Seehäfen an der nördlichen Adria nennen.

Fazit: Auf Grund der Ergebnisse kann festgestellt werden, dass die "südliche" Anbindung Polens mit dem Fernen Osten in Bezug auf die Container-Beförderung eine sich lohnende und vorteilhafte Lösung darstellt, allerdings unter Berücksichtigung der Interessen der mit den polnischen Ostsee-Häfen verbundenen Lokalgemeinschaften. Es bleibt also die Frage der Zeit, die man für die Modernisierung der adriatischen Häfen braucht, bis die südliche Richtung des Container-Transportes die Richtung werden wird, die mit den "traditionsmäßigen" Richtungen erfolgreich im Wettbewerb steht. Ausschlaggebend wird die Veränderung der Betrachtungsweise (und der Preislisten) seitens der Seefracht-Betreiber sein.

Schlüsselwörter: Containerverkehr, Transport von Containern.

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A HEURISTIC APPROACH TO THE DAILY DELIVERY SCHEDULING PROBLEM. CASE STUDY: ALCOHOL PRODUCTS DELIVERY SCHEDULING WITHIN INTRA-COMMUNITY TRADE LEGISLATION

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ABSTRACT. Background: Delivery scheduling plays a significant role in business activities of enterprises which operate on EU market, especially the ones which deal with production and trade of alcohol products. The character of such activities requires to take into consideration various regulations which determine many guidelines and constraints in storing and transporting of such products between EU countries. On the other hand, these issues are not well recognized in the literature.

Methods: Authors proposed a heuristic algorithm for solving the problem of scheduling this type of deliveries. Basing on the constraints and input data, which includes demand for deliveries in wider planning horizon, the algorithm creates a daily delivery schedule from one or many suppliers to one consignee. The algorithm takes into consideration the consignee's, suppliers' and carrier's interests. This is done by including their constraints as well as by including three criteria in the scheduling process, i.e. minimization of the stock in transit and minimization of the dispersion of loadings and unloadings in consignee's and each supplier's warehouses.

Results: The proposed algorithm has been implemented in spreadsheet with solver extension. It was applied for solving the real delivery scheduling problem in one of alcohol products importing companies, in which manually filling of DRP matrixes method was previously used. The results show that algorithm works correctly and efficiently in comparison to previously used method.

Conclusions: The results show, that there is a need for further research on the field of determination suppliers order in the scheduling process. The possibility of implementation of multiple criteria analysis or optimization methods for solving such problems may be also a good direction of further research.

Key words: delivery scheduling, Intra-Community Trade, importation of alcohol products, heuristic approach, spreadsheet implementation, optimization.

INTRODUCTION

Delivery scheduling plays a significant role in business activities of enterprises which operate on EU market, especially the ones which deal with production and trading of alcohol products. The character of such activities requires to take into consideration various regulations which determine many guidelines and constraints in storing and transporting of such products between EU countries. More extensive description of such issues may be found in authors' previous works [Grajek 2011a, 2011b, 2012, Grajek and Żak 2012]. The key issues which should be considered are as follows:

1. The excise warehousing regime for excise-duty suspended goods: very limited number of warehouses is available on the market. There are also legal and technical

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difficulties in changing capacities of such warehouses.
2. Very difficult or in practice impossible to introduce transshipments of excise goods.
3. Homogenous and full truck loadings are desired due to tax & customs requirements.
4. No necessity to conduct customs clearance. However there is necessity to declare in advance the exact time and place of delivery.
5. International transport, specific distances, time of transportation and means of transport characteristic for EU.

The aim of this work is to solve the daily delivery scheduling problem in which alcohol products are delivered from one or many suppliers to one consignee within Intra-Community Trade regulations. In order to fulfill this aim authors proposed a heuristic algorithm which was implemented in spreadsheet software and then applied to solve the real problem in one of alcohol products importers.

MATERIAL AND METHODS

Delivery scheduling is an activity in which the size and future dates of deliveries are determined on the basis of inventory level forecast [Fertsch 1996]. Delivery scheduling problem is a subclass of wider class of scheduling problems. Scheduling problems applies to such areas as: management, production, transportation, computer systems and others [Zinder, Shkurba 2001]. Scheduling problems are usually formulated as P or NP-hard combinatorial problems [Lenstra, RinnooyKan 1978]. There are many different approaches to solving of such problems in the literature. These approaches are depended on the character and complexity of solved problems. Very often dynamic programming method is used for solving such problems, e.g. in works authored by Chen and Chung-Yee [2008], Cheng, Wang [2010], Hall and Potts [2005], Kovalyow and Cheng [2001] or Lixin and Hua [2009]. Approximation techniques, which are less time and resources consuming, are utilized in case of more complex instances of the problem. Some examples of such techniques are: genetic algorithms [Cha et al. 2008], fuzzy logic [Xue et al. 2001], tabu search [Garcia and Lozano 2005, Herka 2004], simulated annealing [Gupta et al. 1999] as well as other heuristics [Tang et al. 2008]. The problem considered in this work is a specific instance of delivery scheduling, as many stakeholders are involved in the decision process, i.e. consignee (e.g. alcohol products importer), suppliers (e.g. alcohol products exporters) and carriers. It should be noticed, that in case of alcohol products Intra Community Trade market, the consignee and suppliers are often associated within one consortium. Interests and constraints of each stakeholder should be meet in order to create an effective supply chain which will be able to satisfy the final consumers' needs. Also all regulations related to trade of excise goods between various EU countries should be meet [Grajek 2011a, 2011b, 2012, Grajek, Żak 2012]. Authors have not managed to find any article scoped on solving this type of scheduling problems. They develop a heuristic algorithm for solving such problem. The algorithm and its implementation are presented in the next paragraphs of this paper.

The proposed algorithm utilizes the following criteria: stock in transit minimization and minimization of the daily dispersion of loadings and unloadings in supplier's and consignee's warehouses. Stock in transit minimization is related to the transport cost minimization. There are a lot of constraints related to excise goods transport under Intra Community Trade regulations. For example, from practical point of view if transport is done under excise-duty suspended procedure it is very complicated to join excise and non-excise goods in one trailer. Thus transport cost of excise goods may be higher than transport cost of non-excise goods and much higher than logistic cost related to the warehouses operations, such as loadings and unloadings. Therefore the criterion of stock in transit minimization is considered as more important than two other used within algorithm. The two other criteria are related to the cost of warehouses' operations. Authors make an assumption that consignee is the decision maker in the scheduling process. The consignee is interested more in optimization its own operations, than in optimization its suppliers operations. Furthermore very often consignees do not manage its suppliers operations, so it is only capable to propose them a delivery schedule. Such situation occurs in the case presented in 'Results' chapter. Therefore the criterion of minimization of the dispersion of unloadings in consignee's warehouse is considered as more important than the criterion related to the dispersion of loadings in suppliers' warehouses.

The algorithm requires the following input data: defined quantity of deliveries from suppliers to the consignee within wider planning horizon (e.g. one week or month), the minimal transport time between each consignee-supplier pair as well as possible dates:
- of loadings in each supplier's warehouse;
- unloadings in consignee's warehouse;
- of transporting shipments.

The second group of constraints is related to days in which loadings, unloadings or transport activities are not possible due to national or company's regulations, e.g. weekends, public holidays, stocktakings, days of increased sales and others. Third group of constraints, which is optional, defines warehouses and carrier capabilities, i.e. the maximum number of loadings, unloadings and shipments per day as well as the maximum capacities of consignee's and suppliers' warehouses. The algorithm allows also to define the number of predefined loadings and unloadings in consignee's and each supplier's warehouse for each day. So it is possible to model shipments delivered from/to other suppliers/consignees.

The algorithm is consisted of five main phases, i.e.:

6. Determination the optimal dates of loadings for each consignee-supplier pair.
7. Determination the order of suppliers in delivery scheduling process. Selection the first supplier.
8. Creation the best possible unloading schedule in consignee's warehouse for selected consignee-supplier pair.
9. Creation the best possible loading schedule in selected supplier's warehouse which does not worsen the schedule created in phase 3.
10. Updating loadings and unloadings schedules. Checking whether the schedule has been created for all suppliers. If "yes" then the algorithm ends. Otherwise the algorithm selects the next in order supplier and returns to phase 3.

In the first phase of the algorithm the optimal dates of loadings are determined. The optimal dates are these for which the stock in transit is minimal, i.e. there is no waiting for loading or unloading caused by non-working period of the warehouse and the transport time is not extended by days when transport of goods is not allowed. The algorithm check for each possible day of unloading whether the transport time equals to the minimal transport time and whether there is a possibility to load the shipment in supplier's warehouse at the day, when the transport should begin. Only dates that meet these conditions are taken into account in further phases of the algorithm. The optimal dates are determined separately for each consignee-supplier pair.

In the second phase of the algorithm the order of suppliers in delivery scheduling process is determined. In business practice, this order may be a result of cooperation conditionings between consignee and each supplier. These conditionings may be related to political or technical issues, such as lead times. Thus the situation, where there is only one possible order, may occur. However, one cannot exclude that the decision maker is able to change this order. In this case the decision maker may use such criteria as: the total quantity of shipments delivered from each supplier, the duration of transport between consignee and each supplier, the number of days when loadings are possible, the number of optimal dates of loadings or others.

In the third phase of the algorithm the best possible unloadings schedule in consignee's warehouse is generated for selected consignee-supplier pair. The optimization criterion here is the minimization of the dispersion of unloadings. The measure of the dispersion is the sum of squared subtraction of the number of unloadings in consignee's warehouse at day di minus the mean value of unloadings in consignee's warehouse in the planning horizon. So the goal function is nonlinear (see. eq. 1). This form of the goal function is better than the mean dispersion from the mean value of unloadings in consignee's warehouse. In the first case any dispersion from the mean value worsens the goal function more noticeably. There are following constraints in the optimization process in this phase: the maximum number of loadings in consignee's warehouse and unloadings in selected supplier's warehouse.

$$GOAL = \min(R^2) = \min\left[\sum_{di=1}^{x}(U_{di} - \overline{U})^2\right] \qquad (11)$$

where:

R^2 - dispersion of the number of unloadings in consignee's warehouse within the planning horizon,

U_d - number of unloadings in consignee's warehouse at day *di*.

$\overline{U}$ - mean value of unloadings in consignee's warehouse within the planning horizon.

di - index of optimal day of unloading, di∈{1,2,…,xi} where *xi* is the last optimal day in the planning horizon for the consignee-supplier *i* pair.

There may be more than one optimal unloadings schedule. Thus in the fourth phase of the algorithm the optimization of the loading schedule for selected supplier is done. The goal function (see eq. 2) is formulated analogously as in phase 3 of the algorithm as the dispersion of the number of loadings in supplier's *i* warehouse within the planning horizon. There are the same constraints as in phase 3 of the algorithm. One additional constraint related to the dispersion of the number of unloadings in consignee's warehouse within the planning horizon, which cannot be worse that the dispersion computed in phase 3 of the algorithm, is added.

$$GOAL = \min(R_i^2) = \min\left[\sum_{li=1}^{y}\left(L_{li}^i - \overline{L^i}\right)^2\right] \qquad (2)$$

where:

R_i^2 - dispersion of the number of loadings in supplier's *i* warehouse within the planning horizon,

L^i_{li} - number of loadings in supplier's *i* warehouse at day *d*,

$\overline{L^i}$ - mean value of loadings in supplier's *i* warehouse within the planning horizon.

li - index of optimal day of loading in supplier i warehouse, li∈{1,2,…,y} where *yi* is the last optimal day of loading in supplier's *i* warehouse in the planning horizon.

In the last phase of the algorithm predefined loadings and unloadings schedules are updated by the results obtained in phase 4 of the algorithm. Then the algorithm checks whether all of the suppliers have been considered in the delivery scheduling process. If the answer is "yes", then the algorithm ends. Otherwise the algorithm selects the next in order supplier and returns to phase 3. It should be noticed that the unloading schedule for the newly selected supplier includes scheduling results for all earlier suppliers.

RESULTS

The presented algorithm has been implemented in MS Excel 2010 software. The standard version of the solver, which is delivered with this software, is utilized in optimization phases of the algorithm. The implemented algorithm was tested by authors on the real data obtained from one of the alcohol product importers. Due to the necessity to maintain full confidentiality, some random changes had to be applied to the data set which is utilized in the computational example presented in this paper. However these changes were applied in the manner, which does not affect the major characteristics of the considered problem.

The considered company is located in Poland. It is associated in one of the international corporations of alcohol products producers. Thus the company is the exclusive distributor of corporation's products on Polish market. Alcohol products are imported mainly from three EU countries, but there may be more than one supplier or more than one loading location in each country. Depending on the period of time, from a dozen to several dozen of various SKU's are imported from some or all suppliers. Transport is done exclusively by external carriers, which utilize fleets consisted of side-loading semi-trailers. Goods are transported as palletized unit loads. Assumed distances between loading and unloading places are relatively long. Therefore shipments are considered as full truck loads (homogenous or heterogeneous). Due to Intra Community Trade regulations transport takes place in excise duty suspension procedure using eAD document. So all deliveries are unloaded in company's excise warehouse. EXW Incoterms rule is applied in the transport process.

Delivery scheduling of products imported from other EU countries was previously conducted with the usage of typical DRP matrixes which were manually filled by planners hired by the company. The computational tools were utilized by planners only for data analysis and automatic recalculations of DRP matrixes. The decision about the quantity of pallets, which have to be delivered to the company each day, is made by planners and manually entered into DRP matrixes. Therefore the delivery scheduling process requires a lot of time, knowledge and experience from planners, while the results are not reproducible nor optimal.

The planning horizon in the considered problem is set to 56 days (8 weeks). The shipments are delivered from three suppliers. The quantity of shipments, which have to be delivered from each supplier every week, is determined on the basis of sales forecast and current stock. Detailed input data related to suppliers is presented in table 1.

Table 1. Input data related to suppliers
Tabela 1. Dane wejściowe dotyczące dostawców

Parameter	Supplier 1	Supplier 2	Supplier 3
No. of deliveries at week 1	3	10	8
No. of deliveries at week 2	3	9	2
No. of deliveries at week 3	4	5	8
No. of deliveries at week 4	5	8	10
No. of deliveries at week 5	5	7	5
No. of deliveries at week 6	5	10	2
No. of deliveries at week 7	8	5	9
No. of deliveries at week 8	4	10	6
Total no. of deliveries	37	64	50
Transport time [days]	2	1	3
Days, when loadings are not possible	6, 7, 13, 14, 20, 21, 26, 27, 28, 34, 35, 41, 42, 48, 49, 55, 56	6, 7, 10, 13, 14, 18, 19, 20, 21, 24, 26, 27, 28, 34, 35, 38, 41, 42, 48, 49, 52, 55, 56	none
Total no. of days without loading possibility	17	23	0

Source: own work

Table 1 shows that supplier's 1 warehouse does not work in the weekends and in one additional day which is reserved for stocktaking. In case of supplier's 2 warehouse, the non-working days are in each weekend. Two more days are non-working due to national holiday in supplier's 2 country. One more day is reserved for stocktaking and four more days for other activities related to fulfillment of sales plans. The consignee's warehouse does not work at days no. 6,7,13,14,20,21,25,26,27,28,34,35,41,42,48,49, 54,55,56, i.e. 19 days in total. Supplier's 3 warehouse as well as carriers do not have any constraints related to working days within the planning horizon. The scheduling process is conducted within pull system. Also consignee's, suppliers' and carrier's capabilities related to warehousing and transport processes are much higher than needed in this case. Thus there is no need to use constraints related to these aspects.

The consignee's fiscal warehouse does not have predefined any other shipments planned to be delivered within the planning horizon. Table 2 shows loadings in suppliers' warehouses realized for other consignees within the planning horizon.

The results generated by the proposed algorithm are shown below. Optimal dates of unloadings were calculated at the 1st phase of the algorithm. The results are shown in table 3.

Table 2. Schedule of predefined loadings to other consignees in supplier's warehouses
Tabela 2. Dchemat załadunków do innych odbiorców w magazynach dostawcy

Suplier 1														
	Day (d)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	SUM
d+0	4	7	9	3	2	0	0	5	6	1	5	4	0	0	46
d+14	5	5	8	6	2	0	0	2	4	5	7	0	0	0	44
d+28	5	4	5	4	3	0	0	4	5	2	3	5	0	0	40
d+42	5	2	0	3	5	0	0	6	3	5	4	4	0	0	37
Suplier 2															
	Day (d)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	SUM
d+0	8	7	5	4	3	0	0	6	6	0	9	8	0	0	56
d+14	2	9	7	0	0	0	0	1	3	0	1	0	0	0	23
d+28	1	6	5	8	1	0	0	4	9	0	4	7	0	0	45
d+42	7	4	5	0	8	0	0	2	1	0	1	8	0	0	36
Suplier 3															
	Day (d)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	SUM
d+0	8	5	2	3	9	0	4	5	5	6	4	3	10	2	66
d+14	6	0	0	7	0	2	8	2	3	9	9	7	0	6	59
d+28	6	5	7	5	7	9	9	6	7	8	6	1	10	0	86
d+42	10	0	4	2	3	4	10	0	6	9	6	9	0	6	69

Source: own work

Table 3. Optimal days of unloadings for each supplier
Tabela 3. Optymalne dni rozłunku dla poszczególnych dostawców

Parameter	**Supplier1**	**Supplier 2**	**Supplier 3**
Optimal days of unloadings	3,4,5,10,11,12,17,18,19,24,31, 32,33,38,39,40,45,46,47,52,53	2,3,4,5,9,10,12,16,17,18,23,24,30, 31,32,33,37,38,40,44,45,46,47,51,52	All with the exception of days 1, 2, 3 and these resulting from consignee's constraints
Total no. of optimal days	21	25	34

Source: own work

In the second phase of the algorithm the order of suppliers in the delivery scheduling process was determined. Due to the cooperation conditionings between consignee and suppliers, the following order was determined: supplier 1 -> supplier 2 -> supplier 3.

Due to the nonlinearity of the goal functions, the solver extension was configured to use Generalized Reduced Gradient method in 3rd and 4th phase of the algorithm. The optimization was conducted for each consignee-supplier pair on Intel Core i7 Q720, 4GB RAM system. The final results generated by the algorithm are shown in tables 4 and 5.

Table 4. Schedules of loadings and unloadings in suppliers' and consignee's warehouses generated by the algorithm
Tabela 4. Schemat załadunków i rozładunków w magazynach dostawców i odbiorców wygenerowany przez algorytm

Supplier 1															
	Day (d)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	**GOAL**
d+0	5	8	10	3	2	0	0	6	7	2	5	4	0	0	137,71
d+14	6	7	9	6	2	0	0	7	4	5	7	0	0	0	140,86
d+28	7	6	6	4	3	0	0	6	6	4	3	5	0	0	89,14
d+42	7	5	3	3	5	0	0	8	5	5	4	4	0	0	90,86
														sum	**458,57**
Supplier 2															
	Day (d)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	**GOAL**
d+0	11	10	7	6	3	0	0	10	9	0	11	8	0	0	279,14
d+14	5	10	8	0	0	0	0	7	5	0	1	0	0	0	164,24
d+28	4	7	6	10	1	0	0	9	11	0	7	7	0	0	224,86
d+42	10	5	5	1	8	0	0	8	5	0	1	8	0	0	179,71
														sum	**848,00**
Supplier 3															
	Day (d)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	**GOAL**
d+0	12	9	2	3	10	0	4	6	5	6	4	6	10	4	166,29
d+14	6	3	0	7	8	4	8	2	3	9	9	10	1	6	156,86
d+28	6	6	7	5	8	9	9	7	7	8	6	5	11	2	60,57
d+42	11	1	4	2	7	4	10	2	6	9	6	9	0	6	157,43
														sum	**541,14**
Consignee															
	Day (d)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	**GOAL**
d+0	0	3	4	7	7	0	0	1	4	4	2	3	0	0	60,00
d+14	3	3	4	3	4	0	0	8	8	7	0	0	0	0	18,00
d+28	3	4	3	3	4	0	0	1	5	4	2	5	0	0	17,71
d+42	4	4	5	4	5	0	0	4	6	6	4	0	0	0	101,43
														sum	**320,29**

Source: own work

Table 5. Results generated by the scheduling algorithm
Tabela 5. Wyniki wygenerowany przez algorytm harmonizujący

Parameter	**Consignee**	**Supplier 1**	**Supplier 2**	**Supplier 3**
Number of planned loadings/unloadings	151	204	224	330
Number of scheduled loadings/unloadings	151	204	224	330
Value of the goal function before optimization conducted in phase 4	320,29	464,57	874,00	551,14
Value of the goal function after optimization conducted in phase 4	320,29	458,57	848,00	504,57
Phase 4 improvement of the goal functions values [%]	0	1,3%	3,0%	8,4%
Computational time [s]	267	55	90	122

Source: own work

As it is shown in tables 4 and 5, the algorithm managed to schedule all of the planned deliveries in 267 seconds. So it needed much less time to complete the task than average planner hired in the company. Generated schedules were also usually better than schedules generated by planners from the goal functions perspective. The optimization conducted in phase 4th of the algorithm resulted in the average improvement of suppliers' schedules by 4,2%.

DISCUSSION

In order to check whether further improvements of the goal functions values are possible, authors assumed that there is a possibility to change the order of suppliers in the scheduling process in the second phase of the algorithm. Additional five computational experiments were conducted for the input data presented in previous chapter. These experiments cover all possible combinations of suppliers order. The algorithm managed to schedule all planned deliveries in each experiment. The detailed results of all six experiments were summarized in table 6.

Table 6. Values of goal functions, improvements in loading schedules after phase 4 optimization and computational time of each of six experiments which were conducted

Tabela 6. Wartości celów funkcji, poprawy w schematach załadunków po przeprowadzeniu optymalizacji z punktu 4 we wszystkich 6 eksperymentach

	Values of the goal functions					Phase 4 average	Computational
Order	Consignee	Supplier 1	Supplier 2	Supplier 3	All suppliers	improvement [%]	Time [s]
S1->S2->S3	320,29	458,57	848,00	504,57	1811,14	4,2%	267
S1->S3->S2	344,29	458,57	894,00	527,43	1880,00	4,7%	300
S2->S1->S3	312,29	508,57	838,00	550,29	1896,86	4,4%	263
S2->S3->S1	344,29	458,57	838,00	512,57	1809,14	4,7%	303
S3->S1->S2	380,29	442,57	874,00	529,14	1845,71	5,8%	338
S3->S2->S1	380,29	486,57	888,00	529,14	1903,71	5,6%	342
					mean	4,9%	302,17

Source: own work

As it is shown in table 6, values of the goal functions may depend on the order of suppliers determined in 2nd phase of the algorithm. The best result on the value of criterion related to consignee's warehouse, i.e. 312,29, is achieved for the following suppliers order: S2 -> S1 -> S3. Comparing this order with the character of input data one may presume that the best result on the value of mentioned criterion may be achieved by ordering suppliers by the minimal time of transport (from the shortest one to the longest one), or by the number of days in which there is no possibility to load the shipment (from the largest number, to the smallest number). However further and more extensive research is needed in order to draw more binding conclusions. On the other hand, the values of the goal functions related to suppliers' schedules may achieve their best values for other suppliers order. E.g. the sum of the suppliers' goal functions achieved the best result in case of S2->S3->S1 order. However at this point it is almost impossible to draw any conclusions about the ordering rules which result in the best values of goal functions related to suppliers' warehouses. This may be related to the fact, that the criterion of minimization of the dispersion of unloadings in consignee's warehouse is considered in the algorithm as more important than the criteria related to suppliers' warehouses. Therefore the optimization of this criterion results in narrowing of the feasible solutions sets for other criteria. It should be also noticed, that in case of each experiment, the computational time was similar and oscillated near 5 minutes value. The average improvement of the goal functions after optimization done in 4th phase of the algorithm was 4,9%. This confirms the necessity of including this phase in the algorithm.

CONCLUSIONS

One of the advantages of the proposed algorithm is the fact that it could be easily implemented in standard spreadsheet software which is available in most companies. So there is no need to purchase specialized software.

The proposed algorithm allows to achieve good results in relatively short time. On the other hand the results of the experiments show a need for further research which may be conducted on two fields. The first direction of the research is related to the need to better recognition of suppliers ordering rules in the 2nd phase of the algorithm. The second direction refers to multiple criteria character of the problem. Usage of multiple criteria analysis or optimization methods may lead to achieve better results, especially in the situations, when suppliers and consignees are equally ranked in the decision process or in the situations, when increasing the stock in transit does not imply much higher cost of the whole logistic process.

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HEURYSTYCZNE PODEJŚCIE DO PROBLEMU DZIENNEGO HARMONOGRAMOWANIA DOSTAW. STUDIUM PRZYPADKU: HARMONOGRAMOWANIE DOSTAW WYROBÓW ALKOHOLOWYCH W RAMACH WEWNĄTRZWSPÓLNOTOWEJ WYMIANY HANDLOWEJ

STRESZCZENIE. **Wstęp:** Harmonogramowanie dostaw odgrywa znaczącą rolę w działalności przedsiębiorstw funkcjonujących na rynku Unii Europejskiej, w tym tych zajmujących się produkcją i obrotem wyrobami alkoholowymi. Specyfika tejże działalności wymaga uwzględnienia przepisów prawnych, które warunkują szereg wytycznych i ograniczeń w magazynowaniu i przewozach tego rodzaju produktów pomiędzy krajami UE. Jednocześnie problematyka ta jest stosunkowo słabo rozpoznana w literaturze.
Metody: Autorzy zaproponowali heurystyczny algorytm rozwiązywania problemu harmonogramowania tego rodzaju dostaw. W oparciu o dane wejściowe zawierające zapotrzebowanie w dłuższym horyzoncie czasowym oraz przy uwzględnieniu ograniczeń, zaprezentowana procedura pozwala na ustalenie harmonogramu dostaw od jednego lub wielu dostawców do jednego odbiorcy z dokładnością do jednego dnia. Algorytm uwzględnia interesy odbiorcy, dostawców oraz przewoźnika poprzez uwzględnienie ich ograniczeń oraz zastosowanie trzech kryteriów w procesie harmonogramowania, tj.: minimalizacji zapasu w drodze, a także minimalizacji rozrzutu liczby załadunków w magazynach odbiorcy i dostawców.
Wyniki: Zaproponowany algorytm zaimplementowano w arkuszu kalkulacyjnym z dodatkiem solver. Zaaplikowano go do rozwiązania rzeczywistego problemu w jednej z firm importujących wyroby alkoholowe, w której stosowano dotychczas metodę manualnego wypełniania tablic DRP. Rezultaty wskazały na poprawność działania algorytmu i jego wysoką efektywność względem dotychczas stosowanej metody.
Wnioski: Rezultaty wskazały na potrzebę dalszych badań w zakresie wyboru kolejności harmonogramowania dostaw od poszczególnych dostawców, a także na możliwość zastosowania narzędzi wielokryterialnej analizy lub optymalizacji do rozwiązywania tego rodzaju problemów.

Słowa kluczowe: harmonogramowanie dostaw, węwnątrzwspólnotowa wymiana handlowa, import wyrobów alkoholowych, podejście heurystyczne, implementacja w arkuszu kalkulacyjnym, optymalizacja.

DER HEURISTISCHE VERSUCH ZUM PLANUNGSPROBLEM DER TAGESLIEFERZEIT. DER KASUS: LIEFERZEITPLAN VON MONOPOLWAREN IM RAHMEN DES INNERGEMEINSCHAFTICHEN HANDELS

ZUSAMMENFASSUNG. Einleitung: Der Lieferzeitplan spielt eine wichtige Rolle für die auf dem Markt der Europäischen Union funktionierenden Firmen. Er ist besonders bedeutend für die Firmen, die sich mit der Herstellung und dem Umsatz von Monopolwaren beschäftigen. Die Eigentümlichkeit einer solchen Wirtschaftstätigkeit erfordert, dass viele gesetzliche Regelungen beachtet werden müssen, die auch zahlreiche Richtlinien und Beschränkungen in Lagerhaltung und Transport von diesen Produkten in der Europäischen Union bedingen. Man soll hier betonen, dass diese Problematik bisher nur in einem gewissen Maße in der betreffenden Literatur erforscht wurde.

Methoden: Es wird die heuristische Methode für den obengenannten Lieferzeitplan vorgeschlagen. Die Methode ermöglicht die Festsetzung des Lieferzeitplans von einem oder vielen Lieferanten zu einem Empfänger (auf den Tag genau) in Anlehnung an die Eingabedaten, die den Bedarf in längerer Zeit und mit Rücksicht auf die Beschränkungen enthalten. Die Methode berücksichtigt die Interessen sowohl des Lieferanten, des Empfängers als auch des Transporteurs, denn sie beachtet die Beschränkungen und nutzt drei Kriterien, d.h. Minimalisierung des Bestandes, der unterwegs ist, Minimalisierung der Verladungsverteilung und Minimalisierung der Entladung.
Ergebnisse: Die Methode wird in den Kalkulationsbogen, der mit einem Solver ausgerüstet ist, implementiert. Die Methode kann auch in einer Firma, die Monopolwaren importiert, angewendet werden. Früher hat diese Firma die Methode von DRP Matrix-Ausfüllen in Anspruch genommen. Die Ergebnisse haben bewiesen, dass die neue Methode richtiger und besser als die früher benutzte ist.
Fazit: Die Ergebnisse beweisen, dass die weitere Forschung notwendig ist und die Methoden von Multikriterien-Analysen und die betreffende Optimierung in Frage kommen.

Codewörter: Lieferzeitplan, innergemeinschaftlicher Handel, Monopolwarenimport, der heuristische Versuch, Optimierung, Implementierung in den Kalkulationsbogen.

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FRANCHISING AS AN INSTRUMENT OF INTEGRATION IN HIGHER EDUCATION

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ABSTRACT. Background: It can be observed recently, that the sector of educational services is seen to have potential of changes in the system of the higher education. The problems of this area are more and more visible ones along with the growth of its competitiveness, which are a consequence of demographic changes and the maladjustment of an educational offer to the need of the labor market. Therefore, the tendency to the concentration seems to be more and more distinct and fully justified one, especially for private universities. The franchising seems to be a mechanism, which is most predestined for this type of actions covering the area of educational services. The essence and the possibilities of the implementation of franchising methods are presented in this paper. The process of creation of a franchising system and factors determining its choice as well as the mechanism of its implementation in the education were described.

Methods: The paper is based on the analysis of literature sources and indicates the possibility to use the potential of franchising in the management of a university. The attempt was made to present this problem in the context of a franchisor and a franchisee as well as possible market changes.

Results and conclusions: The paper is a study of the literature and uses the experiences of the implementation of franchising in various services areas. Its purposefulness as well as the possibilities of its application in higher education was shown. The lack of results of researches in this area makes impossible to precise the system and the scope of its implementation. The need of such researches was shown as well as the need of preparing a report showing the existing facts and possibilities to use franchising methods in this area.

Key words: management, services, education, higher education, franchising systems, franchising, franchisors, franchisees.

INTRODUCTION

Franchising is quite new and special type of economical and business relationships in Poland. Therefore there are not enough results of researches or legal solutions. The associated terminology raises also a lot of controversy. Initially, English description "franchising" or French "franchise" (privilege) was used in this context. However, the Council of Polish Language acknowledged already in 2001 the word "franczyza" to be a correct and proper one.

However, both previous descriptions are still in use in the literature.

The turbulent environment and especially changing demand and its qualitative requirements for educational services offered by universities allows to make an assumption, that franchising can be an institution to be used to stabilize and to develop this market in the intended direction.

The globalization and the internationalization of many business areas, including the

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educational one, leads to the franchising implementation [Burzio 2010, Pecerskaja 2009]. The globalization creates gaps on national markets, which enables to adopt the international proposals concerning franchising methods. It could also concern educational services which implement the distance learning. The internationalization of educational services at the higher level (originated by Bologna Declaration) causes to begin the cooperation with foreign universities. There are also proposals of franchising in this area.

THE IDEA OF FRANCHISING AND REASONS FOR ITS IMPLEMENTATION

There are many reasons of franchising. The European Franchising Code gives following definition: Franchising is a system of sales of goods, services or technology, which is based on close and continuing cooperation between financially and legally independent enterprises, between franchisor and its franchisees [Ziółkowska 2010]. The other definition describes franchising as the relationships between market partners, where the owner of goods, services or technological process gives a right to sell them under the name of the owner and on his/her conditions. Additionally the owner receives some financial benefits for that relationship [Sztucki 1998]. Therefore, the franchisee profits from the reputation and experiences of the franchisor.

As it can be stated in above-mentioned definitions, the franchisor devolves on the franchisee (being independent company) rights and obligations to conduct business operations according to his concept. Franchising is based on the agreement, where the frameworks and the period of the duration of the cooperation between parties is determined and settled.

Initially the franchising system was used mainly in the distribution of goods, but gradually together with the growth of the globalization and the competitiveness, it began to be used also in other areas of the business. It was implemented in the growing number of branches, especially in the dynamic area of services. The franchising system in this area takes benefits from the brand (whose reputation stimulates the demand), know-how of the donor as well as his support. The acceleration of the development of a company and the integration among services companies is the effect of the implementation of a franchising method. It could give an effect in higher quality of more professional attitude in offered services. Of course, signing the franchising agreement results, as it was already mentioned, in the obligation to pay charges in favor of the franchisor.

It should be emphasized that franchising may appear in the form of various connections depending on the business type, the type of business connection or the form of business activities as well as relationships between contracting parties. Therefore there are many forms of the franchising agreement. One of them is the service franchising, when the subject of the agreement is the procedure of services and the need of obeying procedures in exchange for using the donor's brand. In such a case, usually the direct (individual) franchising comes in use, which enables to tighten relationships and cooperation between partners. All activities and cooperation is strictly between partners, which are contracting parties. The franchisor conducts all services, covered by the agreement, personally in favor of the franchisee. The franchising agreement is a new concept in Polish law, without strict legal regulations. It causes many difficulties connecting with its implementation into practical solutions. The additional difficulty is the fact, that the franchising agreement is an agreement of no special name. It connects elements of many various agreements such as: sales, license, agency and joint-venture one. The giver of the franchising agreement should provide the model of business activities within the frames of proposed system. At the other side the franchisee receives a packet of rights and obligations, which creates certain rules of the conduct. The big part of his obligations is related to the care of brand and image of the franchisor.

DETERMINATES OF IMPLEMENTATION OF FRANCHISING ON THE MARKET OF EDUCATIONAL SERVICES

As it was mentioned already before, educational services are a special type of business area, where franchising can be used. The main subject of franchising in this area is the service procedure using the brand and logo of a franchisor, especially these which have a great market value.

It is especially important in case of higher education in Poland due to few reasons. The first one - the choice of the university by a candidate is based on his faith in the high educational level of a university and its ability to train professionals according to the demand of the labor market. Therefore the image of the university, its identity and a valuable brand is of big importance. These features are created over long period of time, being a valuable intangible asset, which requires constant attention. This attention and care for the brand value and offered services requires decisions related to areas of intended and unintended relationships, in which the university is a party as well as to develop appropriate operating procedures. It also confirms an assumption that at present universities cannot operate in the isolation from the environment. This situation occurs particularly in case of big competitiveness on the educational market in connection with decreasing number of candidates (due to demographic reasons), which could be observed especially in Poland. This issue is connected with activities and the growth of so called "social responsibility" of the organization. It means long-term realization of the aim of the organization while developing right relations with stakeholders and operating in accordance with law and ethical standards [Gasparski 2004]. This responsibility is especially important in educational services and at the same time very difficult to be precisely defined.

The quality of educational services is difficult to be measured and to be assessed. Generally it is defined as an indicator how much the realization of a service meets the expectations of a client [Mazur 2002]. Taking into account the previously given definition of the quality, it is difficult to precise this responsibility in the area of educational services.

There are many factors, which have influence on the quality like a syllabus and a scope of the knowledge, i.e. an educational minimum which should be fulfilled. Yet this scope is not always fully accepted by clients. Therefore it is necessary to maintain above-mentioned relationships with the environment of the university. The orientation of some universities only "inside", the faith in its tradition and lasting value is very often the reason of the decrease of brand value of such universities.

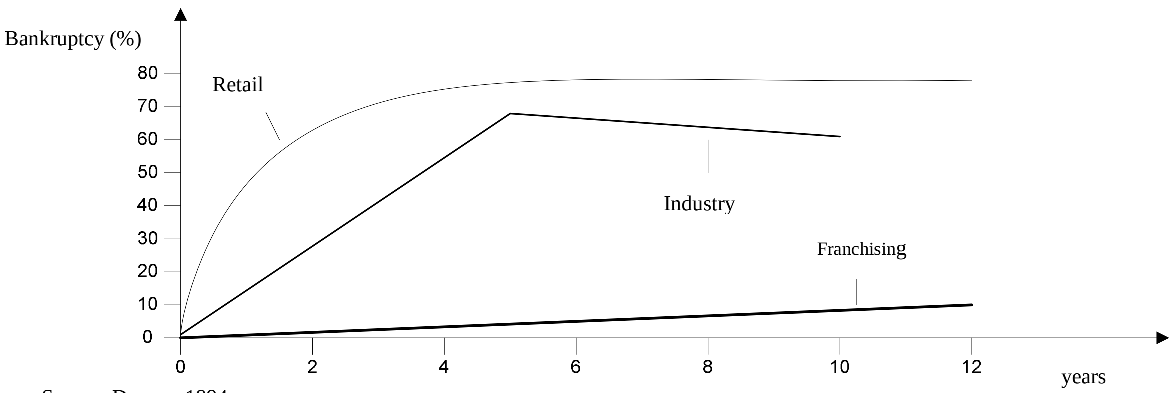
The growing competitiveness on the market of educational services, the decreasing number of candidates and the diverse university image causes the liquidation of this university or, in best case, takeover by stronger universities.

Assuming the concentration process of universities for unavoidable one and remembering that many of these universities have big properties, the franchising idea seems to be worthy of use. Due to the subject of activities the best type of franchising would be so called business format franchising [Ziółkowska 2010], characterized by licensing of donor's brand and know-how. Of course, franchisor would supervise the maintenance of the university reputation. It would be a kind of cooperation franchising, characterized by chargeable transfer of so called franchising packet, which is the subject of the agreement. It should be emphasized, that the parties of an agreement can shape freely the content of the franchising agreement, which is of big importance in case of franchising of educational services. Till now, the franchising system has developed especially dynamical in catering networks. It should be pointed here, that this service includes a lot of material elements. However the development of franchising is much slower in other areas of services like educational, hairdresser, cosmetic, financial or tourist services. It should be emphasized that there is still lack of reputable foreign franchisors of services operating on Polish market.

The reasons of the use of franchising system in educational services are specific. To maintain the good reputation of the company and to have ability to operate in a big way is very important for a franchisor. The preservation of the autonomy of the university (which is a franchisee) allows to keep basic activities in its hands, restricting them e.g. by supervisor and direct control of employees. It reduces franchisor's costs and enables spatial expansion and the strengthening of brand value while the franchising agreement is fully respected. It should be stated, that the concentration of a university and therefore stronger control of educational services is a necessary condition in present global reality. The provision of educational services based on franchising given by strong universities of good reputation, is the only opportunity to survive for worse universities. In such a situation, the advantages of franchising system are much higher than limitations of this system.

Franchising relationships in the area of higher education are not always executed, although they are built on mutual dependency and cooperation. Therefore franchising is not free of risks, contradictions and conflicts. It influences the final decision of universities to accept this system or not. It is necessary to understand the specific features of franchising and its organizational and economical limitations.

The above mentioned relevance must convince possible franchisees that franchising of educational services is available and effective type of operation for higher universities. It is also confirmed by foreign experiences, which show that the percentage of bankruptcy by enterprises operating on the base of franchising agreement is very low (Fig. 1).



Source: Dovgan 1994

Fig. 1. Stability of franchising structures
Rys. 1. Ilustracja stabilności struktur franczajzingowych

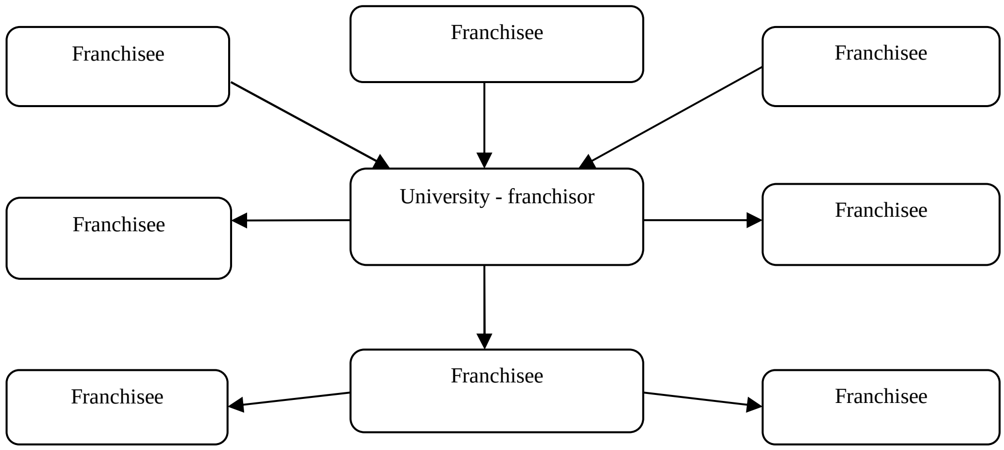
The other very important fact is that the globalization and the development of communication technologies enable the development of a positive reputation of foreign universities on domestic markets. The use of their brand by franchising system allows their promotion and not only the popularization of franchisor's image.

Assuming that national potential purchasers of foreign educational services show no big mobility, it can be stated that there is a big demand for distance learning. It allows avoiding limitations connected with the distance between the place of residence and the place of obtaining educational services in reputable universities.

It should be added that franchising system, using the reputation and brand of foreign universities do not require big expenditures. It is related to marketing costs, which show growing tendency in the environment of growing competitiveness on the market of educational services and decreasing demand of potential purchasers.

Finally, providing educational services based on franchising agreement, allows not only broadening of university's activities but also the fulfillment of modern international service standards in the area of educational services.

Operating in franchising system enables to create nets, which configuration is presented in Figure 2.



Source: own work

Fig. 2. Configuration of franchising net of the university
Rys. 2. Konfiguracja franczajzingowej sieci uczelni

ORGANIZATIONAL AND LEGAL CONDITIONS FOR THE DEVELOPMENT OF FRANCHISING IN HIGHER EDUCATION

The problem of franchising system in Polish education is recognized only in a small part. Practically this system is implemented only in creating of language schools. The definition of educational franchising and conditions of its functioning in Polish reality is given in the Guide for Experts, which was prepared within the framework of Matra Mato 2/PL/9/1 project. This definition is as follows: "franchising is the situation, when a university agrees to authorize another university (in Poland or outside boarders) to conduct accepted program, while it maintains the general control over the subject, realization, evaluation and assurance of the quality of the education. There are some differences among various franchising relationships. In Poland, the institution, which operations are based on franchising relationships, is obliged to fulfill all Polish requirements for higher schools [Guide for Experts 2004].

The act "Law of Higher Education" does not mention in any of its parts about possibilities of the use of franchising method to increase the competitiveness on the educational services market. There is only one remark in Part 1 "General Rules", Article 6.1. point 2 that "an university has a right to cooperate with other universities and scientific centers (also foreign ones) to realize scientific researches and development projects based on the agreements and to gain funds from the realization of researches, including their commercialization and supporting the mobility of researchers" [Law of Higher Education 2005].

There is a remark in the Part 2 Articles 18, 19, 20, 21, 22, 23 entitled “Creation and liquidation of universities” about creation, liquidation, change of the name and connection with other university [Law of Higher Education 2005].

Finally the following record can be found in the Part 3 “Organization of a university” Art. 85.1, Point 1 and 2: “the university has the right to create new organizational units outside its base location in the form of:

- basic organizational unit of an university,
- a branch,

to fulfill its didactic goals” [Law of Higher Education 2005].

There is one factor related to mutual cooperation between a franchisor and a franchisee which is emphasized among all factors of economical and organizational nature, which characterizes disadvantages of educational franchising. Its principles are related to the conception of specific investments connected with formulating of special type of assets [Balboa, Slavnova 1996]. The peculiarity of university assets of franchisees covers following activities:

- the purchase of specialized programs necessary to provides educational services,
- investments of specialized equipments or buildings,
- to possess the staff, capable of providing educational services on base of franchising.

The subject of the estimation of franchising relationships is:

- the effect of long-term relationships of parties of the commercial license,
- the effectiveness of the use of existing resources,
- the quality of bought goods related to the educational service,
- the risk of cooperation in the framework of franchising,
- the coordination of operations of parties of the franchising agreement,
- the significance of franchisor’s brand for potential receivers of educational services.

The possibility to use the brand of the high value is one of most important factors of franchisee’s success. It is necessary to prepare reports for franchisor, who creates sometimes extensive franchising networks (cooperates in franchising system with many universities). The creation of franchising network is a risky operation for a franchisor, due to the fact, that providing educational services at weak level by only one of franchisees can cause the decline of the confidence to all universities operating in this net. Therefore, before taking the decision to access to a franchising network, universities should examine carefully the reputation of the franchisor’s brand and its possibility to provide good competitive position.

The conflict of goals of the franchisor and the franchisee is a typical feature of educational franchising. The franchisor’s goal is to increase profits in the form of license fees from brutto profits received by the sale of educational services. He is interested in the increase of these services. Franchisees are also interested in the profit, the price determined by them is one of the factors, which affects the profit.

The effectiveness of franchisee’s university depends on the level of the help, provided by the franchisor. The training of the whole staff of the franchisee’s university is of special importance. It is necessary to acquire the necessary knowledge and habits by this staff. Additionally current help is also very important, e.g. in elaborating marketing data provided by the universities which operate in franchising system or in the operational implementation of changes in the technology of educational services occurring due to errors or innovations. The objective reasons for creating positive development of relationships between a franchisor and a franchisee are created through numerous contacts between their representants at the professional and organizational levels.

The significance of close contacts ensuring the effectiveness between a franchisor and the franchisee’s university lies in the motivation of franchisees to increase their efforts in providing educational services base on franchising agreement, as well as to reduce the risk related to possible conflicts between parties of the agreement. The relationships between parties are usually included in the agreement, which allows excluding the ambiguity of the interpretation of processes aspects of providing educational services. The goals of the creation of an organization in the area of educational franchising are as follows:

- to improve cooperation between two partners,
- to ensure proper conditions to solve occurring problems,
- to create contacts.

CONCLUSIONS

The economical processes occurring on the markets are related to the globalization as well as to the technological progress. Therefore the market environment of the organization is more and more unpredictable. The organizations, which want to survive on the market, are forced to quick adaptations and usually to broaden the range of their activities. Various forms of the internationalization are used for this purpose. The educational franchising is one of them.

The franchising system gives the typical market features to educational services at the higher level.

It can be concluded from presented pondering that the implementation of franchising system in modern conditions creates chances to uniform the level and the quality of the education at the university level. These possibilities are especially important for many weaken universities to survive on the market and for maintaining by them expected level of provided educational services. It is especially important due to the fact, that in many cases they facilitate the necessary access to the education. Although the franchising system, which enables to use the brand and intellectual resources, necessary for educational purposes, is related to the big risk, e.g. in case of incomplete and unreliable information provided by the franchisor.

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FRANCZYZA JAKO INSTRUMENT INTEGRACJI W SZKOLNICTWIE WYŻSZYM

STRESZCZENIE. **Wstęp:** Coraz częściej sektor usług edukacyjnych jest postrzegany jako potencjał zmian w systemie szkolnictwa wyższego. Problemy tego obszaru stają się bardziej wyraziste wraz ze wzrostem jego konkurencyjności, które jest następstwem zmian demograficznych i niedostosowania oferty edukacyjnej do potrzeb rynku pracy. W tej sytuacji coraz wyraźniejsza i w pełni uzasadniona jest tendencja do koncentracji, szczególnie w sferze uczelni niepublicznych. Mechanizmem najbardziej predestynowanym do tego typu działań w sferze usług edukacyjnych wydaje się być franczyza. W artykule zaprezentowano istotę i możliwości zastosowania franczyzy w omawianym obszarze. Opisano proces budowy systemu franczyzowego, czynniki decydujące o jego wyborze oraz mechanizm jego zastosowania w edukacji.
Metody: Artykuł oparty o analizę źródeł literaturowych wskazuje na możliwość wykorzystania potencjału franczyzowego w zarządzaniu szkołą wyższą. Zagadnienie to próbowano ująć w kontekście zarówno franczyzodawców, jak i franczyzobiorców oraz możliwych efektów rynkowych i ekonomicznych.
Wyniki i wnioski: Artykuł jest studium literaturowym wykorzystującym doświadczenia zastosowania franczyzy w różnych obszarach działań usługowych. Wskazano na celowość i możliwości jej zastosowania w obszarze szkolnictwa wyższego. Brak wyników badań w tej sferze nie pozwala sprecyzować systemu i zakresu jego wdrożenia. Wskazuje to na konieczność przeprowadzenia badań i przygotowania raportu ukazującego istniejące fakty oraz możliwości zastosowania działań franczyzowych w tym obszarze..

Słowa kluczowe: zarządzanie, sektor usług, edukacja, szkolnictwo wyższe, systemy franczyzowe, franczyza, franczyzodawcy, franczyzobiorcy.

FRANCHISE ALS INSTRUMENT FÜR INTEGRATION IM HOCHSCHULWESEN

ZUSAMMENFASSUNG. Einleitung: Der Sektor edukativer Dienstleistungen wird des Öfteren als ein Potenzial der Veränderungen im System des Hochschulwesens wahrgenommen. Die Probleme aus diesem Bereich werden angesichts des eintretenden Wettbewerbskampfes innerhalb des Bildungssystems immer krasser, sie sind sicherlich auf die demografischen Veränderungen und die Nichtanpassung des Edukationsangebotes an den Bedarf des Arbeitsmarktes zurückzuführen. In dieser Situation zeichnet sich eine klare und völlig begründete Tendenz zur Konzentration ab, insbesondere im Sektor von privaten Hochschuleinrichtungen. Die Franchise scheint ein für solche Aktivitäten innerhalb der edukativen Dienstleistungen am meisten prädestinierter Mechanismus zu sein. Im Beitrag wurden das Wesen und die Möglichkeiten der Anwendung der Franchise im besagten Bereich präsentiert. Man hat dabei den Prozess des Aufbaus des Franchise-Systems, die für dessen Auswahl entscheidenden Faktoren und den Mechanismus dessen Anwendung im Bildungssystem dargestellt.
Methoden: Der auf die Analyse der Literaturquellen gestützte Beitrag weist auf die Möglichkeit der Inanspruchnahme des franchiseartigen Potenzials für die Verwaltung einer Hochschule hin. Die Fragenstellung versuchte man im Kontext sowohl der Franchisegeber, als auch der Franchisenehmer, sowie der möglichen Markt- und Wirtschaftseffekte zu projizieren.

Ergebnisse und Fazit: Der Artikel ist eine Literaturstudie, die die Erfahrungen von der Anwendung der Franchise im Bereich verschiedenartiger Dienstleistungsaktivitäten in Anspruch nimmt. Man hat dabei auf die Zweckmäßigkeit und Möglichkeit deren Anwendung im Hochschulwesen hingewiesen. Der Mangel an Untersuchungsergebnissen auf diesem Gebiet lässt jedoch das System und den Umfang seiner Einführung nicht erschließen. Der Sachverhalt weist auf die Notwendigkeit der Durchführung von entsprechenden Untersuchungen und der Vorbereitung eines Rapportes, der die bestehenden Fakten und die Möglichkeiten der Inanspruchnahme der faranchiseartigen Vorhaben in diesem Bereich projizieren würde, hin..

Codewörter: Verwaltung, Sektor von Dienstleistungen, Bildung, Hochschulwesen, Franchise-Systeme, Franchise, Franchisegeber, Franchisenehmer.

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THE USE OF OXYGEN INDICATORS - ELEMENTS OF INTELLIGENT PACKAGING FOR MONITORING OF FOOD QUALITY

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ABSTRACT. Background: Producers and researchers are looking at not only the methods of protection against ingress of oxygen into the package, but also want to provide consumers with guarantees of quality food they buy. Therefore, large-scale studies are conducted and implementation of intelligent packaging. The operation of these packages is the use of interactive, the most colorful indicators to assess the quality of the packaged product.
Methods: This article describes intelligent packaging technologies and presents research for different types of oxygen indicators.
Results and conclusion: Indicators for the detection of oxygen allows the consumer to provide some information on the suitability of the product for consumption. Apart from that, they are a simple tool that allows you to reduce the costs associated with loss replacement, repair damaged products or their disposal. Construction of indicator contained in the package is related to the specific product and factor to be controlled.

Key words: intelligent food packaging, oxygen indicators.

INTRODUCTION

Oxygen is an essential element for all living organisms and also plays an important role in many chemical industrial processes, including those in which an absence of oxygen is required. On the other hand, oxygen level in the package headspace can increase with time due to poor sealing, air permeation through the package materials, and the package tampered with or damaged during storage and/or transportation. As the result, the food can be contaminated with oxygen and spoiled. Whereas conventional oxygen detection methods require expensive instruments and trained operators, visual oxygen indicators are cheap and enable consumers to detect the presence of oxygen in the food package with naked eyes [Ahvenainen, 2003]. Therefore, it is no surprise that the removal of oxygen in the food packaging industry is of immense importance. Producers and researchers are looking at not only the methods of protection against ingress of oxygen into the package, but also want to provide consumers with guarantees of quality food they buy.

In order to maximise the quality and safety of foodstuffs, a prediction of shelf-life based on standard quality control procedures is normally undertaken. Replacement of such time-consuming and expensive quality measurements with rapid, reliable and inexpensive alternatives has lead to greater efforts being made to identify and measure chemical or physical indicators of food quality. The possibility of developing a sensor for rapid quantification of such an indicator is known as the marker approach [Kress-Rogers, 2001].

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Determination of indicator headspace gases provides a means by which the quality of product and the integrity of the packaging in which it is held can be established rapidly and inexpensively. One means of doing so is through the production of intelligent packaging incorporating gas sensor technology [Kerry et.al.2006]. Therefore, large-scale studies are conducted and implementation of intelligent packaging. As a result, global market of intelligent packaging in 2008 represented a $1.4 billion, increasing to $2.3 billion by 2013 [Restuccia et al., 2010]. The operation of these packages is the use of interactive, the most colorful indicators to assess the quality of the packaged product. Oxygen sensors are used in intelligent food packaging, which monitors the condition of packaged food to give information on the food quality during transport and storage [Ahvenainen 2003]. Using sensors is related to the specifics of the product and factor that is to be inspected. Sensors for the detection of oxygen allow the consumer to provide some information on the suitability of the product for consumption. Also, ideal oxygen indicator should meet several conditions: characterized by ease of use and reading, speed, attractive price, high sensitivity and reliability. In addition, indicator should be very inexpensive, and not add significantly to the overall cost of the package. It should be non-toxic, and have non-water soluble nature. Besides, the sensor components should have approval for use in food-contact materials [Puligundla et al., 2012]. Construction of indicator contained in the package should relate to the specific product and factor to be controlled.

The potential advantages of oxygen indicators for foods are many and varied. Apart from aspects of quality, safety, and distribution, intelligent packaging offers considerable potential as a marketing tool and the establishment of brand differentiation for products. As a result, intelligent packaging with oxygen indicators can effectively provide solutions to current producer and consumer problems. Also, it appears likely that intelligent packaging systems for food will become more commercially viable and common-place in the years to come [Kerry et.al., 2006].

INDICATORS AS ELEMENTS OF INTELLIGENT PACKAGING

Intelligent packaging (also more loosely described as smart packaging) is packaging that in some way senses some properties of the food it encloses or the environment in which it is kept and which is able to inform the manufacturer, retailer and consumer of the state of these properties. Although distinctly different from the concept of active packaging, features of intelligent packaging can be used to check the effectiveness and integrity of active packaging systems [Hutton 2003]. Intelligent packaging devices are capable of sensing and providing information about the function and properties of packaged food and can provide assurances of pack integrity, tamper evidence, product safety and quality, and are being utilized in applications such as product authenticity, anti-theft and product traceability [Summers 1992, Day 2001]. Also, intelligent packaging makes it possible to monitor specific parameters in the medium of the packaged product [Bilska 2011].

Intelligent packaging devices include sensors, time-temperature indicators, gas sensing dyes, microbial growth indicators, physical shock indicators, and numerous examples of tamper proof, anti-counterfeiting and anti-theft technologies. Information on intelligent packaging technology can be obtained from other reference sources [Summers 1992; Day, 1989, 2001]. Besides, intelligent packaging systems attached as labels, incorporated into, or printed onto a food packaging material offer enhanced possibilities to monitor product quality, trace the critical points, and give more detailed information throughout the supply chain [Rodrigues & Han, 2003]. Intelligent tags such as electronic labelling, designed with ink technology in a printed circuit and built-in battery radio- frequency identity tags, all placed outside the primary packaging, are being developed in order to increase the efficiency of the flow of information and to offer innovative communicative functions. Diagnostic indicators were first designed to provide information on the food storage conditions, such as temperature, time, oxygen or carbon dioxide content, and thus, indirectly, information on food quality, as an interesting complement to end-use dates [Dainelli et al., 2008]. Indicators are called smart or interactive because they interact with compounds in the food. Microwave heating enhancers, such as susceptors and another temperature regulation methods, are sometimes regarded as intelligent methods as well.

OXYGEN INDICATORS-REVIEW

First reports concerning indicators of oxygen presence were delivered in the 1970s. The structure of an indicator attached to the packaging is connected to the character of the product and factor which should be monitored. Indicators which change their color are most frequently used. The change of the color is combined with activity of a selected factor and allows for evaluation of the quality of the packed product . Indicator should be easy to use and read, should be cheap, should work fast and be highly sensitive. Most of these indicators are based on colour change as a result of a chemical or enzymatic reaction. These indicators have to be in contact with the gaseous environment inside the package and hence are in direct contact with the food [De Jong et al., 2005]. Also, in the following section, presented examples of different types of oxygen indicators and their characteristics.

Lee et al. [2008] developed a new range of colourimetric oxygen indicators that are irreversible, reusable, and UV-light activated. Such "intelligent ink" oxygen sensors comprise a UV-absorbing semiconductor, such as TiO_2, a redox-indicator, such as methylene blue, a sacrificial electron donor, such as triethanolamine, and an encapsulating polymer such as hydroxyethyl cellulose; the ingredients are mixed together, with water as the solvent, to form an ink. The ink can be coated or printed subsequently onto a variety of substrates to produce a blue oxygen indicator film, which, when activated by UV light, becomes colourless. The activated, that is, UV-photobleached, film remains colourless unless, or until, exposed to oxygen, at which point the reduced methylene blue is reoxidised back to its original blue form. Generated in this reaction, electrons are the particles of semiconductor SC [e-], and the electrons reduce the dye to a colorless form Dox Dred. The reduced form of the dye quickly returns to its original color in the presence of oxygen. This cycle can be repeated inducing UV index [Mills, 2005]. Some commercial colorimetric oxygen indicators already exist, for example the Ageless Eye produced by the Mitsubishi Gas Chemical Company, but these indicators suffer from high retail costs and some ambiguity as package integrity indicators, due to their reversible nature. These indicator tablet turns from blue into pink within 2-3 hours after O_2 has reached a zero concentration at $25^{O}C$ and into blue again in about five minutes when it is in contact with O_2. In 2009, Mills and Hazafy proposed nanocrystalline *nc*SnO_2-based, UVB-activated oxygen indicator. Instead of TiO_2, they used SnO_2 as a photosensitiser. These UV-activated colourimetric oxygen indicator comprising: polymer/SED/redox dye/photocatalyst, where polymer = HEC, donor = glycerol, dye =MB and photocatalyst = *nc*SnO_2. Also, the use of *nc*SnO_2 as a photocatalyst in the UV activated oxygen-sensitive inks opens up many possible avenues of application as it allows for a much more controllable UV-activation step.

Vu and Won prepared in [2013] novel water-resistant UV-activated oxygen indicator. This novel alginate-based UV-activated oxygen indicator, which is not only highly resistant to dye leakage, but also fast in the colour recovery. Alginate is a linear anionic polysaccharide containing blocks of [1,4]-linked b-D-mannuronate [M] and a-L-guluronate [G] residues from brown seaweeds and bacterial species, and has been applied to various areas including biomedicine, food, and biocatalyst due to its biocompatibility, low toxicity, low price, and mild gelation by addition of divalent metal ions such as Ca^{2+} [Fernández-Pan, Ignacio, & Caballero, 2011; Kanmani et al., 2011; Lee & Mooney, 2012; Mongkolkajit, Pullsirisombat, Limtong, & Phisalaphong, 2011; Rehm, 2010; Won, Kim, Kim, Park, & Moon, 2005]. They used alginate because most of the redox dyes used for oxygen indicators are cations, and discovered that alginate can form water-insoluble complex with a redox dye. In this indicator alginate was used as the coating polymer so that it can bind to a redox dye and thus prevent the dye from leaching into water.

The most common dye used in the indicators is methylene blue, which is typically white in the reduced state and blue in the oxidised state. Other redox dyes used in O_2 indicators are 2,6-dichloroindophenol [Shirozaki, 1990] and *N,N,N',N'*-tetramethyl-p-phenylenediamine [Lenarvor, et al.,1993]. A reducing compound is added to the O_2 indicator to reduce the dye and to keep it in the reduced state during the packaging process. Common reducing compounds for O_2 indicators are reducing sugars, but inorganic salts as well as reduction by irradiation have also been used. An alkaline compound is added to the indicator to maintain the pH on the alkaline side and thus prevent too rapid an oxidation reaction of the dye [Mattila-Sandholm, 1998; Perlman, 1985]. Inorganic compounds, such as sodium hydroxide, potassium hydroxide, calcium hydroxide and magnesium hydroxide, have typically been used for this purpose [Arin 2001; Yoshikawa, 1982]. Krumhar & Karel [1992] presented two-step colour reaction indicator. In the first reaction step O_2-sensitive material is oxidised and the formation of an acid or peroxide occurs. These components will cause a colour change in the specific colorant included in the system.

Sumitani et al., [2004], presented oxygen indicator based on an organic/inorganic hybrid compound consisting of methylene blue, a cationic surfactant and a reductant intercalated into saponite. Researches proposed a mixture of a blue colored dye, methylene blue, a reductant in the form of ascorbic acid or reducing sugar, and cetyltrimethylammonium ion intercalated into synthetic saponite became colorless in an atmosphere having an oxygen concentration of less than 0.1 vol%, and then returned to its blue color as a result of subsequent exposure to air. Besides, oxygen indicator, in the form of a thin film coated on paper prepared by adding a pigment, phloxine B, to the above organic/inorganic hybrid compound, exhibited a pink color at oxygen concentrations of less than 0.1 vol%, and a blue color at oxygen concentrations of higher than 0.5 vol%.

Others researchers proposed oxygen indicator, formulated from a combination of electrochrome, titanium dioxide and EDTA [Roberts et al., 2001]. They used polyviologen electrochromes which showed much faster reduction after exposure to UV light. Viologens are a family of electrochromic compounds which are pale in the oxidised form and highly coloured in the reduced form [Monk, 1998]. Besides, viologens have highly anodic redox potentials. Polyviologens retain the redox properties of the viologen parent compounds but are less susceptible to possible migration within food packaging [Factor, 1972 ; Simon, 1972]

Kaas R.L., in [2010], prepared oxygen indicator dye formulation utilizing methylene blue has been used to qualitatively demonstrate the oxygen barrier level of four side sealed pouches made with various barrier laminations before and after retort processing. Presented method can be used to assess barrier of the entire package and demonstrate areas of localized damage to the barrier. This indicator was prepared to quick and efficient means of assessing the barrier level of completed packages. Also, the formulation of oxygen indicator was based on methylene blue and glucose dissolved in water adjusted to pH of 11-12 with NaOH. Natural agar is added to gel the system and immobilize the indicator

Lawrie et al., [2012] presented simple inkjet-printed, UV-activated oxygen indicator. In this indicator colloidal TiO_2 particles are made prior to inkjet-printing, allowing a water-based, UV activated, oxygen-sensitive ink for inkjet printing to be formulated that is suitable for printing by a DOD PIJ desktop printer. This colorimetric oxygen indicator does not contain a resin, consisting only of titania intimately mixed with MB and tartaric acid, and so is unlike any previous O_2-sensitive inks, such as the powder TiO_2/MB/glycerol/HEC inks. On the other hand, more recently, TiO_2 inks contributing added photocatalytic functionality [Arin et.al., 2011; Oh et.al., 2012; Manga et.al., 2010; Bernacka-Wojcik et.al., 2010] rather than simply colour, have been achieved, with the advantage of more uniform coverings spanning larger areas, in comparison to the more traditional spin, dip, or doctor blade coating techniques. These inkjet-printed TiO_2 thin films involve printing a TiO_2 sol-gel precursor [Dzik et.al., 2010; Cerná et.al., 2011] on glass, followed by high temperature treatment of the printed layer to create a highly crystalline film of titania.

Inkjet printing is now becoming increasing popular in the packaging industry. The most common applications of inkjet printing in the food packaging industry [Leach & Pierce, 1999] are: date-stamps, batch codes and any other variable information required on a package, with most food packages marked in some manner by inkjet printing. Inkjet-printing is becoming increasingly popular for functional [Magdassi, 2010] as well as standard, coloured-inks. Such functional inks include electrically conductive inks for flexible displays or sensors, [Wu et al., 2009, Courbat et al., 2010] ceramic inks for printing on tiles, [Magdassi, 2010] and inks which can be printed to form 3D structures. Inkjet printing itself falls under two broad classifications [Leach & Pierce, 1999; Magdassi, 2010] - continuous inkjet [CIJ] printing and drop on demand [DOD] inkjet printing. Of the two, DOD inkjet-printing is a much simpler and more environmentally-friendly system and is increasingly being used in the packaging industry to print directly on packages still on the packaging line, or on a web of polymer material similar to a flexo printing system. The most common DOD inkjetprinting method, used here, is piezoelectric inkjet [PIJ] printing whereby the oscillation of a piezo crystal [Magdassi, 2010; Kui & Tay, 2003] creates a pressure pulse, forcing an ink droplet out of the print head and onto the substrate.

SUMMARY

A numerous of literature reports on the oxygen sensor indicates a growing interest in this type of intelligent solutions. This is undoubtedly a significant role containing the food packaging. Packaging plays an increasingly important role in the whole food chain 'from the field to the consumer's table'. Also, packaging has allowed us to have a wide variety of foods year round that would not be possible without the protection of the package. Foods now have a longer shelf life, resulting in less loss due to spoilage. For this undoubtedly contributes to use oxygen indicators. Oxygen indicators are used in intelligent food packaging, which monitors the condition of packaged food to give information on the food quality during transport and storage. Today, application of intelligent package leak-indicating systems in Europe has been limited to some time-temperature indicators. However, some food producers are increasingly seeking extra merchandising and safety features. The visible indicators are ideal in many cases, however, in the future it can be expected that an intelligent package can contain more complex invisible messages that can be read at a distance [Hurme & Ahvenainen, 2003].

To sum up, there are several reasons for the bright future of intelligent packaging with oxygen indicators:

– the significance of freshness and safety will increase,
– the demands of consumers will increase,
– globalisation and expansion of the marketing area make logistic chains longer placing more demands on traceability,
– the facilitation of in-house control for industry and retailing in the complete food supply chain
- intelligent packaging can also monitor product quality and trace the critical points in the food supply chain [Ahvenainen, 2003].

Besides, oxygen indicators should be inexpensive, easy to read and store, irreversible in response and provide instant assurance of package integrity, both on the packaging line and once it reaches the consumer. Ideal indicators should change a colour which is easily perceived by the untrained eye, without requiring any specialist analytical equipment [Mills, 2005].

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ZASTOSOWANIE WSKAŹNIKÓW TLENU - ELEMENTÓW OPAKOWAŃ INTELIGENTNYCH DO MONITOROWANIA JAKOŚCI ŻYWNOŚCI

STRESZCZENIE. **Wstęp:** Producenci i naukowcy zwracają uwagę nie tylko na zabezpieczeniem opakowania przed wnikaniem tlenu, ale również na zapewnieniu konsumentom odpowiedniej jakości żywności. W związku z tym na dużą skalę prowadzone są badania i wdrażanie opakowań inteligentnych.
Działanie opakowań inteligentnych opiera sie na zastosowaniu interaktywnych wskaźników, które poprzez zmianę barwy pozwalają ocenić jakość zapakowanego produktu
Metody: W artykule opisano inteligentne technologie pakowania żywności oraz przedstawiono badania nad różnego rodzaju wskaźnikami tlenu.
Wyniki i podsumowanie: Wskaźniki do wykrywania obecności tlenu dają konsumentowi informację o przydatności produktu do spożycia. Poza tym, są prostym narzędziem, które pozwala na zmniejszenie kosztów związanych z wycofywaniem przeterminowanych produktów. Budowa wskaźnika umieszczanego w opakowaniu jest związana z konkretnym produktem i kontrolowanym parametrem.

Słowa kluczowe: inteligentne opakowania żywności, wskaźniki tlenu

DIE ANWENDUNG VON SAUERSTOFF-ANZEIGERN ALS ELEMENTEN DER INTELLIGENTEN VERPACKUNGEN ZUR ÜBERWACHUNG VON LEBENSMITTEL-QUALITÄT

ZUSAMMENFASSUNG. Einleitung: Produzenten und Wissenschaftler zielen in ihrem Wirken darauf hin, die Verpackungen nicht nur vor dem Eindringen des Sauerstoffes zu schützen, sondern auch den Konsumenten die entsprechende Qualität von Lebensmitteln zu gewährleisten. Im Zusammenhang damit werden im großen Umfang Untersuchungen geführt und effektive Einführungen von intelligenten Verpackungen betrieben. Die Funktionsbetätigung der intelligenten Verpackungen stützt auf die Anwendung von interaktiven Anzeigern, die durch Veränderung von Farben die Qualität des verpackten Produktes zu beurteilen erlauben.
Methoden: Im Beitrag wurden intelligente Technologien für das Verpacken von Lebensmitteln beschrieben und Untersuchungen von verschiedenartigen Sauerstoff-Anzeigern dargestellt.
Ergebnisse und Fazit: Die Sauerstoff-Anzeiger geben dem Konsumenten Auskunft über Auftreten des Sauerstoffes und somit über den Ablauf der Brauchbarkeit eines Produktes. Darüber hinaus stellen sie ein einfaches Werkzeug dar, das die Herabsetzung der mit dem Rückziehen der abgelaufenen Produkte verbundenen Kosten erlaubt. Der Aufbau eines innerhalb der Verpackung eingesetzten Anzeigers ist jeweils mit einem konkreten Produkt und dem zu kontrollierenden Parameter verbunden.

Codewörter: intelligente Verpackungen für Lebensmittel, Sauerstoff-Anzeiger

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A SIMPLIFIED, RESULT ORIENTED SUPPLIER PERFORMANCE MANAGEMENT SYSTEM TESTING FRAMEWORK FOR SME

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ABSTRACT. Background: Supplier performance management continues to be a significant concern for small & medium enterprises (SME). How can small & medium enterprises better position themselves to check and sustain actual supplier performance improvement? A key framework is the establishment of a value-added supplier performance audit program that places significant emphasis on supplier performance controls. A value-added supplier audit program can help SME mitigate business and regulatory risk while reducing the cost of poor quality (COPQ). Thus a good supplier performance audit program is the cornerstone of supplier performance management integrity.

Methods: By acknowledging and addressing the challenges to an effective supplier Performance Audit program, this paper proposes an objective framework of supplier performance audit program, built on a strong, yet versatile statistical methodology - Analysis of variance (ANOVA). This performance audit framework considers process definition, standardization, review of the contemporary literature on ANOVA & its practical application in supplier performance scorecard of one of the reputed Sports Goods Industry in India.

Results and conclusions: The advantages of this framework are that: it simultaneously considers multiple supplier performance in multiple time frames and effectively identifies the differences across the suppliers in terms of their performance. Through this framework the organization will be able to increase the odds of performing a predictable and successful implementation of a value-added supplier performance audit.

Key words: Supplier Performance Audit, Analysis of variance (ANOVA), Supply Chain, Supplier Performance Management, Small & Medium Enterprises (SME).

INTRODUCTION

"In today's competitive environment it is impossible to successfully produce high quality, low cost products without considering a satisfactory set of suppliers" [Soukoup 1987]. Supplier performance can be used as a strategic accelerator and to achieve cost savings, which can average 8 percent to 12 percent of total procurement costs, and as much as 40 percent for some categories. Also, Supplier performance improvements can result in shorter cycle times, product innovation and increased revenue. "However, without careful monitoring of supplier performance, a firm is unable to accurately assess whether its current suppliers are meeting the needs of the firm, and suppliers are unable to respond to unexpressed partner needs" [Simpson et al. 2002].

Purpose

Each Purchasing organization as per their respective objectives, select different supplier performance metrics & suitable supplier performance management system (IV) to prepare selected suppliers performance scorecards (DV) for effective supplier

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performance management. If we do not have a value-added supplier performance management system audit framework in place: How do we know whether used supplier performance management system is really genuine & effective? A value-added supplier performance management system audit framework can help organizations mitigate business and regulatory risk while reducing the cost of poor quality (COPQ). Generally such supplier performance management system audit framework comprises of buyer, supplier and sourcing, supplier performance management system, supplier scorecard and framework for auditing the effect of used supplier performance management system on supplier scores.

In this paper, the author worked as Head Of Materials Department for more than 14 years has proposed & tested an objective framework of supplier performance management audit framework, built on a strong, yet versatile statistical methodology - the 1-Way within Subjects ANOVA in a reputed Indian Sports Goods Industry to audit effectiveness & genuineness of used supplier performance management system (IV) on suppliers performance scores (DV) & move for further improvement suggestions for effective supplier performance management to reduce cost and support a lean procurement organization. This framework audited that implemented supplier performance management system really did have an effect on Supplier Performance Score. Did Supplier Performance Score significantly increase or decrease? Was there no difference in Supplier Performance Score?

Question

Whether a suggested supplier performance management system audit framework, built on the repeated 1-Way within Subjects ANOVA methodology effectively audits the effect of used supplier performance management system (IV) on supplier performance score (DV)?

Hypothesis

It is hypothesized that suggested supplier performance management system audit framework, built on the repeated 1-Way within Subjects ANOVA methodology effectively audits the effect of used supplier performance management system (IV) on supplier performance score (DV)?

LITERATURE REVIEW

"Supply Management is a process responsible for the development & management of a firm's total supply system - focuses heavily on the strategic aspects of the key elements of a firm's supply system" [Dobler et al. 2002]. As noted by fine, "supply chains are the next source of competitive advantage" [Fine, Charles 1999]. "Supply chain consists of all stages involved, directly or indirectly, in fulfilling a customer request. The supply chain not only includes the manufacturer & suppliers, but also transporters, warehouses, retailers & customer themselves" [Chopra et al. 2001]. "Good supplier performance is a key ingredient in enabling firms to achieve business performance excellence. But how can firms manage or even influence the performance of outside suppliers? Supplier performance management (SPM) is being widely adopted as a method to understand and improve the performance of the extended enterprise" [Gordon, Sherry 2010]. "Firms should concentrate on strategic suppliers who are integrated business partners as well as core suppliers, who require integration and development plus other suppliers that may supply a high-cost or high-risk item" [Barrett et al. 2008].

In literature, there exists a lot of contribution in the form of practice and models for evaluating and measuring supplier performance [Tan et al., 1999, Neely, 1999, Anderson, Lee 1999, Tracey, Tan, 2001, Çebi, Bayaktar 2003, Gunasekaran et al. 2004]. Several formal methods for supplier performance evaluation have appeared in the literature, such as the categorical method, weighted point method, cost ratio method [Dobler et al. 1990, Leenders et al. 1981, Timmerman 1986, Zenz 1987], and analytic hierarchic process (AHP) etc. [Narasimhan 1983]. However, to the author's best knowledge, this is the first framework of supplier performance management audit program, built on a strong, yet versatile statistical methodology - the 1-Way within Subjects ANOVA to audit effectiveness & genuineness of used supplier performance management system (IV) on suppliers performance scores (DV).

The One-Way within Subjects ANOVA

What is ANOVA?

Sometimes, we want to compare more than two groups of data to see if more than two groups of data are different. While T-tests could be used to compare the means from two different groups of data, but we need a different kind of test when comparing three or more groups. Here 1-Way ANOVA test can be used to compare three or more groups or conditions in an experiment. A 1-Way ANOVA can find out if the means for each group / condition are significantly different from one another or if they are relatively the same. If the means are significantly different, it means that the variable being manipulated, Independent Variable (IV), had an effect on the variable being measured, i.e. Dependent Variable (DV). In statistics, one-way analysis of variance (abbreviated one-way ANOVA) is a technique used to compare means of two or more samples (using the F distribution). This technique can be used only for numerical data [Howell 2002]. ANOVA allows one to determine whether the differences between the samples are simply due to random error (sampling errors) or whether there are systematic treatment effects that cause the mean in one group to differ from the mean in another.

Variables in ANOVA

Dependent variable is metric.

Independent variable(s) is nominal with two or more levels - also called treatment, manipulation, or factor.

Types of ANOVA

One-way ANOVA: only one independent variable (IV) with two or more levels.

Two-way ANOVA: two independent variables (IV) each with two or more levels

With ANOVA, a single metric dependent variable is tested as the outcome of a treatment or manipulation whereas with MANOVA (Multiple Analysis of Variance), two or more metric dependent variables are tested as the outcome of a treatment(s). The one-way ANOVA is used to test for differences among at least three groups, since the two-group case can be covered by a t-test [Gosset 1908]. ANOVA can analyze and compare the variability of scores between conditions and within conditions. This helps us find out if the IV had a significant effect on the DV.

1-Way between Subjects ANOVA

This type of test is used to compare more three or more groups of participants that are not related in any way. The groups of participants are independent from one another. So, participants in one group have no relationship to participants in the other groups.

1-Way within Subjects ANOVA:

This type of test used to compare three or more groups of participants that are related in some way. There are many ways that participants in three or more groups can be related. One of the most common ways is that participants in the first group are the same as participants in the other groups. This is called a repeated measures design. Such type of 1-Way within Subjects ANOVA is also called as 1-Way Repeated Measures ANOVA.

A second way is that participants in the first group are genetically related to participants in the other groups. For example, a pair of triplets could be divided up so one triplet participated with the first group, a second triplet participated with the second group and a third triplet participate with a third group. A third way is if participants in one group are matched with participants in the other groups by some attribute. For example, if a participant in the first group rates low on intelligence, researchers might try to find a participant for each of the other groups who also rates low on intelligence.

1-Way Repeated Measures ANOVA:

A One-Way within subjects design involves repeated measures on the same participants (multiple observations overtime, or under experimental different conditions). The simplest example of one-way repeated measures ANOVA is measuring before and after scores for participants who have been exposed to some experiment (before-after design).

Example: An employer measures employee's knowledge before a workshop and two weeks after the workshop. One-way repeated measure ANOVA and paired-samples t test are both appropriate for comparing scores in before and after designs for the same participants. Repeated-measures designs are considered an extension of the paired-samples t test when comparisons between more than two repeated measures are needed.

Hypotheses

Generally Software like SPSS conducts 3 types of tests if the within-subject factor has more than 2 levels:
- The standard univariate F within subjects
- Alternative univariatetests, and
- Multivariate tests [SPSS Statistics Base 17.0]

All these repeated measures ANOVA tests evaluate the same hypothesis:
- The population means are equal for all levels of a factor.
- H0: $\mu 1 = \mu 2 = \mu 3 \ldots$
- HA: At least one treatment or observation mean (μ) is different from the others.

Sources of Variability

In repeated measure ANOVA, there are three potential sources of variability:
- treatment variability: between columns,
- within subjects variability: between rows,
- -random variability: residual (chance factor or experimental error beyond the control of a researcher).

A repeated measure design is powerful, as it controls for all potential sources of variability.

The test statistic for the repeated measures ANOVA has the following structure:

$$F = \frac{\text{Variance between treatments}}{\text{Variance within subjects + variance expected by chance/error}}$$

The logic of Repeated measures ANOVA

Any differences that are found between treatments can be explained by only two factors:
- Treatment Effect.
- Error or Chance

This formula leaves only differences due to treatment/observation effects.

A large F value indicates that the differences between treatments/observations are greater than would be expected by chance or error alone.

Univariate Assumptions

Normality Assumption: ANOVA is a relatively robust procedure with respect to violations of the normality assumption [Kirk 1995].
- The dependent variable is normally distributed in the population for each level of the within-subject factor.
- With a moderate or large sample sizes the test may still yield accurate p values even if the normality assumption is violated except in thick tailed and heavily skewed distributions.
- A commonly accepted value for a moderate sample size is 30 subjects.

Sphericity Assumption: Non-Robust

- The population variance of difference scores computed between any two levels of a within subject factor is the same.
- The sphericity assumption (also known as the homogeneity of variance of differences assumption) is meaningful only if there are more than two levels of a within subjects factor.
- If this assumption is violated the resulting p value should not be trusted.

- Sphericity can be tested using the Mauchly's Sphericity Test. If the Chi-Square value obtained is significant, it means that the assumption was violated.
- If the sphericity assumption is not met, some procedures can be used to correct the univariate results. These tests make adjustments to the degrees of freedom in the denominator and numerator.
- SPSS, computes alternative test which are all robust to violations of the sphericity assumption as they adjust the degrees of freedom to account for any violations of this assumption. These tests include: Univariate Tests (e.g. Greenhouse-Geisser Epsilon, Huynh-Feldt Epsilon, Lower-bound Epsilon) and multivariate tests (e.g. Pillai's Trace, Wilk's Lambda, Hotelling's Trace, Roy's Largest Root

Independence Assumption: Non-Robust

-The cases represent a random sample from the population and there is no dependency in the scores between participants.

- Dependency can exist only across scores for individuals.
- Results should be not trusted if this assumption is violated.

Multivariate Assumptions

Normality Assumption: Non-Robust

- The difference scores are multivariately normally distributed in the population.
- To the extent that population distributions are not normal and the sample sizes are small, especially in thick tailed or heavily skewed distributions, the p values are invalid.

Independence Assumption: Non-Robust

- The difference scores for any one subject are independent from the scores for any other subjects.
- The test should not be used if the independence assumption is violated.

METHODOLOGICAL APPROACH

This Research Study has been undertaken as a single exploratory descriptive case study with a deductive positivism approach with Cosco (India) Limited, One of the reputed sports & fitness goods company from India for empirical study of whether suggested supplier performance management system audit framework, built on the repeated 1-Way within Subjects ANOVA methodology, effectively audited the effect of used supplier performance management system (IV) on supplier performance score (DV)?

Data Collection

In this study, both primary and secondary data were collected through direct & participant observation along with documentation & archival records. The primary data were gathered through observations noted from company considered for this case study based research study. The secondary data were collected from literature, journals, articles & internet.

The interpretation of results of the researches can be conducted by various types of tests. The test ANOVA was chosen. It is not the best one from mathematical point of view, but it is the simplest one and at the same time enables the unambiguous interpretation of results. It was stated during the preliminary researches.

EMPIRICAL STUDY

We audited the effect of revised supplier performance management system (IV) on supplier performance score (DV) in six continuous quarters (i.e. groups) from January, 2011 to June, 2012 on a sample of 10 main critical suppliers / participants in comparison with performance score in quarter from October, 2010 to December, 2010 on account of earlier supplier performance management system in Cosco (India) Limited. Each participant participated in all seven groups of the experiment. Each group was separated by ninety day's time. Because the participants in each group were related, they were actually the same exact participants in each group; we used the 1-Way within Subjects ANOVA.

Auditing Supplier Performance Management System by ANOVA

There are three steps in conducting the one-way repeated measures ANOVA:

- Conducting the omnibus test
- Conducting polynomial contrasts (compares the linear effect, quadratic effect, and cubic effect).
- Conducting pair wise comparisons.

Required input

Repeated measurements variables: the variables containing the different measurements. Note that the order in which we select the variables is important for trend analysis.

Required output

In this experiment, required output is to know if there is a significant difference between the data collected from each condition/quarter. We want to know revised supplier performance management system really does have an effect on Supplier Performance Score. Does Supplier Performance Score significantly increase or decrease. Is there no difference in Supplier Performance Score?

Let's Start Auditing/Testing

To answer the research question posed in Introduction i.e. "Whether suggested supplier performance management system audit framework, built on the repeated 1-Way within Subjects ANOVA methodology effectively audit the effect of used supplier performance management system (IV) on supplier performance score (DV)?", an hypothesis was created that It is hypothesized that suggested supplier performance management system audit framework, built on the repeated 1-Way within Subjects ANOVA methodology effectively audit the effect of used supplier performance management system (IV) on supplier performance score (DV)? Here we want to audit the effect of revised supplier performance management system (IV) on supplier performance score (DV). This is now being tested by using Repeated One-Way Analysis of Variance (ANOVA). To test this hypothesis we check & test the effect of revised supplier performance management system (IV) on supplier performance score (DV) by collecting data set of supplier performance score in six continuous quarters (i.e. groups) from January, 2011 to June, 2012 on a sample of 10 main critical suppliers / participants in comparison with performance score in quarter from October, 2010 to December, 2010 on account of earlier supplier performance management system.

Table 1. Data set of supplier performance score
Tabela 1. Dane oceny dostawcy

	Oct., 10 to Dec., 10	Jan., 11 to March, 11	April, 11 to June, 11	July, 11 to Sept., 11	Oct., 11 to Dec., 11	Jan., 12 to March, 12	April, 12 to June, 12
SP1	60	69.2	75.8	81.6	85	91	92.6
SP2	67	70.4	75.2	79.2	85	92.6	99
SP3	73.2	78	83	84.8	86	90	92
SP4	66.4	73.2	77	80.2	85.2	89.8	97.2
SP5	69.4	74	78	82.2	89	89.8	93.2
SP6	56	67.2	70	79	81.4	88	93.2
SP7	65.6	71.2	72.6	82.2	86.2	89	92
SP8	68.6	75.4	81	84	85.8	90	90.4
SP9	68.6	74.8	79.4	86.2	85.8	91.6	93.6
SP10	57.8	67.6	73.6	81	83	86.8	91

The null hypothesis:

There is no difference of supplier performance score among the 7 treatment different quarters (Levels) i.e. have the same μ.

Ho: $\mu_1 = \mu_2 = \mu_3 = \mu_5 = \mu_6 = \mu_7$

If we reject null, and say, "no," then at least one of the populations has a different μ.

The alternative hypothesis:

The alternative hypothesis, Ha: Is the opposite of the null hypothesis. i.e. there is difference of supplier performance score among the 7 treatment different quarters (Levels) i.e. either greater μ or lesser μ than one another subsequently but not have the same μ.

Ha: $\mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_5 \neq \mu_6 \neq \mu_7$

Ha: $\mu_1 > \mu_2 > \mu_3 > \mu_5 > \mu_6 > \mu_7$ or

Ha: $\mu_1 < \mu_2 < \mu_3 < \mu_5 < \mu_6 < \mu_7$

A one-tailed test uses an alternate hypothesis that states either H1: $\mu > \mu_0$ or H1: $\mu < \mu_0$, but not both. But here we want to test both, using the alternate hypothesis H1: $\mu \neq \mu_0$, then we need to use a two-tailed test.

Here We have used a statistical program MedCalc Software version 12 - © 1993-2012 for conducting Repeated measures analysis of variance to check & test the effect of revised supplier performance management system (IV) on supplier performance score (DV) by analyzing the data set of supplier performance score from 7 different quarters (Levels) from October, 2010 to June, 2012 of 10 critical supplier firms.

Enter Data

Data for the different variables are entered in different columns of The MedCalc spreadsheet. In the top row of the columns we entered the names of the variables / groups i.e. OCT 10 TO DEC 10, JAN 11 TO MARCH 11, APRIL 11TO JUNE 11, JULY 11 TO SEPT 11, OCT 11 TO DEC 11, JAN 12 TO MARCH 12, APRIL 12 TO JUNE 12. All data for each selected critical supplier or case are entered in one row in the spreadsheet. A variable name should not include any spaces. We can use the underscore character _ to separate words, e.g. GRADE_A. Also the following characters cannot be used in a variable's name: - + / * = < > ^ ( ) $ " ' : ,.

Save the data

Save data file to a meaningful place with a meaningful name. We decided to save our data file as "Effect of simple & superior supplier performance management system on supplier performance score Data.sav."

Statistical Analyses

After entering the data in the spreadsheet, we selected an option in the Statistics menu to perform repeated measures analysis of variance statistical analysis

Results

"A one-way within subjects (or repeated measures) ANOVA was conducted with 10 main critical suppliers to compare the effect of revised supplier performance management system (IV) on supplier performance score (DV) in seven continuous quarters (i.e. groups) from October, 2010 to June, 2012."

Repeated measures ANOVA

Number of subjects	10

Sphericity

It refers to the equality of variances within each of the populations which is an assumption of ANOVA with a repeated measures factor also called as the assumption of homogeneity of variances. One-way ANOVA assumes that the data come from populations that are Gaussian and have equal variances. MedCalc reports the estimates (epsilon) of sphericity proposed by Greenhouse and Geisser (1958) [17-18] and Huynh and Feldt (1976) [19-20] (corrected by Lecoutre, 1991). The closer that epsilon is to 1, the more homogeneous are the variances of differences, and hence the closer the data are to being spherical. Both the Greenhouse-Geisser and Huynh-Feldt estimates are used as a correction factor that is applied to the degrees of freedom used to calculate the P-value for the observed value of F.

Table 2. Estimates (epsilon) of sphericity
Tabela 2. Szacowana sferowość

Method	Epsilon
Greenhouse-Geisser (1959)	0.358
Huynh-Feldt (1976)	0.473

Source: MedCalc Software version 12

The Greenhouse-Geissure & Huynh-Feldt estimates can both range from the lower bound (the most severe departure from sphericity possible given the data) and 1 (no departure from sphericity at all)

Here above reported epsilon by MedCalc is not closure to 1, resulting in to heterogeneity of variances of differences instead of homogeneity of variances. It means that variances are not equal across groups or samples.

Test of Within-Subjects Effects

Table 3. Displaying the variation attributed to "Factor" and "Residual" variation
Tabela 3. Zmienność wartości „Factor" i „Residual"

Source of variation		Sum of Squares	DF	Mean Square	F	P
Factor	Sphericity assumed	5975.792	6	995.965	158.04	<0.001
	Greenhouse-Geisser	5975.792	2.147	2783.403	158.04	<0.001
	Huynh-Feldt	5975.792	2.841	2103.430	158.04	<0.001
Residual	Sphericity assumed	340.299	54	6.302		
	Greenhouse-Geisser	340.299	19.322	17.612		
	Huynh-Feldt	340.299	25.569	13.309		

Source: MedCalc Software version 12

Table 4. Summary of The within-subjects factors
Tabela 4. Podsumowanie czynników within subjects

Factor	Mean	Std. Error	95% CI
OCT_10_TO_DEC_10	65.2600	1.7512	61.2985 to 69.2215
JAN_11_TO_MARCH_11	72.1000	1.1264	69.5520 to 74.6480
APRIL_11_TO_JUNE_11	76.5600	1.2535	73.7243 to 79.3957
JULY_11_TO_SEPT_11	82.0400	0.7512	80.3407 to 83.7393
OCT_11_TO_DEC_11	85.2400	0.6337	83.8064 to 86.6736
JAN_12_TO_MARCH_12	89.8600	0.5317	88.6572 to 91.0628
APRIL_12_TO_JUNE_12	93.4200	0.8514	91.4940 to 95.3460

Source: MedCalc Software version 12

In table 3, the variation attributed to "Factor" and "Residual" variation is displayed. If the P-value next to "Factor" is low ($P<0.05$) it can be concluded that there is significant difference between the different measurements. MedCalc produces two corrections based upon the estimates of sphericity by Greenhouse and Geisser (1958) and Huynh and Feldt (1976) (corrected by Lecoutre, 1991) [21]. Girden (1992) recommends that when epsilon (Greenhouse-Geisser estimate) > 0.75 then the correction according to Huynh and Feldt should be used. If epsilon < 0.75 then the more conservative correction according to Greenhouse-Geisser is preferred.

Here the P value is less than a preset threshold value 0.05. It can be concluded that the populations really are significantly different.

Within-subjects factors

The within-subjects factors are summarized in the following table 4 with Mean, Standard Error and 95% Confidence Interval.

Table 5. The Pair wise comparisons table
Tabela 5 Porównanie par

Factors			Mean Difference	Std. Error	P [a] ([a] Bonferroni corrected)	95% CI [a]
OCT_10_TO_DEC_10	-	JAN_11_TO_MARCH_11	-6.840	0.791	0.0002	-10.145 to -3.535
	-	APRIL_11_TO_JUNE_11	-11.300	0.985	<0.0001	-15.417 to -7.183
	-	JULY_11_TO_SEPT_11	-16.780	1.407	<0.0001	-22.661 to -10.899
	-	OCT_11_TO_DEC_11	-19.980	1.311	<0.0001	-25.458 to -14.502
	-	JAN_12_TO_MARCH_12	-24.600	1.528	<0.0001	-30.987 to -18.213
	-	APRIL_12_TO_JUNE_12	-28.160	1.852	<0.0001	-35.899 to -20.421
JAN_11_TO_MARCH_11	-	OCT_10_TO_DEC_10	6.840	0.791	0.0002	3.535 to 10.145
	-	APRIL_11_TO_JUNE_11	-4.460	0.488	0.0002	-6.500 to -2.420
	-	JULY_11_TO_SEPT_11	-9.940	0.741	<0.0001	-13.035 to -6.845
	-	OCT_11_TO_DEC_11	-13.140	0.831	<0.0001	-16.613 to -9.667
	-	JAN_12_TO_MARCH_12	-17.760	1.036	<0.0001	-22.090 to -13.430
	-	APRIL_12_TO_JUNE_12	-21.320	1.473	<0.0001	-27.477 to -15.163
APRIL_11_TO_JUNE_11	-	OCT_10_TO_DEC_10	11.300	0.985	<0.0001	7.183 to 15.417
	-	JAN_11_TO_MARCH_11	4.460	0.488	0.0002	2.420 to 6.500
	-	JULY_11_TO_SEPT_11	-5.480	0.841	0.0023	-8.993 to -1.967
	-	OCT_11_TO_DEC_11	-8.680	1.010	0.0003	-12.900 to -4.460
	-	JAN_12_TO_MARCH_12	-13.300	1.126	<0.0001	-18.003 to -8.597
	-	APRIL_12_TO_JUNE_12	-16.860	1.611	0.0001	-23.591 to -10.129
JULY_11_TO_SEPT_11	-	OCT_10_TO_DEC_10	16.780	1.407	<0.0001	10.899 to 22.661
	-	JAN_11_TO_MARCH_11	9.940	0.741	<0.0001	6.845 to 13.035
	-	APRIL_11_TO_JUNE_11	5.480	0.841	0.0023	1.967 to 8.993
	-	OCT_11_TO_DEC_11	-3.200	0.704	0.0294	-6.143 to -0.257
	-	JAN_12_TO_MARCH_12	-7.820	0.812	0.0001	-11.215 to -4.425
	-	APRIL_12_TO_JUNE_12	-11.380	1.387	0.0004	-17.177 to -5.583
OCT_11_TO_DEC_11	-	OCT_10_TO_DEC_10	19.980	1.311	<0.0001	14.502 to 25.458
	-	JAN_11_TO_MARCH_11	13.140	0.831	<0.0001	9.667 to 16.613
	-	APRIL_11_TO_JUNE_11	8.680	1.010	0.0003	4.460 to 12.900
	-	JULY_11_TO_SEPT_11	3.200	0.704	0.0294	0.257 to 6.143
	-	JAN_12_TO_MARCH_12	-4.620	0.626	0.0009	-7.235 to -2.005
	-	APRIL_12_TO_JUNE_12	-8.180	1.060	0.0006	-12.610 to -3.750
JAN_12_TO_MARCH_12	-	OCT_10_TO_DEC_10	24.600	1.528	<0.0001	18.213 to 30.987
	-	JAN_11_TO_MARCH_11	17.760	1.036	<0.0001	13.430 to 22.090
	-	APRIL_11_TO_JUNE_11	13.300	1.126	<0.0001	8.597 to 18.003
	-	JULY_11_TO_SEPT_11	7.820	0.812	0.0001	4.425 to 11.215
	-	OCT_11_TO_DEC_11	4.620	0.626	0.0009	2.005 to 7.235
	-	APRIL_12_TO_JUNE_12	-3.560	0.707	0.0147	-6.513 to -0.607
APRIL_12_TO_JUNE_12	-	OCT_10_TO_DEC_10	28.160	1.852	<0.0001	20.421 to 35.899
	-	JAN_11_TO_MARCH_11	21.320	1.473	<0.0001	15.163 to 27.477
	-	APRIL_11_TO_JUNE_11	16.860	1.611	0.0001	10.129 to 23.591
	-	JULY_11_TO_SEPT_11	11.380	1.387	0.0004	5.583 to 17.177
	-	OCT_11_TO_DEC_11	8.180	1.060	0.0006	3.750 to 12.610
	-	JAN_12_TO_MARCH_12	3.560	0.707	0.0147	0.607 to 6.513

Source: MedCalc Software version 12

Pair wise comparisons

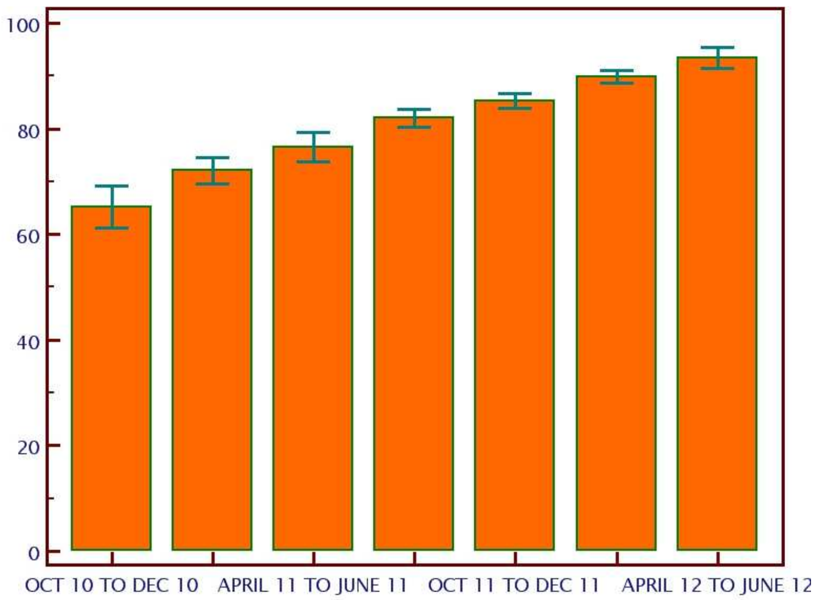
In the Pair wise comparisons table, the different measurements are compared to each other. The mean difference with standard error, P-value, and 95% Confidence Interval of the difference is given. Bonferroni correction for multiple comparisons is applied for P-values and confidence intervals.

The Bonferroni method is a simple method that allows many comparison statements to be made (or confidence intervals to be constructed) while still assuring an overall confidence coefficient is maintained. Which pairs of means differ? The Bonferroni Test is done for all possible pairs of means [http://www2.fiu.edu/].

Table 6. Bonferroni Test for Differences between Means
Tabela 6. Test Bonferroni dla różnicy średnich

Bonferroni Test for Differences Between Means				
Alpha/N	0.0024			
Groups	*Difference*	*Test Statistics*	*p-level*	*Accepted?*
1 vs. 2	-6.84	3.2851	0.0041	*rejected*
1 vs. 3	-11.3	5.247	0.0001	*accepted*
1 vs. 4	-16.78	8.806	0.	*accepted*
1 vs. 5	-19.98	10.7284	0.	*accepted*
1 vs. 6	-24.6	13.4416	0.	*accepted*
1 vs. 7	-28.16	14.4619	0.	*accepted*
2 vs. 3	-4.46	2.6465	0.0164	*rejected*
2 vs. 4	-9.94	7.342	0.	*accepted*
2 vs. 5	-13.14	10.1672	0.	*accepted*
2 vs. 6	-17.76	14.2588	0.	*accepted*
2 vs. 7	-21.32	15.1	0.	*accepted*
3 vs. 4	-5.48	3.7499	0.0015	*accepted*
3 vs. 5	-8.68	6.1796	0.	*accepted*
3 vs. 6	-13.3	9.7676	0.	*accepted*
3 vs. 7	-16.86	11.1263	0.	*accepted*
4 vs. 5	-3.2	3.2561	0.0044	*rejected*
4 vs. 6	-7.82	8.4971	0.	*accepted*
4 vs. 7	-11.38	10.023	0.	*accepted*
5 vs. 6	-4.62	5.5849	0.	*accepted*
5 vs. 7	-8.18	7.7072	0.	*accepted*
6 vs. 7	-3.56	3.5466	0.0023	*accepted*

Source: MedCalc Software version 12



Source: MedCalc Software version 12

Fig. 1. Continuously increasing population means
Rys. 1. Stale wzrastające średnie populacji

Trend analysis

The Trend analysis table shows whether the measurements show a linear or non-linear (quadratic, cubic) trend. A trend analysis tests the hypotheses that the means of the ordered groups change in a linear or higher order (e.g., quadratic or cubic) fashion.

Table 7. Trend analysis table
Tabela 7. Analiza trendu

Trend	t	DF	Significance
Linear	15.8651	9	P < 0.0001
Quadratic	-2.5030	9	P = 0.0337
Cubic	1.5379	9	P = 0.1585

Source: MedCalc Software version 12

There is a significant linear trend (p <0.0001), shown in Figure 1. The results suggest that there is a linear increase in population means.

Decision Rule

The populations really are significantly different. Therefore our Null Hypothesis Ho: $\mu_1 = \mu_2 = \mu_3 = \mu_4 = \mu_5 = \mu_6 = \mu_7$ is not true. We have to reject this & accept following alternative hypothesis:

Ha: $\mu_1 \neq \mu_2 \neq \mu_3 \neq \mu_4 \neq \mu_5 \neq \mu_6 \neq \mu_7$

Ha: $\mu_1 < \mu_2 < \mu_3 < \mu_4 < \mu_5 < \mu_6 < \mu_7$

Audit result can be concluded that a one-way within subjects (or repeated measures) ANOVA was conducted on a sample of 10 critical suppliers to compare the effect of revised supplier performance system on supplier performance score in seven continuous quarters / conditions i.e. from Oct., 10 to June, 12. There was a significant effect of supplier performance system in continuously increasing supplier performance score. Thus supplier performance management system audit framework, built on the repeated 1-Way within Subjects ANOVA methodology effectively audited the effect of used supplier performance management system (IV) on supplier performance score (DV).

CONCLUDING REMARKS

This research paper was aimed to develop & implement an objective framework of supplier performance audit program, built on a strong, yet versatile statistical methodology - Analysis of variance (ANOVA). The empirical study of this supplier performance management system audit framework has been undertaken as a single exploratory descriptive case study with a deductive positivism approach with one of the reputed Sports Goods Manufacturing Industry from India i.e. Cosco (India) Limited.

To check the findings of this supplier performance management system audit framework, during the case study the effect of earlier as well as revised Supplier Performance Management System on supplier performance scores on a sample of 10 critical suppliers in seven concerned & continuous quarters i.e. from Oct., 10 to June, 12 were analyzed & audited/tested through a one-way within subjects (or repeated measures) ANOVA. Test result can be concluded that there is a significant effect of supplier performance system in continuously increasing supplier performance score. Thus this supplier performance management system audit framework effectively audited the effect of used supplier performance management system (IV) on supplier performance score (DV).

From the outset, this supplier performance management system audit framework had the advantages of simplicity, understandability and ease of implementation. It is highly reliable and its implementation costs are moderate & hence suitable for small & medium enterprises (SME).

Research Contributions

This study will help Supply Chain practitioners to take necessary steps to reference their existing or actual facts of prevailing Supplier Performance Management activity in the organization in order to make it more effective. This will also provide guidance to anyone who wants to develop a resulted oriented supplier performance management system in any organization.

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UPROSZCZONA METODA OCENY ZARZĄDZANIA DOSTAWCAMI DLA MAŁYCH I ŚREDNICH PRZEDSIĘBIORSTW

STRESZCZENIE. **Wstęp:** Zarządzanie oceną dostawców jest obszarem o istotnym znaczeniu dla małych I średnich przedsiębiorstw. Jak tego typu przedsiębiorstwa mogą uzyskać lepszą pozycję rynkową poprzez poprawę systemu oceny dostawców? Kluczową sprawą jest zbudowanie systemu oceny wartości dodanej wniesionej przez dostawców opartego na grupie wskaźników. Taki system audytowania może pomóc małych i średnim przedsiębiorstwom obniżyć poziom ryzyka oraz obniżyć koszty wynikające ze złej jakości. Dlatego też dobrej jakości program oceny dostawców jest istotnym narzędziem zarządzania dla przedsiębiorstwa.
Metody: Aby sprostać wymaganiom stawianym programom efektywnej oceny dostawców, w pracy zaproponowano ogólne zasady takiego programu opartego na silnej i jednocześnie wszechstronnej analizie wariancji (ANOVA). Zaprezentowano definicję procesu, standaryzację, przegląd współczesnej literatury oraz praktyczne zastosowanie na przykładzie przedsiębiorstwa Sports Goods Industry z Indii.
Wyniki i wnioski: Zaletą proponowanej metody jest uwzględnienie różnorodności działa przedsiębiorstwa oraz jednocześnie efektywnej identyfikacji różnic pomiędzy dostawcami. Dzięki stosowaniu tej metody możliwe jest podniesie jakość pracy przedsiębiorstwa.

Słowa kluczowe: audit dostawcy, analiza wariancji (ANOVA), łańcuch dostaw, zarządzanie dostawcami, małe i średnie przedsiębiorstwa

EINE VEREINFACHTE METHODE FÜR DIE BEURTEILUNG DES MANAGEMENTS VON LIEFERANTEN FÜR KLEIN- UND MITTELSTÄNDISCHE UNTERNEHMEN

ZUSAMMENFASSUNG. Einleitung: Das Management der Beurteilung von Lieferanten stellt für die klein- und mittelständischen Unternehmen einen Bereich von wesentlicher Bedeutung dar. Auf welche Art und Weise können solche Unternehmen eine bessere Marktposition durch die Verbesserung des die Lieferanten anbetreffenden Beurteilungssystems erlangen? Die Schlüsselfrage dabei ist das Aufbauen eines auf die Gruppe von Kennziffern gestützten Systems für die Beurteilung der durch die Lieferanten erbrachten Wertschöpfung. Solch ein Auditing-System kann bei der Verminderung des Risikoniveaus und der Herabsetzung der aus der schlechten Qualität resultierenden Kosten in den klein- und mittelständischen Unternehmen eine Hilfe leisten. Daher stellt ein hochqualitatives Programm für die Beurteilung der Lieferanten ein brauchbares Tool für das Management im Unternehmen dar.
Methoden: Um den an die Programme der effektiven Beurteilung der Lieferanten gestellten Anforderungen das Genüge zu leisten, hat man die allgemeinen Prinzipien eines solchen Programms, das auf eine strenge und gleichzeitig universale Varianten-Analyse (ANOVA) gestützt ist, vorgeschlagen. Es wurden die Definition des Prozesses, Standardisierung, der Überblick über die gegenwärtige Gegenstandliteratur und die praktische Anwendung am Beispiel des Unternehmens Sports Goods Industry von Indien projiziert.
Ergebnisse und Fazit: Der Vorteil der vorgeschlagenen Methode besteht auf der Berücksichtigung der Unterschiedlichkeit von Aktivitäten des Unternehmens sowie einer effektiven Identifikation von Differenzen zwischen den Lieferanten. Dank der Anwendung dieser Methode ist die Erhöhung der Arbeit-Qualität des Unternehmens möglich..

Codewörter: Auditing des Lieferanten, Varianten-Analyse (ANOVA), Lieferkette, Management von Lieferanten, klein- und mittelständische Unternehmen.

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STRATEGIC VEHICLE FLEET MANAGEMENT - THE MAKE OR BUY PROBLEM

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ABSTRACT. Background: Fleets constitute the most important production means in transportation. Their appropriate management is crucial for all companies having transportation duties. The paper is the first one of a series of three papers that the author dedicates to the strategic vehicle fleet management topic.

Methods: The paper discusses ways of fulfilling company's transportation needs (MAKE-or-BUY problem). It means the choice between using company's own and outside fleet (buying transportation services in a market). The essence of the MAKE-or-BUY problem lies in a time dependency, a seasonal nature of transportation needs. It leads to the MAKE-and-BUY solutions including utilization of both in-house and outside fleets. In the paper an original mathematical model (an optimization method) allowing for the MAKE-and-BUY analysis is proposed.

Results: An application of the proposed optimization method in a real-life decision situation (the case study) within the Polish environment and the obtained solution are presented. The solution shows a low economic justification for using the MAKE option in practice. Especially when a fleet composed of brand new vehicles is considered.

Conclusions: The paper will be continued in two further papers dedicated to strategic vehicle fleet management problems including fleet sizing / composition and fleet replacement.

Key words: management, optimization, fleet, vehicle, transport, make-or-buy.

"Do what you do best, and outsource the rest"
- Peter Drucker

INTRODUCTION

The decision if a given business (activity, function - including transport) to carry out using in-house resources, investing capitals, devoting skills, acquiring assets (e.g. fleet), or to outsource it is called a MAKE-or-BUY (MoB) problem.

Both options MAKE and BUY meet company's transportation requirements. However, the basic difference is that in a case of the MAKE option a company acquires transportation means and as a result meets its own transportation requirements. Whereas, in a case of the BUY option a company buys services that meet its own transportation requirements directly. There are a few different organizational ways to take up the MAKE or the BUY option in practice.

As far as the MAKE option is considered the selection of a form of the investment in a company's "own" (in-hose) fleet is crucial. A company's "own" fleet means vehicles owned by a company (included into company's assets when bought for cash, credited, leased or not included when rented) or just staying in company's exclusive disposal.

There are a few vehicle investment forms available in the Polish market [Bakowski and Redmer 2012a, Bakowski and Redmer 2012b]:

– outright purchase,

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- lease (operating or finance),
- credit (with fixed or variable instalments),
- hiring (short or long-term),
- contract trucks.

Considering the BUY option the attention should be given to the number and the size of transportation service providers a company cooperates with. The way services are accounted is also very important. One can distinguish the following solutions occurring in practice based on cooperation with:

- many small-size carriers (an option that usually results in low costs but high organizational involvement; moreover this option does not allow for putting the risk outside, on a service provider - as a result the majority of outsourcing advantages are lost, apart from costs reduction),
- a few mid-size carriers or logistic service providers (an option that usually results in a partial outsourcing only; moreover this option allows for putting the risk outside, on a service provider to some degree and for a partial diversification of the risk and supply sources as well),
- single big-size logistic service provider (an option that results in a full outsourcing including all its advantages and allows for putting the risk outside, on a service provider, but does not allow for a diversification of the risk and supply sources at all).

The results of using the MAKE or the BUY option can be completely different.

The MAKE option may (but not have to) result in lower costs, higher operational flexibility, better adjustment of services to requirements (e.g. specific features of loads, customers, …), but also:

- high capital invested (often under some uncertainty according to the future market situation and the future transportation requirements),
- high fixed costs (including those of unused resources - downtime, empty movements, underutilized vehicles' loading capacity),
- total kilometers to be covered / paid (including those of approaching and back distances),
- full administrative and organizational responsibility (the risk and its costs on a company's side),
- limited operational / delivery range (e.g. caused by driving time regulations),
- sensitivity to the order sizes (small / big), the geographical dispersion of customers (customers located close or far to each other) or locations of customers (e.g. city centers).

On the other hand the BUY option may (but not have to) result in lower costs (cooperation with many small-size carriers) or higher costs as well (cooperation with a single big-size logistic service provider), less administrative and organizational work, possibility to put the risk outside, on a service provider, low capital invested, but also:

- lower operational flexibility,
- decreased control,
- lost organizational experience / skills,
- limited direct contacts with customers.

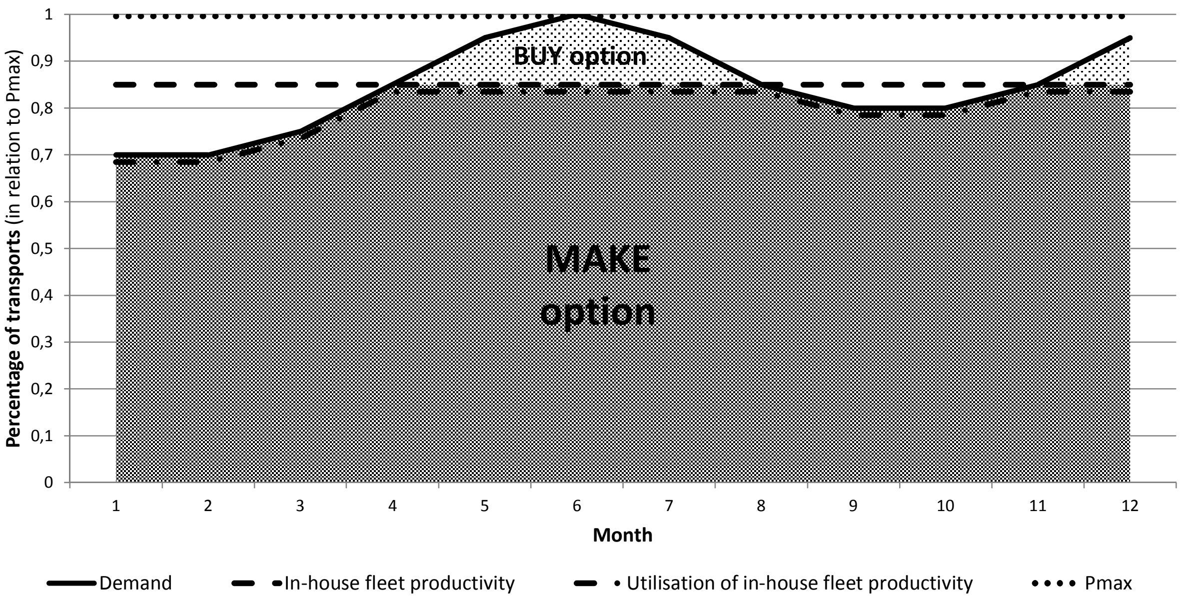
Although discussed above results of using the MAKE or the BUY option can be completely different, the cost effect (savings) based on the Author's experience can reach up to 5-10%, usually no more. So, an assumption that changing the MAKE option to the BUY option or otherwise will result in transportation costs reduction around 20% or more is in the Author's opinion unreal. There are no reasons that buying vehicles and organizing transport on company's own will be significantly cheaper than services delivered by professional carriers (even taking into account their profits). There are also no reasons that carriers buying their vehicles to carry out transportation services and bearing all associated with this costs can provide those services for prices significantly lower than company's in-house costs.

THE METHOD FOR SOLVING THE MOB PROBLEM

There exist not so many methods for solving the MoB problem. All the methods are simple, very similar and based on the economic break-even point or the multi-index (multiobjective) assessment theories. The basic way to decide between the MAKE and the

BUY option is to asses and compare a total costs (quantitative methods [Debinska-Cyran and Gubala 2005, Hines 2004, Jacobs and Chase 2010, Romanow 2003]) or an overall quality (qualitative methods [Debinska-Cyran and Gubala 2005, Min 1998, Trocki 2001, Twarog 2004]) of meeting company's transportation requirements by the both options within assumed time period (usually one year). There are also mixed quantitative-qualitative methods - the trade-off methods combining costs and the quality of the both transportation options, e.g. the method presented by Mankowski [1999].

The general drawback of the mentioned above solution methods is that they are focused on "or" based solutions only. It means that the only one of the both possible transportation options, the MAKE or the BUY, is suggested as the optimal solution. While in practice mixed MAKE-and-BUY (MaB) solutions, based partially on the MAKE and partially on the BUY option are met very often [Parmigiani 2007, Stojanovic et al. 2011] (see Figure 1). Porter [1980] pointed out directly that MaB solutions are very good alternative to a vertical integration strategy since they allow for a better utilization of company's own assets.



Source: author's research

Fig. 1. The mixed MAKE-and-BUY solution concerning seasonal character of a demand for transportation services
Rys. 1. Rozwiązanie mieszane MAKE-and-BUY przy zmiennym sezonowo popycie na przewozy

There arises the question how to find a mixed optimal solution? Not only MAKE or BUY, but MAKE and BUY solution.

The cost calculations for the option MAKE should be based on the TCO - Total Cost of Ownership theory taking into account availability and operating costs of assets (e.g. vehicles). The availability costs are associated with the full readiness of vehicles to work and cover: economic, called also book depreciation (not the tax one), value of capital, drivers' salaries, insurances, taxes, and the other "fixed" costs. Whereas the operating costs are associated with the utilization of vehicles (using them to transport goods) and cover: fuel and other exploitation materials, tires, inspections, services, repairs, and the other "variable" costs depending on a number of kilometers driven. Moreover the cost calculations for the option BUY and partially MAKE (operating costs only) should include seasonal changes of company's transportation requirements resulting in a varying with time (particular periods of analysis) numbers of kilometers covered within both options, MAKE and BUY (see Figure 1).

As a result a generic formula for calculating the total costs of meeting company's whole transportation requirements within an assumed planning horizon *I* (divided into periods of analysis *i*, e.g. months *i* = 1, 2, 3, …, 12) and under assumed percentage %PWMAX of transports carried out (kilometers covered) using an in-house fleet (within the BUY option) can be written as follows:

$$K_C\left(\%P_W^{MAX}\right)=\sum_{i=1}^{I}\left[\begin{array}{l} Min\left\{P^{MAX}\cdot\%P_W^{MAX},P_i\right\}\cdot k_W^w+\left\lceil\dfrac{Min\left\{P^{MAX}\cdot\%P_W^{MAX},P_i\right\}}{W_{Wi}}\right\rceil\cdot k_W^d \\ +Min\left\{P_i-P^{MAX}\cdot\%P_W^{MAX},0\right\}\cdot k_O \end{array}\right]$$

where:

$K_C(\%P_W^{MAX})$	the total costs of meeting company's whole transportation requirements within the planning horizon *I* for a given value of the $\%P_W^{MAX}$ [monetary units – m.u./… e.g. one year],
P_i	company's transportation requirements (demand) within a period of analysis *i*; *i* = 1, 2, 3, …, *I* [kilometers – km, tones – t, ton-kilometers – tkm, pallets – p, m^3, liters – l, routes – r, …/…],
P^{MAX}	the maximum value of company's transportation requirements (demand) within the planning horizon *I*; $P^{MAX} = Max\{P_i\}$ [km, t, tkm, p, m^3, l, r, …/…],
$\%P_W^{MAX}$	the percentage of the maximum value of company's transportation requirements met by a company's "own" (in-hose) fleet (the MAKE option) [%],
W_{wi}	an average, real productivity of a company's "own" (in-hose) fleet, per one vehicle, within a period of analysis *i*, expressed in the same units of measurement as company's transportation requirements (the MAKE option) [km, t, tkm, p, m^3, l, r, …/…],
k_W^w	the unit operating costs of a company's "own" (in-hose) fleet, per one vehicle and unit productivity (the MAKE option) [m.u./ km, t, tkm, p, m^3, l, r, …],
k_W^d	the total availability costs of a company's "own" (in-hose) fleet, per one vehicle within a whole planning horizon *I* (the MAKE option) [m.u./…],
k_O	the unit costs of buying transportation services in the market to meet company's transportation requirements (the BUY option) [m.u./ km, t, tkm, p, m^3, l, r, …],
$\lceil … \rceil$	the rounding up to integer symbol,
$Min\{…\}$	the minimum value of elements of a set.

THE CASE STUDY - SOLVING THE MOB PROBLEM IN POLISH CIRCUMSTANCES

A big trading company operating in the Polish market utilizes warehouses located all over the Polish territory. The company transports about 300 thousand tons of goods annually from warehouses to the customers using outside vehicles (the BUY option). To fulfill bigger orders from the customers (FTL) the company cooperates with many small-size carriers (operating medium and heavy duty vehicles characterized by 10 and 20 ton load capacities respectively - the capacity is utilized in 90% on average). Whereas to fulfill small orders from the customers (LTL) the company cooperates with a single big-size logistic service provider. About 85% of loads (taking into account their weight) are transported by small-size carriers, the remaining 15% by the logistic service provider. It gives about 11 million kilometers in total covered by small-size carriers annually (9 million of them are loaded kilometers being paid and resulting in the cost of 8 million dollars annually). There is no information about kilometers covered by the logistic service provider since its services are accounted based on the weight of loads delivered to the customers (per one tone irrespectively of a destination but depending on the total amount of tones transported - discounts). Company's transportation requirements vary about 15% of the weight of transported loads month to month.

The presented case is the most difficult one from the three possible decision situations when solving the MoB problem. It is the case where a company takes up the BUY option only using outside carriers to meet its own whole transportation requirements. In such a case the availability of necessary data to solve the MoB problem is very limited. The two other possible decision situations are the MAKE option and the mixed (MAKE-and-BUY) one. In such decision situations the availability of data are usually better. In the first case, where a company currently takes up the BUY option only, the most difficult part of the analysis is to calculate costs of the option DO. It requires an estimation of a total number of kilometers to be covered by a perspective company's "own" (in-house) fleet. This number depends on a particular amount of loads to be delivered to customers having particular locations taking into account sizes and frequency of their orders (deliveries as well).

It is worthwhile to mention that there appeared some limitations when solving MoB problem in the presented case study. On the one hand, transporting small size loads (LTL) by the logistic service provider turned out to be the most expensive option (taking into account transportation costs calculated per one tone of loads). But, on the other hand, it turned out to be impossible to transport them using an in-house fleet or outside but small carriers since it results in routes with too many destination points. Such routes are very ineffective and cause problems with deliveries on time (fulfilling time window constraints).

For the described above MoB problem a mathematical model has been constructed to optimize (minimize) a total transportation costs under the all possible combinations of MAKE and BUY options, their share in meeting the whole transportation requirements of the company. The MAKE option has been based on brand new or used medium and heavy duty vehicles, whereas the option BUY has been based on small-size, local carriers and the logistic service provider. The share of MAKE and BUY options in meeting the whole transportation requirements has been defined as the percentage of the total weight of all loads transported within the given option (changing the share by 10% from 0 to 100%). As a result 112 combinations defining potential solutions of the MoB problem has been analyzed. Starting from the 100% of the MAKE option / 0% of the BUY option - small carriers / 0% of the BUY option - logistic service provider solution, through the all combinations of these numbers, including the current one solution that is the 0% of the MAKE option / 85% of the BUY option - small carriers / 15% of the BUY option - logistic service provider.

Obtained feasible solutions of the MoB problem in the analyzed case (see Figure 2) can result in a reduction of the total transportation costs by 16% but also in an increase of the costs by even 34% in comparison to the current solution. Moreover, the three characteristic solutions of the problem, which are the cheapest, the most expensive and the current one include the same fundamental assumption: 0% of the MAKE option / 100% of the BUY option. Thus the share of small carriers and the logistic service provider within the BUY option appears to be crucial. The cheapest solution assumes the 100% share of small carriers in the option BUY, whereas the most expensive solution assumes the 100% share of logistic service provider. It is coherent with a common opinion about the transportation market in Poland, according to which, looking for the cheapest transportation solution, not necessarily the most convenient (high organizational involvement, no chance for putting the risk and the responsibility on a service provider), companies should use small, local carriers. Whereas, looking for the solution not necessarily cheap, but the most convenient, assuring good quality, full service, low organizational involvement and a chance for putting the risk and the responsibility on a service provider, companies should cooperate with only one logistic service provider. At least with a few, but it can result in higher costs.

And finally, as for the MAKE option based on company's "own", brand new vehicles it allows for the significant costs reduction as well. In the analyzed case it was about 10% cost reduction when transporting 90% of loads by company's own fleet and the remaining 10% by the logistic service provider - small, fragmented orders from scattered customers, orders difficult to fulfill by the in-house fleet. However, such the solution requires significant investments and as a result it should be considered as a very risky. The better solution seems to be the MAKE option based on company's "own" used vehicles resulting in 14% costs reduction achieved with significantly lower investments.

Source: author's research based on the real life data

Fig. 2. The total transportation costs v. the share of options MAKE and BUY - small, local carriers and logistic service provider (the black square denominates current transportation solution; black and white circles denominate the cheapest and the most expensive solutions respectively)

Rys. 2. Całkowite koszty przewozów a udział w ich realizacji opcji MAKE i BUY - mali, lokalni przewoźnicy i duży operator logistyczny (czarnym kwadratem zaznaczono rozwiązanie obecne; czarnym i białym kółkiem odpowiednio rozwiązanie najdroższe i najtańsze)

The carried out sensitivity analysis revealed that even 5% increase of the unit operating costs of a company's "own" vehicles reduces the savings resulting from the MAKE option (assuming brand new vehicles in the fleet only) from 10 to less than 7%. Moreover there is a risk associated with an ineffective utilization of the fleet in the future (the necessity of managing the fleet, but especially the necessity to assure an appropriate vehicles' mileage utilization - number of kilometers driven and vehicles' capacity utilization).

CONCLUSIONS

The MoB decision concerning transportation solutions based on company's "own" vehicles or outside services belongs to the group of strategic fleet management problems. This decision, as any other strategic decision, concerns relatively long-term planning horizon and nas postponed in time effects. It means that to asses if the decision made is correct or wrong will be possible after a long time (half a year to one year). Moreover, such decisions are usually crucial for a company and their results that are noticeable outside a company, have an economical character (e.g. investments). That is the cause why it is very important to make this type of decisions not only intuitively, but first of all based on comprehensive and correct analysis. Unfortunately in the literature MoB solution methods are described very superficially and only those which lead to “black or with” solutions, it means 100% of the MAKE or 100% of the BUY option only. But the key to solve the MoB problem lies in mixed MAKE-and-BUY solutions.

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STRATEGICZNE ZARZĄDZANIE TABOREM SAMOCHODOWYM - PROBLEM MAKE-OR-BUY

STRESZCZENIE. **Wstęp:** Floty pojazdów stanowią podstawowy środek produkcji w transporcie. Prawidłowe zarządzanie nimi jest zatem kluczowe dla wszystkich firm realizujących przewozy. Niniejszy artykuł jest pierwszym z serii trzech, jakie Autor chce poświęcić tematyce strategicznego zarządzania taborem samochodowym.
Metody: W artykule omówiono sposoby zaspokajania potrzeb przewozowych przedsiębiorstw (problem MAKE-or-BUY). To znaczy wybór pomiędzy wykorzystaniem własnych środków transportu i/lub zakupem usług przewozowych na rynku. Istota problemu MAKE-or-BUY leży w aspekcie zmienności w czasie, sezonowości potrzeb przewozowych przedsiębiorstw. Prowadzi to do rozwiązań typu MAKE-and-BUY obejmujących jednoczesne wykorzystanie transportu własnego i obcego. W artykule zaproponowano autorską metodę (model optymalizacyjny) pozwalającą na prowadzenie analiz typu MAKE-and-BUY.

Rezultaty: W artykule zaprezentowano zastosowanie opracowanej metody na rzeczywistym przykładzie problemu decyzyjnego w warunkach polskich oraz uzyskane rezultaty. Rezultaty te pokazały brak ekonomicznego uzasadnienia dla zastosowania opcji MAKE w polskiej praktyce gospodarczej. Szczególnie w przypadku, gdy rozwiązanie to miałoby być oparte o tabor złożony z pojazdów fabrycznie nowych.
Wnioski: Niniejszy artykuł będzie kontynuowany w dwu kolejnych artykułach Autora, poświęconych strategicznemu zarządzaniu taborem samochodowym, w tym kwestii jego liczebności / składu oraz wymiany.

Słowa kluczowe: zarządzanie, optymalizacja, flota, pojazd, transport, make-or-buy

STRATEGISCHES FAHRZEUGFLOTTEN-MANAGEMENT - DAS MAKE-OR-BUY PROBLEM

ZUSAMMENFASSUNG. Einleitung: Fahrzeugflotten und Fuhrparks stellen grundlegende Produktionsmittel innerhalb des Transportes dar. Daher ist ein angemessenes Flottenmanagement für alle Unternehmen und Firmen mit Transportaufgaben von großem Belang. Der vorliegende Artikel ist der erste von dreien, die der Autor dem strategischen Fahrzeugflotten-Management widmet.
Methoden: Dieser Artikel beschreibt Möglichkeiten für die Abdeckung des Transportbedarfes im Unternehmen (Make-or-Buy-Problem). Hierbei besteht also die Möglichkeit, Transportleistungen mit einer eigenen Flotte selbst zu erbringen oder sie extern einzukaufen. Die Hauptaspekte des Make-or-Buy-Problems liegen dabei in der Zeitabhängigkeit, bzw. in den saisonalen Schwankungen bezüglich des Bedarfs nach Transportleistungen. Dies führt zu Make-and-Buy-Lösungen, die auf eine Kombination von internen und externen Flottenlösungen setzen. Im vorliegenden Artikel wird ein mathematisches Optimierungsmodell zur Make-and-Buy-Analyse vorgestellt**.**
Ergebnisse: Es werden die Umsetzung und Ergebnisse einer Anwendung der vorgestellten Optimierungsmethode im Rahmen eines Feldversuchs in Polen präsentiert. Die Lösung zeigt auf, dass die wirtschaftliche Begründung für die Make-Entscheidungen in der polnischen Wirtschaftspraxis ausbleibt. Dies trifft insbesondere zu, wenn dieser Lösung der Einsatz einer Flotte von fabrikneuen Fahrzeugen zugrundeliegen sollte**.**
Fazit: Conclusions: The paper will be continued in two further papers dedicated to strategic vehicle fleet management problems including fleet sizing / composition and fleet replacement. Dieser Artikel wird durch zwei weitere Artikel zum Thema strategisches Flottenmanagement ergänzt, welche dann die Fragestellungen der Flottengröße und -zusammenstellung sowie des Flottenersatzes behandeln.

Codewörter: Management, Optimierung, Fahrzeugflotten, Fahrzeuge, Transport, Verkehr, Make-or-Buy, Make-and-Buy**.**

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CREATING THE NETWORKING ENTERPRISES - LOGISTICS DETERMINANTS

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ABSTRACT. Background: The article describes the determinants of creating network enterprises with peculiar consideration of logistic factors which are conditioning the organization of processes, exchange of resources and competences. On the basis of literature analysis, there is proposed a model of creating network enterprises. A model is verified in the application part of the thesis.

Methods: Within the publication a literature review of submitted scope of the interest was presented, as well as the empirical research. A research substance attaches the enterprises created on the basis of the reactivation of organizations which has collapsed due to bankruptcy proceeding. The research was based upon direct interviews with employees of the net-forming entities.

Results and conclusions: Results of the research shows that taking up the cooperation and net-cooperation was the only possibility for new entities to come into existence, that were based upon old assets and human resources liquidated during bankruptcy proceeding. There was indentified many determinants of enterprises network cooperation, however due to the research a conclusion draws, that basic factors of creating network cooperation are those which are profit-achieving oriented.

Key words: network companies, logistics processes, cooperation, resources, specialization, bankruptcy proceeding.

INTRODUCTION

Analysis of the logistic processes organisation within the structure of network cooperating enterprises has a great economic importance. Genesis of such structures coming to existence as network enteprises is seen in scientific and technical Progress, the asset and financial market development, information and communication economy, and global economy. The development of information technology and global informatics network causes dynamization of changes, a shortage of time reaction. In these circumstances, providing an elastic strategy is possible by application of many complementary strategies simultaneously with particular attention to the competences and resources.

In Polish conditions, we should pay attention to yet another determinant, namely, it is sometimes the only chance to shield the company from bankruptcy, or return to the market after the completion of the bankruptcy proceedings.

The sample, which was based on a model of the logistics processes organization network enterprises includes enterprises that arose again on the market, after they have conducted the bankruptcy proceedings.

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GLOBAL BASIS OF CREATING NETWORK ENTERPRISES

One of the key determinants of the creation of network enterprises, looking to market globally, is the development of new technologies, which are the result of scientific development. Changing measures, methods and means of production, distribution processes are evolving, as well as sales and service processes. Economic activity is increasingly adopted to the nature of networking, where production is the result of interaction of many entities that share their methods of management and technology used. A high level of trust and mobility of people and businesses, supports the mutual exchange of information and knowledge resulting in increased quality of factors of production, and for the manufactured goods and / or services. Continuous technological development on the other hand, causes an increase in customer requirements and satisfying their needs is able to provide a comprehensive service several integrated companies - network companies.

Significant impact on economic development is the development of financial and capital markets and the associated process of free movement of capital. Most of the investments in countries with very low economic level are done thanks to foreign investments. Investing in less developed countries by network companies also contribute to the reduction of unemployment there, and to increase the level of consumption.

For very important reasons to create a network companies is the development of information and communication technology. It results in the fact that society and the economy began to operate on the basis of information, organized on the basis of the network model. In this model, certain individuals and businesses creating network nodes are connected to each other with information and communication links, which are the technical infrastructure that supports networks collaboration [Castells, 2007].

A key resource in the modern economy is knowledge, we may even venture to say that economic development is dependent on the development of knowledge. A characteristic feature of this economy is the cooperation of enterprises and the organizations from business area, which results in the generation of innovative products and engages in research and development activities [Nahir, 2007]. In the rapidly changing economic space the networked economy of deep interdependence emerges, which is increasingly able to take advantage of progress in the area of technology, knowledge and management of the development of these same techniques, knowledge and management [Castells, 2007].

On the formation and further development of the network a great impact has the characteristics of the global economy, and its growing importance in forming the basis of the global network economy. According to D. Barney, the political and economic conditions under which the design, use and application of network technology is about to develop are: reduction of political and economic autonomy of sovereign state, the restrictions assigned by international trade agreements on issues of investment and international institutions that bring them to life, the extraordinary concentration of economic power for the minimum number of integrated international organizations [Barney, 2008].

According to T. L. Friedman, at the moment we are entering a period of globalization 3.0., which is still characterized by a decrease in the world. Information technologies and countries distant from each other have become very close, in terms of communication. According to T. L. Friedman, the cumulative importance of these factors results in the triple convergence: a critical mass of enabling technologies, individuals and organizations with sufficient ability to use these new platforms and the sudden appearance on the new "more equal court" more than three billion people in the emerging economies of the world [K. Fung, W.K. Fung, Y. Wind, 2008]. According to T. L. Friedman was this 'flat world' creates the ideal conditions in which businesses can use information technology to combat the obstacles in the course of business [Friedman, 2006]. The global market allows optimized use of resources, tangible and intangible, and the migration of workers in the framework of a unified European market performance of the services or the transfer of assets outsourcing centers, only confirms the operation of the process.

Companies that operate in a constantly changing economy must be flexible to adapt to new and unexpected events occurring in the immediate vicinity [Łobejko 2012]. To achieve this aim, they have to change themselves, their structure, often a form of action. Emerging economic crisis, rapidly increasing competition, more demanding and complex manufacturing processes and supply, means that companies that operate individually, in order to provide comprehensive customer service will deal with it fared worse and worse, so increasing trend towards enterprise network.

Economy that puts us at every step new challenges characterized by the fact, that time is becoming one of the factors contributing to succeed by the company. Increasingly, reduced product life cycle, entry of new or substitution of a product does not encounter major obstacles. New rules of competitive process described by G. Hamel and C.K. Prahalad, claiming that the company, in order to win the competitive fight, they ought to surprise their customers with innovations [G. Hamel, CK Prahalad, 1999]. Innovation processes rely on the growing importance of knowledge, learning and level of technological education in manufacturing processes tier. As a result of defeating these threats, one method is to work in a network of enterprises, particularly small and medium-sized. Cooperation can overcome emerging problems, such as those related to insufficient own resources.

In the modern economy it is increasingly difficult to achieve a sustainable competitive advantage. For such an honor can count on only the company that are highly developed in terms of technology. Therefore, for many companies the only way out of this situation is to achieve a number of competitive advantages of a short term nature. That is confirmed by the words of F. Hesselbeina - if you cannot rely on long-term benefits of the product, the winners of competition will be those that manage to create a series of short-term competitive advantages [Hesselbein, 1998]. Companies must demonstrate a lot of effort to maintain acquired, high market position, and the dynamic changes in the economy do not give certainty on its maintenance [Warnecke, 1999]. In order to meet this challenge, the company in its long-term strategy must find a place on the flexibility with which you can modify the operation of the company according to the market dynamics. According to B. Harrison, the ability to manage changes in the company, thus, gaining a competitive advantage is made possible by new forms of organization of the network, both inside and outside the company [Harrison 1997].

As we can see in accordance to the factors analyzed above, in the modern economy linkages play an important role, that change the relationship to the use of the competence of the company. In single network enterprise organizations, rather than on the protection of their own, are more focused on the use of the competence of other partners. The network can access the resource use where you do not need to be on their own, thanks to the fact that each participant in the network provides these resources, and the network can provide added value. It can therefore be argued that the increasingly changing approach to enterprise's resources, competencies and achievement of value added in the global economy out of the system 'enterprise - centric' system 'is network - centric' [Prahalad, 2009].

A MODEL OF NETWORK ENTERPRISES ORGANISATION IN ACCORDANCE TO LOGISTIC PROCESSES IN POLISH CONDITIONS

Network enterprises can be defined as a group of autonomous individuals or companies that participate in mutual cooperation, operating according to market rules. An important aspect of the network is that they are independent entities related by information technology to form a different configuration in each case. Each configuration is a combination of core competencies participants in the network, which enables better flexibility and speed than in the case of the operation of each of the individual participants [Thompson 2003, Granovetter 1985, Sayer, Walker 1992].

As the key areas of cooperation in business networks, mentioned in the literature are: the organization of resources and materials production, acquisition and exploitation of innovative technological solutions, including research - development, a joint venture in manufacturing and services, organizing the distribution, marketing, and presentation of common interests [Górzyński, Pander, Kuć, 2006].

Few places in this area are devoted to logistics, however, changes in the functioning and organization of companies that have decided to co-operate in the network are visible particularly in the organization of logistics processes.

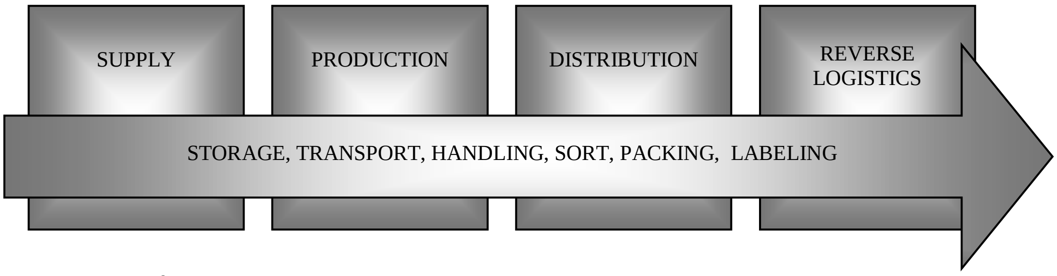

Fig. 1. Subject of the model
Rys. 1. Podmiot modelu

LOGISTIC DETERMINANST OF ENTERPRISES NETWORK COOPERATION

EXTERNAL	**INTERNAL**			
	RESOURCES	**TASKS**	**ORGANIZATION**	**LEGAL AND FINANCIAL**
• Globalization • Socio-cultural • Geographical • Infrastructure • Economic policy of the state • Technology • Macroekonomic	• Concentration of the resources on core competencies • Development and management of human resources • Management of Information resources • Management of financial resources and fixed assets • Management of technical resources	• Mutual commitment in ensuring customer satisfaction • Continuous improvement • High standards of service • Optimization of tasks in terms of supply, production, distribution and reverse logistics • In terms of time • Realization of costs • Realization of management • Impact on the environment • Managing ad hoc tasks	• Management of relationships within the network in terms of subsystems: supply, production, distribution. • Management of relationships between network partners in areas of contact with suppliers, customers, operators. • Risk sharing • Common strategy • Striving to achieve a common goal • Standardization cooperation • Organizational culture values and principles • Management of relationships between the network and its environment • Management of change and improvement	• Legal conditioning regulators • Breakdown of costs • Distribution of profits • Increase in value added • Fixing prices • Potential financial partners • Strict standards of conduct • Ensuring compliance with legal provisions

Fig. 2. Logistics determinants of networking enterprises cooperation
Rys. 2. Logistyczne determinanty kooperacji przedsiębiorstw w sieci

Within logistical processes these are those which, by the coordinated implementation of activities related to the storage, transporting, handling, sorting, packing, labeling assist in the transformation of the main processes allowing companies to maximize the creation of value added for services to internal and external customers [Kulińska 2011]. The subject of the model of logistic processes is understood according to the quoted definition, implemented in different areas of the enterprise - Fig.1.

The basis for the development of space and time integration of processes within and between cooperating companies is frequent contacts and understanding of the different functional areas of the partners. This is what has so far been implemented within a single company, is divided into several cooperating with each other partners. This leads to the broader specialization, concentration on a small number of well-defined processes, sub-processes and activities, and above all on a quest to perfect their execution. It is the first and most important factor in the analysis of the organization of the logistics processes of enterprises operating in the network.

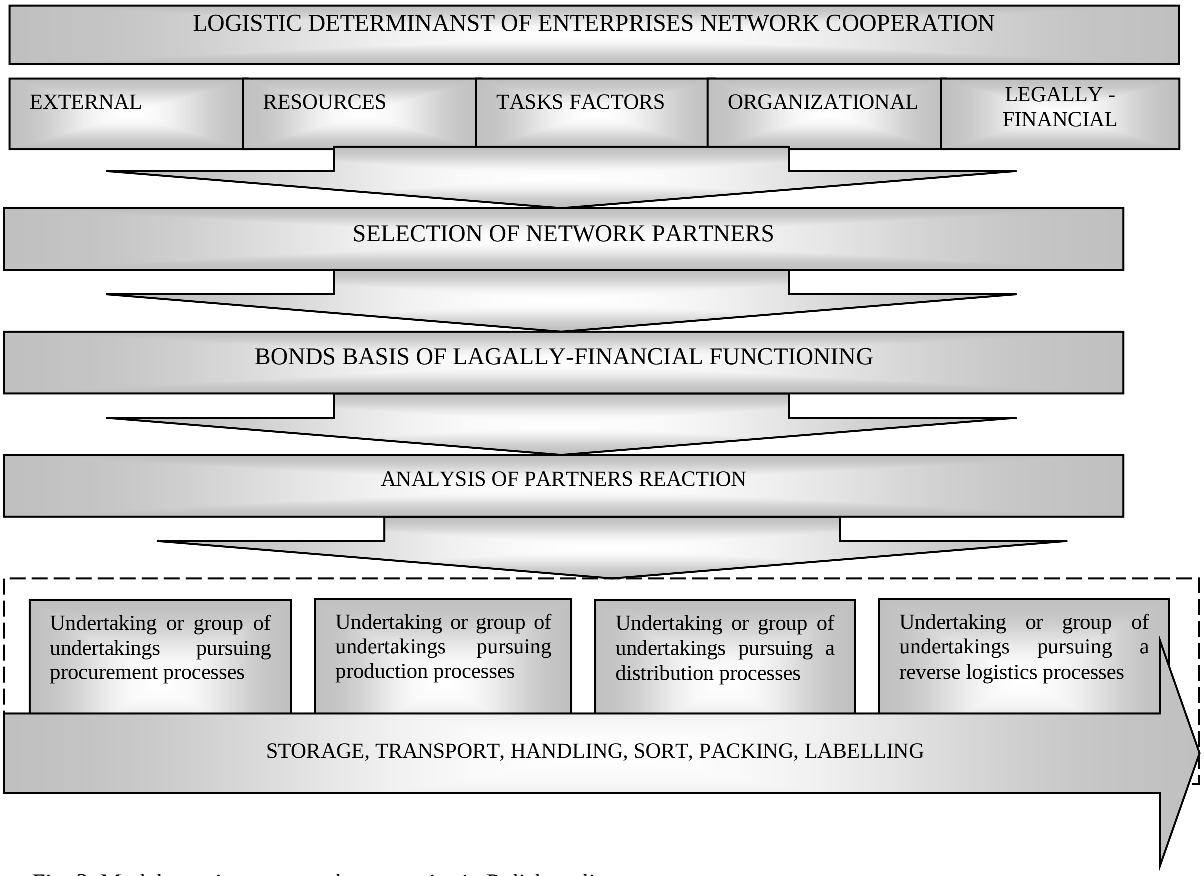

Fig. 3. Model creating a network companies in Polish reality
Rys. 3. Model tworzenia przedsiębiorstw sieciowych w warunkach polskich

The basis for the development of space and time integration of processes within and between cooperating companies, are frequent contacts and understanding of the different functional areas of the partners. Other factors affecting the willingness and time collaboration between partners can be grouped into the following areas: external determinants, the determinants of resource, organizational determinants, the determinants of task forces, legal and financial determinants.

On the basis of the literature research on the determinants of the organization of logistics processes and research in the group of companies which, having performed the bankruptcy proceedings arose again on the market, developed the concept of creating a model of network companies in the Polish conditions. Taking into account all the above described areas of logistics transformation model structure of logistics processes of enterprises operating in the network might look like this - fig. 3.

The proposed model defines the subject that is established by the main areas of the company, in which logistics processes are realized. The base model is the consideration of the chain of the values, with particular emphasis on core processes. The model takes into account the determinants of creating a network linking organizations familiar with the literature of models: Ch. Scott and R. Westbrook [Scott Westbrook 1991], Tanskanena [Tanskanen 1994], advanced logistics partnership model [Frigo-Mosca, 1998], D.M. Lambert, M.A. Emmelhainza and J.T. Gardner [Lambert, Emmelhainz, Gardner 1996].

RESULTS OF APPLICATION LAYER

After the analysis of the literature problems of formation of network companies and organizations in the network of logistics processes, were verified on the basis of the views. The sample was constituted companies that have conducted the bankruptcy proceedings were suppliers to enable them to return to the market, and job security for their employees and the management of other resources.

General scheme of enterprise networks and the relationship between them is shown in Figure 4. It was developed on the basis of information from an interview with the business. On the basis of the research there was established a general scheme of operation of the network companies in the Polish conditions. In each of the entities, there can be distinguished leader and a group of enterprises engaged in processes of sourcing, production and distribution. The practice can also see a group of companies associated networks as competitors. These are usually companies that based on short-term contracts to perform specific network order when collaborators are too overloaded execution of orders, and there is a risk of failure to perform them on time.

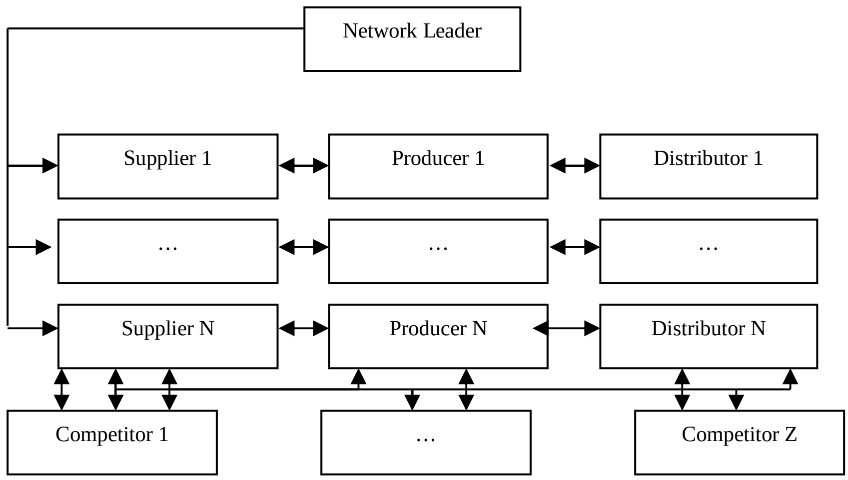

Fig. 4. Schematic operation of the network enterprises
Rys. 4. Schemat funkcjonowania przedsiębiorstw sieciowych

Fig. 4 shows the major companies participating in the network and the relationships between them, marked with arrows. Generally, the activities of individual companies in the network can be characterized as follows:

– Leader of the network - mostly foreign joint-stock group focused in its structure a number of subsidiary companies.

- Enterprise vans - these are the subsidiaries of 'mother company'. Enterprises are direct principals for manufacturing companies. These companies, usually geographically cover the whole territory of Europe.
- Production companies - are a subcontractor for commercial enterprises, in terms of production itself .
- Competitors - firms are competing for the producers, because the network meets the same function as subcontractors. Such companies are appointed to the network for safeguarding the interests of the leader of the network. In the event that any of the companies could not accept the next job, competing firms would find an opportunity to place in the network. Initially, their activities do not endanger other entities in the network, but over the years, the development of management, may become dangerous competitors. In the contemporary moment, all companies serve each other with mutual assistance.
- Distribution companies - are the providers for manufacturing companies . Engaged in international transport and have their own magazine. They are used by manufacturing companies in the field such as rental agents for handling, or repair and maintenance of electrical installations in the enterprise.

Another area of research is the indication of material resources flowing between the undertakings. Moving map resources is shown in fig. 5.

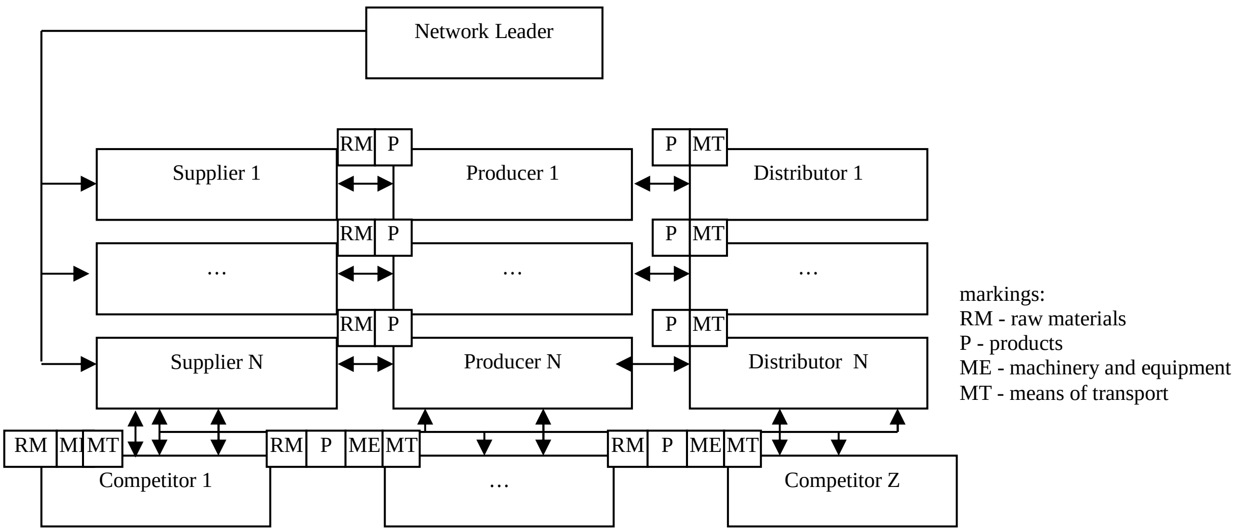

Fig. 5. The flow of material resources in the network structure
Rys. 5. Przepływ zasobów materialnych w strukturze sieciowej

Figure 5 shows the flow of raw materials and finished goods occurring between the leader of the network - the principal, and the Polish manufacturing companies and entities competing. Manufacturing companies are most common in Poland, the group entering into the relationship network. These are companies that have built up on the basis of the assets and human resources companies liquidated during bankruptcy proceedings.

Manufacturing companies are supplied with raw materials directly by the client. This gives you the opportunity to specialize in their activities for each party. In turn, the final products are shipped to distribution centers for the client who sells these products. Discussing the service operators - production can be seen that also take place between material flows. Are moved raw materials, when in one of the companies gaps storage. This system saves time because you do not need a sudden bring raw material from the client, and simply 'borrow' material from a friendly competitor.

As raw materials are also moved the machine. Depending on the needs of manufacturing companies exchange machinery and equipment manufacturing. This fact allows for greater flexibility in the production process. The last of the material flow is the exchange of internal transport. Such cooperation is beneficial in the case of warehousing, and especially when the cash transport are failures. Then, without any problems, the devices are borrowed from a partner network.

In addition to the material flows, the network offers other types of exchanges. Between enterprises move the competence. Figure 6 illustrates the flow of powers between the network partners.

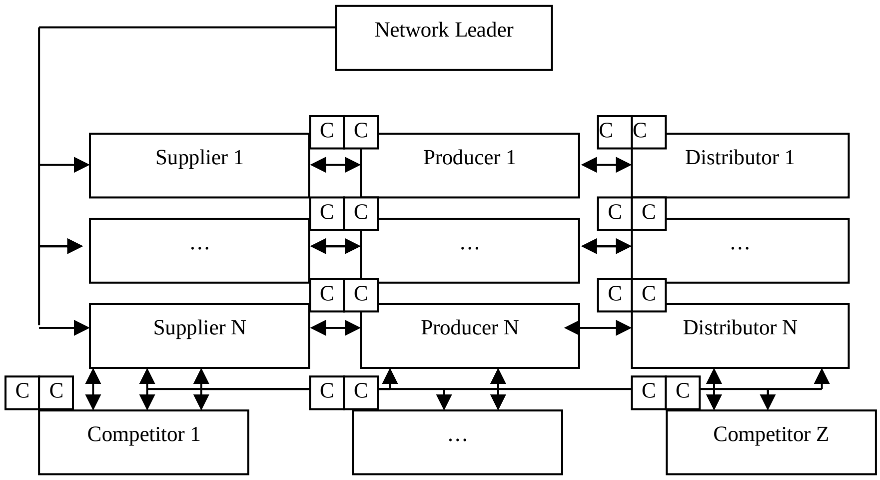

Fig. 6. The flow of information in the network structure (c - competence)
Rys. 6. Przepływ informacji w strukturze sieciowej (k - kompetencje)

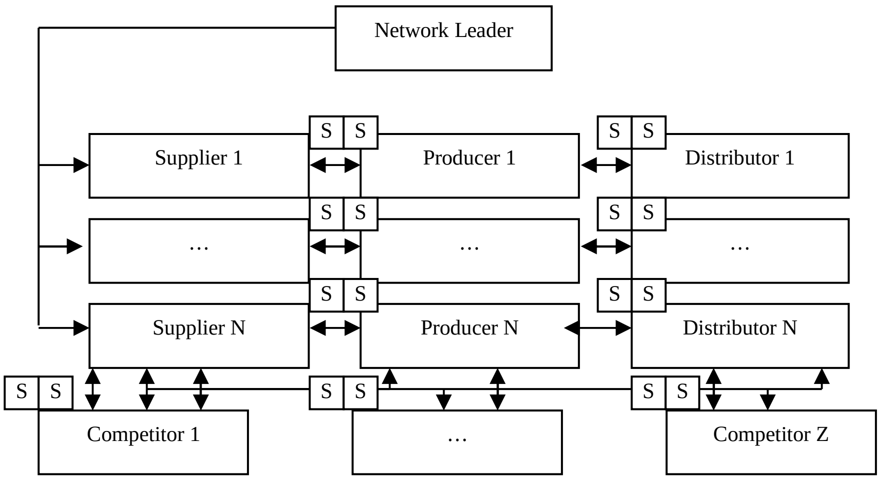

Fig. 7. Movement of services in the network structure (S - services)
Rys. 7. Przepływ usług w strukturze sieciowej (U - usługi)

The most important flow of information in the network is the transfer of powers between the client and the service providers. These competencies include the characteristics of the production process, product specifications, job descriptions of employees and the entire technical knowledge concerning production. If the flow does not exist, there would also be discussed manufacturing companies. Customer has an insight into the functional structure of the manufacturing company can use it or advise changes. Information flows between these businesses are also reports of orders and production. Shipments of information also exist between competing entities. Exchange systems are subject to the operation of each of the companies.

The exchange of material resources and competences are not all the possible aspects of the partnership in the network. Flows are also activities provided to other companies or services. Figure 7 clearly shows the movement of services between cooperators Network.

The study assumed only a general scheme , but there are cases that the essential role of manufacturing enterprises is the role of the service provider. The division was made because of the two types of services, and more specifically on two types of products, such as the most frequent in the studied networks. This division is important because of the differences in the production process. The same relationship in terms of services exists between the client and the business competitive. I should also mention about the services provided by the distribution companies. These services are performed only to suppliers, companies are not dependent on the rest of the network partners. These activities include the most assistance in respect of the rental of internal transport, repair and maintenance of electrical installations in the workplace.

After discussing the components of cash flow between business network, you must also take into account what type of relationship frequently occurs between partners. The model takes into account logistical determinants that influence the development of the organization of logistics processes in the network. Identified determinants of an external and internal. Impact determinant schematically shown in Figure 8.

As shown in Figure 8, the external determinants act on all parties cooperating in the network. This is due to the progressive globalization processes, the processes of socio - cultural, geographical differences, as well as the policies of the state and emerging technologies.

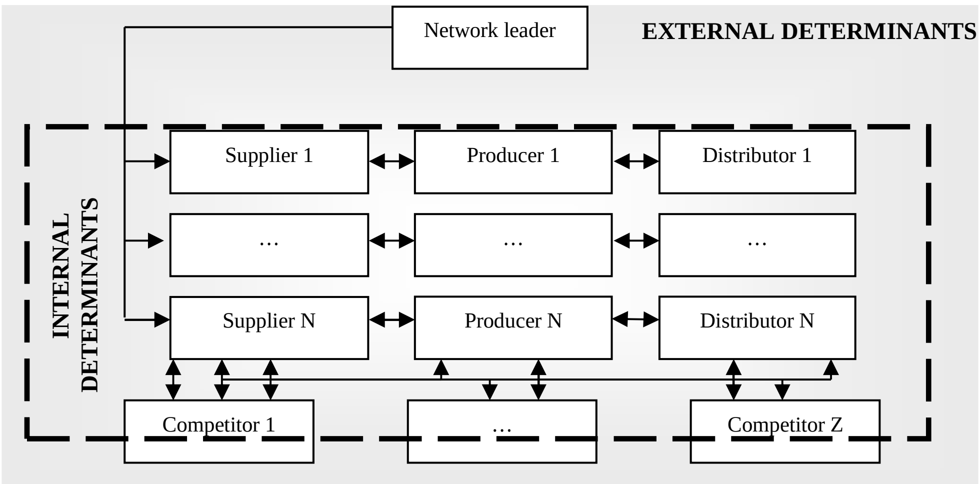

Fig. 8. The nature of the relationships between business networks
Rys. 8. Charakter relacji występujących pomiędzy przedsiębiorstwami sieci

When it comes to internal determinants can replace them very much already selected summarized in Figure 2. However, based on the research we can conclude that the main factors are creating a network of cooperation aimed at achieving these benefits. Cooperation for the implementation of the main activities towards specializing associated with each of the partners. In general, all activities in the network of companies are profit-driven. It should also take into account the risks of functioning in such a structure. The benefits that have reached the company include:

– The ability to exchange resources and competencies - without this factor would not be possible operation of enterprises . The entire manufacturing schedule, providing machinery and equipment and providing raw materials, the main leader of the resources provided by the network - the client. Resources exchanged between partners support the continuous development of enterprises.

- Acquisition of knowledge - beyond acquiring resources and expertise, the network operates the exchange of knowledge .
- Improving the quality of services - possible also thanks to the networking companies.
- Expertise, lack of responsibility for other departments and the lack of extensive management
- system improves the quality of our services and products aiming to meet the needs of the final customer.
- Elimination of competition - continuing the theme of the specialized and limited risks, you should also mention avoiding the cost of competition.
- Maintain flexibility - cooperation with the customer is not limited network of companies. Enterprises can at any time establish a partnership with another client, from another industry.
- Reduce the cost of design - therefore , that some companies in the network are only a service provider is not liable for the costs associated with product design . There is no need to analyze the company had a market, anticipate potential gains from the sale, calculate the target cost of the product, or the cost of its components. For these activities is the responsibility of the customer.
- Reduction of the duration of the process - it is a benefit, which feels every network operator.

These benefits encouraged to participate in the network structure. However, the analysis deeper way of functioning in such a form , you can find a defect or hazard that is associated with the partnership. The disadvantages and risks include: reduction of independence, the possibility of information leakage, selfish behavior of partners, exploitation of vulnerable network operators, or obstruction of access to finance. The most serious threat to the network is the lack of diversification of sales and the threat of bankruptcy leadership network.

After analyzing the advantages and disadvantages of participation in the network structure can take many doubts whether cooperation is beneficial . It is worth noting, however, that the advantages are advantages that companies have already achieved. On the other hand, disadvantages are primarily risks, which may or may not occur. Any form of economic activity carries risks, so it appears also in the functioning of the network companies.

CONCLUSIONS

The research problem was to present the organization of logistics processes in the functioning of the network companies.

You can find several aspects of the logistics of participating companies in the network. The first is webbyness inside the enterprise. It consists in the fact that different departments work closely together so that they can provide their client a comprehensive service . Another aspect relates to the organizational structure, and more specifically its type, which belongs to a group of staff structures. They are characterized by, among others, delegation of responsibility to lower-level positions, so many decisions to be made faster, which is desirable in the operation of network structures. A stuff organization also makes the company more flexible, making it easy to build collaborative relationships with new cooperators . Another feature is the focus on processes that can improve the functioning of the company and for the effective fight against competitors and to provide flexibility, which, as previously explained facilitates networking .

Analyzing the main process enterprise which influenced the decision to embark upon the structure of the network . One of the main conclusions of this area is that the re-emergence of companies was dependent on whether or joins the network structure or not. Division factors have also been made to external and internal.

External factors were determinants of global, on the broader economy and the changes taking place in it . In turn, the latter directly related to network companies and the potential benefits that companies can gain.

After hearing the reasons to join the network, further research has focused on the functioning of the whole network, therefore, been developed schemes cooperating companies mentioned resources, communications, services, as well as a diagram determinants affecting the organization of logistics processes and links in the network. Analyzing the net cooperation, it can be seen that the most important partners are the principal, but it is the cooperation with other network operators enables the most efficient execution of orders. In the final step being shown benefit and risk the functioning of the network structure, chosen by the trader.

First, referring to the benefits, it is worth noting that in addition to a reduction in the cost of design, eliminating the cost of competition and the acquisition of material resources, indicated the benefits are intangible. The conclusion from the above reasoning is that the enterprise network is essential to acquire knowledge of how to function and not necessarily to raise funds to function. Just received and put to good use competencies can bring profits to each of the companies.

In summary, we can conclude that cooperation network companies meet the objectives and principles of the proposed model. Each of the suppliers has a chance to develop their own profit . Networks operate in order to produce high quality products, meeting fully the needs of end customers, without losing the high market position. Companies participating in the network to specialize in their field and limit liability only to the performance of their tasks. Networking determines their existence.

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PODSTAWY TWORZENIA PRZEDSIĘBIORSTW SIECIOWYCH - DETERMINANTY LOGISTYCZNE

STRESZCZENIE. **Wstęp:** W artykule omówiono determinanty tworzenia przedsiębiorstw sieciowych ze szczególnym uwzględnieniem czynników logistycznych warunkujących organizacje procesów, wymianę zasobów i kompetencji. Na bazie analizy literaturowej zaproponowano model tworzenia przedsiębiorstw sieciowych. Model został zweryfikowany w aplikacyjnej części pracy.
Metody: W publikacji przedstawiono przegląd literatury w omawianym zakresie oraz badania empiryczne. Materiał badawczy dotyczy przedsiębiorstw powstałych na bazie organizacji reaktywowanych po postępowaniach upadłościowych. Badania prowadzono na podstawie wywiadów bezpośrednich z pracownikami podmiotów tworzących sieć.
Wyniki i wnioski: Wyniki badań wskazują, że podjęcie współpracy i kooperacja w sieci były jedyną możliwością powstania nowych podmiotów na bazie starego majątku i zasobów ludzkich firm zlikwidowanych podczas postępowania upadłościowego. Zidentyfikowano wiele determinant kooperacji przedsiębiorstw w sieci, jednak na podstawie badań wyciągnięto wnioski, że podstawowymi czynnikami kreowania kooperacji sieciowej są te nastawione na osiąganie korzyści. Współdziałanie dla realizacji celu głównego jest związane z wyspecjalizowaniem działalności każdego z partnerów. Ogólnie, wszystkie działania podejmowane w sieci przedsiębiorstw są nastawione na zysk.

Słowa kluczowe: przedsiębiorstwa sieciowe, procesy logistyczne, kooperacja, zasoby, specjalizacja, postępowanie upadłościowe.

GRUNDLAGEN DER ERSTELLUNG VON NETZWERK-UNTERNEHMEN - DETERMINANTEN DER LOGISTIK

ZUSAMMENFASSUNG. Einleitung: Der Artikel beschreibt die Determinanten für die Schaffung von Netzwerk-Unternehmen mit dem Schwerpunkt auf die Faktoren, die die logistischen Prozesse, den Austausch von Ressourcen und Kompetenzen voraussetzen. Auf der Grundlage einer Analyse der betreffenden Literatur wurde ein Modell für die Erstellung von Netzwerk-Unternehmen vorgeschlagen. Das Modell wurde im Anwendungsteil der Arbeit überprüft.
Methoden: Diese Veröffentlichung gibt einen Überblick über die Literatur in diesem Bereich und über die empirischen Forschungen. Das Forschungsmaterial betrifft die Unternehmen, die durch die nach dem Konkurs reaktivierte Organisation entstanden sind. Die Studie wurde anhand direkter Interviews mit den Mitarbeitern der Unternehmen durchgeführt.

Ergebnisse und Fazit: Die Ergebnisse zeigen, dass die Aufnahme der Zusammenarbeit und Kooperation im Netzwerk die einzige Möglichkeit war, um neue Einrichtungen auf der Grundlage der alten Immobilien -und Personalbestände der während des Insolvenzverfahrens liquidierten Unternehmen zu erstellen. Es wurde eine Reihe von Determinanten der Unternehmen im Netzwerk identifiziert, allerdings stellte man im Ergebnis der Forschungen fest, dass die wichtigsten Faktoren bei der Schaffung eines Kooperationsnetzwerkes diejenigen sind, die auf die Erzielung von Profiten ausgerichtet werden. Die Zusammenarbeit für die Umsetzung der wichtigsten Aktivitäten ist mit einer entsprechenden Spezialisierung jedes Partners im Netze verbunden. Generell gesehen sind alle Aktivitäten in den Netzwerk-Unternehmen gewinnorientiert..

Codewörter: Netzwerk-Unternehmen, Logistikprozesse, die Zusammenarbeit, Ressourcen, Spezialisierung, Konkursverfahren.

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SUPPLY CHAIN MANAGEMENT BASED ON LOGISTIC AND STATICAL INDICATORS

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ABSTRACT. Background: Article presents a model concept of supporting supply chain management based on predefined correlation between logistic and statistical performance indicators. Paper presents how, set of logistics indicators at different levels of management and a set of statistical indicators broken down by macroeconomic and microeconomic level, can be used in order to improve supply chain management. The correlation coefficients are presented for evaluating the relationships between the selected samples of individual indicators.
Methods: In order to present relationships between the indicators used are elements of statistics such as correlation coefficients Spearman's rho and Kendall's tau-b.
Results: As a result of work carried out obtained a list of logistics indicators and statistics that can be used when making decisions in supply chain management. Obtained the degree of relationships between the individual indicators, through the designation values of correlation indicators.
Conclusions: Efficient supply chain management requires not only the proper selection of indicators, both logistical and statistical, which support decision-making. Important element is also identification of the correlation between the indicators at micro (company) and macro (environment) level. This will enable the correct way to draw conclusions from the reports and take corrective action for a specific branch or a company.

Key words: indicators of logistics and statistics, coefficient of correlation.

INTRODUCTION

The European economy has been experiencing some radical changes in the last few years. The analysis of the data of the European Statistical Office shows a 5% increase in the sales and turnover in wholesale and retail trade in European Union states. Companies have been adjusting their strategies to the changing market conditions. Merges of companies take place, new process management concepts are introduced. At the same time, competition gets stiffer and consumers' expectations grow. It should be also noted that regardless of the economic growth rate, the transportation of goods by road increased in the last four years. As an example, on the basis of the latest data made available by the European Statistical Office (Eurostat), the share of road transportation in goods shipping in Europe was 79% in total inland freight tonne-km.

These changes forced companies who not only wish to survive, but also to develop and bring the expected profits, to introduce changes to their operation and supply chain management. The challenge lies in the complexity of the relations between the activities performed by the companies and the environment where they are active. For example the more frequent deliveries to the clients the higher traffic on the road appears. Such traffic can cause delays in delivery time, so finally can reduce

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the efficiency and effectiveness of the delivery process. Thus, identification of real correlation between logistics and statistical indicators is a must once the company wants to consciously manage their supply chain.

Companies usually have a twofold attitude towards indicators that enables them to measure efficiency and effectiveness of their activities. On the one hand, there are companies that try to measure as many elements and areas in particular processes as possible and react to changing indicators and standards whenever they come up while, on the other hand, some companies end their analysis on the financial stage.

Objectively, both approaches have their advantages and disadvantages. The most effective solution would be to work out such a set of indicators that would suit an individual company's needs. The choice of suitable indicators which support making decisions at individual stages of management is a vital element which has an influence on the efficiency of the actions taken and on the shape of a company's policy.

Analyses carried out by the Institute of Logistics and Warehousing show that the indicators used by a company should include customers' needs and deal with efficiency as well as be coherent with a company's strategy.

The subject matter literature defines efficiency as a characteristic which can be ascribed to every action and which defines the achievement level of set actions' results, which generally cater for needs and enable achieving goals and coming up to one's expectations. Efficiency is also a non-economic term which characterises an action intended to achieve a set result. Efficiency needs a comparison of the effects with the costs incurred to achieve the set results [Lichocik, Sadowski, 2013]. It also means effective economic action which can be defined by the relation between achieved effects and the cost incurred to achieve these effects. There is a cause and effect relation between the cost input and the effects.

An additionally important element in a management process is setting current values of individual indicators, defining the target (normative) value of these indicators as well as the targets for which individual indicators are measured. The aforementioned information should be handed over to particular departments or the people responsible for a given indicator so that they would be aware of their duties in this area. A good practice is also a cyclic analysis of the values of individual indicators and setting possible repairing actions which should improve the present situation and aim at the target value of a given indicator.

Nevertheless, it should be remembered that measurement only of logistic indicators will not give the same opportunities as combining them with statistical indicators. Setting a correlation indicator between individual indicators (logistics and statistical) can give much adequate results for drawing correct conclusions on each of management stages.

The aim of the article is to present an example approach how managers can define set of logistic and statistical indicators standards for different stages of management. The article also shows connections between individual indicators. As a result an article shows analyses to what extent the decisions concerning supply chains can be supported by identification of strong relations between different indicators and its further constant measurement.

LOGISTIC INDICATORS ESSENTIAL FOR DECISION MAKERS ON PARTICULAR MANAGEMENT STAGES

The subject matter literature gives different divisions of indicators and standards according to a particular criterion. A detailed analysis can reveal a division of indicators and standards according to:

- the data they are connected to- quantitative/ qualitative,
- the element of the process it concerns- input, output

- the stage of the management at which they are used- operational, tactical, strategic.

The present article focuses on the indicators classified according to the management level at which decisions are made. The management level consists of three main parts [Heizer, Render, 2008]:

- operation,
- tactical,
- strategic.

Operations management is the set of activities that creates value ih the form of goods and services by trans forming inputs into outputs. Activities creating goods and services take place in all organizations. In manufacturing firms, the production activities that create goods and usually qualite obvious parts [Heizer, Render, 2008].

Table 1. A list of chosen logistic indicators used at particular management stages
Tabela 1. Lista wybranych wskaźników logistycznych używanych na poszczególnych poziomach zarządzania

No.	Name of indicator and measure	Level of management		
		operation	tactical	strategic
1	Stock coverage rate	X		X
2	The share not rotating stock in total stock	X		
3	Indicator exceeded the planned lead time	X		
4	Accuracy of sales forecast	X		
5	Fill-factor vehicles	X		
6	Technical readiness indicator of transport fleet	X		
7	Utilization indicator of car mileage	X		
8	Indicator of timeliness of carriage	X	X	X
9	Indicator cargo of damage during transport	X	X	
10	Share of transport costs in total costs of enterprises	X	X	X
11	Indicator of exploitation of warehouse (in terms of quantity and value)	X		
12	Indicator of surface inventory management (in terms of quantity and value)	X		
13	Indicator of cubature inventory management	X		
14	Indicator of performance warehouse	X	X	X
15	Indicator of warehousing costs in relation to value of stocks			X
16	Indicator of warehousing costs in relation to value of stocks	X	X	X
17	Cost of completing a single order	X		
18	Indicator timely deliveries by suppliers [%]	X	X	X
19	Indicator timely deliveries to customers [%]	X	X	X
20	indicator of level of execution of orders [%]	X	X	X
21	Level indicator complaints from suppliers [%]	X		
22	Level indicator complaints from customers [%]	X	X	X
23	Number of tonnes transported freight	X	X	X
24	Number of car accidents in enterprise	X	X	X
25	Expenses on R&D			X
26	Greenhouse gas emissions			X
27	Customer Satisfaction	X	X	X
28	Transport costs	X	X	X
29	Labour costs		X	
30	Level of noise emission			X
31	Level of waste			X
32	Level of recycling of products			X
33	Emission level of CO_2 from transport processes			X
34	Level of leakage of harmful substances			X

Source: own study based on Sergeev, 2005, Heizer, Render, 2008

The administrative process of selecting among appropriate ways and means of achieving a strategic plan or objective is understood as tactical management. The use of tactical management in a business environment allows a manager to choose the best tactics or methods for each situation that arises, rather than following a particular standard procedure [Reda, Lederking, 2004].

Finally, strategic management is the process and approach of specifying an organization's objectives, developing policies and plans. In other words, strategic management can be seen as a combination of strategy formulation, implementation and evaluation [Raduan, Jegak, 2009].

Dividing level of management into three parts is caused by the necessity to differentiate between the level of detail and the area of influence of particular indicators.

Table 1 shows a list of chosen logistic indicators which can be used by companies to support making decision on different management stages.

STATISTICAL INDICATORS AND STANDARDS SUPPORTING MAKING DECISIONS IN A COMPANY

Eurostat as well as statistical agencies in given countries (e.g. The Main Statistical Office in Poland) publishes statistical data on a microeconomic level as well as on a macroeconomic level which describes basic tendencies of a social-economic development.

Table 2. A list of statistical indicators and standards supporting making decisions in a company
Tabela 2. Lista wskaźników statystycznych i standardów wspomagających podejmowanie decyzji w przedsiębiorstwach

No.	Name of indicator and measure	Source of data about indicator	Level	
			macroeconomic	microeconomic
1	Traffic intensity on the roads (vehicles/h)	GDDKiA		X
2	Average trip length by purpose (km) for the different modes of transport	GUS		X
3	Number of tons of cargo for transport modes	GUS, Eurostat		X
4	Degree of congestion for individual transport modes	GDDKiA		X
5	Transport broken down into modes of transport (tkm)	GUS, Eurostat		X
6	Quality of environment (noice level and pollution from modes of transport)	GUS, Eurostat		X
7	Number of accidents / year	The Main Police Station database		X
8	Gross Domestic Product (GDP)	GUS	X	
9	Average monthly gross nominal wage in the corporate sector (Enterprises, in which the number of employees exceeds 9 persons) (in zł)	GUS	X	
10	Price indicator of consumer goods and services	GUS	X	
11	International Trade (import / eksport)	GUS	X	
12	Industrial Production	GUS	X	
13	Retail sales of selected foods	GUS		X
14	Number of flats for which building permits were issued and construction started	GUS		X
15	Employment rate	GUS, Eurostat		X
16	Gross domestic expenditure on R&D	Eurostat	X	
17	Greenhouse gas emissions	Eurostat	X	
18	Primary energy consumption	Eurostat	X	

In the case of The Main Statistical Office in Poland (GUS), the data on the macroeconomic level is presented according to types of business defined by the Polish Business Classification 2007. Other institutions which can be a potential source of data concerning indicators are the following: (in case of Poland) The Main National Roads and Motorways Management (GGDKiA) and The Main Police Station.

The choice of accurate indicators and standards depends on individual company as well as on the type of decisions which making should be supported by particular indicators. Table 2 presents statistical indicators and standards which support making decisions in companies in different sectors and branches.

Individual indicators and standards can be used to support making decisions at different management stages as well as for benchmarking [Fertsch, 2008], in order to determine where a company is located in comparison to other companies in a given country.

CORRELATION BETWEEN LOGISTIC AND STATISTICAL INDICATORS

An important aspect of an analysis of logistic processes efficiency is intentional formulation of a set of indicators which make it possible to avoid contradictory results. Thus, an essential element of developing the set of indicators is their correlation with statistical indicators. Statistical indicators predispose developing a correlation between variables in the form of, for example, a function which enables shaping the analysed logistic processes and, consequently, supporting decision making of a company's management board.

The measurement of correlation between two variables which are randomly dependent can be carried out with the use of a few measures. Most often used measurements of the power of variables correlation are the following [Wang, Xie, Chena, Yang J., Yang M., 2013, Monjardet, 1998]:

Czuprow coefficient of convergence

The indicator of the convergence can have values in the <0,1> bracket. It can be used to measure measurable as well as immeasurable correlations. The smaller the real power of the correlation of measured variables, the lower the number value of the indicator (it aims at 0). The disadvantage of this ratio is lack of presenting the direction of the measured variables.

Pearson coefficient of correlation

This indicator takes the values from the <0, 1> brackets not showing the direction of the correlation. The advantage of this measure is the possibility of using it not only in the case of linear correlation but also in the case of askew linear correlation.

Pearson linear coefficient of correlation

The measure takes the values from the <-1, 1> brackets showing the direction of the correlation. The suggestion for the interpretation of the indicator has been shown in a table. The disadvantage of this measure is the possibility of using it to measure the power of variables interdependence only in the case of linear correlation as well as the possibility to measure both variables.

Table 3. Interpretaion of the linear coefficient of correlation
Tabela 3. Interpretacja liniowego współczynnika korelacji

Value of the coefficient		Interpretation
0 – (- 0,3)	0 – 0,3	No correlation or very poor correlation
-0,3 – (- 0,5)	0,3 – 0,5	Moderate correlation
-0,5 – (- 0,7)	0,5 – 0,7	Strong correlation
- 0,7 – (- 1)	0,7 – 1	Very strong correlation

Source: Ścibor-Rylski, 2007

Spearman Rank Correlation

This indicator is used to measure rank correlation of two variables and it takes the vales from the <-1, 1> brackets showing the direction of the correlation. In the case when the measure equals 0 it reflects variables independence, while -1 or 1 shows dependence between the variables. This indicator is used in the case when there is an ordinal scale.

Kendall Rank Correlation

This measure is used in the case of an ordinal scale and it takes the values from the <-1, 1> brackets showing the direction of the correlation.

Depending on the data, an appropriate correlation indicator should be chosen thanks to which it will be possible to determine the interdependence between measured variables.

Presenting the relation between chosen indicators is possible in two ways. On the one hand, we can set a correlation indicator between individual indicators and standards. On the other hand, we can determine the dependence of indicators based on our knowledge and experience.

Table 4. Matrix of correlation between indicators and measures that assess mezo, micro and macro scale
Tabela 4. Macierz korelacji pomiędzy wskaźnikami, które są wykorzystywane w scali mezo, makro i mikro

Mezo and macro scale / Micro scale	Region / Country							
	Traffic intensity on the road (vehicles / h)	Average trip length by purpose (km) for the different transport branches	Number of tons of cargo in branches of transport	Degree of congestion for individual transport branches	Transport performance divided into branches of transport (tkm)	Quality of the environment	Number of accidents	Number of cooperating companies
Transport costs								X
Share of transport costs in value of the exported foods								X
Maximum value of discount on the price of product resulting from the new organization of transport processes								X
Structure of shipments	X	X		X	X	X		X
Average duration of delivery		X		X				X
Correct of order (Prawidłowe zamówienie)								X
Degree of use of means of transport				X	X	X		X
Degree of use of working time of means of transport				X	X	X		X
Share of each mode of transport in carriage of foods	X	X	X	X	X	X	X	X

Source: own study

In the first case we need to know the values of the individual indicators in order to determine the correlation indicator. In the other case numerical data is not necessary. Nevertheless, this solution has an important disadvantage. It is the fact that the information about indicators dependence is determined on the basis of one person's subjective opinion.

The table 4 presents a correlation matrix between given logistic indicators and standards as well as statistical indicators assessing the micro, mezon and macro scale.

Due to a great number of presented indicators and standards it would be difficult to show all set correlation indicators in the present article. Therefore, the table presents only Spearman Rank Correlation and Kendall Rank Correlation for a few exemplary indicators.

The data for each indicator has been collected from the questionnaires carried out among companies (109 companies) from Poland and other European or world countries. Half of the companies taking part in the questionnaires are companies employing up to 100 people. The questionnaire used an ordinal five-level scale. Therefore, the factors that could have been set for individual indicators were the Spearman Rank Correlation and Kendall Rank Correlation.

The aforementioned types of factors were set using the SPSS Statistics tool. Table 5 presents list of indicators with the highest correlation coefficient identified during the survey.

Table 5. Correlation coefficients of Spearman's rho and tau-b Kendall's for selected indicators
Tabela 5. Współczynnik korelacji Rho Spearmana i tau-b Kendalla dla wybranych wskaźników

Indicator 1	Indicator 2	Correlation					
		rho Spearmana			tau-b Kendalla		
		Correlation coefficient	Significance (both sides)	N	Correlation coefficient	Significance (both sides)	N
Customer satisfaction	Transport costs	0,287**	0,004	100	0,256**	0,004	100
Customer satisfaction	Labour costs	0,285**	0,004	101	0,263**	0,003	101
Customer satisfaction	Level of waste	0,302**	0,007	79	0,266**	0,008	79
Customer satisfaction	Level of recycling products	0,248*	0,032	75	0,214*	0,035	75
Customer satisfaction	Emission level of CO2 from transport processes	0,291*	0,018	66	0,258*	0,018	66
Transport costs	Labour costs	0,534**	0,000	102	0,503**	0,000	102
Transport costs	Emission level of CO2 from transport processes	0,306*	0,013	66	0,268*	0,011	66
Emission level of CO2 from transport processes	Labour costs	0,297*	0,015	66	0,257*	0,016	66
Emission level of CO2 from transport processes	Level of noise emission	0,527**	0,001	53	0,509**	0,001	53
Emission level of CO2 from transport processes	Level of waste	0,577**	0,000	61	0,521**	0,000	61
* Correlation is significant at the 0.05 level (both sides)							
** Correlation is significant at the 0.01 level (both sides)							

Source: own study

When analysing the aforementioned results, it can be seen that, according to the surveyed sample, there are three pairs of indicators between which there is a strong correlation:

- the level of CO2 emission coming from transport processes- the level of waste,
- the level of CO2 emission coming from transport processes- the level of noise emission,
- transport costs- labour costs.

When it comes to other indicators, the dependence is on a very low level. The closer the value of a correlation indicator to zero, the lower the level of the dependence.

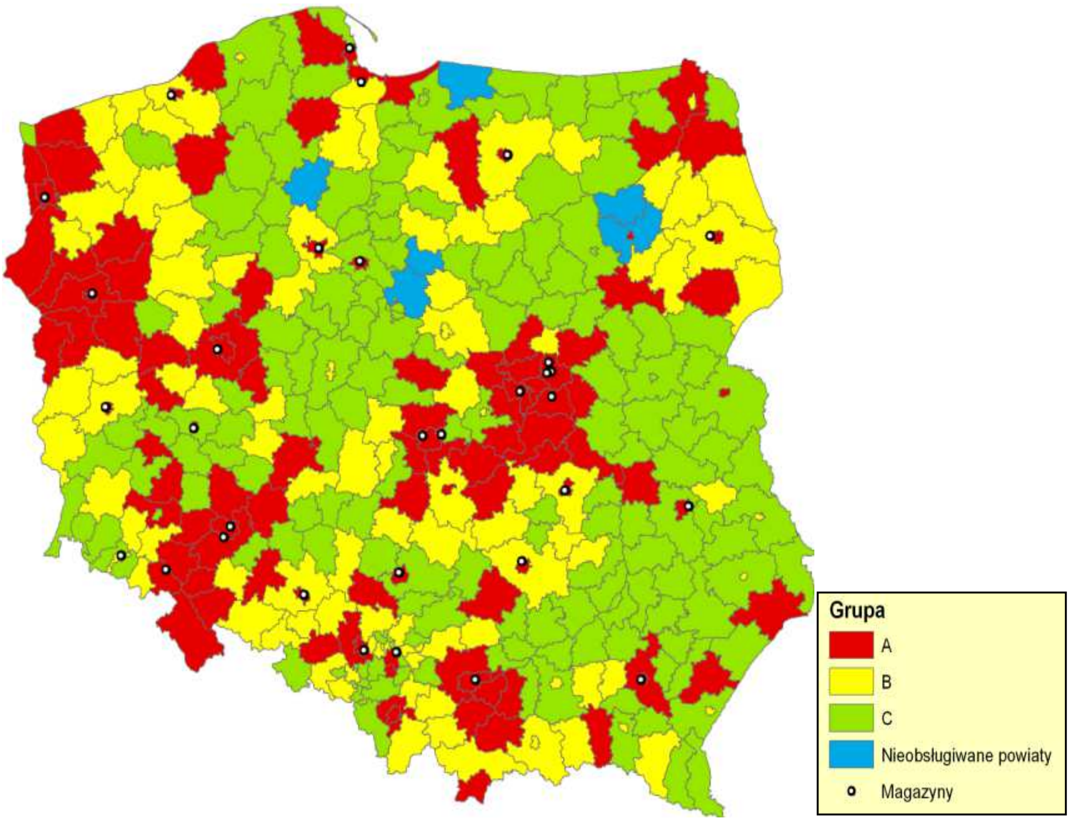
SHAPING THE SALES POLICY OF A COMPANY

A suitably developed sales policy of a company is a vital element of a proper functioning of the whole company. We should also remember about verification of sales policy and taking into account in that process a number of variables which influence a company's shape, such as, for example, the indicators and standards presented in the chapters of this article. It is also essential to analyse the indicators with the high level of correlation, as the actions taken to improve one element will also affect another element of the process.

In the previous years companies have aimed at eliminating or at least limiting the influence of individual's salesman characteristics in order to improve the sales and the process efficiency. Nowadays this attitude has been changing. Therefore, when shaping the sales policy such elements as sales management control system and sales territory design are analysed as moderators and/or determinants of performance of salespeople and effectiveness of sales organizations [Babakus, 1996].

When shaping a company's sales policy, it is worthwhile to take into consideration the data in micro and macro scale which considerably affect a company's appointed policy.

An exemplary process of supervision and verification of sales policy can include the following elements:
– monthly meetings of a sales manager with the trade team,
– weekly reports monitoring a sales budget,
– monthly meetings of Sales Department,
– competitors' analysis- on the basis of the information included in companies' balance sheets,
– monitoring the changes in the prices of products which are on a company's offer,
– an analysis of reports concerning the markets on which a company functions.



Source: own study

Fig. 1. The division of districts on ABC group by value of sales
Rys. 1. Podział powiatów na grupy ABC wg wartości sprzedaży

Such a wide range of analysed data enables companies to manage a sales process fast and effectively. It also helps to react quickly to a changing situation on the market.

It is also advisable to use the ABC analysis (Pareto analysis) according to a sales' value in order to present counties which generate the highest and the lowest income for the analysed company. Therefore, it is possible to determine an accurate allocation of new warehouses or the need to carry out a detailed analysis concerning the workload of the warehouses which serve the counties classified as group A.

CONCLUSION

Nowadays every manager has to make a number of decisions on a daily basis. The decision can be connected with an operational, tactical or strategic level. Making decisions on different levels of management requires support from different logistic as well as statistical indicators and standards [Hernández, García, Hernández, 2013]. As every manager makes his/her decisions based on different set of indicators. They can be very wide, depends on the company profile, but need to take into consideration correlation between logistics and their impact to the environment where the company is active.

Another important aspect which should be taken into account when choosing a particular set of indicators is determining the dependence between individual indicators on the basis of statistical calculations. In this way we can avoid inappropriate conclusions and, consequently, making wrong decisions.

It is possible to determine a correlation indicator between many indicators without using an appropriate tool. However, it is very time- consuming and requires lots of calculations. An example of a tool which helps to calculate the correlation ratio is the SPSS by IBM.

Another vital element necessary for determining the correlation indicator is having the values for individual indicators and standards between which we are to set the level of dependence. Lack of such data results in only one possibility, that of determining the dependence between the indicators based on knowledge and experience.

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ZARZĄDZANIE ŁAŃCUCHEM DOSTAW W OPRARCIU O WSKAŹNIKI LOGISTYCZNE I STATYSTYCZNE

STRESZCZENIE. **Wstęp:** Artykuł prezentuje modelową koncepcję wspierającą zarządzanie łańcuchem dostaw w oparciu o zidentyfikowane korelacje pomiędzy wskaźnikami opisującymi procesy logistyczne oraz procesy makroekonomiczne w regionie, w którym dana firma działa. Artykuł prezentuje przykładowy zestaw wskaźników logistycznych na poszczególnych poziomach zarządzania oraz zestaw wskaźników statystycznych w podziale na poziom makroekonomiczny i mikroekonomiczny, które mogą zostać wykorzystane w usprawnieniu zarządzania łańcuchem dostaw. Dodatkowo przedstawione zostały współczynniki korelacji służące do oceny powiązań pomiędzy poszczególnymi wskaźnikami.

Metody: W celu przedstawienia relacji pomiędzy poszczególnymi wskaźnikami zastosowane zostały elementy statystyki tj. współczynniki korelacji Rho Spearmana i tau-b Kendalla.

Wyniki: W wyniku przeprowadzonych prac uzyskano zestaw wskaźników logistycznych jak i statystycznych, które mogą być wykorzystane podczas podejmowania decyzji w obszarze zarządzania łańcuchem dostaw. Uzyskano również stopień powiązań poszczególnych wskaźników pomiędzy sobą wyznaczając wartości wskaźników korelacji.

Wnioski: Racjonalne zarządzanie łańcuchem dostaw wymaga nie tylko odpowiedniego doboru wskaźników zarówno logistycznych jak i statystycznych wspomagających podejmowania decyzji. Istotnym elementem jest również zidentyfikowanie korelacji pomiędzy poszczególnymi wskaźnikami, aby w poprawny sposób wyciągać wnioski z raportów i podejmować działania naprawcze.

Słowa kluczowe: wskaźniki logistyczne, wskaźniki statystyczne, współczynnik korelacji Rho Spearmana i tau-b Kendalla

MANAGEMENT DER LIEFERKETTE IN ANLEHNUNG AN LOGISTISCHE UND STATISTISCHE KENNZIFFERN

ZUSAMMENFASSUNG. Einleitung: Der Artikel präsentiert ein modellhaftes Konzept, das das Management der Lieferkette in Anlehnung an die ermittelten Zusammenhänge zwischen den die logistischen und die makroökonomischen Prozesse beschreibenden Kennziffern unterstützt. Die ermittelten Prozesse und Zusammenhänge gelten für die Region, in der die analysierte Firma tätig ist. Der Beitrag stellt einen beispielhaften Satz von logistischen Kennziffern auf den einzelnen Management-Ebenen sowie den Satz von statistischen Kennziffern auf dem makro- und mikroökonomischen Niveau dar, für die Vervollkommnung des Managements der Lieferkette in Anspruch genommen werden können. Darüber hinaus wurden die Koeffizienten der Zusammenhänge, die zur Beurteilung von Verbindungen zwischen den einzelnen Kennziffern dienen, präsentiert.

Methoden: Zwecks der Projizierung der Zusammenhänge zwischen den einzelnen Kennziffern wurden die Elemente der Statistik, d.h. Koeffizienten der Korrelation von Rho Spearman und tau-b Kendall in Anspruch genommen.

Ergebnisse: Infolge der durchgeführten Arbeiten hat man einen Satz von logistischen und statistischen Kennziffern, die von Entscheidungsträgern im Management der Lieferkette angewendet werden können, ermittelt. Man stellte dabei den Grad der gemeinsamen Zusammenhänge zwischen den einzelnen Kennziffern fest, indem man die Werte für die Kennziffern der betreffenden Korrelation erfasste

Fazit: Das rationelle Management innerhalb einer Lieferkette bedarf nicht nur einer entsprechenden Auswahl sowohl logistischer als auch statistischer Kennziffern, die das Entscheidungstreffen unterstützen. Das wesentliche Element ist auch die Ermittlung der Korrelation zwischen den einzelnen Kennziffern zwecks einer richtigen Schlussfolgerung in Bezug auf die Berichterstattungen vor Ort und der Inangriffnahme von Verbesserungsvorhaben..

Codewörter: logistische Kennziffern, statistische Kennziffern, Koeffizient der Korrelation von Rho Spearman und tau-b Kendall

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OPTIMIZATION IN FUZZY ECONOMIC ORDER QUANTITY (FEOQ) MODEL WITH DETERIORATING INVENTORY AND UNITS LOST

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ABSTRACT. Background: This model presents the effect of deteriorating items in fuzzy optimal instantaneous replenishment for finite planning horizon. Accounting for holding cost per unit per unit time and ordering cost per order have traditionally been the case of modeling inventory systems in fuzzy environment. These imprecise parameters defined on a bounded interval on the axis of real numbers and the physical characteristics of stocked items dictate the nature of inventory policies implemented to manage and control in the production system.

Methods: The modified fuzzy EOQ (FEOQ) model is introduced, it assumes that a percentage of the on-hand inventory is wasted due to deterioration and considered as an enhancement to EOQ model to determine the optimal replenishment quantity so that the net profit is maximized. In theoretical analysis, the necessary and sufficient conditions of the existence and uniqueness of the optimal solutions are proved and further the concavity of the fuzzy net profit function is established. Computational algorithm using the software LINGO 13.0 version is developed to find the optimal solution.

Results and conclusions: The results of the numerical analysis enable decision-makers to quantify the effect of units lost due to deterioration on optimizing the fuzzy net profit for the retailer. Finally, sensitivity analyses of the optimal solution with respect the major parameters are also carried out. Furthermore fuzzy decision making is shown to be superior then crisp decision making in terms of profit maximization.

Key words: Optimization, Fuzzy, FEOQ, Deterioration, Units Lost.

INTRODUCTION

In the whole production system production function is the mid between the procurement function and physical distribution function. Other two functions are not processing in terms of production only they are facilitating for the smooth functioning and cost effecting of the production system in competitive advantage but production function processes to produce the finished products. So inventory plays a significant role in smooth functioning of the production function in a supply chain management. The physical characteristics of stocked items dictate the nature of inventory policies implemented to manage and control in production system. The question is how reliable are the EOQ models when items stocked deteriorate one time.

Many models have been proposed to deal with a variety of inventory problems. Comprehensive reviews of inventory models can be found in Gupta and Gerchak [1995], Osteryoung et al. [1986] and Water [1994] and Tripathy et al. [2013] introduced a single item EOQ model with two constraints. This model considers a continuous review, using fuzzy arithmetic approach to the system cost for instantaneous production process. In traditional inventory models it has been common to apply fuzzy on demand rate, production rate and deterioration rate, whereas applying fuzzy arithmetic in system cost usually ignored in Salameh et al. [1999]. From

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practical experience, it has been found that uncertainty occurs not only due to lack of information but also as a result of ambiguity concerning the description of the semantic meaning of declaration of statements relating to an economic world. The fuzzy set theory was developed on the basis of non-random uncertainties. Vujosevic et al. [1996] introduced the EOQ model where inventory system cost is fuzzy. Mahata and Goswami [2006] then presented production lot size model with fuzzy production rate and fuzzy demand rate for deteriorating items where permissible delay in payments are allowed. Tripathy and Pattnaik [2011] presented an optimal inventory policy with reliability consideration and instantaneous receipt under imperfect production process. Later, Tripathy and Pattnaik [2009, 2011] also investigated fuzzy EOQ model with reliability consideration in instantaneous production plan. Again Tripathy and Pattnaik [2008, 2011] developed fuzzy entropic order quantity model for perishable items under two component demand and discounted selling price, where entropic means the amount of the disorder in the production system. Pattnaik [2013] discussed the fuzzy EOQ model with demand dependent unit price and variable setup cost, Pattnaik [2011, 2013, 2013] investigated the fuzzy method for supplier selection in manufacturing system for smooth function of supply chain management and manpower selection for micro, small and medium enterprises respectively. For this reason, this model considers the same by introducing the holding cost and ordering cost as with allowing promotion and wasting the percentage of the fuzzy numbers. Sahoo and Pattnaik [2013] developed linear programming problem and post optimality analyses in fuzzy space with case study applications. Pattnaik [2013] defined linear programming problems with crisp and fuzzy based optimization methods and sensitivity analyses have also evaluated for decision parameters. Pattnaik [2013] derived profit maximization fuzzy EOQ models for deteriorating items with two dimension sensitive demand. The model provides an approach for quantifying the benefits of nonrandom uncertainty which can be substantial, and should be reflected in fuzzy arithmetic system cost.

Product perishability is an important aspect of inventory control. Deterioration in general, may be considered as the result of various effects on stock, some of which are damage, decay, decreasing usefulness and many more. While kept in store fruits, vegetables, food stuffs etc. suffer from depletion by decent spoilage. Decaying products are of two types. Product which deteriorate from the very beginning and the products which start to deteriorate after a certain time. Lot of articles is available in inventory literature considering deterioration. Interested readers may consult the survey model of Pattnaik [2011] investigated an entropic order quantity model for perishable items with pre and post deterioration discounts under two component demand in finite horizon. Pattnaik [2011] discussed an economic order quantity model for perishable items with constant demand where instant deterioration discount is allowed to obtain maximum profit. Goyal and Gunasekaran [1995] and Raafat [1991] surveyed for perishable items to optimize the EOQ model. The EOQ inventory control model was introduced in the earliest decades of this century and is still widely accepted by many industries today. Tripathy and Pattnaik [2008, 2011] studied profit maximization entropic order quantity model for deteriorated items with stock dependent demand where discounts are allowed for acquiring more profit. Pattnaik [2012] derived different types of typical deterministic EOQ models in crisp and fuzzy decision space.

Comprehensive reviews of inventory models under deterioration can be found in Bose et al. [1995]. In previous deterministic inventory models, many are developed under the assumption that demand is either constant or stock dependent for deteriorated items. Jain and Silver (1994) developed a stochastic dynamic programming model presented for determining the optimal ordering policy for a perishable or potentially obsolete product so as to satisfy known time-varying demand over a specified planning horizon. They assumed a random lifetime perishability, where, at the end of each discrete period, the total remaining inventory either becomes worthless or remains usable for at least the next period. Gupta and Gerchak [1995] examined the simultaneous selection product durability and order quantity for items that deteriorate over time. Their choice of product durability is modeled as the values of a single design parameter that effects the distribution of the time-to-onset of deterioration (TOD) and analyzed two scenarios; the first considers TOD as a constant and the store manager may choose an appropriate value, while the second assumes that TOD is a random variable. Hariga [1995] considered the effects of inflation and the time-value of money with the assumption of two inflation rates rather than one, i.e. the internal (company) inflation rate and the external (general economy) inflation rate. Hariga [1994] argued that the analysis of Bose et al. [1995] contained mathematical errors for which he proposed the correct theory for the problem supplied with numerical examples. Padmanavan and Vrat [1995] presented an EOQ inventory model for perishable items with a stock dependent selling rate. They assumed that the selling rate is a function of the current inventory level and the rate of deterioration is taken to be constant. The most recent work found in the literature is that of Hariga [1996] who extended his earlier work by assuming a time-varying demand over a finite planning horizon. Goyal et al. [2001] and Shah [2000] explored the inventory models for deteriorating items. Pattnaik [2010, 2011] studied profit maximization entropic order quantity model for deteriorated items with stock dependent demand where instant deterioration and post deterioration cash discounts respectively are allowed for acquiring more profit. Pattnaik [2011] developed an entropic order quantity model for deteriorating items where cash discounts are allowed but Pattnaik [2011] modified again to obtain the decision parameters for perishable items where instant deterioration discount is allowed in EOQ model. Pattnaik [2012] introduced a non linear profit maximization entropic order quantity model for deteriorating items with stock dependent demand rate. Pattnaik [2012] derived an EOQ model for perishable items with constant demand and instant deterioration.

Furthermore, retailer promotional activity has become more and more common in today's business world. For example, Wall Mart and Costco often try to stimulate demand for specific types of electric equipment by offering price discounts; clothiers Baleno and NET make shelf space for specific clothes items available for longer periods; McDonald's and Burger King often use coupons to attract consumers. Other promotional strategies include free goods, advertising, and displays and so on. The promotion policy is very important for the retailer. How much promotional effort the retailer makes has a big impact on annual profit. Residual costs may be incurred by too many promotions while too few may result in lower sales revenue. Tsao and Sheen (2008) discussed dynamic pricing, promotion and replenishment policies for a deteriorating item under permissible delay in payment. Salameh et al. [1999] studied an EOQ inventory model in which it assumes that the percentage of on-hand inventory wasted due to deterioration is a key feature of the inventory conditions which govern the item stocked. The effect of deteriorating items on the instantaneous profit maximization replenishment model under promotion is considered in this model. The market demand may increase with the promotion of the product over time when the units lost due to deterioration. In the existing literature about promotion it is assumed that the promotional effort cost is a function of promotion. Tripathy et al. [2012] investigated an optimal EOQ model for deteriorating items with promotional effort cost. Pattnaik [2012] explored the effect of promotion in fuzzy optimal replenishment model with units lost due to deterioration. Hence Pattnaik [2013] developed many instantaneous EOQ models and fuzzy EOQ models which are incorporated with promotional effort cost, fixed ordering cost, variable ordering cost and units lost due to deterioration. This model introduces a modified fuzzy EOQ model in which it assumes that a percentage of the on-hand inventory is wasted due to deterioration. There is hidden cost not account for when modeling inventory cost. This model studies the problem of promotion for a deteriorating item subject to loss of these deteriorated units. This model postulates that measuring the behavior of production systems may be achievable by incorporating the idea of retailer in making optimum decision on replenishment with wasting the percentage of on-hand inventory due to deterioration and then compares the optimal results with none wasting the percentage of on-hand inventory due to deterioration traditional model. This model addresses the problem by proposing an inventory model under promotion by assuming that the units lost due to deterioration of the items. In this model, promotional effort and replenishment decision are adjusted arbitrarily upward or downward for profit maximization model in response to the change in market demand within the planning horizon. The objective of this model is to determine the optimal time length, optimal units lost due to deterioration, the promotional effort and the replenishment quantity with fixed ordering cost so that the net profit is maximized in an instantaneous replenishment fuzzy EOQ model and the numerical analysis show that an appropriate promotion policy can benefit the retailer and that promotion policy is important in fuzzy space, especially for deteriorating items. Finally, sensitivity analyses of the optimal solution with respect to the major parameters are also studied to draw the managerial insights. Furthermore crisp decision making is shown to be superior to crisp decision making without promotional effort cost in terms of profit maximization.

This model establishes and analyzes the fuzzy inventory model under profit maximization which extends the classical economic order quantity (EOQ) model. An efficient FEOQ does more than just reduce cost. It also creates revenue for the retailer and the manufacturer. The evolution of the FEOQ model concept tends toward revenue and demand focused strategic formation and decision making in business operations. Evidence can be found in the increasingly prosperous revenue and yield management practices and the continuous shift away from supply-side cost control to demand-side revenue stimulus.

Table 1. Summary of the Related Researches
Tabela 1. Podsumowanie prac o podobnej tematyce

Author(s) and published Year	**Structure of the model**	**Demand**	**Demand patterns**	**Deterioration**	**Planning**	**Units Lost due Deterioration**	**Model**
Hariga (1994)	Crisp (EOQ)	Time	Non-stationary	Yes	Finite	No	Cost
Tsao et al. (2008)	Crisp (EOQ)	Time and Price	Linear and Decreasing	Yes	Finite	No	Profit
Pattnaik (2009)	Crisp (EnOQ)	Constant (Deterministic)	Constant	Yes (Instant)	Finite	No	Profit
Pattnaik (2011)	Crisp (EOQ)	Constant (Deterministic)	Constant	Yes (Instant)	Finite	No	Profit
Present model (2013)	Fuzzy (FEOQ)	Constant (Deterministic)	Constant	Yes (Wasting)	Finite	Yes	Profit

In recent years, companies have started to recognize that a tradeoff exists between product varieties in terms of quality of the product for running in the market smoothly. In the absence of a proper quantitative model to measure the effect of product quality of the product, these companies have mainly relied on qualitative judgment. The model tackles to investigate the effect of the wasting the percentage of on-hand inventory due to deterioration for obtaining the optimum average payoff and the optimal values of the policy variables. The problem consists of the optimization of fuzzy EOQ model, taking into account the conflicting payoffs of the different decision makers involved in the process. A policy iteration algorithm is designed and optimum solution is obtained through LINGO 13.0 version software. In order to make the comparisons equitable a particular evaluation function based on units lost is suggested. This model postulates that measuring the behavior of production systems may be achievable by incorporating the idea of retailer promotional effort in making optimum decision on replenishment units lost due to deterioration. Numerical experiment is carried out to analyze the magnitude of the approximation error. However, adding wasting the percentage of on-hand inventory due to deterioration in fuzzy model might lead to super gain for the retailer. The major assumptions used in the above research articles are summarized in Table1.

The remainder of the model is organized as follows. In Section 2 assumptions and notations are provided for the development of the model. The mathematical formulation is developed in Section 3 and the fuzzy mathematical model is developed in 4. The solution procedure is given in Section 5. In Section 6, numerical example is presented to illustrate the development of the model. The sensitivity analyses are studied in Section 7 to observe the changes in the optimal solution for change in major parameter. Finally in Section 8 the summary and the concluding remarks are explained.

ASSUMPTIONS AND NOTATIONS

r	Consumption rate,
t_c	Cycle length,
h	Holding cost of one unit for one unit of time,
HC (q)	Holding cost per cycle,
K	Setup cost per cycle,
c	Purchasing cost per unit,
P_s	Selling Price per unit,
α	Percentage of on-hand inventory that is lost due to deterioration,
q	Order quantity,
q**	Modified economic ordering / production quantity (EOQ/EPQ),
q*	Traditional economic ordering quantity (EOQ),
φ(t)	On-hand inventory level at time t,
π_1(q)	Net profit per unit of producing q units per cycle in crisp strategy,
π (q)	Average profit per unit of producing q units per cycle in crisp strategy,
$\tilde{\pi}_1(q,\rho)$	The net profit per unit per cycle in fuzzy decision space,
$\tilde{\pi}$ (q, ρ)	The average profit per unit per cycle in fuzzy decision space,
$\tilde{h}$	Fuzzy holding cost per unit,
$\tilde{K} \times (q^{\gamma-1})$	Fuzzy setup cost per cycle.

MATHEMATICAL MODEL

Denote φ(t) as the on-hand inventory level at time t. During a change in time from point t to t+dt, where t + dt > t, the on-hand inventory drops from φ(t) to φ(t+dt).

Then φ(t+dt) is given as:

$$\varphi(t+dt) = \varphi(t) - r\,dt - \alpha\,\varphi(t)\,dt$$
φ(t+dt)

can be re-written as:

$$\frac{\varphi(t+dt)-\varphi(t)}{dt} = -r - \alpha\varphi(t)$$

and dt → 0, equation $\frac{\varphi(t+dt)-\varphi(t)}{dt}$ reduces to: $\frac{d\varphi(t)}{dt} + \alpha\varphi(t) + r = 0$

It is a differential equation, solution is

$$\varphi(t) = \frac{-r}{\alpha} + \left(q + \frac{r}{\alpha}\right) \times e^{-\alpha t}$$

Where q is the order quantity which is instantaneously replenished at the beginning of each cycle of length t_c units of time. The stock is replenished by q units each time these units are totally depleted as a result of outside demand and deterioration. Behavior of the inventory level for the above model is illustrated in Fig. 1. The cycle length, t_c, is determined by first substituting t_c into equation φ(t) and then setting it equal to zero to get:

$$t_c = \frac{1}{\alpha}\ln\left(\frac{\propto q + r}{r}\right)$$

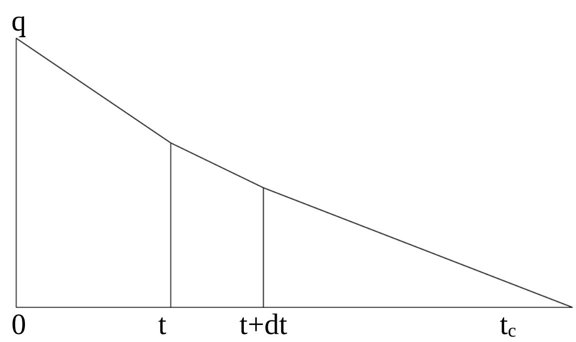

Fig. 1. Behavior of the Inventory over a Cycle for a Deteriorating Item
Rys. 1. Poziom zapasu badanego artykułu w czasie cyklu

Equation $\varphi(t)$ and t_c are used to develop the mathematical model. It is worthy to mention that as α approaches to zero, t_c approaches to $\frac{q}{r}$. Then the total number of units lost per cycle, L, is given as:

$$L = r\left[\frac{q}{r} - \frac{1}{\alpha} ln\left(\frac{\alpha q + r}{r}\right)\right]$$

The total cost per cycle, TC(q), is the sum of the procurement cost per cycle, K+cq and the holding cost per cycle, HC(q). HC(q) is obtained from equation $\varphi(t)$ as:

$$HC(q) = \int_0^{tc} h\varphi(t)dt$$

$$= h\int_0^{\frac{1}{\propto}ln\left(\frac{\propto q+r}{r}\right)} \left[-\frac{r}{\alpha} + \left(q + \frac{r}{\alpha}\right) \times e^{-\alpha t}\right] dt$$

$$= h \times \left[\frac{q}{\propto} - \frac{r}{\alpha^2} ln\left(\frac{\alpha q + r}{r}\right)\right]$$

$$TC(q) = K + cq + h \times \left[\frac{q}{\propto} - \frac{r}{\alpha^2} ln\left(\frac{\alpha q + r}{r}\right)\right]$$

The total cost per unit of time, TCU (q), is given by dividing equation TC(q) by t_c to give:

$$TCU(q) = \left[K + cq + h \times \left[\frac{q}{\alpha} - \frac{r}{\alpha^2} ln\left(\frac{\alpha q + r}{r}\right)\right]\right] \times \left[\frac{1}{\alpha}\ln\left(\frac{\propto q + r}{r}\right)\right]^{-1}$$

$$= \frac{K\propto + (c\propto + h)q}{ln\left(1 + \frac{\propto q}{r}\right)} - \frac{hr}{\alpha}$$

As α approaches zero in equation TCU(q) reduces to TCU (q) = $\frac{Kr}{q} + cr + \frac{hq}{2}$, whose solution is given by the traditional EOQ formula, $q^* = \sqrt{\frac{2Kr}{h}}$. The total profit per cycle is $\pi_1(q)$.

$$\pi_1(q) = (q-L) \times Ps - TC(q)$$

$$= (q-L)\times Ps - K - cq - h \times \left[\frac{q}{\alpha} - \frac{r}{\alpha^2} \times ln\left(\frac{\alpha q + r}{r}\right)\right]$$

Where L, the number of units lost per cycle due to deterioration, and TC (q) the total cost per cycle, are calculated from equations L and TC(q), respectively. The average profit $\pi(q)$ per unit time is obtained by dividing t_c in $\pi_1(q)$. Hence the profit maximization problem is:

Maximize π_1 (q)
$\forall\, q \geq 0$.

$$\pi_1(q) = F_1(q) + F_2(q)h + F_3(q)K$$

where,

$F_1(q) = ((q - L) \times P_s) - cq$, $F_2(q) = -\left[\frac{q}{\alpha} - \frac{r}{\alpha^2} \times ln\left(\frac{\alpha q + r}{r}\right)\right]$, and $F_3(q, \rho) = -1$

FUZZY MATHEMATICAL MODEL

The holding cost and ordering cost are replaced by fuzzy numbers $\tilde{h}$ and $\tilde{K}$ respectively. By expressing $\tilde{h}$ and $\tilde{K}$ as the normal triangular fuzzy numbers *(h_1, h_0, h_2)* and (K_1, K_0, K_2**)**, where, $h_1 = h - \Delta_1$, $ho = h$, $h_2 = h + \Delta_2$, $K_1 = K - \Delta_3$, $K_0 = K$, $K_2 = K + \Delta_4$ such that $0 < \Delta_1 < h$, $0 < \Delta_2$, $0 < \Delta_3 < K$, $0 < \Delta_4$, $\Delta_1, \Delta_2, \Delta_3$ and Δ_4 are determined by the decision maker based on the uncertainty of the problem.

The membership function of fuzzy holding cost and fuzzy ordering cost are considered as:

$$\mu_{\tilde{h}}(h) = \begin{cases} \frac{h - h_1}{h_0 - h_1}, & h_1 \leq h \leq h_0 \\ \frac{h_2 - h}{h_2 - h_0}, & h_0 \leq h \leq h_2 \\ 0 & , otherwise \end{cases}$$

$$\mu_{\tilde{k}}(K) = \begin{cases} \frac{K - K_1}{K_0 - K_1}, & K_1 \leq K \leq K_0 \\ \frac{K_2 - K}{K_2 - K_0}, & K_0 \leq K \leq K_2 \\ 0 & , \text{otherwise} \end{cases}$$

Then the centroid for $\tilde{h}$ and $\tilde{K}$ are given by

$M_{\tilde{h}} = \frac{h_1 + h_o + h_2}{3} = h + \frac{\Delta_2 - \Delta_1}{3}$ and

$M_{\tilde{k}} = \frac{K_1 + K_o + K_2}{3} = K + \frac{\Delta_4 - \Delta_3}{3}$

respectively.

For fixed values of q and ρ, let $\pi_1(h,K) = F_1(q) + F_2(q)h + F_3(q)K = y$

Let $h = \frac{y - F_1 - F_3K}{F_2}$, $\frac{\Delta_2 - \Delta_1}{3} = \psi_1$ and $\frac{\Delta_4 - \Delta_3}{3} = \psi_2$

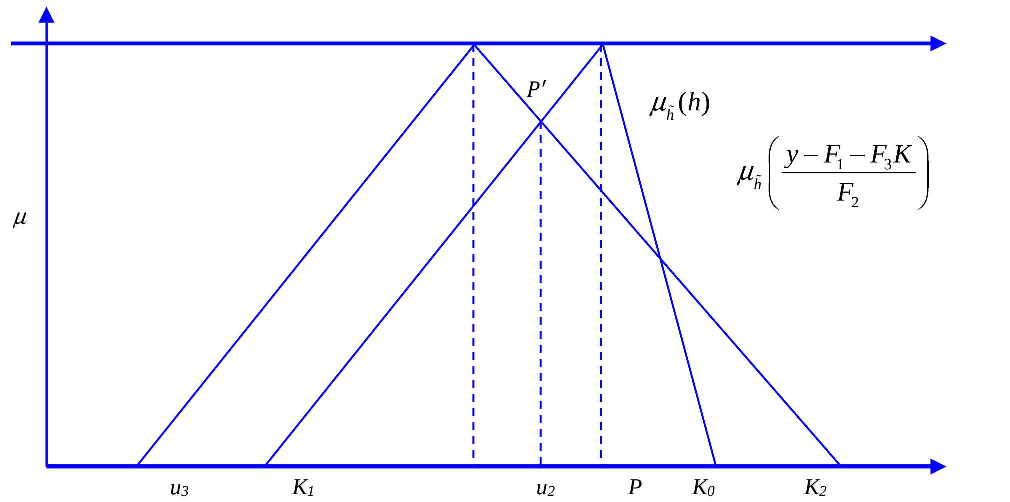

Fig. 2. Defuzzification by using Centroid Method
Rys. 2. Dezufikacja przy zastosowaniu metody centroidowej

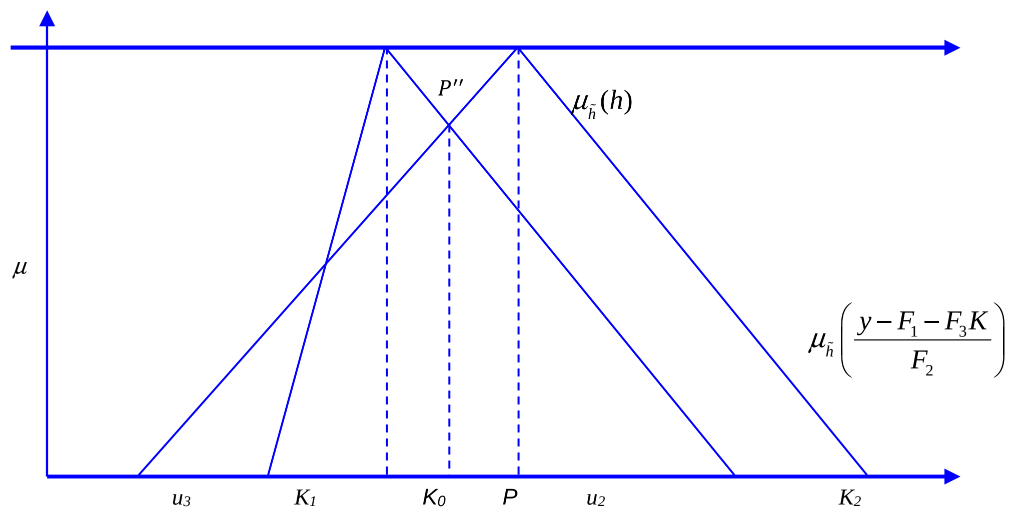

Fig. 3. Defuzzification by using Centroid Method
Rys. 3. Dezufikacja przy zastosowaniu metody centroidowej

By extension principle the membership function of the fuzzy profit function is given by

$$\mu_{\pi_1(\tilde{h},\tilde{k})}(y) = \operatorname*{Sup}_{(h,k)\in\pi_1^{-1}(y)} \{\mu_{\tilde{h}}(h) \wedge \mu_{\tilde{k}}(K)\}$$
$$= \operatorname*{Sup}_{k_1\le k\le k_2} \left\{\mu_{\tilde{h}}\left(\frac{y-F_1-F_3K}{F_2}\right) \wedge \mu_{\tilde{k}}(K)\right\}$$

Now,

$$\mu_{\tilde{h}}\left(\frac{y-F_1-F_3K}{F_2}\right) = \begin{cases} \dfrac{y-F_1-F_2h_1-F_3K}{F_2(h_0-h_1)} & , \quad u_2 \le K \le u_1 \\ \dfrac{F_1+F_2h_2+F_3K-y}{F_2(h_2-h_0)} & , \quad u_3 \le K \le u_2 \\ 0 & , \quad \text{otherwise} \end{cases}$$

where, $u_1 = \dfrac{y - F_1 - F_2 h_1}{F_3}$, $u_2 = \dfrac{y - F_1 - F_2 h_0}{F_3}$ and $u_3 = \dfrac{y - F_1 - F_2 h_2}{F_3}$

Fig. 2 exhibits the graph of $\mu_{\tilde{h}}\left(\dfrac{y-F_1-F_3K}{F_2}\right)$ and $\mu_{\tilde{h}}(h)$ when $u_2 \le K$ and $K \le u_1$ then $y \le F_1 + F_2h_0 + F_3K_0$ and $y \ge F_1 + F_2h_1 + F_3K_1$. It is clear that for every $y \in [F_1 + F_2h_1 + F_3K_1\ ,\ F_1 + F_2h_0 + F_3K_0], \mu_y(y) = PP'$. From the $\mu_{\tilde{h}}(h)$ and $\mu_{\tilde{h}}\left(\dfrac{y-F_1-F_3K}{F_2}\right)$ the value of PP may be found by solving the following equation:

$$\frac{K-K_1}{K_0-K_1} = \frac{y-F_1-F_2h_1-F_3K}{F_2(h_0-h_1)} \text{ or } \qquad K = \frac{(y-F_1-F_2h_1)(K_0-K_1)+F_2K_1(h_0-h_1)}{F_2(h_0-h_1)+F_3(K_0-K_1)}$$

Therefore, $PP' = \dfrac{K-K_1}{K_0-K_1} = \dfrac{y-F_1-F_2h_1-F_3K}{F_2(h_0-h_1)+F_3(K_0-K_1)} = \mu_1(y)$, (say).

Fig. 3 exhibits the graph of $\mu_{\tilde{h}}\left(\dfrac{y-F_1-F_3K}{F_2}\right)$ and $\mu_{\tilde{h}}(h)$ when $u_3 \le K$ and $K \le u_2$ then $y \le F_1 + F_2h_2 + F_3K_2$ and $y \ge F_1 + F_2h_0 + F_3K_0$.

It is evident that for every $y \in [F_1 + F_2h_0 + F_3k_0\ ,\ F_1 + F_2h_2 + F_3K_2], \mu_{\tilde{y}}(y) = PP''$. From the $\mu_{\tilde{h}}(h)$ and $\mu_{\tilde{h}}\left(\dfrac{y-F_1-F_3K}{F_2}\right)$, the value of PP'' may be found by solving the following equation:

$$\frac{K_2-K}{K_2-K_0} = \frac{F_1+F_2h_2+F_3K-y}{F_2(h_2-h_0)} \text{ or, } \qquad K = \frac{F_2K_2(h_2-h_0)-(F_1+F_2h_2-y)(K_2-K_0)}{F_2(h_2-h_0)+F_3(K_2-K_0)}$$

Therefore, $PP'' = \dfrac{K_2-K}{K_2-K_0} = \dfrac{F_1+F_2h_2+F_3K_2-y}{F_2(h_2-h_0)+F_3(K_2-K_0)} = \mu_2(y)$, (say).

Thus the membership function for fuzzy total profit is given by

$$\mu_{\pi_1(\tilde{h},K)}(y) = \begin{cases} \mu_1(y); & F_1 + F_2 h_1 + F_3 K_1 \le y \le F_1 + F_2 h_0 + F_3 K_0 \\ \mu_2(y); & F_1 + F_2 h_0 + F_3 K_0 \le y \le F_1 + F_2 h_2 + F_3 K_2 \\ 0 \quad ; & \text{otherwise} \end{cases}$$

Now, let $P_1 = \int_{-\infty}^{\infty} \mu_{\pi_1(\tilde{h},\tilde{k})}(y)\,dy$ and $R_1 = \int_{-\infty}^{\infty} y\,\mu_{\pi_1(\tilde{h},\tilde{k})}(y)\,dy$

Hence, the centroid for fuzzy total profit is given by $\tilde{\pi}_1(q) = M_{\tilde{TP}}(q) = \dfrac{R_1}{P_1}$

$$= F_1(q) + F_2(q)h + F_3(q)K$$
$$+\psi_1 F_2(q) + \psi_2 F_2(q)$$

$$\tilde{\pi}_1(q) = M_{\tilde{TP}}(q) = F_1 + (h+\psi_1)F_2 + (K+\psi_2)F_3$$

where, $F_1(q)$, $F_2(q)$ and $F_3(q)$ are given by the equations.
Hence the profit maximization problem is
Maximize $\tilde{\pi}_1(q) = M_{\tilde{TP}}(q)$ $\forall$ q ≥ 0.

OPTIMIZATION

The optimal ordering quantity q per cycle can be determined by differentiating equation? $\tilde{\pi}_1(q)$ with respect to q, then setting these to zero.

In order to show the uniqueness of the solution in, it is sufficient to show that the net profit function throughout the cycle is concave in terms of ordering quantity q. The second order derivates of equation $\tilde{\pi}_1(q)$ with respect to q are strictly negative. Consider the following proposition.

Proposition 1 *The net profit $\tilde{\pi}_1(q)$ per cycle is concave in q.*

Conditions for optimal q

$$\frac{d\tilde{\pi}_1(q)}{dq} = \frac{r}{\alpha q + r}\left(P_s + \frac{(h+\Psi_1)}{\alpha}\right) - \left(c + \frac{(h+\Psi_1)}{\alpha}\right) = 0$$

The second order derivative of the net profit per cycle with respect to q can be expressed as:

$$\frac{d^2\tilde{\pi}_1(q)}{dq^2} = -\frac{r}{(\alpha q + r)^2}\left(P_s\alpha + (h+\Psi_1)\right)$$

Since, r > 0 and $P_s\alpha + (h+\Psi_1) > 0$ equation $\frac{d^2\tilde{\pi}_1(q)}{dq^2}$ is negative.

Proposition 1 shows that the second order derivative of equation $\tilde{\pi}_1(q)$ with respect to q are strictly negative.

The objective is to determine the optimal values of q to maximize the unit profit function of equation$\tilde{\pi}_1(q)$. It is very difficult to derive the optimal values of q, hence unit profit function. There are several methods to cope with constraints optimization problem numerically. But here LINGO 13.0 software is used to derive the optimal values of the decision variables.

NUMERICAL EXAMPLE

Consider an inventory situation where K is Rs. 200 per order, h is Rs. 5 per unit per unit of time, r is 1200 units per unit of time, c is Rs. 100 per unit, the selling price per unit P_s is Rs. 125 $\Delta_1 = 0.002$, $\Delta_2 = 0.02$, $\Delta_3 = 0.002$ and Δ_4=0.2 and α is 5%. Fig. 2 shows the relationship between the order quantity q and units lost per cycle due to deterioration L and Fig. 3 represents the three dimensional mesh plot of units lost per cycle due to deterioration L, order quantity q and net profit per cycle $\tilde{\pi}_1(q)$. Fig. 4 is the sensitivity plotting of units lost per cycle L, order quantity q and net profit per cycle$\tilde{\pi}_1(q)$..

The optimal solution that maximizes $\tilde{\pi}_1(q)$ and q^{**} and q^* are determined by using LINGO 13.0 version software and the results are tabulated in Table 2.

Table 2. Optimal values of the proposed model
Tabela 2. Wartości optymalne proponowanego modelu

Model	**Iteration**	t^*	L^*	**Q**	$\tilde{\pi}_1(q)$	$\tilde{\pi}(q)$
Fuzzy	90	2.354328	173.0073	$q^{**} = 2998.201$	35807.55	15209.25
Crisp	87	2.355661	173.2071	$q^* = 3000$	35828.39	15209.49
	-	0.05662	0.1155	0.06	0.0582	0.00158
Crisp	41	0.2581989	-	$q^* = 309.8387$	28450.81	7345.96784 6
% Change	-	89.021	-	89.666	20.5452	51.701

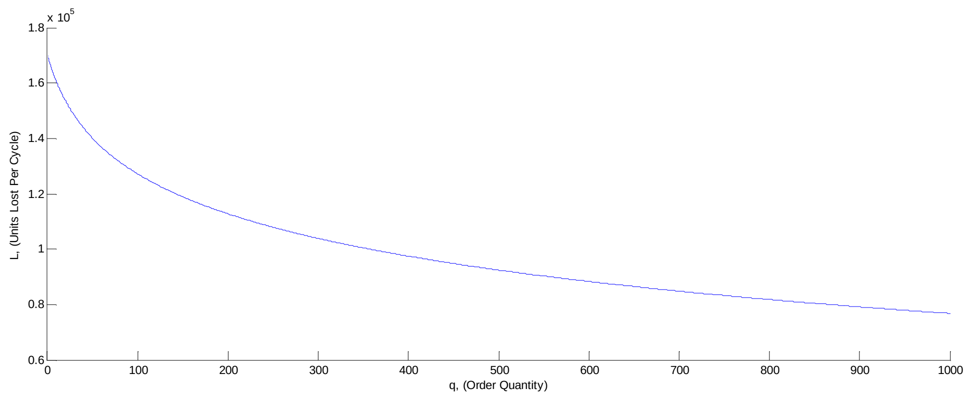

Fig. 4. Two Dimensional Plot of Order Quantity q and Units Lost per Cycle L
Rys. 4. Dwuwymiarowy wykres zależności wielkości zamówienia q i strat w cyklu L

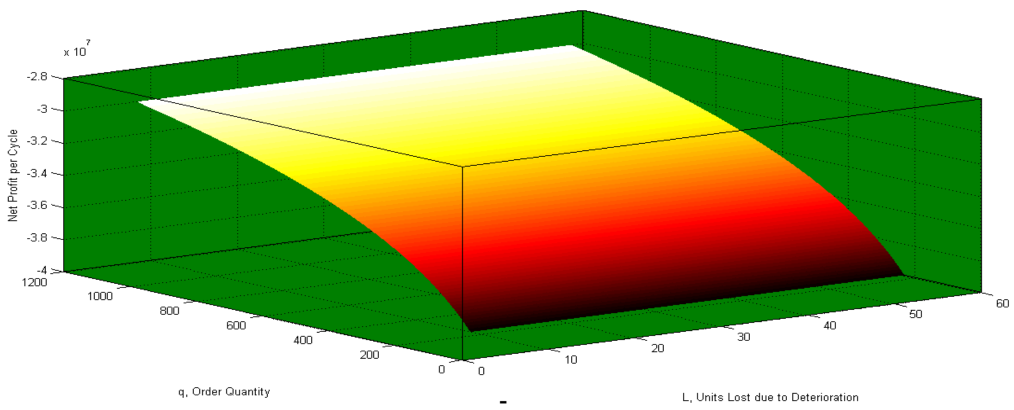

Fig. 5. Three Dimensional Mesh Plot of Units Lost per Cycle L, Order Quantity q and Fuzzy Net Profit per Cycle $\tilde{\pi}_1(q)$
Rys. 5. Trójwymiarowy wykres zależności wielkości strat w cyklu L, wielkości zamówienia q oraz zysku netto w cyklu $\tilde{\pi}_1(q)$

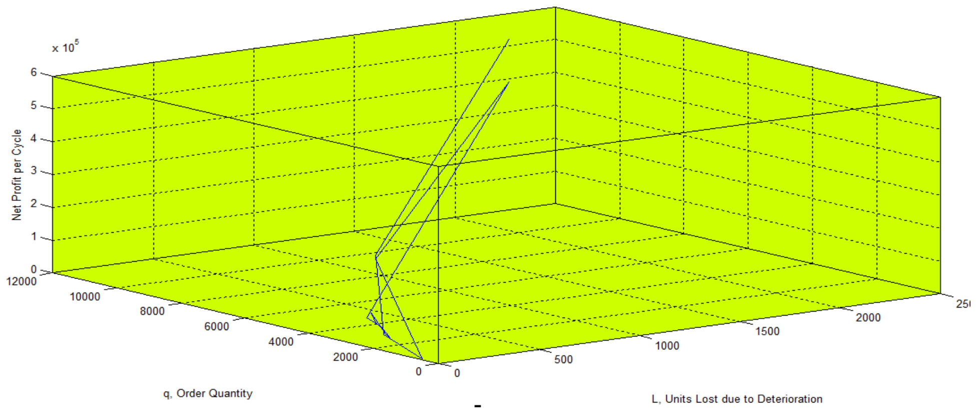

Fig. 6. Sensitivity Plotting of Units Lost due to Deterioration L, Order Quantity q and Fuzzy Net Profit per Cycle $\tilde{\pi}_1(q)$

Rys. 6. Wykresu wrażliwości strat spowodowanych psuciem się L, wielkości zamówienia q oraz zysku netto w cyklu $\tilde{\pi}_1(q)$

SENSITIVITY ANALYSIS

It is interesting to investigate the influence of? on retailer behaviour. The computational results shown in Table 3 indicates the following managerial phenomena: when the percentage of on-hand inventory that is lost due to deterioration α increases, the replenishment cycle length, the optimal replenishment quantity and optimal net profit per unit per cycle decrease respectively. The optimal total number of units lost per cycle and optimal average profit per unit per cycle are fluctuated with increase in the percentage value of the major parameter α.

Table 3. Sensitivity analysis of α
Tabela 3. Analiza wrażliwości α

α%	Iteration	t^*	L^*	q^{**}	$\tilde{\pi}_1(q)$	$\tilde{\pi}(q)$
.01	75	4.078203	101.161	4995.005	61388.77	15052.81
.10	66	1.540936	150.0776	1999.2	23507.35	15255.25
.20	73	0.9114078	106.0227	1199.712	13886.15	15235.94
.30	73	0.6470859	80.49288	856.9959	9820.065	15175.83
.40	64	0.5016161	64.63842	666.5778	7575.626	15102.44

It is interesting to investigate the influence of the major parameters $\tilde{K}$, $\tilde{h}$, r, c and P_s on retailer's behavior. The computational results shown in Table 4 indicate the following managerial phenomena:

- $t_c$the replenishment cycle length, q the optimal replenishment quantity, $\tilde{\pi}_1$ the optimal net profit per unit per cycle and $\tilde{\pi}$ the optimal average profit per unit per cycle are insensitive to the parameter $\tilde{K}$.
- $t_c$the replenishment cycle length , q the optimal replenishment quantity and $\tilde{\pi}_1$ the optimal net profit per unit per cycle are sensitive to the parameter h but $\tilde{\pi}$ the optimal average profit per unit per cycle is insensitive to the parameter $\tilde{h}$.
- q the optimal replenishment quantity, $\tilde{\pi}_1$ the optimal net profit per unit per cycle and $\tilde{\pi}$ the optimal average profit per unit per cycle are sensitive to the parameter r but $t_c$the replenishment cycle length is insensitive to the parameter r.
- $t_c$the replenishment cycle length , q the optimal replenishment quantity, $\tilde{\pi}_1$ the optimal net profit per unit per cycle and $\tilde{\pi}$ the optimal average profit per unit per cycle are sensitive to both the parameters c and P_s.

Table 4. Sensitivity analyses of the parameters $\widetilde{K}$, $\tilde{h}$, r, c and P_s
Tabela 4. Analiza wrażliwości parametrów $\widetilde{K}$, $\tilde{h}$, r, c oraz P_s

Parameter	Value	Iteration	t^*	L^*	q^*	$\tilde{\pi}_1(q)$	$\tilde{\pi}(q)$
$\widetilde{K}$	150	80	2.354328	173.0073	2998.201	35857.55	15230.48
	155	82	2.354328	173.0073	2998.201	35852.55	15228.36
	210	87	2.354328	173.0073	2998.201	35797.55	15205.00
$\tilde{h}$	3	89	2.901615	265.2521	3747.19	44376.20	15293.62
	4	88	2.599	211.7875	3331.113	39635.89	15247.87
	6	75	2.151501	143.9851	2725.786	32650.95	15175.90
r	1100	74	2.354328	158.5900	2748.351	32806.92	13934.73
	1300	73	2.354328	187.4246	3248.051	38808.19	16483.76
	1400	73	2.354328	201.8419	3497.901	41808.82	17758.28
c	50	65	8.103972	2265.641	11990.41	389039.4	48006.02
	80	72	4.460206	643.7555	5996.003	124697.8	27957.86
	120	74	0.4492148	6.099399	545.1572	1152.623	2565.862
P_s	120	74	1.905113	112.4249	2398.561	23024.18	12085.47
	150	75	4.460472	643.8354	5996.402	138583.9	31069.34
	200	86	8.105304	2266.439	11992.80	518876.6	64016.92

CONCLUSION

In this model, a modified FEOQ model is introduced which investigates the optimal order quantity assumes that a percentage of the on-hand inventory is wasted due to deterioration as a characteristic feature and the inventory conditions govern the item stocked in fuzzy space. This model provides a useful property for finding the optimal profit and ordering quantity with units lost due to deterioration. A new mathematical model is developed and compared to the traditional EOQ model numerically. The economic order quantity, q^{**} and the net profit for the modified model, were found to be less than that of the traditional, q^*, i.e. $q^{**} < q^*$ and the net profit respectively. But the modified average profit per unit per cycle is less than that of the traditional profit per unit per cycle. Finally, wasting the percentage of on-hand inventory due to deterioration effect was demonstrated numerically to have an adverse effect on the average profit per unit per cycle. Hence the utilization of units lost due to deterioration makes the scope of the application broader. Further, a numerical example is presented to illustrate the theoretical results, and some observations are obtained from sensitivity analysis with respect to the major parameters. The model in this study is a general framework that considers wasting/ none wasting the percentage of on-hand inventory due to deterioration simultaneously.

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OPTYMIZACJA MODELU ZMIENNEJ WIELKOŚCI EKONOMICZNEJ ZAMÓWIENIA (FEOQ) DLA PRODUKTÓW PODLEGAJĄCYCH PSUCIU SIĘ ORAZ UWZGLĘDNIAJĄCY STRATY TOWARU

STRESZCZENIE. **Wstęp:** Model ten prezentuje wpływ psucia się produktów w systemie ciągłego uzupełniania dla skończonego horyzontu planowania. Tradycyjnie zostały wyliczone w tym modelowym systemie koszty magazynowania na jednostkę artykułu, na jednostkę czasu oraz koszt zamówienia na zamówienie. Te nieprecyzyjne parametry zdefiniowane w określonych przedziałach osi dla rzeczywistych wartości i fizycznych charakterystyk magazynowanych produktów określają zasady zarządzania zapasami stosowanymi w danym systemie produkcyjnym.
Metody: Zastosowano zmodyfikowany model zmiennej ekonomicznej wielkości zamówienia (FEOQ), zakładający, że pewien odsetek zapasów jest tracony w wyniku psucia się wyrobów. Model ten został tak zmieniony aby uzyskać optymalną wielkość zamówienia przy maksymalizacji zysku netto. W analizie teoretycznej, koniecznym i wystarczającym warunkiem istnienia i unikalności optymalnego rozwiązania jest znalezienie przegięcia funkcji zysku netto. Opracowano algorytm obliczeniowy w celu znalezienia optymalnego rozwiązania przy zastosowaniu oprogramowania LINGO 13.0.
Wyniki i wnioski: Wyniki analizy matematycznej umożliwiają osobom podejmującym decyzję określenie wielkości wpływu psucia się zapasów na optymalizację zysku netto detalisty. Przeprowadzono również analizę wrażliwości dla optymalnego rozwiązania uwzględniając istotne parametry. Przedstawiono dowody, że podejmowanie decyzji na zasadzie prawdopodobieństwa jest istotniejsze w procesie maksymalizacji zysku od decyzji typu Crisp.

Słowa kluczowe: optymalizacja, FEOQ, psucie się, straty jednostkowe

OPTIMALISIERUNG DES MODELLS DER VARIABLEN WIRTSCHAFTLICHEN GRÖ?E EINER BESTELLUNG (FEOQ) FÜR VERDERBANFÄLLIGE PRODUKTE UNTER BERÜCKSICHTIGUNG VON WARENVERUSTEN

ZUSAMMENFASSUNG. Einleitung: Das Modell präsentiert die Einflussnahme des Produktenverderbs innerhalb des Systems einer ständigen Vervollständigung der Vorräte für den finiten Zeitplan-Horizont. In diesem Modellsystem wurden die Lagerkosten traditionsgemäß auf die Artikeleinheit, ferner auf die Zeiteinheit und die Auftragskosten auf die Bestellungseinheit ausgerechnet. Diese unpräzisen Parameter, die innerhalb der bestimmten Intervalle der Achse für die Echtwerte sowie für physische Charakteristika von gelagerten Produkten definiert wurden, bestimmen die im jeweiligen Produktionssystem angewendeten Prinzipien der Bestandsführung.

Methoden: Es wurde ein modifiziertes Modell der variablen wirtschaftlichen Größe einer Bestellung (FEOQ), in dem angenommen wird, dass eine gewisse Losgröße von Vorräten infolge des Verderbs von Produkten verloren geht, angewendet. Das Modell wurde so verändert, dass man die optimale Losgröße der Bestellung bei Maximalisierung des Netto-Gewinns erzielen konnte. In der theoretischen Analyse besteht die unentbehrliche und genügende Voraussetzung für das Bestehen und die Einmaligkeit der meist optimalen Lösung in der Ermittlung der Verbeugung von Funktion des Netto-Gewinns. Für die Ermittlung einer optimalen Lösung wurde ein Berechnungsalgorithmus unter Anwendung der Software LINGO 13.0 ausgearbeitet.
Ergebnisse und Fazit: Die Ergebnisse der mathematischen Analyse befähigen die Entscheidungsträger zur Bestimmung der Einflussnahme des Verderbs von Vorräten auf die Optimierung des Netto-Gewinns beim Einzelhändler. Darüber hinaus wurde auch eine Analyse der Empfindlichkeit für die optimale Lösung unter Berücksichtigung von relevanten Parametern durchgeführt. Man stellte dabei die Beweise dafür dar, dass das auf das Wahrscheinlichkeitsprinzip gestützte Entscheidungstreffen im Prozess der Maximalisierung des Gewinns mehr brauchbar ist als die Crisp-Entscheidungen selbst.

Codewörter: Optimierung, FEOQ, Verderb, einheitliche Verluste

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INTEGRATED LOGISTICS MANAGEMENT SYSTEM FOR OPERATION OF MACHINERY AND EQUIPMENT

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ABSTRACT. Background: The main issue in the operations of machinery and equipment, which is the subject of theoretical and empirical research is to provide high reliability and durability with qualitative post-trade services of machinery and equipment. Quality of service can be achieved through planned maintenance activities supported by computer technology. The article presents the concept of an integrated system of logistics management operation of machinery and equipment, especially special one for stationary transport equipment. At the outset, it emphasized the importance and essence of technological transport and storage systems storage in modern manufacturing enterprise. Then the objective and the method of research have been set. An essential part of deliberations in the article is the concept of integrated logistics management system operation for stationary transport equipment. Authors of this article have presented the results the implementation and operation of the system. The results are presented in a descriptive and graphic form.

Methods: The purpose of this article is to present the concept of implementing an integrated logistics management system for operation of stationary transport equipment. It goes through combination of planning, event logging service, warehouse management in the field of spare parts, account and records of the cost of service activities. The paper presents an analysis and evaluation method of brainstorming a new approach to logistics management operation stationary transport equipment. Authors takes into account the specific conditions of use of transport equipment and conduct the service, which have a significant impact on the time and place of cost and service as well. It should be noted that the developed system has been implemented. It was also carried out an assessment of its functionality and efficiency as the new IT tool for logistics management operation.

Results and conclusions: The paper presents a new concept of integrated logistics management of operation for the stationary transport equipment system. Specific conditions relating to the operation of these devices have been identified. This is essential prerequisites for the development of the concept of the computer solution. The article presents the concepts of the inclusive servicing of warehouse management and cost accounting records and maintenance. Comprehensive integration of these aspects creates a new opportunities in logistics in the field of the operation for stationary transport equipment. This way of design, implementation and recording of maintenance work supported by the integrated management system is a modern tool for conducting maintenance. It's should be mentioned that this conception remains in competition with traditional servicing operators servicing.

Key words: management, management system, logistics operation.

INTRODUCTION

Stationary transport systems are used in many sectors of the global economy. Raw materials and products are transported by means of so-called conveyor system and storage. Reliable operation of these systems is a prerequisite for trouble-free use of all further devices in the logistics chains of different production processes and transport Therefore the reliability and use of stationary transport systems are put very high demands. Stationary transport and storage systems are used in the economy, including in:

– coal, lignite mine and mineral resources,

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- heat and power plants,
- steel mills and cement plants,
- automotive industry,
- ports.

In technological transport systems and storage we can distinguish the following carriers:
- belt,
- roller,
- chain,
- bucket,
- worm,
- special purpose, and others like complete lines for the continuous transport.

Source: www.fugor.com.pl

Fig. 1. The technological transport of lignite opencast mine (conveyor belt)
Rys. 1. Transport węgla brunatnego (pas transmisyjny)

PLACE OF LOGISTICS SERVICE IN ENTERPRISE

Logistics is defined as the process management of movement of goods and / or persons and activities supporting these processes in systems in which they occurred [Słowinski, 2009]. It follows that the essence of logistics management is to link the processes of movement. That is why logistics is now included in the core business as for example factors of value added (Fig. 2).

Efficiency of movement processes, use of modern IT tools in controlling these processes, economics of operation and cost reduction are necessary conditions to maintain the market position. The most important task of logistics at the operational level is optimization of the five basic factors: time, space, quantity, size range and information. Thus, regardless of the substance of the concept of logistics, it should be able to answer for a string of questions: what? to whom? where? when? how much? how? The answers of these questions about the client - manufacturer, are in fact essential for the success of any enterprise.

Logistics, which have been started, it is development of the configuration: production-transportation-storage-stocks, constantly ex-panding the sphere of their interests. Today - on the basis of logistics - you can now build an integrated business management system and determine the strategic directions of the growth of its effectiveness. Logistics also entered into the field of quality and reliability. Now also increasingly unites its objectives with the strategic and operational management of the company [Słowinski, 2009].

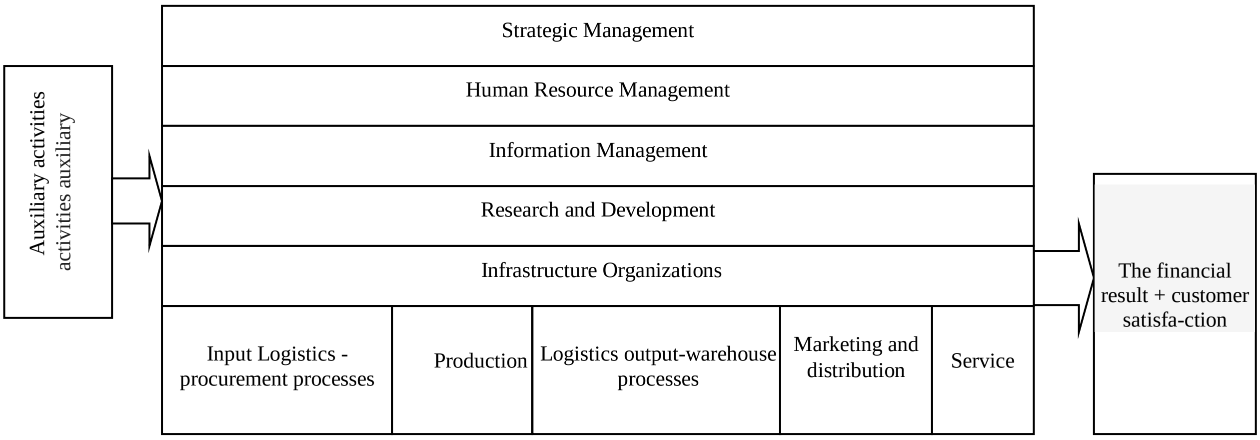
One of the key tasks performed by each company's is logistics customer service – the common area of marketing and logistics in the company. Presented in the literature synergistic areas of marketing and logistics are related with logistics customer service processes. It taking place in the distribution of products [Schenk, 2010].

Marketing focuses on customer service in the field of communication, especially interpersonal one, and also as part of the distribution strategy involving the creation clients the ability to purchase products company [Strojny, 2011]. Logistics customer service concerns the distribution of products in an optimal way, so that the customer received the product in the right quantity and condition, and to allow him to get on the effects of supply at a particular time and place [Pokusa, 2001].

Logistics customer service in the field of marketing and logistics is analyzed and presented in the literature in the form of three phases:
- pre-trade phase, which refers to the policy of the company in the preparation of customer service, service policies, the adequacy of the organizational structure and the flexibility of the customer service process,

- phase of the transaction, which decides on the proper and consistent with the client's expectations of the process of the transaction (purchase), and covers the time from order placement until the transfer of the product to the customer,
- post-trade phase, which involves actions to support reliable and durable operation of the product during use (operation) on the client. It includes such activities as installing (first run), maintenance and warranty and post-warranty repairs, modernization and installation of additional equipment, training for customers in the use of the products, complaint procedures, delivery of materials and spare parts.

Therefore, the logistics operation belongs partially to pre-trade phase in terms of developing policy and partly - to post-trade service. It covers all the activities related to the reliable operation of the product at the customer.



Source: the authors of the paper

Fig. 2. The Place of operational logistics in the creation of value-added businesses
Rys. 2. Rola operacji logistycznych w tworzeniu wartości dodanej przedsiębiorstwa

Reliable use of machinery and equipment, including stationary transport equipment, requires a systemic approach to service, and so - do their service and repairs and periodic inspections. Planning, organizing and conducting activities service and repair of transport equipment and storage technology is a demanding task of engineering and technology. Much space is also devoted to this issue in the studies of H. Wildeman. Thus, a necessary condition for the implementation of these measures is the use of computer technology-based logistics management system operating in the field of maintenance and repair stationary technological transport and storage. So the decision-making process for the effective and timely implementation of tasks in line with the strategy of the company is necessary, first of all, to build operational plans. They are essential elements of decision-making to create relationships in the production function [Mleczko, 2008].

We must also remember that production planning, scheduling and control operations forces to use both the various technologies and methodologies, including the production function. The use of systems such as Just in Time, MRP, ERP and Kanban will accurately plan production requirements. The rules control the production, may be included in the five points, which are:

- agreed production plan,
- fast and effective way to manage change,
- control of production scheduling system,

- production under conditions of limited capacity,
- availability and accuracy of data [Towers, 2008].

PROJECT SERVICE FOR FIXED TRANSPORT EQUIPMENT

Service activities in the logistics operation of machinery and equipment encountered a number of problems, which arise primarily from the fact that [Antoniak, 2007]:

- Fixed transport equipment are often subjected to extreme and its intensity strongly varying operating conditions impeding planning point of time and the scope of service and repair work. The reasons in this regard are: the impact of weather conditions for the operation of the open space, scuffing and wear through the material transported (e.g. dust). Other important matter is large variations in the behavior of these devices in terms of susceptibility to damage and failures as a result of changing operating conditions. Thus, the planning point of time and the scope of service and repair work is extremely difficult.
- Transport equipment often contain a large number of widely spaced points requiring maintenance service activities. At the point of use devices with virtually no information about the disposal of property maintenance and its history. It means that maintenance work will be carried out without targeting them to the correct destination and often by using a lot of work and resources.
- Documentation of maintenance work and repair or results of technical inspections creates problems, because the documenttation directly on the site is often difficult and requires a lot of work. The implementation period for maintenance & repair and their documenting are sharing now considerable periods of time. This is related to the danger of incorrect and incomplete documentation of performed maintenance activities.

For overcome these shortcomings, you will clearly improve both maintenance and corrective actions in the context of quality and reliability of the equipment, while maintaining the same cost or even reducing them. So it becomes necessary to take appropriate action relating to the operation and overhaul and repair. As a result of exploratory studies the following tasks was carried out:

- gathering the necessary information concerning the operation of the transport device and the necessary tasks to perform maintenance and repair work directly on-site by an employee performing maintenance or repair,
- specification of conditions for documenting the activities performed service-repair or results of technical review directly on-site
- providing conditions for the central storage, analysis and evaluation of information relevant to the implementation of measures to repair & maintenance and preparation of the data for planning, accounting and control of maintenance activities.

These considerations were the basis for the development and application of computer technology-based information and management system, called logistics management system for stationary transport equipment operation [Reichel, 2009]. This system has the following functional characteristics:

- provides records data directly in the place of use, and transfer of data to the central data bank without further manual processing them,
- documented and accounted for maintenance and service work,
- prepares and offers service status information for object in order to prepare and carry out the necessary work to repair & maintenance,
- prepares the current data of the periods of machine downtime associated with planned treatments and service - repair, consumable materials and spare parts and the cost of service and repair work,
- documented reliability and identify their weak points,
- prepares the information for operational and strategic planning service and repair.

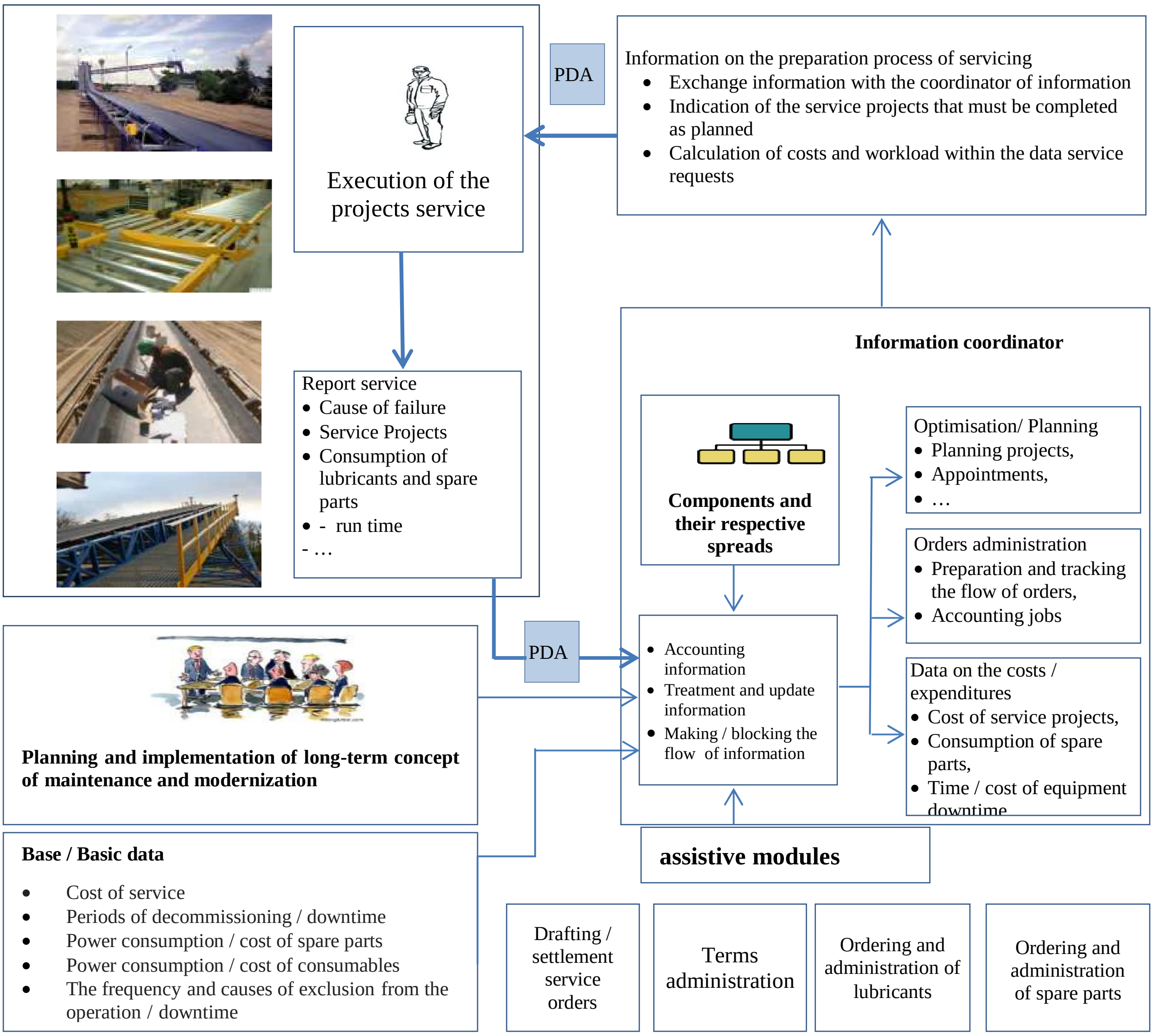
This system has the following characteristics:

- some functioning and reliable data storage,

- easy to use without any special knowledge in the field of computer technology,
- environmental compatibility of enterprise information technology,
- possible low cost of acquisition, use and maintenance.

CONCEPTION OF LOGISTICS MANAGEMENT SYSTEM FOR OPERATION OF STATIONARY EQUIPMENT TRANSPORT

Functional characteristics and structure developed logistics management system operation is shown in Figure 3.



Source: the authors of the paper

Fig. 3. Functional characteristics and structure of logistics management system for operation of stationary transport equipment
Rys. 3. Charakterystyka funkcjonalna struktury systemu zarządzania logistystycznego działania stacjonarnego wyposażenia transportowego

Presented system has been developed for the purpose of service of conveyor systems and storage, and it is possible to use regardless of the type and area of use of the facilities. For each of the cases, it is necessary - before you start - the introduction of baseline data, specific to several device (in the case of this project, the object of study are conveyors).

These tasks can be carried out on the basis of the computer program documentation by the employee which has a basic knowledge about electronic records and data processing. Logistics management system for operation stationary transport equipment developed in the following stages:

- structural separation in terms of transport equipment service and work - repair maintenance,
- technological preparation and organization of the service and work - repair maintenance,
- develop baseline data as a list for the "service equipment",
- installation and commissioning of the "service equipment",
- use (testing) program and correction.

TECHNOLOGICAL PREPARATION AND ORGANIZATION OF SERVICE WORK

Technological basis for the preparation and organization of service work create the relevant documents from the manufacturer and the user of the device. In this case that are: the stationary transport equipment, as well as applicable laws, standards, rules and regulations. In particular, one should take into account the specific service processes and practical expertise and experience of employees. Service projects can be planned with regard to their implementation point of time and the content and scope.

For this purpose, the necessary data are entered into the correct directory data in the logistics management operation. That type of the system is installed in the base unit. It is a computer located in the service department, it works with a mobile unit in order to record the data.

DATA BASE INPUT

The baseline data are the basis of the data program. They are stored in directories underlying data. When one use the program they are called and if necessary - updated by writing down information by user of the program (e.g., type, content, point in time, service projects). The user accesses the corresponding windows that contain a number of texts help, including information on produced data. Text help facilitate data entry as well.

Baseline data are divided into the following categories: customers, location of equipment, cost centers, suppliers, types of equipment, materials, parts, materials, performance, parts, service personnel, operations, machinery.

Relevant data base allows the user to program making contact in the form of oral or written with the principal of servicing - repair task or employee of his own company. It becomes necessary, for example, when one will decide to carry out unplanned, required maintenance projects. Available "entry" windows for the introduction of data flows presents program homepage of the that is called "service equipment".

MOBILE DATA REGISTRATION

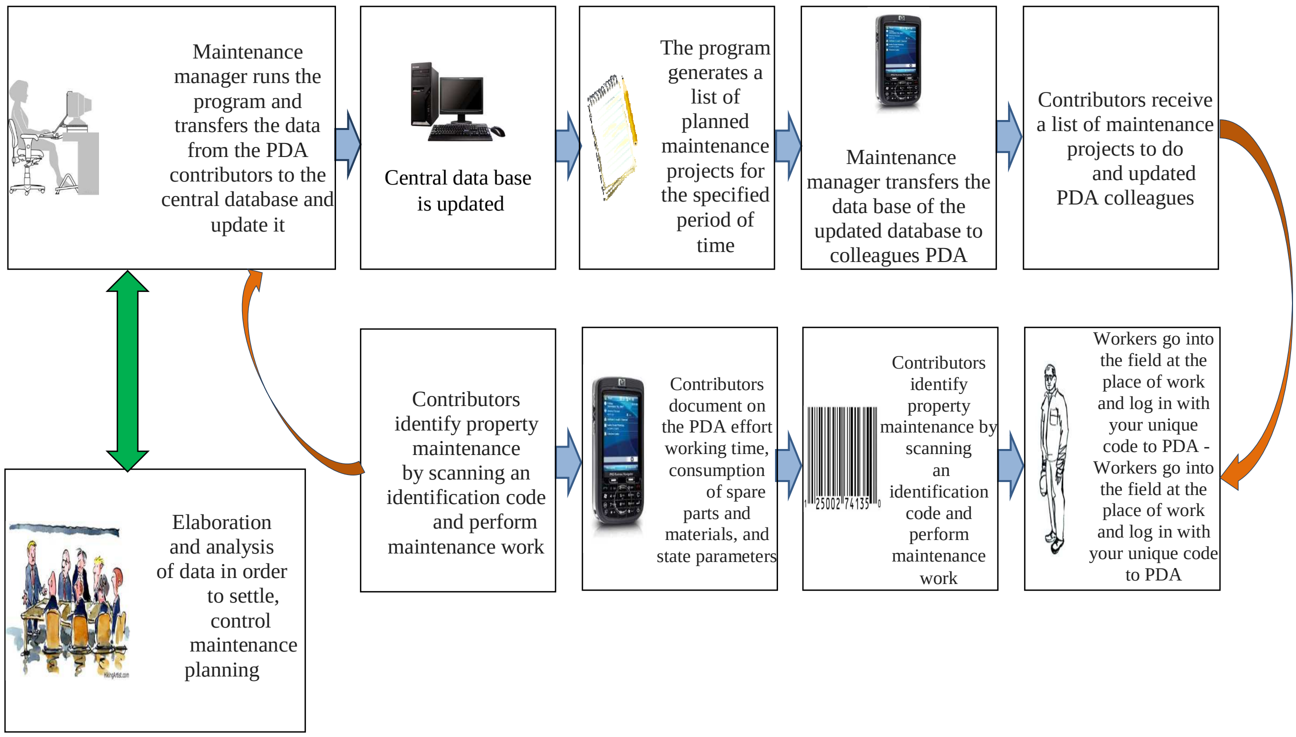
Mobile Registration data and their transmission to a central computer database is done by using a standard PC PDA - Pocket (Fig. 4), and the process of accounting data and the transmission is shown in Figure 5.

Source: the authors of the paper

Fig. 4. Input Window PC PDA - Pocket - Registration
Rys. 4. Strona wejściowa PC PDA

After logging by using a personal password it's possible - for the purpose of documenting planned to carry out the service - to choose different input window and records the data.

By pressing the buttons the user accesses the database introduced into the PDA (e.g. the list of machines). By clicking on the current machine, used lubricant or other items included on the lists, they are properly taken into the input window. It is a way of reducing the workload for documenting the maintenance project and increases the quality of the recording of data. The data documented in the PDA which concern the carried out service are sent by using the transfer station to a central database. In the updated database data are collected and made available for the purpose of further evaluation and analysis, such as the settlement of warranty made or post-warranty maintenance.



Source: the authors of the paper

Fig. 5. The algorithm for recording and transmission data by using a standard PC PDA - Pocket
Rys. 5. Algorytm zbierający i przekazujący dane przy zastosowaniu standard PC PDA-Pocket

The purpose of the proper and reliable functioning of the "service equipment" its installation along with connecting functions, i.e. mobile handheld Pocket PC type - mobile data records. It should be done by a specialist service department in the field of electronic data processing and accounting. As part of the development of the software installation and using the "service equipment" is included. It should be done by using generally occurring and operated enterprises, standard computer equipment (hardware) and basic software (software), such as a computer running Microsoft Windows Professional.

It is expected that as a result of planned further research will be formulated practical guidance on opportunities to improve and streamline the management system. They will be implemented in the framework of the final modification and improvement program within the author's own research. Its value in use will be verified practically at its dissemination.

SUMMARY

The use of computer technology - based on logistics management system for operating stationary transport device contributes significantly to the elimination of currently outstanding service errors in the use and repair of warehouse transport systems and technology. As part of own research was developed adequate system of logistics management operation of machinery and equipment, and completed work on a software and IT technical implementation of the system. Service management system for stationary transport and the associated software are - after proper alignment - possible to apply for service management of machinery and equipment in all sectors of the economy.

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ZINTEGROWANY SYSTEM ZARZĄDZANIA LOGISTYKĄ EKSPLOATACJI MASZYN I URZĄDZEŃ

STRESZCZENIE. Wstęp: Podstawowym zagadnieniem w eksploatacji maszyn i urządzeń, które stanowi przedmiot rozważań teoretycznych jak i badań empirycznych jest zapewnienie ich wysokiej niezawodności i trwałości poprzez jakościową obsługę potransakcyjną. Jakość serwisu można osiągnąć poprzez planowe działania obsługowe wsparte technika komputerową. W artykule zaprezentowana została koncepcja zintegrowanego systemu zarządzania logistyką eksploatacji maszyn i urządzeń, szczególnie stacjonarnych urządzeń transportowych. Na wstępie zaprezentowano znaczenie i istotę systemów transportu technologicznego i magazynowego współczesnego przedsiębiorstwa produkcyjnego, następnie określono cel i metodę badań. Zasadniczą część opracowania stanowi opis koncepcji zintegrowanego systemu zarządzania logistyką eksploatacji stacjonarnych urządzeń transportowych. Zaprezentowano efekty wdrożenia i funkcjonowania systemu. Wyniki przedstawiono w formie opisowej i graficznej.
Metody: Celem opracowania jest zaprezentowanie koncepcji wdrożenia zintegrowanego systemu zarządzania logistyką eksploatacji stacjonarnych urządzeń transportowych, poprzez połączenie procesów planowania, rejestrowania zdarzeń serwisowych, gospodarki magazynowej w zakresie części zamiennych, rachunku i ewidencji kosztów działań serwisowych. W artykule przedstawiono analizę i ocenę metodą burzy mózgów nowego podejścia do zarządzania logistyką eksploatacji stacjonarnych urządzeń transportowych, uwzględniając specyficzne warunki ich eksploatacji i prowadzenia prac serwisowych, które mają istotny wpływ na czas i miejsce powstawania kosztów prac serwisowych. Opracowany system wdrożono w praktyce gospodarczej. Dokonano też oceny jego funkcjonalności oraz efektywności, jako nowego informatycznego narzędzia wspierającego proces zarządzania logistyką eksploatacji.
Wyniki i wnioski: Opracowanie prezentuje nowa koncepcję zintegrowanego systemu zarządzania logistyką eksploatacji stacjonarnych urządzeń transportowych. Zidentyfikowane zostały specyficzne uwarunkowania dotyczące eksploatacji tych urządzeń, które stanowiły istotne przesłanki do opracowania koncepcji programu informatycznego. W opracowaniu zaprezentowano koncepcję programu integrującego prace serwisowe z gospodarką magazynową i ewidencją oraz rachunkiem kosztów prac serwisowych. Kompleksowa integracja tych obszarów stwarza nowe możliwości w logistyce eksploatacji stacjonarnych urządzeń transportowych. Tak zaplanowane i realizowane oraz ewidencjonowane prace obsługowe, wsparte zintegrowanym systemem zarządzania należy traktować jako nowoczesne narzędzie prowadzenia prac serwisowych, które stanowi konkurencję dla tradycyjnych operatorów prac serwisowych.

Słowa kluczowe: zarządzanie, metoda zarządzania, operacje logistyczne.

INTEGRIERTES SYSTEM FÜR LOGISTIK-MANAGEMENT DER AUSNUTZUNG VON MASCHINEN UND EINRICHTUNGEN

ZUSAMMENFASSUNG. Einleitung: Die Hauptfrage der Ausnutzung von Maschinen und Einrichtungen, die den Gegenstand sowohl theoretischer, als auch empirischer Erwägungen ausmacht, ist die Gewährleistung einer hohen Zuverlässigkeit und Beständigkeit durch einen entsprechenden Qualitäts-Service der in Betrieb genommenen, technischen Anlagen. Die erwünschte Qualität des Services kann mit geplanten, rechnerunterstützten Service-Leistungen erreicht werden. In der Arbeit wurde ein Konzept des integrierten Systems für Logistik-Management der Ausnutzung von Maschinen und Einrichtungen, insbesondere von stationären Transport-Anlagen, dargestellt. Einleitend präsentierte man die Bedeutung und das Wesen von Transport- und Lagersystemen innerhalb eines gegenwärtigen Produktionsunternehmens, nachfolgend bestimmte man das Ziel und die Methode für die durchzuführenden Forschungen. Das Konzept des integrierten Systems für Logistik-Management der Ausnutzung von stationären Transport-Anlagen macht den Hauptteil der Arbeit aus. Es wurden Ergebnisse der Einführung und Betätigung des Systems präsentiert und sie in einer die Systemfunktionalität kommentierenden und grafischen Form projiziert.
Methoden: Das Ziel der Arbeit war es, ein Konzept des integrierten Systems für Logistik-Management der Ausnutzung von stationären Transport-Anlagen auszuarbeiten und es einzuführen, und dies anhand einer Integration von Planungsprozessen, der Erfassung von Service-Ereignissen, ferner durch eine effiziente Lagerwirtschaft im Bereich der Bewirtschaftung von Ersatzteilen, Bestandsführung und Identifikation der Kosten von Service-Leistungen. In der Arbeit stellte man mittels eines "Brainstormings" die Analyse und Einschätzung eines neuen Herangehens an die Fragen des Logistik-Managements bei der Ausnutzung von Transport-Anlagen dar, und dies unter Betrachtung von spezifischen Betriebsbedingungen der Transporteinrichtungen und der Durchführung von Service-Leistungen, die einen wesentlichen Einfluss auf die Zeit und den Ort der Entstehung der Kosten von Service-Leistungen ausüben. Das konzipierte System wurde eingeführt und die Einschätzung dessen Effektivität und Funktionalität als eines Informatik-Werkzeuges für die Betriebslogistik vorgenommen.

Ergebnisse und Fazit: Die Arbeit präsentiert ein neues Konzept des integrierten Systems für das Logistik-Management bei der Ausnutzung von stationären Transport-Anlagen. Es wurden spezifische Betriebsbedingungen solcher Einrichtungen, die wesentliche Voraussetzungen für die Ausarbeitung des Konzeptes eines Informatik-Programms schufen, ermittelt. Im Rahmen des Vorhabens wurde das Konzept eines Programms, das die Service-Leistungen mit der Lagerwirtschaft, Evidenz und Kostenrechnung von Service-Ereignissen integriert, ausgearbeitet. Die komplexe Integration dieser Funktionsbereiche schafft neue Möglichkeiten innerhalb der Logistik beim Betreiben von stationären Transport-Anlagen. Die auf diese Art und Weise geplanten, realisierten und evidenzmäßig erfassten Service-Dienstleistungen, die von einem integrierten Management-System unterstützt werden, sollen als ein modernes Tool für die Durchführung der Service-Leistungen angesehen werden. Solch ein Konzept und Herangehen an den Kundenservice sind durchaus wettbewerbsfähig im Verhältnis zu herkömmlichen Anbietern von den betreffenden Service-Dienstleistungen.

Codewörter: Management, Management-System, Logistik von Maschinenausnutzung.

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MAINTENANCE IN SUSTAINABLE MANUFACTURING

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ABSTRACT. Background: Sustainable development is about reaching a balance between economic, social, and environmental goals, as well as people's participation in the planning process in order to gain their input and support. For a company, sustainable development means adoption of such business strategy and actions that contribute to satisfying present needs of company and stakeholders, as well as simultaneous protection, maintenance and strengthening of human and environmental potential which will be needed in the future. This new approach forces manufacturing companies to change their previous management paradigms. New management paradigm should include new issues and develop innovative methods, practices and technologies striving for solving problem of shortages of resources, softening environment overload and enabling development of environment-friendly lifecycle of products. Hence, its realization requires updating existing production models as they are based on previously accepted paradigm of unlimited resources and unlimited regeneration capabilities. Maintenance plays a crucial role because of its impact on availability, reliability, quality and life cycle cost, thus it should be one of the main pillars of new business running model.

Material and methods: The following paper is a result of research on the literature and observation of practices undertaken by a company within maintenance area.

Results and conclusions: The main message is that considering sustainable manufacturing requires considerable expanding range of analysis and focusing on supporting processes. Maintenance offers numerous opportunities of decreasing influence of business processes on natural environment and more efficient resources utilization. The goal of maintenance processes realizing sustainable development strategy is increased profitability of exploitation and optimization of total lifecycle cost without disturbing safety and environmental issues.

Key words: sustainable manufacturing, maintenance generations, sustainable maintenance.

INTRODUCTION

Sustainable development became popular with the publication of the Brundtland Report [World Commission on Environment and Development 1987]. There, it was defined as a process aiming for development aspirations of contemporary generation meeting, and in the same enabling meeting these aspirations by the future generations as well. Thus sustainable development is about reaching a balance between economic, social, and environmental goals, as well as people's participation in the planning process in order to gain their input and support [Sneddon et. al 2006] For a company, sustainable development means adoption of such business strategy and such actions that contribute to satisfying present needs of company and its stakeholders, as well as simultaneous protection, maintenance and strengthening of human and environmental potential which will be needed in the future [Sidorczuk-Pietraszko 2007].

This new approach forces manufacturing companies to change their previous management paradigms. New management paradigm should include new issues and develop innovative methods, practices and technologies striving for solving problem of shortages of resources, softening environment

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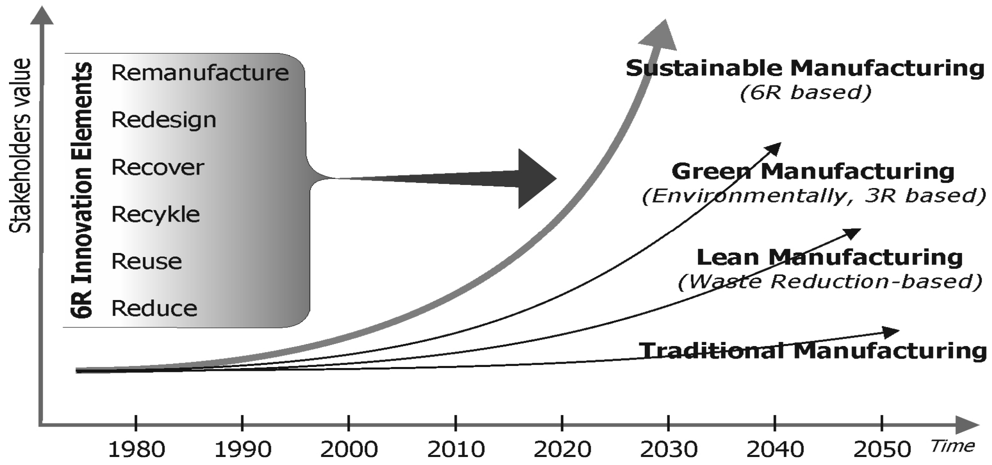
overload and enabling development of environment-friendly lifecycle of products [Saniuk et. al 2013, Saniuk et. al 2012]. Hence, its realization requires updating existing production models as they are based on previously accepted paradigm of unlimited resources and unlimited regeneration capabilities. Maintenance plays a crucial role because of its impact on availability, reliability, quality and life cycle thus it should be one of the main pillars of new business running model.

Maintenance should be considered a long-term strategic planning integrating all stages of a product lifecycle, including and anticipating changes in social, economic and environmental trends, incorporating innovative technologies to operational actions (e.g. e-maintenance, e-diagnostics). Whereas the goal of maintenance in a company realizing strategy of sustainable development is increased profitability of exploitation and optimization of total lifecycle of a product without disturbing safety and environmental issues.

SUSTAINABLE MANUFACTURING

Observation of development of a manufacturing system from a sustainable development perspective leads to the conclusion that there are four main production paradigms identifiable: mass production, lean production, green production and sustainable production (fig 1).



Source: Jayal et al. 2010

Fig. 1. Sustainable Manufacturing
Rys. 1. Zrównoważona produkcja

Mass Production systems were focused on the reduction of product cost. The consequence was limited ability to meet individualized needs and requirements of customers. Lean Manufacturing places emphasis on continuous improvement in product quality while decreasing product costs. In this case, the consequences increased the ability of manufacturers to meet individualized needs of customers, decreased direct and indirect costs and improved quality of final products. As a result, manufacturers could shape prices of final products at the level that compensated economies of scale, an effect that characterized the previous paradigm [Trzecieliński 2011]. The term green manufacturing was coined to reflect the new manufacturing paradigm that employs various green strategies and techniques to become more eco - efficient. These strategies include creating products/systems that consumes less material and energy, substituting input materials (e.g. non - toxic for toxic, renewable for non - renewable), reducing unwanted outputs and converting outputs to inputs (recycling).

Sawhney, Teparakul, Aruna, and Li [Sawhney et al., 2007] show the connection between lean manufacturing and the environmental movement stating that "it is natural that the lean concept, its inherent value - stream view and its focus on the systematic elimination of waste, fits with the overall strategy of protecting the environment", which they call Environmental Lean (En - Lean).

The end of the 20th century and the beginning of the 21st century has seen intensive searching for new business models in accordance with the sustainable development approach. Sustainable manufacturing is a new paradigm which has to take into consideration all the three aspects of sustainable development (financial, environmental and social) and develop innovative methods, practices and technologies enabling an environment-friendly lifecycle of products. To achieve this goal, contemporary models of production must be updated to meet new requirements and leave previous assumptions on unlimited availability of resources and ability of regeneration behind.

Sustainable production was introduced at the 1992 UNCED conference in Rio de Janeiro as a guide to help companies and governments transition towards sustainable development. Several definitions exist for sustainable manufacturing and production. Alting and Jegensen [Alting & Jegensen 1993] defined sustainable production as the management of the whole product life cycle starting from design, production, and distribution, to the disposal stage. This involves minimizing material and energy resources. The U.S. Department of Commerce defined sustainable manufacturing as "the creation of manufactured products that use processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers and are economically sound" [The U.S. Department of Commerce 2010]. Quinn et al. [1998] define sustainable manufacturing as "systems of production that integrate concerns for the long-term viability of the environment, workers health and safety, the community, and the economic life of a particular firm". In recent years, many aspects of sustainability in the context of manufacturing have been investigated [Velázquez et al. 2006, Nasr et al. 2011, Amrina & Yusof 2012]. Jayal et al. [2010] suggest, that sustainable manufacturing must respond to:

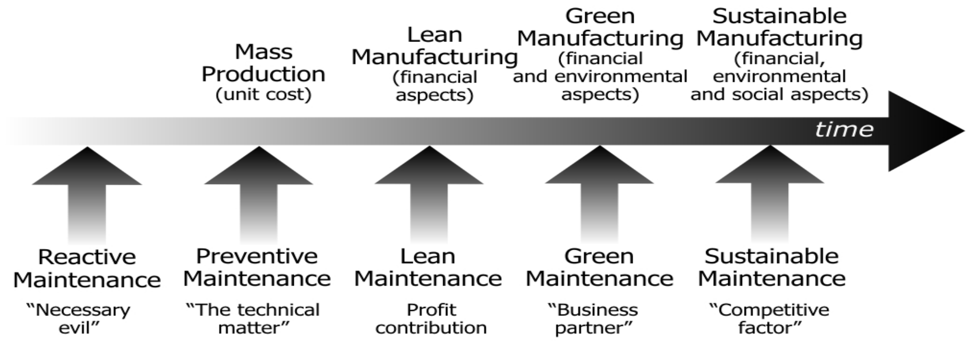
– economic challenges, by producing wealth and new services ensuring development and competitiveness through time
– environmental challenges, by promoting minimal use of natural resources (in particular non-renewable) and managing them in the best possible way while reducing environmental impact
– social challenges, by promoting social development and improved quality of life through renewed quality of wealth and jobs.

The move towards sustainability will require changes on many levels: not only production methods must be more respectful ethically and environmentally, but all the other processes performed in a company must also be changed.

A key to sustainable manufacturing is finding where and why the production process is wasting resources and energy. The consequence is that production processes have to be analyzed not only in the context of the technology applied, but also in the context of resources used (incl. human, material, technical and information resources).

MAINTENANCE GENERATIONS

A production system consists of different types of equipment and all equipment must be available and reliable at the highest level possible in order to ensure stability of a process. The maintenance department is responsible for keeping the equipment in the condition it initially was procured for and also to ensure that it can deliver outputs according to the specification. This is an important role in a production system and if it is performed successfully it can facilitate the journey towards becoming sustainable through high assets utilization, thus providing to the overall profitability. During the last decades, maintenance theory has radically changed according to the new manufacturing paradigms (fig. 2).



Source: Jasiulewicz-Kaczmarek 2013b

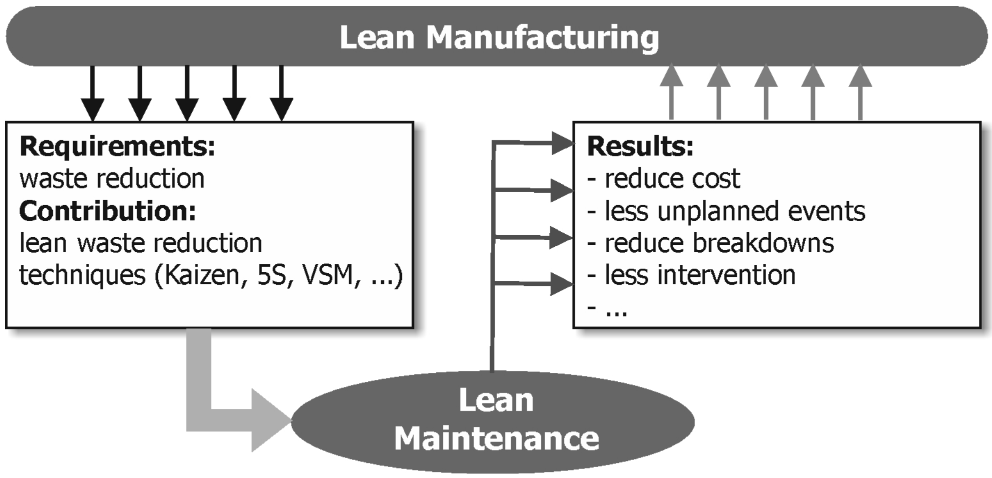
Fig. 2. The evolution of maintenance on a time perspective
Rys. 2. Ewolucja w postrzeganiu utrzymania ruchu

Until World War II, industry was not very highly mechanized, as the downtimes were not considerate. Most of the equipment was simple and over-designed. Failure consequences were not vital and had a neglectable effect. This was the time when preventing the equipment from failure was not a high priority. Therefore, industrial equipment was operated until it failed, at which point it was either repaired or replaced according to "fix it when it breaks" principle. Maintenance was considered as a production task and a necessary evil. The first maintenance approach could be described as reactive maintenance where no action is taken to prevent failures or to detect the onset of failure.

The next generation of maintenance was initiated with the industrialization process. The manufacturing plants became complex. Availability, longevity and cost were considered important factors for achieving business objectives. Maintenance became a task of the maintenance department and was considered as a technical matter according to "I operate- you fix" principle. Thus, the second maintenance approach could be described as a preventive approach.

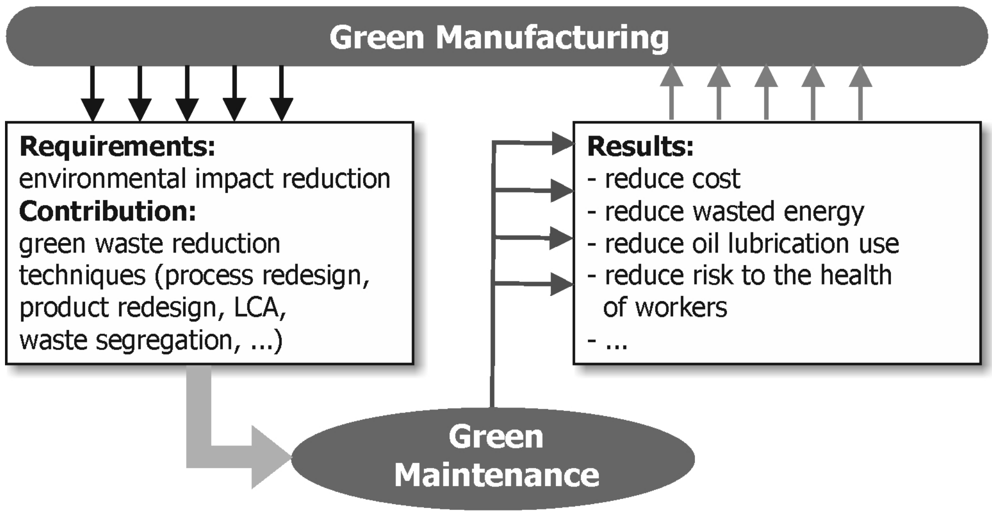
From the beginning of the 1970s, new options for maintenance realization appeared with the development of diagnostic tools and new approaches to corporate management, such as Just In Time paradigm, Total Quality Management philosophy, and waste elimination according to the Lean Manufacturing. According to the "lean" concept, "waste" is anything that does not add value to a product, a process, or a service. In maintenance system, the waste usually consists of outdated procedures, overstocked, underused inventory of equipment, material, parts, as well as wasted labor, time, transportation, exc.. All the principles, methods and technologies that can reduce the waste above listed and add value during the maintenance process are called "Lean Maintenance" [Smith 2004]. Levitt [2008], defined lean maintenance as delivery of maintenance services to customers with as little waste as possible. This promotes achievement of a desirable maintenance outcome with fewest inputs possible. Inputs include: labor, spare parts, tools, energy, capital, and management effort. The gains are improved plant reliability (availability) and improved repeatability of process (less variation).

The characteristic of lean thinking, associated with maintenance to improve efficiency and reduce waste, is the use of such tools as: VSM, visual displays (e.g. 5S), kanban, kaizen (i.e. continuous improvement), Six-Sigma quality, setup time reduction and preventative maintenance (fig. 3).



Source: Jasiulewicz-Kaczmarek 2014

Fig. 3. Lean manufacturing and lean maintenance
Rys. 3. Szczupła produkcja i szczupłe utrzymanie ruchu



Source: Jasiulewicz-Kaczmarek 2014

Fig. 4. Green manufacturing and green maintenance
Rys. 4. Zielona produkcja i zielone utrzymanie ruchu

As a contributor to current management techniques, lean thinking approaches are now more commonly used in maintenance area. The current production planning and shop floor control systems require dedicated solutions (tailored) using the tools of Lean, TOC, and others (depending on the organization conditions) [Hadaś and Cyplik 2010]. A similar path followed maintenance systems that use the tools of many concepts.

In the early 1990s, the idea of green maintenance was developed, which required the aim of maintenance to be realized by using advanced technologies and equipment at the cost of the least resources and energy consumption, the least waste and environmental impact. Green Maintenance is management of maintenance operations in an environmentally friendly way. It includes all the processes of maintenance, starting with selecting a strategy for an object's servicing (e.g., reactive, preventive, proactive), through material selection of raw materials and components necessary for equipment servicing purchasing, warehousing, maintaining (planned and unplanned) services, managing used materials, and exploitation fluids and lubricants (fig. 4).

Lean and Green manufacturing systems require efficient production and low use of resources such as energy, materials, etc. One major facilitator of this is effective maintenance. Sometimes regarded as the necessary evil, maintenance still has a negative image in the industry. But as the paradigm on manufacturing shift towards realizing a sustainable manufacturing, the changing role of maintenance should also be considered and appreciated.

SUSTAINABLE MAINTENANCE

Creating a sustainable production environment requires, among other things, the elimination of breakdowns and other sources of energy waste. The inadequate maintenance can result in higher levels of unplanned equipment failure, which has many inherent costs to the organization including rework, labor, and fines for late order, scrap, and lost order due to unsatisfied customers [Moore & Starr 2006]. The consequences of maintenance activities are not limited to the plant's boundaries. Frequent breakdowns cause unplanned downtimes which hinder delivery of products to customers. Persistent delivery delay gives the company a poor delivery reputation. Breakdowns also influence quality of products. Defective products damage company's reputation, reducing the selling price and the number of customers. Finally, because of the unpredictable and uncontrollable nature of breakdowns, they are typically the main source of safety and environmental hazards. Companies with low safety and high environmental hazard rates also lose status in society and in the labor market

In contemporary maintenance not only financial aspects should be included. Also the balance between environmental (green) and social aspects of actions realized should be found and kept, and systematic approach to actions, their consequences, results and benefits expected should be applied (table 1).

Table 1. The basics for assessing maintenance impact in term of gains and losses
Tabela 1. Ocena wpływu utrzymania z perspektywy zysków i strat

Assessing impact in terms of *gains*	**Assessing impact in terms of *losses***
What is the level of *financial impact* arising from excellent technical condition of systems/equipment of an asset due to effective and efficient maintenance practices?	What is the level of *financial impact* arising from poor technical condition of systems/equipment of an asset due to ill-defined and/or poor maintenance practices?
What is the level of *social impact* arising from excellent technical condition of systems/equipment of an asset due to effective and efficient maintenance practices?	What is the level of *social impact* arising from poor technical condition of systems/equipment of an asset due to ill-defined and/or poor maintenance practices?
What is the level of *environmental impact* arising from excellent technical condition of systems/equipment of an asset due to effective and efficient maintenance practices?	What is the level of *environmental impact* arising from poor technical condition of systems/equipment of an asset due to ill-defined and/or poor maintenance practices?

Source: Liyanage et al. 2009

Hence, to efficiently support actions realized in a company and striving for sustainable manufacturing, maintenance should cope with the following challenges:

- to identify the important stakeholders and understand their demands,
- to develop and deliver maintenance processes in all phases of the life cycle of the machine,
- to identify involved risks and chances,
- to quality the staff.

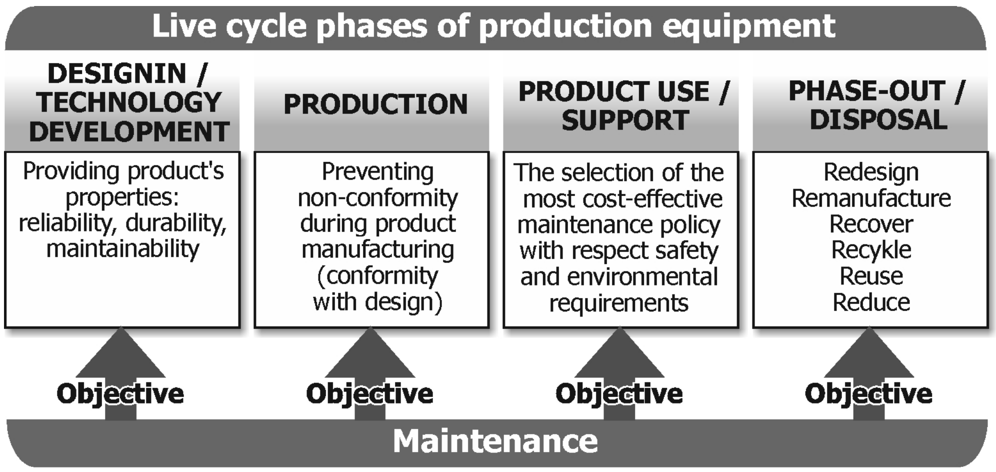
Maintenance management oriented on stakeholders is on one hand focused on goals of the stakeholders who are interested in work and results of maintenance management and on the other hand the stakeholders who influence maintenance performance success. Usually, stakeholders are groups of people who are the most important for overall success of maintenance. They have the ability to influence realization of maintenance operations and either win or lose depending on results of actions taken. A positive result of action depends on high information capacity of a maintenance system, while information capacity of maintenance is an outcome of cooperation of the system: maintenance – a stakeholder's (the environment the system operates in) maintenance system acquires resources from both external and internal sources. The ability to acquire resources from the environment and process them according to a system's own needs and needs of environment is a basic task of constructive actions and development of the system. This is why efficient management of stakeholders is so important for maintenance success. To manage stakeholders, it is necessary to identify them and identify motifs for their commitment. Stakeholders can be of both internal and external character. Examples of internal maintenance stakeholders are employees of the department, as well as production staff, logistics staff, accounting staff etc., while examples of external stakeholders are spare parts providers, exploitation material providers, service providers, designers and producers of machines and devices, etc.

As needs and expectations of stakeholders are sometimes contradictive (trade-off relation between production and maintenance represents a classic example), for providing a sustainable approach to meeting these requirements it is necessary to identify strategic goals and priorities for maintenance. The goals emerge from goals and strategies of a company that result from obligations made towards internal and external stakeholders. This is how maintenance is included in the internal value chain of a company. The chain needs to be supported with properly designed maintenance processes at every stage of a product's lifecycle, in which technical staff and employees in other functional departments and external units (e.g., designers and manufacturers of equipment, spare part providers, service providers) take part. Hence, maintenance development from a product's lifecycle point of view requires numerous interfaces between maintenance and its stakeholders.

The system life cycle is a sequence of phases, each containing tasks, covering the total life of a system from the initial concept to decommissioning and disposal. The many decisions made during the process of a technical object's design, production and operation directly influence the effect and outcome on all the dimensions of sustainable manufacturing (fig.5). The maintenance managers hold all the instruments that allow the firm's technical service workers to participate in all phases of the life cycle of the machine and thus engage in the implementation of the sustainable manufacturing.

The first phase of a product's life cycle is its design. In the context of sustainable manufacturing it is necessary to carefully check construction materials used and their influence on the natural environment, opportunity to re-use materials after exploitation is finished, high reliability of a machine in the exploitation stage and possibly low energy demand, stability of construction of machines and devices, maintainability, serviceability, safety and ergonomics for operators and technical department staff. Maintenance staff should be proactively committed to this stage of a machine's lifecycle. Their suggestions, remarks and initiatives should be the basic input data for design.

The next stage of a product's lifecycle, which is influenced by maintenance staff and which maintenance staff actively takes part in, is exploitation of a machine in a company. From the sustainable manufacturing point of view, maintenance of machines in the exploitation stage is focused on providing systems, procedures and trainings which build operative knowledge and skills, as well as functional capabilities of systems to prevent, manage and eliminate losses, environmental incidents and problems with safety and health of employees. Thus, knowledge of the influence of breakdowns of functional machines on the environment and safety of people is essential, as well as planning maintenance operations and monitoring systems adequate for potential consequences. Maintenance planning methods, as they are based on identification of risk emerging from a machine's failure, enable maintenance planning for manufacturing equipment in appropriate context, which refers to definition of correct proportions between predefined maintenance policies (incl. reactive, preventive, proactive and others) with respect not only to financial issues, but also to environmental and social issues (safety of people). The set of the most often used techniques includes: Reliability Centered Maintenance, Risk Based Inspection, Risk Based Maintenance, fault-tree analysis, Failure Mode and Effect Analysis, etc. Risk assessment integrates reliability with environmental and safety issues and can therefore be used as a decision tool for proactive maintenance planning. It helps management in making correct decisions concerning investment in maintenance or a related field. This will, in turn, result in better asset and capital utilization.



Source: Own study

Fig. 5. Maintenance objectives in life cycle phases of production equipment
Rys. 5. Cele utrzymania ruchu w cyklu życia wyposażenia produkcyjnego

Proactive operations seem to be the most important for sustainable maintenance in this stage of a machine's lifecycle. Proactivity in maintenance provides real opportunity for the e-maintenance philosophy to support "predict and prevent" strategies while keeping maintenance as an enterprise process. E-maintenance is a sub-concept of e-manufacturing and e-business for supporting next generation manufacturing practices.

This approach is the synthesis of two major trends in today's society: the growing importance of maintenance as a key technology and the rapid development of information and communication technology. E-maintenance seeks to implement maintenance management, wherein maintenance operations, planning and decision data and tools to process and act upon them become available anytime, anywhere and to anyone at multiple levels of operation [Muller et al. 2008, Iung et al. 2009].

Disposal is the last stage in a machine's lifecycle. It is the state of terminal use value of a machine and its further exploitation is either impossible or economically unjustified. The only problem left is management of used parts and components of a machine to be disposed of at the minimum load for the natural environment and some positive economic effects. After exploitation, each machine has a number of precious materials and components that can be used for regeneration or repair of similar technical objects. Hence, the goal of maintenance staff is to assess whether subassemblies or components of a machine disposed of fit other machines or devices owned by a company, whether they need repair or regeneration.

In every predetermined stage of a lifecycle maintenance integrates both own requirements of a company and its stakeholders. In this way, sustainable maintenance enables companies achieving numerous benefits of internal and external character.

Sustainable maintenance is a new challenge for companies that follow the strategy of sustainable manufacturing. It can be defined as proactive maintenance operations striving for providing balance in social (welfare and satisfaction of operators and maintenance staff), environmental and financial (losses, consequences, benefits) dimensions. It requires conducting broad analysis of loss and of the possibility of endangering the continuity of a company's functioning (in economic, environmental and social dimensions), if a maintenance strategy developed and implemented, and operations performed, do not provide the required technical condition of technical infrastructure (e.g., machines, devices, installations) [Jasiulewicz-Kaczmarek 2013a].

CONCLUSIONS

The main message is that considering sustainable manufacturing requires considerable expanding range of analysis and focusing on supporting processes. Maintenance offers numerous opportunities of decreasing influence of business processes on natural environment and more efficient resources utilization. The goal of maintenance processes realizing sustainable development strategy is increased profitability of exploitation and optimization of total lifecycle cost without disturbing safety and environmental issues. Including the category of sustainable development to processes and actions realized in maintenance area is a challenge but also a necessary support in sustainable manufacturing realization. The challenge, because it is not one, separate action but a process which requires building maintenance strategy and goals in consistency with sustainable development corporate strategy, as well as commitment and participation of all the employees, knowledge, experience and consequent performance (the process is evolutionary). Necessary support because maintenance is a crucial process in internal supply chain and if neglected or missed makes sustainable development corporate strategy only theoretical declaration of managers.

From practical point of view it requires changes in approach to maintenance represented by managers and changes in actions performed within maintenance area. Managers have to understand that maintenance is not only about repairs and conservations of machines and devices, but also actions striving for more efficient resources management and care for safety and health of employees. Whereas maintenance striving for meeting sustainable manufacturing requirements needs to be [Jasiulewicz-Kaczmarek 2013b]:

- creative and innovative, which means focusing on problem solving and continuous search for improvement options and using innovative solutions like e.g. ICT;
- scalable, which means taking requirements and expectations of a broader group of stakeholders instead of classic approach to relations between manufacturing and maintenance (most of the effect of maintenance can be found outside the maintenance function, in other work areas of the company);
- committed and involving, which means breaking manufacturing's hegemony and creating bonds with both internal and external stakeholders (development and integration of maintenance from product's lifecycle perspective requires numerous interfaces with other systems, internal as well as external ones).

Many companies declaring realization of sustainable production strives for improvement of ecologic aspects of products and technological processes and forgetting in the same time that sustainable production is an answer of industrial companies to challenges of sustainable development and it should refer to all its aspects (financial, environmental and social). One interesting area to continue this paper is to develop maintenance strategy in sustainable manufacturing environment and methodologies to measure their efficiency.

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UTRZYMANIE RUCHU W ZRÓWNOWAŻONYM WYTWARZANIU

STRESZCZENIE. **Wstęp:** Zrównoważony rozwój opiera się osiąganiu równowagi pomiędzy celami ekonomicznymi, społecznymi i ekologicznymi i na udziale ludzi w planowanie procesu tak, by zdobyć ich zaangażowanie i wsparcie. Dla przedsiębiorstwa, zrównoważony rozwój oznacza przyjęcie takiej strategii biznesowej i realizacja takich działań, które przyczyniają się do zaspokajania bieżących potrzeb przedsiębiorstwa i stron zainteresowanych, przy jednoczesnej ochronie, utrzymaniu i wzmacnianiu potencjału ludzkiego i środowiskowego, który potrzebny będzie w przyszłości. To nowe podejście zmusza przedsiębiorstwa produkcyjne do zmiany uprzednio stosowanych przez nie paradygmatów zarządzania. Nowy paradygmat produkcji musi uwzględnić nowe zagadnienia i rozwijać innowacyjne metody, praktyki i technologie, na rzecz rozwiązania światowych niedoborów zasobów i złagodzenia nadmiernego obciążenia środowiska, umożliwiając przyjazny środowisku cykl życia produktów. Jego realizacja natomiast, wymaga aktualizacji obecnych modeli produkcji, opartych na starym paradygmacie nieograniczonych zasobów i nieograniczonej zdolności do regeneracji. Utrzymanie ruchu odgrywa kluczową rolę ze względu na swój wpływ na dostępność, niezawodność, jakość i koszt w całym cyklu życia wyrobu, zatem powinno być jednym z głównych filarów nowego modelu prowadzenia biznesu.
Wyniki i wnioski: głównym przesłaniem niniejszego artykułu jest stwierdzenie, że aby rozważać koncepcję zrównoważonej produkcji musimy znacznie rozszerzyć granicę analiz i skierować uwagę na procesy wsparcia. Utrzymanie ruchu oferuje wiele możliwości zmniejszenia wpływu na środowisko naturalne i bardziej efektywne wykorzystanie zasobów. Celem bowiem procesów utrzymania ruchu w przedsiębiorstwie realizującym strategię zrównoważonego rozwoju jest zwiększenie efektywności eksploatacji i optymalizacja całkowitego kosztu cyklu życia wyrobu bez naruszania bezpieczeństwa i kwestii dotyczących środowiska.

Słowa kluczowe: zrównoważone wytwarzanie, generacje utrzymania ruchu, zrównoważone utrzymanie ruchu

TOTAL PRODUCTIVE MANUFACTURING (TPM) IN DER AUSGEWOGENEN UND NACHHALTIGEN PRODUKTION

ZUSAMMENFASSUNG. Einleitung: Die ausgewogene und nachhaltige Entwicklung stützt auf die Erzielung eines Gleichgewichtes zwischen wirtschaftlichen, sozialen und ökologischen Zielen sowie auf die Beteiligung von Menschen an der Prozessplanung mit ihrem bewussten Engagement und ihrer Unterstützung der Abwicklung von Prozessen. Die nachhaltige Entwicklung bedeutet für das Unternehmen die Annahme jener Business-Strategie und die Ausführung jener Aktivitäten, die zur Sicherstellung von laufenden Bedürfnissen eines Unternehmens und der interessierten Seiten beitragen bei gleichzeitigem Schutz, ferner bei gleichzeitiger Aufrechterhaltung und Verstärkung menschlichen und Umwelt-Potenzials, dessen man in der Zukunft bedarf. Die neue Vorgehensweise zwingt die Produktionsunternehmen zum Wechsel von früheren Management-Paradigmen. Das neue Produktions-Paradigma muss neue Fragestellungen berücksichtigen und innovative Methoden, Verfahren und Technologien für die Lösung von Problemen der Welt-Defizite

von Rohstoffen sowie für die Milderung von übermäßigen Umwelt-Belastungen entwickeln, damit man einen umweltfreundlichen Zyklus des Produkten-Lebens ermöglichen kann. Die Ausführung des Vorhabens bedarf einer Aktualisierung von gegenwärtigen Produktionsmodellen, die auf das herkömmliche Paradigma unbegrenzter Ressourcen und des unbegrenzten Regenerationsvermögens stützen. Total Productive Manufacturing spielt wegen seines Einflusses auf die Zugreifbarkeit, die Zuverlässigkeit, die Qualität und die Kosten innerhalb des ganzen Lebenszyklus eines Produktes eine Schlüsselrolle. Daher soll es eine der Hauptstützen des neuen Modells für Betreiben eines Business werden.
Ergebnisse und Fazit: Der Kernpunkt des vorliegenden Artikels liegt in der Feststellung, dass man bei der Erwägung eines Konzeptes für Total Productive Manufacturing die Analysen-Grenze bedeutend ausdehnen und den unterstützenden Prozessen Aufmerksamkeit schenken muss. Das TPM bietet viele Möglichkeiten für eine Milderung der negativen Beeinflussung der Umwelt sowie für bessere Ausnutzung von Ressourcen. Das Ziel der TPM-Prozesse im Unternehmen, das die Strategie der ausgewogenen und nachhaltigen Entwicklung realisiert, ist es, die Effektivität des Betriebs zu erhöhen und die Gesamtkosten des Lebenszyklus eines Produktes zu optimieren ohne die Sicherheit und Umweltschutzfragen zu beeinträchtigen.

Codewörter: nachhaltige Produktion, Generationen von Total Productive Manufacturing, ausgewogenes und nachhaltiges TPM

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THE LEAN APPROACH FOR IMPROVEMENT OF THE SUSTAINABILITY OF A REMANUFACTURING PROCESS

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ABSTRACT. Background: The lean production is a well-established managerial concept, which helps companies to provide the customer value and to reduce cost. Recently it gains a lot of attention among the remanufacturers. In this paper the assumption is made that remanufacturing process is more sustainable, if there will be efficient utilization of the resources. The resource utilization is efficient when there is no waste of resources. The implementation of lean principles and tools into a remanufacturing process can benefit to improved sustainability but also it suffers some constrains, which are identified in this paper.

Methods: The research methodology consists of a literature review, where research papers from the Scopus, Science Direct and Business Source Premier databases were used. The search criterion was the phrase "lean remanufacturing". On the basis of literature review the lean remanufacturing problems are identified. The framework for lean remanufacturing analysis was established. Author presents also case studies on assessment of the leanness of remanufacturing process and discusses the potential for waste elimination in order to improve sustainability of remanufacturing process.

Results: Problem identification and analysis framework of lean remanufacturing process is discussed. The case studies results are analysed in the context of the finding of the literature review. The advantages and constrains of lean remanufacturing are discussed.

Conclusions: A remanufacturing process is more complex than the respective production process. The implementation of lean production principles and tools into remanufacturing process is at a very early stage comparing to the traditional manufacturing. There are evidences from the industrial studies and the academic research on lean remanufacturing benefits. There is a need to distinguish between lean remanufacturing on an operational and a strategic level. From the perspective of sustainability of remanufacturing process an operational framework seems to be more suitable.

Key words: lean production, remanufacturing process, waste reduction, sustainability.

INTRODUCTION

Remanufacturing is an example of sustainable practice in a business environment. It allows multiple usages of the same product. It has a positive environmental impact because usually in the remanufacturing processed reused components and recycled materials are applied. Remanufacturing process requires less energy than the primary production of the same goods. Furthermore it has positive economic impact, because costs of remanufacturing are lower than the primary production of the similar products. The positive social impact is achieved for example by the redistribution of remanufactured products to the lower income countries where first life cycle products won't be availed for big number of customers due to the too high price. The remanufacturing facilities create more working places than respective production facilities because it is difficult to automate most of the remanufacturing operations.

Remanufacturing companies especially small and medium sized face problems to achieve adequate economy of scale of their

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operations and an operational excellence. The assumption is made that remanufacturing process is more sustainable, if there will be efficient utilization of the resources. The resource utilization is efficient when there is no waste of resources. For these reasons there is a growing interest in the application of the lean principles in remanufacturing facilities.

This paper presents the overview of the literature analysis on the challenges and opportunities to be lean in a remanufacturing facility. The tool for quick scan of the remanufacturing facility is discussed as well as some case studies results. At the end of this paper are stated conclusions and are described further research steps.

THEORETICAL BACKGROUND - REMANUFACTURING PROCESS AND THE LEAN PPRODUCTION PRINCIPLES

Remanufacturing is an industrial process, which allows to bring back the obsolete or worn out products to "like a new" condition. The remanufacturing process consists of operations which might be put in different order or omitted. For this reason operations were defined in a generic way by Sundin and Bras [2005]. In the literature different classification of remanufacturing operations can be found (see table 1). The sequence and amount of the above mentioned activities is case-dependent.

Table 1. Remanufacturing operations/phases
Tabela 1. Operacje/fazy w procesie remanufacturing

Author	Remanufacturing phases/operation	Sequence predefined
[Steinhilper 1998]	disassembly, cleaning, inspection, reconditioning, reassembly and testing	yes
[Bras & Hammond 1996]	cleaning, damage correction (repair, refurbishment, replacement), quality assurance (inspection and testing) and part interfacing (disassembly and reassembly).	no
[Sundin 2004]	inspection, cleaning, disassembly, storage, reprocessing, reassembly, testing	no
[Ostlin 2006]	pre-disassembly, disassembly, reprocessing, reassembly and post-reassembly	yes
[Kim et al. 2008]	disassembly, cleaning, inspection & storing, reconditioning & replenishment, reassembly, final testing &packing	yes
[Golinska 2013]	collection & material handling, disassembly, cleaning & inspection, parts reprocessing/re-supply, reassembly, testing, painting and packing	no

Source: own elaboration

In this paper for further reference the considered remanufacturing phases are:
- preassembly,
- disassembly, cleaning & sorting,
- reprocessing & replacing,
- reassembly,
- post-reassembly (testing& packing).

Sudin [2006] also stated that "remanufacturing is often a more complex process than manufacturing, due to a higher level of uncertainty in process steps and time, as well as unpredictability of cores' (returned products or their parts) quality and quantity". The papers on possibilities of the imple-mentation of lean principles into remanufacturing started to appear about 15 years ago. One of the first works on this topic by Amezquita and Bras [1996] reported on the successful lean remanufacturing of the clutch. The reported by the authors benefit was a more robust process with lower costs than by the remanufacturing process that utilized craft and mass production practices. The analysed company had rather high output of remanufacturing (423 pcs/day) and applied batch production. They defined lean production as an entire production system with the fundamental characteristics [Amezquita and Bras, 1996] as following:

1. economies of scale (from mass production),
2. production of large varieties of products (from craft production),

3. elimination of non-value added resources and activities, and
4. integration of all production system elements and functions (functional relationships).

The economy of scale is usually obtained by standardization. In the remanufacturing facilities, where proliferation of products is very high, it is rather difficult to introduce the standardization. Furthermore the quality and characteristics of products cause a situation when the amount of work and the routings of reprocessed units are stochastic. Usually when defining the problems of application of lean principles into remanufacturing process seven characteristics are listed as defined by Guide (2000):

– the uncertain timing and quantity of returns,
– the need to balance returns with demands,
– the disassembly of returned products,
– the uncertainty in materials recovered from return items,
– the requirements for a reverse logistics network,
– the complication of material matching restrictions,
– the problems of stochastic routings for materials for remanufacturing operations and highly variable processing times.

Petersen [2007] stated that there is no consensus on a definition of lean production among the experts and that the absence of it has a number of consequences for practitioners seeking to implement lean as well as researchers trying to capture the essence of this concept. He identified over 30 lean production characteristics which were addressed by the most cited authors in this field (based on results from Scopus and ISI). The conclusion was made that only continuous improvement and set-up reduction were discussed by all the analysed authors. Petersen [2009] combined the previously identified specific characteristics into the nine collective categories, as listed below:

– Just in time practices,
– Resource reduction,
– Human relations management,
– Improvement strategies,
– Defects control,
– Supply chain management,
– Standardization,
– Scientific management,
– Bundled techniques (e.g. statistical quality control, TPM),

There is on-going academic discussion whether lean is "a collection of waste reduction tools" or more than a set of tools (see e.g. Bicheno, 2004). Hines et al. [2004] distinguished between strategic and operational dimensions of lean. The strategic orientation refers to the customer-centred thinking on the strategic value chain (value creation and understanding customers' requirements). The lean thinking strategic level is based on 5 lean principles: identification of customer value, the management of the value stream, developing the capability to flow production, the use of "pull" mechanisms to support flow of materials, and the pursuit of perfection through reducing to zero waste in the production system [Womack and Jones, 1996]. The operational orientation should focus on application of the shop-floor tools to reduce waste in order to improve quality, cost and delivery (QCD) [Hines et al. 2004].

According to Shah and Ward [2007] lean can be both a general philosophy (lean thinking), as well as has a strong practical orientation (lean toolbox). Petersen concludes that "lean seems to be a reasonably consistent concept comprising just in time practices, resource reduction, improvement strategies, defects control, standardization and scientific management techniques". It can be assumed that lean remanufacturing have the same focus as lean production (see figure 1).

	Strategic	**Operational**
General philosophy	Lean thinking	Leanness
Practical	Becoming lean	Toolbox

Source: modified from Petersen, 2009

Fig. 1. Approaches to lean production
Rys. 1. Podejścia do lean production

From the perspective of improving sustainability is it crucial to focus on operational issues of lean implementation. The operational approach presents "shop-floor-focus" on waste and cost reduction. This can be translated into better utilization of resources in environmental friendly way. Furthermore lean focus on human relations management and improvement provides a base for archiving the social dimension of sustainability.

ASSESSMENT OF A REMANUFACTURING PROCESS LEANNESS

The main constrains of remanufacturing in the context of lean production were analysed in some previous research [Kurilova-Palisaitiene and Sundin 2013; Amezquita and Bras 1996; Sundin 2006; Fargher2007, Hunter and Black 2007, Ostlin and Ekholm 2007; Rubio and Corominas 2008]. Based on the findings of these studies the main constraints of remanufacturing can be summarized, as:

- insufficient availability of the good quality cores (lack of just in time supplies),
- high product variability (product proliferation),
- process complexity (stochastic lead times and stochastic routings, variable number of operations needed),
- process bottlenecks (long processing an waiting times),
- product design-related problems (variation of the rate of materials recovered, materials matching problems),
- limited information flow (mainly on incoming cores).

Kurilova-Palisaitiene and Sundin [2013] provided the analysis of the gap between manufacturing and remanufacturing with regards to the 19 characteristics which are important for application of the lean principles. They stated that remanufacturers are much behind remanufacturers (17 out of 19 characteristics) but lean principles and tools can help remanufacturers gain competitive advantage. The examples of the successful implementation of the lean tools in remanufacturing at the operational level can be found in the studies of: [Fargher2007, Hunter and Black 2007, Ostlin and Ekholm 2007; Rubio and Corominas 2008; Kunikula and Koch 2011].

In this paper are presented the case studies, which were performed in order to assess the leanness of remanufacturers. The next step includes identification of the improvement potential for sustainability with application of lean tools. The analysed case studies were conducted in 2 steps:

1. Leanness assessment.
2. Toolbox application (value stream mapping, process mapping, waste identification/reduction).

In order to assess the leanness of the remanufacturing facilities the Rapid Plant Assessment (RPA) is applied. This method has been elaborated by Goodson [2002], as a tool for assessment of the leanness of a plant. The RPA method consists of the 2 tools:

- The leanness score matrix for 11 categories - each company is scored from "poor" to "best in class" for each category. The scale for scoring includes options: "poor" equals 1 point, "below average" equals 3 points, "average" scores 5 points, "above average" gets 7 points, "excellent" equals 9 points, and finally "best in the class" is 11 points.
- The leanness questionnaire provides 20 yes/no questions to determine if the plant uses best practises.

The categories of the RPA matrix are presented in table 2. They are assigned to the three dimensions of the sustainability: economic (ECON), ecological (ECO) and social (SOC).

Figure 2 presents example of the leanness levels in the remanufacturing facilities. The companies A,B,C were examined within the SIRO project (Sustainability of Remanufacturing Operations) and the company D is a benchmark from Sundin studies [2004]. All the analysed companies are involved in remanufacturing of the automotive parts (see table 3). They represent all the identified in the literature four types of the remanufacturers: IR- independent remanufacturer, CR- contracted remanufacturer, OEM- original equipment manufacturer, who performs as well remanufacturing of own products, RSP- remanufacturing services provider.

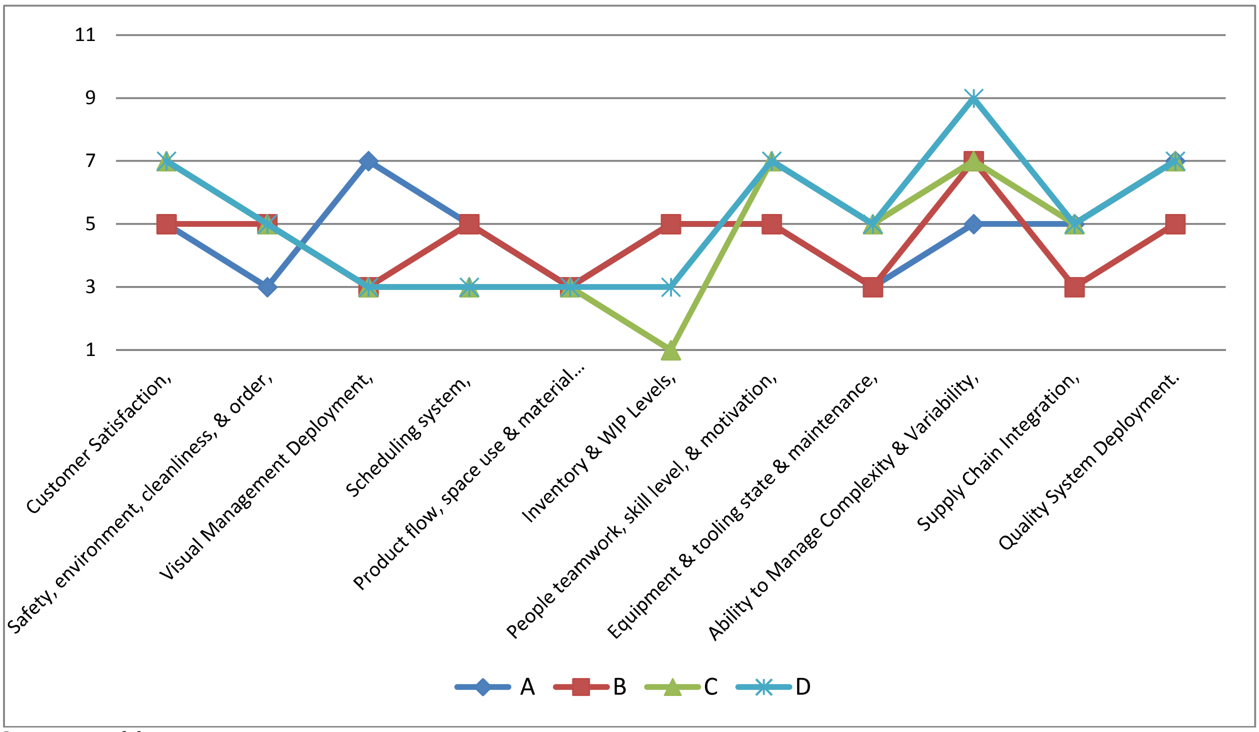
Table2. Categories of the RPA assessment
Tabela 2. Kategorie w ocenie RPA

Dimension	No	Category
CON/SOC	C1	Customer Satisfaction
SOC	C2	Safety, environment, cleanliness, & order
SOC/ECON	C3	Visual Management Deployment
ECON	C4	Scheduling system
ECON/SOC	C5	Product flow, space use & material movement means
ECON	C6	Inventory & WIP Levels
SOC/EKON	C7	People teamwork, skill level, & motivation
ECON/ECO	C8	Equipment & tooling state & maintenance
ECON	C9	Ability to Manage Complexity & Variability
ECO/ECON	C10	Supply Chain Integration
ECON/SOC	C11	Quality System Deployment

Table3. Categories of the RPA assessment
Tabela 3. Kategorie w ocenie RPA

	Company A	Company B	Company C	Company D
Remanufactured products	Alternators, starters	Engines	Alternators, starters	Engines
Size	Small	Small	Small	Big
Type	Contracted remanufacturer	Remanufacturing service providers	Independent remanufacturer	OEM

Source: own elaboration



Source: own elaboration

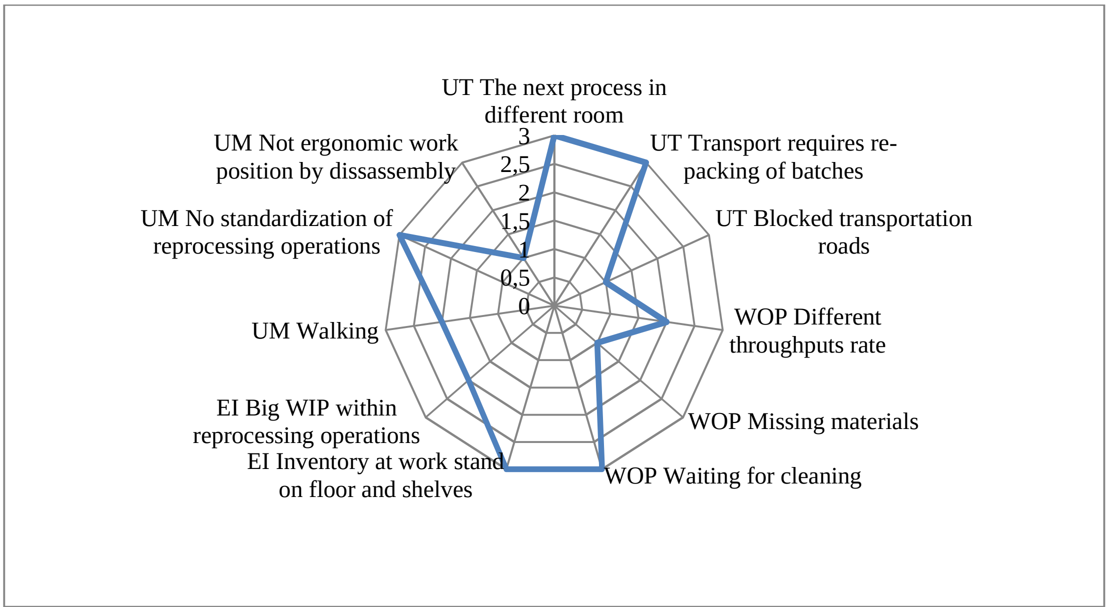
Fig. 3. Facility leanness assessment
Rys. 3. Ocena Facility Leanness

The assessment on the leanness score matrix allows to identify the categories (C1-C11) of strength and weakness. Categories with low ratings are having the potential for improvement, and should be explored first to provide the leanness [Godsoon 2002]. The low score of RPA shows the weaknesses of remanufacturing facility. As presented in figure 2 companies have low scores mainly in the area related to safety, environment, cleanness & order (social and environmental dimension) and in the categories related to materials management (C4-C6).

Table 4. Classification leanness results (RPA) into muda type
Tabela 4. Przyporządkowanie wyników analizy szczupłości (RPA) do typów marnotrawstwa

	RPA Question	**RPA Category**	**Muda type**
C1	Q1,2, 20	Customer Satisfaction	Defects/ Underutilization of Employees
C2	Q3-5, 20	Safety, environment, cleanliness & order	Unnecessary Motion/Transport
C3	Q2,4, Q6-10, 20	Visual Management Deployment	Unnecessary Motion /Inappropriate processing/ Overproduction/ Excess inventory/ Underutilization of Employees
C4	Q11, 20	Scheduling system	Excess inventory
C5	Q7,12,13,20	Product flow, space use & material movement	Excess inventory/ Transport/Waiting
C6	Q7,11,20	Inventory & WIP Levels	Excess Inventory
C7	Q6,9,14,15,20	People teamwork, skill level, & motivation	Overproduction/Underutilization of Employees
C8	Q16,20	Equipment & tooling state & maintenance	Inappropriate processing
C9	Q8,17,20	Ability to Manage Complexity & Variability	Overproduction/ Defects
C10	Q18,20	Supply Chain Integration	Defects
C11	Q15,17, 19,20	Quality System Deployment	Underutilization of Employees/ Overproduction/ defects

Source: Golinska 2013



Source: own elaboration

Fig. 4. Example of the muda assessment
Rys. 4. Przykładowa ocena rodzajów marnotrawstwa

These leanness scores are consistent with the previous literature findings (see previous section). Due to the fact that most of the C1-C11 categories are related to more than one dimension of the sustainability (e.g. ECON/SOC) the analysis is followed by the remanufacturing process analyses with usage of lean toolbox. The results from the leanness matrix and the leanness questionnaire (Y/N) are then translated into muda questions. The waste identification questions are divided first into 8 muda (waste) types: overproduction (OP), inappropriate processing (IP), waiting for operations (WOP), unnecessary transportation (UT), unnecessary motion (UM), excess inventory (EI), defects products (DP), Underutilization of Employees (UE). Then the muda questions are assigned to the three dimensions of the sustainability. Only questions are picked up which cover area with low RPA score and "no" answer in the leanness questionnaire. In order to do that a correlation matrix was designed by the author. The matrix was send to about 30 experts from Academia and industry, which have some experience in lean management. The response rate was about 50% (15 questioners received back). Table 4 presents the results of the survey. The matrix correlates leanness categories (C1-C11) and RPA questions (Q1-Q20) to the 8 muda (waste types). The RPA (leanness questionnaire) consists originally of 20 question no 20 according to Godson [2002] applies to the all eleven category so it could be excluded from further analyses. Experts were confident about classification of most questions but questions number 5 and number 17 were not classified to only one category.

Each applicable muda question from check list is assessed, where: 0 means no waste; 1 means small waste; 2 means medium waste and 3 is big waste (serious). The results are presented in the graphical from (see figure 3).

Based on the assessment, for each identified "big waste" (preferably also medium) improvements measures must be elaborated. The usage of the presented approach allows to scan the remanufacturing process and order to identify areas with low performance. The results can be used as an input for the design of the improvement measures in the three dimensions of sustainability.

CONCLUSIONS

Application of the lean production methods and techniques gains recently a lot of interest among remanufacturers. The structure and characteristics of remanufacturing process is more complex than a production process for similar products. The existing examples of the industrial evidence and the academic research proofs that remanufacturer might benefit from application of the lean principles and toolbox. They also reported the constrains which are faced by the remanufacturers when applying lean approach. First of all it is difficult to scan the process and identify areas where reorganization of facility layout or different resources configuration are needed. Presented by the author assessment approach is related to the operational level of lean concept. It allows to use the lean approach for identification of waste in the relation to sustainability dimensions: economic, ecological and social. The findings of this research will contribute to the development of the improvement measures for increasing the remanufacturing process sustainability.

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LEAN JAKO SPOSÓB NA POPRAWĘ PROCESU REMANUFACTURINGU

STRESZCZENIE. **Wstęp:** Lean production jest powszechnie wykorzystywaną koncepcją zarządzania, która pomaga przedsiębiorstwom dostarczać wartość dla klientów i redukować koszty. Obecnie budzi ona coraz większe zainteresowanie ze strony przedsiębiorstw zajmujących się remanufacturingiem (fabryczną regeneracją). W tym artykule przyjęto założenie, że proces remanufacturingu będzie miał wyższy poziom zrównoważonego wykorzystania zasobów jeżeli nie będzie w nim marnotrawstwa. Wdrożenie zasad i narzędzi lean production w procesie remanufacturingu może przynieść znaczne korzyści, równocześnie napotyka jednak wiele przeszkód, które zostały zidentyfikowane w tym artykule.

Metody: Przeprowadzono badania literaturowe, w tym celu przeszukano bazy Scopus, Science Direct and Business Source Premier databases dla kryterium "lean remanufacturing". Na podstawie analizy literaturowej dokonano identyfikacji problemów lean remanufacturing. Stworzone zostały ramy teoretyczne dla oceny procesu remanufacuringu z perspektywy zrównoważonego wykorzystania zasobów. Następnie dokonano analizy studiów przypadku, w celu identyfikacji poziomu szczupłości dla wybranych przykładów procesu remanufacturingu. Kolejnym krokiem badań była identyfikacja marnotrawstwa w celu wskazania obszarów kluczowych dla podniesienia poziomu zrównoważonego wykorzystania zasobów w procesie remanufacturingu.

Wyniki: W artykule przedstawiono teoretyczne rozważania na temat problemu oraz zdobyte doświadczenia praktyczne. Autorka omawia problemy lean remanufacturing. Analiza studiów przypadku została zrealizowana pod kątem oceny poziomu szczupłości procesu oraz identyfikacji obszarów wymagających usprawnień. Wyniki omówiono w kontekście wcześniejszych wniosków ze studiów literaturowych.

Wnioski: Proces remanufacturingu jest znacznie bardziej skomplikowany niż proces produkcji pierwotnej dla analogicznego produktu, Wdrożenia zasad i narzędzi lean production do procesu remanufacturingu jest na niższym poziomie niż w przypadku tradycyjnego wytwarzania. Jednak istnieją przykłady pochodzące z praktyki jak również studia teoretyczne dostarczające dowodów, że mimo licznych problemów i ograniczeń wdrażanie narzędzi lean może przynieść pozytywne efekty Równocześnie istotne jest rozróżnienie lean remanufacturing na poziomie strategicznym i operacyjnym. Z perspektywy zrównoważonego wykorzystania zasobów bardziej odpowiednie wydaje się zastosowanie narzędzi i metod lean production na poziomie operacyjnym.

Słowa kluczowe: proces remanufacturingu, zrównoważone wykorzystanie zasobów (sustainability), lean production, eliminacja marnotrawstwa.

LEAN ALS VERFAHREN FÜR DIE VERBESSERUNG VON WIEDERAUFBEREITUNGSPROZESSEN

ZUSAMMENFASSUNG. Einleitung: Lean Produktion ist ein etabliertes Management-Konzept, welches den Unternehmen es ermöglicht, Werte für Kunden zu schöpfen und Kosten zu reduzieren. Gegenwärtig erweckt es ein immer größeres Interesse bei den Unternehmen, die sich mit dem Remanufacturing (fabrikmäßige Wiederaufbereitung) beschäftigen. Im vorliegenden Artikel ging man von der Annahme heraus, dass der Wiederaufbereitungsprozess bei der Ressourcennutzung nachhaltiger werden kann, wenn er keine Verschwendung von Ressourcen zulässt. Die Einführung von Prinzipien und Werkzeugen des Lean Production-Systems innerhalb eines Wiederaufbereitungsprozesses kann bedeutende Vorteile mit sich bringen, sie begegnet allerdings vielen Hindernissen, die in diesem Artikel identifiziert wurden.

Methoden: Die Forschungsmethodik beruhte auf einer Literaturrecherche, wobei man die Datenbasen von Scopus und Science Direct und Business Source Premier Databases in Anspruch nahm. Das Suchkriterium war dabei der Begriff "Lean Remanufacturing". Auf der Grundlage der Literaturanalyse wurden die Fragestellungen des Lean Remanufacturings ermittelt. Für die Beurteilung des Remanufacturingsprozesses wurden angesichts der nachhaltigen und ausgewogenen Ressourcennutzung theoretische Rahmen erstellt. Ferner wurden Fallstudien für die Bewertung der "Schlankheit" von ausgewählten Beispielen des Wiederaufbereitungsprozesses durchgeführt. Ein nächster Schritt in diesem Forschungsvorhaben war die Identifikation von Verschwendungen. Das geschah zwecks der Ermittlung von Schlüsselbereichen, die für die Erhöhung des Niveaus einer nachhaltigen Ressourcennutzung im Wiederaufbereitungsprozess ausschlaggebend sind.

Ergebnisse: Im Artikel stellte man theoretische Erwägungen zum betreffenden Problem und die gewonnene praktische Erfahrung dar. Darin bespricht die Autorin also die Problemstellungen des Lean Remanufacturings. Die Analyse der Studienfälle wurde in Bezug auf das Niveau der Schlankheit des Prozesses und auf die Identifikation von verbesserungsbedürftigen Bereichen durchgeführt. Die Ergebnisse sind im Kontext der früheren Schlussfolgerungen von der Literaturrecherche kommentiert worden.

Fazit: Der Wiederaufbereitungsprozess ist komplexer als der primäre Produktionsprozess bei der Herstellung eines analogischen Produktes. Die Umsetzung von Prinzipien und Werkzeugen der Lean Produktion innerhalb eines Wiederaufbereitungsprozesses geschieht auf einem niedrigeren Niveau als dies bei der traditionsgemäßen Erzeugung der Fall ist. Es gibt jedoch genügend Beispiele von der Praxis und Beweise von theoretischen Studien dafür, dass trotz zahlreicher Probleme und Einschränkungen die Einführung von Lean-Werkzeugen positive Resultate sichern kann. Gleichzeitig ist es nötig, die schlanke Wiederaufarbeitung auf operativer und strategischer Ebene zu unterscheiden. Aus der Perspektive der Nachhaltigkeit der Ressourcennutzung im Wiederaufbereitungsprozess scheint die Anwendung der Werkzeuge und Methoden von Lean Production auf der operativen Ebene mehr geeignet zu sein.

Codewörter: Schlanke Produktion, Verschwendung von Ressourcen, Nachhaltigkeit des Wiederaufbereitungsprozesses.

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RETURNS MANAGEMENT IN THE SUPPLY CHAIN

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ABSTRACT. Background: The aim of this exploratory empirical research was to evaluate the level of cooperation in the area of reverse logistics between selected retail chains and logistics operators and suppliers; to identify and evaluate the influence the procedures of handling returns have on the relationships with customers, cost reduction, value recovery, inventory reduction and increasing profitability; as well as determining to what extent logistics operators are involved in the procedures of handling returns in the analysed chains.

Methods: Based on the literature and the experience of researchers from developed countries a questionnaire was constructed which was subsequently used to conduct empirical research in selected retail chains operating in two provinces in Poland. The questionnaire survey involved the sales personnel of selected retail chains in the clothing industry. Overall, 105 questionnaires were collected and analysed.

Results: Various aspects of cooperation with suppliers and logistics operators in respect of handling returns were evaluated. Most indicators of cooperation were evaluated favourably, with the exception of joint access to the database, the use of inventory data available online, and access to information from the warehouse, which received low marks from the respondents. In the case of the studied stores, some of the activities in the area of reverse logistics are outsourced; for example, obtaining products from users, logistics, and the transport of returns are typically done by an outside operator. Inspection, sorting, appraisal, repairs, as well as the sales of refurbished products are usually performed within the studied retail corporations.

Conclusions: The research has shown that the retail chains developed very good programmes for handling returns in the supply chain, as evidenced by the presented and highly rated indicators of cooperation, with the exception of information exchange where there is still much room for improvement. The sales personnel assessed the impact of corporate know-how in respect of handling returns on the relationships with customers, cost reduction, value recovery, inventory reduction and increasing profitability, of which the most significant turned out to be the impact on improving relationships with customers.

Key words: supply chain, collaboration, returns management performance.

INTRODUCTION

The attention of logisticians focuses primarily on the sales and delivery of the product to the customer, although experience shows that returns (reverse flow) in the supply chain, although undesirable, are also inevitable. There are a number of questions, such as: when do returns of goods occur at different stages in the flow of the supply chain?; what are the reasons for the intensification of this phenomenon? how can the returns volume be limited?; as well as other aspects of returns management, which should be of interest to practitioners and academics. This is an increasingly important issue in logistics management, and for academics this can serve as an inspiration for further study.

The information which forms the basis of this empirical research relates to the cooperation with suppliers and logistics operators among networks of clothing stores. The second aspect which was examined was

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the results of returns management in the industry under examination. The research sample consisted of over 100 stores belonging to the apparel industry. This article is an exploratory academic study and its aim is to answer several questions relating to the management of returns in the clothing industry.

COLLABORATION IN THE SUPPLY CHAIN

Cooperation in the supply chain is a concept which has been discussed for many years. Popular and widely used in practice, projects such as the ECR, CPFR and VMI are characteristic of the FMCG sector. Until now, the issue of cooperation between suppliers, logistics providers and customers in the apparel industry has not attracted a great deal of interest. One of the major benefits of such cooperation should be a lower level of inventory at every link of the supply chain. Trade returns are closely connected with a mismatch between stocks and sales forecasts. This article attempts to explore the relationship between collaboration in the supply chain and returns management performance. In order to fully understand the issues relating to supply chain management it may be useful to make a conceptual distinction between the following two areas:

- in the narrower sense - supply chain management is the ultimate form of integrated logistics (a network of companies jointly managing the flow of goods and information) - an approach reflected in the trend of operational integration and the evolution of logistics,
- in a broader sense - supply chain management is the management of collaborative business networks in many areas of activity (new products, logistics, marketing) - an approach promoted by the creators of the Supply Chain Operations Reference (SCOR) model and the Global Supply Chain Forum (GSCF) model.

Example definitions of supply chain management (SCM) are presented below:

Supply Chain Management, according to the Council of Supply Chain Management Professionals (CSCMP), encompasses the planning and management of all the activities involved in sourcing, procurement, conversion, and logistics management. It also includes coordination and collaboration with channel partners, which may be suppliers, intermediaries, third-party service providers, or customers. Supply chain management integrates supply and demand management within and across companies. More recently, the loosely coupled self-organizing network of businesses that cooperate to provide product and service offerings has been called the extended enterprise [Schary&Skjott-Larsen 2001].

The supply chain refers to the network of organizations that are involved in the diverse processes and activities that generate value in the form of goods and services in the hands of the end customer. Supply Chain Management (SCM) is the "strategic and efficient coordination of the conventional business functions and the strategies across these business functions within a specific corporate and across businesses within a supply chain, for the aims of developing the long-term performance of the corporate and the supply chain as an entire process" [Christopher 2009].

Supply Chain management (SCM) refers to "a set of methods used to effectively coordinate suppliers, producers, depots, and stores, so that the commodity is produced and distributed at the correct quantities, to the correct locations, and at the correct time, in order to reduce system costs while satisfying service level requirements." The fundamental notion of these definitions is that a Supply Chain must be controlled in order to be fast and trustworthy, cost-effective, and flexible enough to meet customers' requirements. [Simchi-Levi, Kaminsky, & Simchi-Levi 2009].

Supply Chain management refers to corporate business processes integration from end users through suppliers that provides information, goods, and services that add value for customers [Lambert 1998].

Definitions of SCM commonly use phrases such as planning, relationship management, link integration, coordination of activities, flow of information, cost reduction and inventory levels. Some of the definitions focus on activities, while others focus on the flows or on individual links. Some of them refer to a narrower understanding of SCM (a form of integrated logistics), whereas others adopt a broader approach to SCM in terms of network business management. In this study it has been assumed that cooperation in the supply chain - with suppliers and logistics operators - can result in performance improvements in the management of returns.

RETURNS MANAGEMENT

In the literature there is a distinction between two terms: reverse logistics and returns management. REVLOG – The European Working Group on Reverse Logistics in 1998 proposed the following definition of reverse logistics: "The process of planning, implementing and controlling backward flows of raw materials, in-process inventory, packaging and finished goods, from a manufacturing, distribution or use point, to a point of recovery or point of proper disposal."

The management of returned products is known as returns management. In this analysis, we are primarily interested in the relationship between the supplier and the recipient. The management of returns has a wider context than is usually perceived by managers. It is necessary to understand the multi-functional components of marketing, logistics, operations and finance / accounting functions which actively engage in managing return products. [Mollenkopf, Frankel, and Russo, 2011].

Returns management entails significant costs relating to the implementation of each individual process, which is connected with the involvement of human and equipment resources.

Returns management is costly and time-consuming [Rogers and Tibben Lembke, 2001]. This has a direct impact on logistics costs and consequently on the financial results of companies. It is estimated that the volume of product returns is between 5% and as much as 40% of the goods sold, depending on the industry. [Rogers and Tibben-Lembke, 1998]. In catalogue retailing the figure can be up to 60%. [Richey, Chen, Genchev and Daugherty, 2005]. It seems, therefore, that returns management issues deserve the attention of managers, as there is a need for efficient management of returned goods, which can lead to a lowering of costs. Taking into account the growing number of returns and the relationship between effective returns management and a company's financial results there are many questions that should be considered and answered.

To begin with, it seems useful to systematise the available knowledge in this field. As in the conventional direction of the movement of goods from the vendor to the customer, the stages of product flow in the supply chain have their counterparts in the opposite direction. Thus, three types of returns can be distinguished: returns in production, customer returns and returns in distribution. The case under analysis concerns the management of returns in distribution. The following categories will be considered [Blumberg, 2004, Rogers and Tibben-Lembke, 1999, Rogers and Tibben-Lembke 1998, De Brito and Dekker 2003]: distribution returns - referring to types of returns such as product recalls (for the safety and health of consumers, usually initiated by the manufacturer or supplier); or B2B commercial returns where the retailer under the terms of the contract can return a product to the supplier which refers to goods which do not comply with the order, are damaged, have too short shelf life / expiration date, or are unsold goods which the retailer (distributor) has the right to return to the manufacturer or wholesaler. This includes products which are past the expiration date (such as food products and pharmaceuticals). Other reasons for returns in distribution include the adjustment and redistribution of stocks of seasonal products (e.g. connected with festivals) between warehouses and shops, or returns of packaging and unit loads (functional returns) that allow the flow of products in the supply chain. A retailer can also return goods to the supplier when a product has been discontinued or replaced with a newer version, when the stock is too high because the product is slow-moving, or because a retail outlet closes down.

RESEARCH QUESTIONS

In the context of the need to rationalize costs and the increased efficiency that can be achieved by strengthening cooperation in the supply chain, attention should paid to the possibilities offered by the effective management of returns. Taking into account the increasing number of returns and the relationship between effective returns management and the chance of reducing costs by companies, the following important questions arise:

1. What does cooperation with suppliers and logistics operator in the studied clothing chains look like?
2. Does the company policy for handling returned goods result in better relations with customers, cost reduction, value recovery, inventory reduction and increased profitability?
3. Which of the actions involved in the returns management are transferred to the logistics operator?

SELECTION OF THE SAMPLE

Returns management is perceived by managers as a problem. Their focus is mainly on the sale of products. The fashion industry is one of the sectors where returns management plays a unique role. The sale of clothes is determined by fashion and seasonal fluctuations. Variation in demand is dependent on trends in fashion, design and the current collections. The success of the previous collection does not guarantee a similar success in the new season, as the new collection may not suit the tastes of consumers, the more so that collections are designed a year in advance. The analysis has involved shops that are part of retail chains (the ownership status was not taken into account), and the choice of clothing retailers (franchise or retail stores) as subjects of the analysis can be justified by several arguments.

The characteristics of such shops include the necessity for the adjustment and redistribution of stocks of seasonal products. Also, the retailer (distributor) is entitled to return goods which have not been sold due to changing seasons (spring/summer/autumn/ winter). In retail chains deliveries sometimes do not comply with orders, the stocks can turn out to be too large, the sales forecasts can be overestimated, or sometimes outlets in unprofitable locations are closed down, which involves a movement of unsold goods. The research sample comprised shops located in large shopping centres; the number of shops per number of inhabitants being taken into account.

THE QUESTIONNAIRE AND DATA COLLECTION

The questionnaire was developed on the basis of the literature and interviews with employees of retail networks. After a pilot study (12 questionnaires), which was intended to eliminate any ambiguity so that respondents would not have any doubts as to the meaning of the questions, the principal part of the study began. Due to financial and organisational constraints the representative sample of retailers was restricted to the regions of Wielkopolska and Lubuskie (western Poland). Data was collected by students in National and International Logistics at the Poznan University of Economics. Out of 128 questionnaires, 10 were eliminated for formal reasons.

ANALYSIS AND RESULTS

The study on co-operation and exchange of information in the supply chain was adapted from (Olorunniwo and Li, 2010). When analysing collaboration between the suppliers and logistics operators of the companies surveyed, for all the questions the most common answer was 'good' (median = good for all the questions). However, the answer 'very good' was more often given by the respondents to questions 5, 6, 7 and 8, which were related to the trust between partners (55 responses); well-defined objectives, scope and responsibilities within the framework of cooperation (54); and joint arrangements regarding planning and forecasting (55). When the respondents were asked to assess the joint arrangements regarding planning and forecasting and the mutually agreed performance indicators they tended to indicate the answer 'average' (25 and 28 indications respectively). The companies surveyed were not generally satisfied regarding the area of information and data exchange with suppliers and operators in the supply chain. For questions about the evaluation of mutual access to databases, using data on stock levels over the Internet and access to information from warehouses the number of 'average' answers was 25, 20 and 23 respectively, and 'low' 17, 17 and 15. This may mean that in respect of the exchange of information there is a lot of room for improvement. The results are shown in Table 1 and Figure 1.

Table 1. Cooperation and exchange of information in the supply chain with suppliers and third party logistics operators
Tabela 1. Współpraca i wymiana informacji w obrębie łańcucha dostaw między dostawcami i operatorami logistycznymi

	Median	average	Standard deviation
Accuracy of information shared with our partners	3	3,2	0,8
Mutual access to our partners' databases	3	2,7	1,1
The use of web-enabled inventory data that we share	3	2,8	1,1
Warehouse information we both share	3	2,8	1,0
Trust between us and our partners	3	3,2	0,8
Long term alliances	3	3,2	0,7
Well defined collaborative objectives, scope and responsibilities	3	3,1	0,8
Joint forecast and planning arrangements	3	2,9	0,8
Joint established performance measures	3	2,8	0,8
Sharing of risk and reward with our partners	3	2,6	0,8

Source: Empirical research

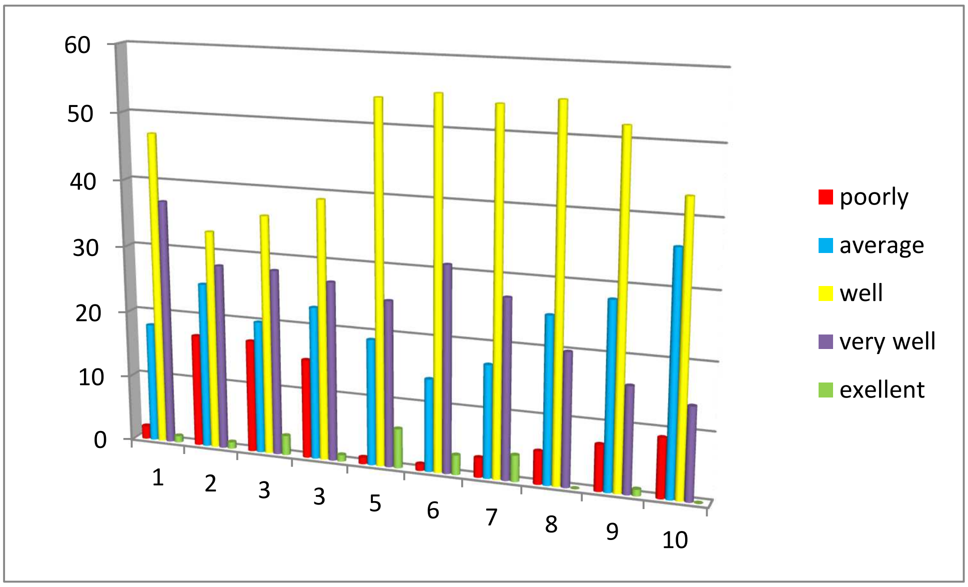


Fig. 1. The cooperation of stores with suppliers and logistics operators
Rys. 1. Współpraca sieci handlowych z dostawcami i operatorami logistycznymi

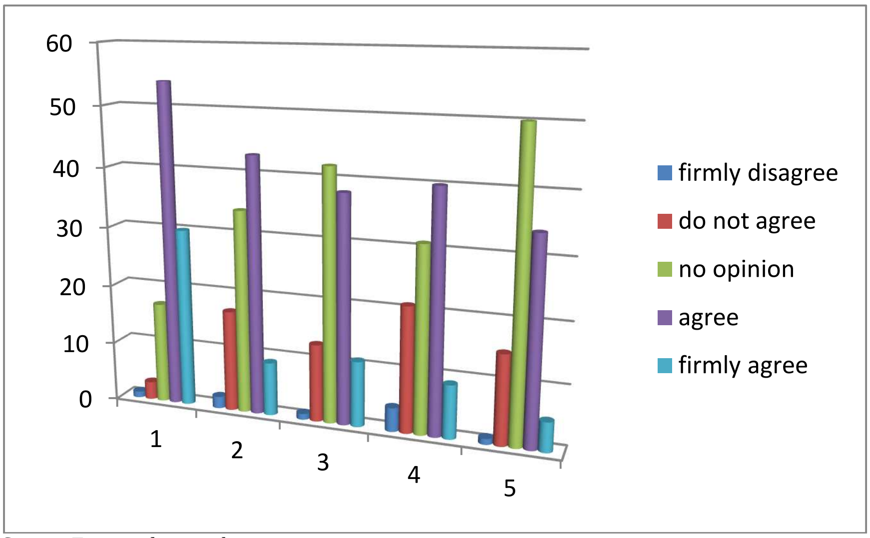
RETURNS MANAGEMENT PERFORMANCE

Questions about returns management results were partially adapted from (Autry, 2005). The analysed stores confirm that the management of returns has a positive effect on customer relations (53 indicated "agree" and 30 indicated "strongly agree") and on cost reduction (43). As regards the impact of the management of goods returned to the supplier on the costs, 33 respondents had no opinion; and 50 respondents had no opinion as to its influence on profitability. This is probably due to the fact that store managers do not have access to the full financial data. According to 21 respondents the handling of returns did not contribute to a decrease in stocks, whereas 40 respondents believed that it did play a significant role in this respect. The results are shown in Table 2 and Figure 2.

Table 2. Returns management performance
Tabela 2. Zarządzanie zwrotami

	Median	average
Improved customer relations	4	4,0
Cost reduction	3	3,4
Value recovery	3	3,4
Decrease in stock	3	3,3
Increase in profitability	3	3,3

Source: Empirical research



Source: Empirical research

Fig. 2. Do you think that the handling of the returned goods affects returns management performance?
Rys. 2. Czy handling zwrotów wpływana za jakość zarządzania zwrotami?

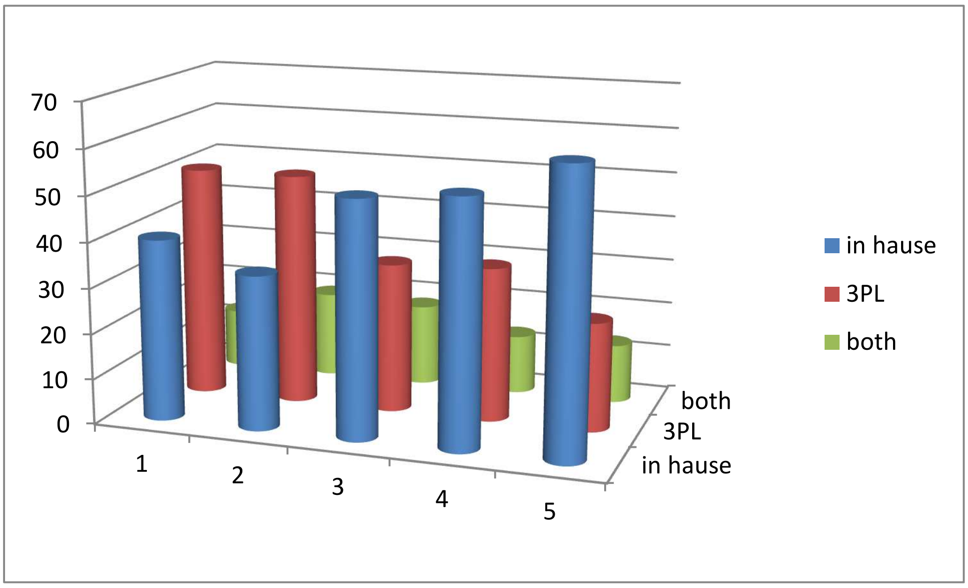
RETURNS MANAGEMENT AND 3PL

The questions about returns management activities outsourced to logistics providers are derived from (Saibani, 2010). What is characteristic about this question is the fact that in most cases the stores surveyed outsourced part of the work: collecting goods from users as well as the logistics and transport of the returned products normally belonged to an outside operator (51 indications); however, the inspection, sorting, classification (question 3), repair and sale of the refurbished products (question number 4) as well as remarketing (question 5) are typically implemented within the enterprise (52, 54 and 62 indications respectively). The results are shown in Table 3 and Figure 3.

Table 3. Which of the activities do you / your company outsource to logistics operators?
Tabela 3. Które obszary działań Państwa firmy są obsugiwane outsourcingowo przez operatorów logistycznych?

Type of activity	Median	average
Product acquisitions (obtaining products from the last user or point of return)	2	1,7
Reverse distribution (logistics involved in transporting returned products)	2	1,9
Test control dispositioning	1	1,7
Refurbishing	1	1,6
Remarketing (development of secondary market)	1	1,5

Source: Empirical research



Source: Empirical research

Fig. 3. Which activities related to the management of returns are usually outsourced to logistics operators?
Rys. 3. Które obszary działalności związane z zarządzaniem zwrotami są zwykle outsourcingowane do operatorów logistycznych?

CONCLUSION

On the basis of empirical research conducted on a sample of clothing chains in Poland it is possible to formulate some conclusions. The study answers the questions on how the clothing retail industry assesses collaboration with suppliers and logistics operators and how the actions undertaken in the management of returns affect the results of returns management, such as the relationship with the customers and costs; as well as which operations and activities of reverse logistics are transferred to logistics operators.

The generally held opinion is that cooperation with suppliers in the supply chain increases the efficiency, effectiveness and improves financial results. Here, collaboration in the supply chain and the exchange of information between the supplier, the customer and the logistics operator was related to the results of returns management.

Based on Spearman's and Kendall's correlation test - respectively 0.077 and 0,055 ($p<0,05$) it can be concluded that this relationship does not exist: there seems to be no correlation between co-operation and exchange of information and returns management performance.

Most empirical studies refer to a segment of the market or a particular group of companies. So it was in this case. The sample was narrowed down to the clothing retail chains in two provinces in Poland.

Methodologically, the study was based on a questionnaire survey and the analysis is strongly based on the perceptions of the respondents. This resulted from two factors: the complexity and the amount of data collected, and in particular the confidentiality of data that we guaranteed in the course of the study. The research study results are used as measures of perceived performance results. Hard data in the form of financial results could reveal other relationships and connections. Future studies ought to take this into account.

This study focused on describing a state of affairs and making a diagnosis but it did not take into account changes over time. Future research ought to conduct an analysis over a period of time and include different industries.

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ZARZĄDZANIE ZWROTAMI W ŁAŃCUCHU DOSTAW

STRESZCZENIE. **Wstęp:** Celem eksploracyjnych badań empirycznych była ocena poziomu współpracy w zakresie logistyki zawrotów wybranych sieci handlowych z operatorem logistycznym i dostawcami, ocena i diagnoza wpływu sposobu postępowania z towarem zwróconym na relacje z klientami, ograniczanie kosztów, odzyskiwanie wartości, zmniejszenie zapasów, zwiększenie rentowności oraz rozpoznanie w jakim stopniu operatorzy logistyczni uczestniczą w obsłudze zwrotów analizowanych sieci handlowych.

Metody: Na podstawie literatury i doświadczeń naukowców z krajów rozwiniętych sformułowano formularz ankiety a następie przeprowadzono badania empiryczne na wybranych sieciach handlowych na terenie dwóch województw w Polsce. Przeprowadzono badania opinii sprzedawców w wybranych sieciach handlowych branży odzieżowej. Zebrano i ostatecznie poddano analizie 105 wywiadów.

Wyniki: Ocenie poddano różne aspekty współpracy z dostawcami i operatorami logistycznymi w zakresie obsługi zwrotów towarów. Większość wskaźników współpracy zostało ocenionych dobrze. Sprzedawcy źle ocenili wzajemny dostęp do bazy danych, wykorzystywania danych dotyczących zapasów przez Internet oraz dostęp do informacji z magazynu. W przypadku badanych sklepów w zakresie logistyki zwrotnej część działań jest zlecanych na zewnątrz tj. pozyskiwanie produktów od użytkowników, logistyka i transport produktów zwróconych zazwyczaj należy do operatora. Kontrola, sortowanie, kwalifikacja, naprawa oraz sprzedaż odnowionych produktów zazwyczaj są realizowane w ramach badanych korporacji handlowych.

Wnioski i podsumowanie: Przeprowadzone badania pokazują, że sieci wypracowały bardzo dobre programy obsługi zwrotów w łańcuchu dostaw. Dowodem są opisane i wysoko ocenione wskaźniki współpracy, jedynie w kwestii wymiany informacji jest wiele miejsca na poprawę wyników. Sprzedawcy ocenili wpływ korporacyjnego know-how w zakresie obsługi zwrotów na relacje z klientami, ograniczanie kosztów, odzyskiwanie wartości, zmniejszenie zapasów, zwiększenie rentowności, z czego najistotniejszy okazał się wpływ na poprawę relacji z klientami..

Słowa kluczowe: łańcuch dostaw, współpraca, efektywność zarządzania zwrotami produktów.

MANAGEMENT VON RÜCKSENDUNGEN IN DER LIEFERKETTE

ZUSAMMENFASSUNG. Einleitung: Das Ziel der empirischen Untersuchungen war es, das Niveau der Zusammenarbeit im Bereich der Logistik von Rücksendungen in ausgewählten Handelsnetzen mit Logistik-Betreibern und Zulieferanten zu beurteilen, die Vorgehensweise bei den Rücksendungen und deren Einfluss auf Relationen mit den Kunden zu diagnostizieren und zu beurteilen, Kosten einzuschränken, Werte wiederzugewinnen, Vorräte zu minimalisieren, ferner die Rentabilität zu erhöhen und es zu erkunden, in welchem Ausmaße die Logistik-Betreiber sich an der Abwicklung der in den ausgewählten Handelsnetzen analysierten Rücksendungen beteiligen.

Methoden: Auf Grund einer Literaturrecherche und gestützt auf die Erfahrungen aus den hochentwickelten Ländern sind ein Umfrage-Bogen formuliert und dann empirische Untersuchungen innerhalb der in zwei Wojewodschaften in Polen lokalisierten Handelsnetzen durchgeführt worden. Dazu nahm man Meinungsuntersuchungen bei Verkäufern in ausgewählten Handelsnetzen in der Bekleidungsbranche vor. Es wurden 105 Interviews erfasst und endgültig einer Analyse unterzogen.

Ergebnisse: Einer Beurteilung wurden unterschiedliche Aspekte der Zusammenarbeit mit den Lieferanten und Logistik-Betreibern im Bereich der Bedienung von Waren-Rücksendungen unterzogen. Die meisten Kennziffern der Kooperation wurden als positiv beurteilt. Die Verkäufer haben dagegen den gegenseitigen Zugriff zur Datenbank, ferner die Inanspruchnahme der die Vorräte anbetreffenden Daten durch das Internet und den Zugriff zu den Informationen aus dem Lager negativ beurteilt. Im Falle der in Bezug auf die Entsorgungslogistik untersuchten Handelseinrichtungen wird ein Teil der Aktivitäten außerhalb der Einrichtungen in Auftrag gestellt, d.h. die Gewinnung der Rückwaren von den Benutzern, die Logistik und der Transport der Rücksendungen fällt dem jeweiligen Logistik-Betreiber anheim. Dagegen

die Kontrolle, Sortierung, ferner die Reparaturen und der Verkauf der sanierten Produkte werden gewöhnlich innerhalb der untersuchten Handelseinrichtungen vorgenommen.
Fazit: Die durchgeführten Untersuchungen bestätigen, dass die Handelsnetze sehr gute Programme für die Abwicklung der Waren-Rücksendungen in der Lieferkette ausgearbeitet haben. Die Beweise dafür stellen die beschriebenen und hoch bewerteten Kennziffern der Kooperation dar. Lediglich die Fragen des Informationsaustausches weisen gewisse Verbesserungspotenziale auf. Die Verkäufer haben den Einfluss des handelseinrichtungsmäßigen Know-Hows im Bereich der Bedienung der Waren-Rücksendungen auf den Kundenservice, auf die Verminderung von Kosten, die Rückgewinnung von Werten, ferner die Minimalisierung von Vorräten und die Erhöhung der Rentabilität als positiv beurteilt, wobei der Einfluss auf die Verbesserung der Relationen mit den Kunden sich als der wesentlichste erwiesen hat..

Codewörter: Lieferkette, Zusammenarbeit, Management-Effizienz bei Produkten-Rücksendungen

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EFFECTS OF PRODUCT'S WARRANTY ON CUSTOMERS' PREFERENCES: EMPIRICAL FINDINGS ON REVERSE LOGISTICS MODELS

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ABSTRACT. Background: IT products are now becoming the part of every one's life. Since Pakistan didn't manufacture IT products, so the customers had to purchase the products that are available in the markets. During such purchase, customers not only gave preference to brand or price or both but they also consider its warranty so that they are secured with the post purchase risks.

Methods: This study was aimed to identify the impact of the warranty on customers' preferences towards brand and price. A conceptual framework was made on the basis of available literature and then data was collected. It was collected from 298 respondents through survey questionnaire and after applying Factor Analysis, One Way MANOVA was applied on the factors.

Results and conclusions: The study found that the product's warranty has a significant impact on preferences towards brand, concern for price and price intentions whereas the impact on willingness to pay was found insignificant. The results conclude that Pakistani customers need a branded IT product on competitive prices, which give more in less along with the warranty so that they can enjoy the same quality of the product for a period of time whereas, they are not willing to pay any additional amount for the product just because of Warranty.

Key words: product warranty, customers' preferences, brand, price, reverse logistics models.

INTRODUCTION

Purchasing an Information Technology (IT) product is always an excitement for consumers. As the technology is rapidly changing, its products are now becoming the part of every one's life. Customers had recognized the IT products as need and now it is of importance for them to be technologically updated. In order to fulfilling that need, customers had frequent purchase of IT products, so that they can update themselves technologically. With an intense increase in competition by globalization, the availability of variety made consumers indifference between the products.

Kilic and Kendirli [2011] reported after collecting the data from 400 university students of Turkey and found that university students prefers global brands specifically related to IT products. This study also reveals the consumer attitude towards the theoretical characteristics of brand personality. Furthermore a positive relationship was also found in the demographic factors of the respondents with their attitudes and preference towards global brands. On the other hand, after analyzing the preferences of the consumers towards eight different product categories, consumers prefer brand and quality of the product which makes them brand conscious

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whereas a segment was also found to be price seeking [Stamer & Diller, 2006].

Huysentruyt and Read [2012] reported that warranty support give consumers a peace of mind during their purchase decisions. It also helps the consumer to actually pay for the product. The study also reveals that people having cognitive skills are less likely to predict the benefits of the warranty and therefore they are still influenced by the product's warranty to buy that product. On the other hand, Hossain and AL Mahmud [2012] reported after examining different respondents from the city of Dhaka, Bangladesh that, respondents equally prefer brand and product's warranty. In fact the respondents believe that the better brand gives the better warranty and they also recommend that customer should give preference to the brand of the product so that they can get better warranty as well.

Chernev [2007] examined the impact of positioning strategies on the consumer choice, in which the consumer was given two options. The first option was differentiated by only one feature whereas the second option was having all the features. They proposed that consumer while purchasing give preference to the product on the basis of its overall attractiveness. It was also revealed that while purchasing that option which has all the features, consumers also acknowledge and appreciate the features which was not basically required.

Consumer preferences towards brand and price are found equally, depending upon the respondents and their attitudes. Different trends were observed in Pakistani customers stating different preferences. On one hand it was observed that customers preferred Price on Brand when they purchased a relatively cheaper Product. For instance, it has been observed that while purchasing key board or mouse which is relatively cheaper, customers normally purchase the cheaper products. On the other hand, while purchasing a product which is relatively expensive, they are willing to pay even high in order to get a quality product. For instance, while purchasing Web cameras, customers gave preference to the cameras that have high resolution in terms of pixels so that they can have better quality. A trend is also observed among the Pakistani consumers that they prefer brand towards price, keeping them warranty secured for the future expected risks. For instance, while purchasing laptops, customers gave preference to the laptops of HP, DELL and Acer etc because these brands are familiar to them and are available with warranty. Therefore, considering all these current trends, this research will focused on the impact that whether the products' warranty affects the consumers' preferences towards Brand or Price or both while purchasing an IT product.

Keeping in mind the costs associated with the purchase of an IT related product, the comfort and satisfaction with the brand that customers feels and give, and the risks associated with the after purchase, company along with utilizing its marketing mix also used to give a warranty for a time period in order to attract the customers and minimize the post purchase risks. These are the factors from the sellers' perspective. From customer' perspective, product's warranty may or may not be considered as an important factor that influenced their purchase intension while purchasing an IT product. This research is aimed to fill this gap and to find out whether product's warranty plays any significant role in customers' preferences towards Brand and/or Price of the product.

LITERATURE REVIEW

In order to mitigate the post purchase risks that barred the customers from purchasing durable products, the sellers started giving their products a Warranty. Products' warranty is the part of Reverse Logistics of Supply Chain Management in which the information or products moves in a reverse direction which is from point of buyer to the point of seller. Products warranty is of two types. One is the basic warranty which the manufacturers used to give with the product itself as its part and which can't be purchased separately. The second is the extended warranty in which the seller at any level of the downstream intermediaries or manufacturer offered that for an additional charge and that type of warranty can be purchased separately depending upon the time period [Chu, Chintagunta, 2011].

The decision of purchase got difficult when the selection criterion is limited. The literature is filled with various factors that the customer prefers while purchasing a durable product but this study is primarily focused to the basic warranty of the product and the customers' preferences towards brand and price.

Teng, Ho, and Shumar [2005] reported that the warranty of the product is becoming an assurance of the product quality which ultimately increases the loyalty of the customers with the companies. With the immense increase in the competition between the manufacturers in the market, manufacturers have also incorporated the product warranty as the differentiation strategy which differentiates its product with the competitors. The study further investigated the classification of the warranty returns which is the part of the reverse logistics in Supply Chain Management by applying Discriminant Analysis and Logistics Regression Model, which helps the Original Equipment Manufacturers (OEMs) to have the accurate information for classifying the warranty returns which is helpful in minimization of costs that are associated with the warranty returns and the maintaining the efficient flow of the whole supply chain.

Lin, Kuo, Huang, Lin, and Ho [2007] reported that warranty plays an important role in order to increase the sale of the products because customers are willing to purchase the product which is reliable and durable and its warranty assures the reliability and durability. They also proposed a model for the fuzzy environment for determining the warranty period of the products so that optimum warranty can be given and maximum profit can be achieved.

Oumlil [2008] explored different types of warranty, use of warranty as the product differentiation strategy, a tool to compete and a sort of quality assurance related to product that the customers got in terms of warranty. The author also discussed different theories on warranty so that the right theory is adopted by the manufactures depending upon the product's nature, market competition and customers. A general framework was proposed for making a warranty policy containing two components naming Planning and Development. The author conducted a case study on a multinational High Tech company and data from 49 employees were collected by using a survey questionnaire. It was found that making of the warranty policy should depend on the complexity. The results showed a difference between types of warranty which was based on the buyer's knowledge related to product. It was also found that the standardized warranty is easy to manage and its management becomes more complex with the diversity in product line.

Ambad and Kulkarni [2013] stated that the manufacturers having similar kind of products are using warranty as a tool that increases the customers' confidence towards the product, but at the same time this tool increases the costs on the manufactures as well. So a conceptual framework was proposed in which the technology and the other related issues are integrated on the manufacturing stage so that the expected warranty costs can be reduced. A model was also developed to optimize the warranty costs and tested on the data of an engine manufacturer, which showed a significant reduction in the warranty costs keeping in mind the reliability of the engines, the price level in the engines' market and the warranty policies.

Oumlil [2013] empirically investigated the issues related to the warranty policy formulation, management and its application by examining the survey from the employees of a large scale US based High Tech firm. The study revealed that the budgeted costs that are associated with the warranty should be allocated to the departments based on their activities. In addition to this, it was found that the employees are against the option of outsourcing the warranty to the third party as other companies have started. The study further resulted in making the warranty policy as per the markets and customers locally and internationally, whereas need of proper communication of the warranty policy and its understanding to the employees of the said firm was also observed which is helpful in increasing the productivity and reduction in warranty costs.

Stamer and Diller [2006] empirically investigated different consumer segments related to price on eight consumer goods. A survey was conducted by using Likert scale questions related to the consumer preferences towards the prices of the eight products categories. Data was collected from 2621 shoppers and Factor Analysis was applied. The study revealed five segments of shoppers and their preferences towards price and quality. One segment is of the buyers who are brand conscious, who consider brand as the sign of high quality and are even willing to pay high for that brand, price seekers that are willing to purchase the products having low prices, optimizers who give equal preferences to price and quality, a segment who are only willing to purchase the product when offered on discounted prices irrespectively of brand or quality and lastly a segment who assume the high price as signal of quality and willing to purchase the product at high price that gives them high quality.

Suki [2013] examined the relationship between features of products, its price, brand name and the social influence with the demand of smart phones by university students of Malaysia. The students were considered as well aware with the smart phones and its usage. The sample consists of 320 University students and Structural Equation Modeling (SEM) was applied. The study revealed that the students demand has a significant impact of the name of the brand and social influence whereas the impact of the price is found insignificant. The study also recommends that the smart phones manufactures should also increase the features, operating system, software and hardware of the smart phones so that it can also have a significant impact on the consumer demand for smart phones.

Karjaluoto et al. [2005] examined various factors that influence the choices of consumers while purchasing new mobile phones for the first time and switching to other mobile phones by two different studies. In the first study, focused group interview technique was used and the sample consists of 79 graduate students. The study shows that the only factor that influences the consumer choice for purchasing the new mobile phone for the very first time is the need recognition for the technology. On the other hand, a survey questionnaire was used in the second study in which 179 respondents were considered valid. By the help of Factor Analysis, the results revealed that while switching and changing to new mobile phones, prices of the mobile phones have found strong influence and brands have found medium influence on the consumer choice.

Perez, Padgett, and Burgers [2011] investigated the impact of the Intergenerational Influence (IGI) on the brand preferences on Mexican females (mothers and daughters). The sample consists of 300 mothers and daughters and Z- statistic was used. The study revealed that the intergenerational influence in family life cycle have stronger impact on the brand preferences rather than the amount of time the daughters live apart from their mothers.

Miremadi and Faghani [2012] empirically examined the factors that affect the consumer buying attitude and the factors that consumer preferred while purchasing a branded shampoo in the Iranian fast moving consumer goods (FMCGs) market. By the help of a survey questionnaire, valid data from 374 respondents were considered for the Regression Analysis. The study shows that the attractive packaging, anti dandruff and shiny are the attributes that influenced the consumer buying attitude whereas the sustainability, price and quality are the factors that affect consumer preference while purchasing a branded shampoo.

Mendez, Oubina, and Rubio [2011] examined the factors that form consumer brand preferences. Factors include packaging and price as extrinsic cues and taste as intrinsic cue with respect to brand on the two food products which are cola products and stuffed olives. The research was conducted on three different products in each product category of which two are internationally recognized manufacturer brands and one is the locally recognized store brand by conjoint analysis. The study was conducted in a way that at first, respondents were asked to use the products without knowing its brand, this is known as blind test and then the brands were revealed to them. The response was recorded at both stages. The result revealed that consumer gave different preference to the brands in both categories. Since the consumers are well aware with cola products that are highly differentiated so the brand names and taste formed their preference. In the case of stuffed olives, price and taste are the factors that have strong influence on the consumer preferences and since this product category is not have much differentiation between brands so even after revealing brands consumer gave preference to the store brands.

Walley, Custance, Taylor, Lindgreen, and Hingley [2007] examined various factors that affect the customer's preferences while purchasing a tractor in United Kingdom. The researchers identified five factors namely brand, price, service quality of dealer, dealer proximity and buyers' experience with respect to dealer. Data was collected from 428 contractors and farmers and conjoint analysis was applied on the data. The results revealed that the most important factor that respondent prefer while purchasing the tractor is the brand followed by price. The study suggest the manufacturers and marketers to have a proper brand management whereas price can be of premium so that the expenses of branding can easily be managed by charging higher in UK since customers preferred brand mostly.

Sardar [2012] examined the factors that affect consumer preference towards brand in the passenger car market of the Aurangabad District of Maharashtra (India). The sample consists of 150 respondents by using convenience sampling technique. The study revealed that most important factor customer preferred towards brand is the brand status whereas the second most important factor is price. The study also reveals that personal factors which is also known as demographic factors consist of age, gender, education, occupation and income status; have significant influence on the brand preference. The study suggests that the Indian consumers are much more price conscious and are fuel efficient so the manufacturers must have low price and high fuel efficient passenger cars which helps them to increase their market share and revenues.

Mokhlis and Yaakop [2012] investigated the various factors that the Malaysian University students consider before selecting Mobile Phones. Data was collected from 376 students through survey questionnaire having 7point Likert scale, on which factor analysis and Friedman test was applied. Factor Analysis generates 7 factors which were named as Innovative features, image, price personal recommendations, durability and portable aspects, media influence and post sale service. Friedman test was further applied on the factors which show that university students give more importance to innovative features, followed by personal recommendations. The third rank was given to the price whereas durability and post sale service was ranked as fourth and fifth. The students was least influenced by the media influence and image which ranked as sixth and seventh respectively.

Mokhlis [2012] comparatively analyzed that whether there is a difference exists between different ethnic subculture while evaluating a product on the basis of its attributes and whether different customers having different ethnic subculture have different preference to a product while purchasing. The researcher use mobile phone as the product and the respondents were asked to give importance to its different attributes on 7-point Likert scale by a survey questionnaire. The respondents consist of Malay, Chinese and Indian students studying in Malaysian University, totaling sample of 371. After using Factor Analysis, seven factors were generated of which four have shown a significant difference in ranking by the three subculture groups. These are image, post sale service, influence by reference group and influence by media. The study further gives Marketers an idea to have different strategies while targeting different groups.

Pankhania and Modi [2011] investigated that what factors should the organizations must incorporate while targeting the desired target market so that companies can increase their revenues and can easily penetrate in the market. The data was collected by the industrial employees from top, middle and lower management of Vitthal Udyognagar which is in Anand District of Gujarat (India). The respondents were asked to rate the importance on Likert scale in Survey questionnaire having 14 scales related to brand, packaging, price, discounts, service, warranties and guaranties etc. The sample size of 156 employees was considered for Factor Analysis. The result shows four factors which explain 64.013% of variation of the data. On the basis of this result, the researchers suggested that the companies should consider and give preference to convenience, quality and service, discounts and price and guaranty while targeting any market.

Queenette and Jerome [2011] explored the factors that respondents prefers while procuring the computer hardware and software. Data was collected from the 6 respondents of Edo and Delta states of Nigeria by the questionnaire and the results were evaluated on the basis of simple percentages. The study revealed that respondents prefer factors like memory, speed, costs, durability, brand, reliability and warranty before acquiring computer hardware. On the other hand, while purchasing computer software, respondents prefer factors like reliability and past record of the vendors, technical support and service, costs and compatibility with the existing software.

Gajghate and Khorgade [2013] examined that what factors significantly influence the purchase decision of the consumers while considering laptop purchase. Student market was found to be potential for laptop purchase by the researchers therefore convenience sampling technique was used and by the help of survey questionnaire, sample of 200 students from Nagpur City was taken and 25 factors were presented to them including Brand, Price, Brand Ambassador, Social Influence, Warranty, after Sale Service etc. From those 25 factors, 18 factors were considered for Factor Analysis. The analysis generates 8 factors which were named as Brand, Offer, Design, Hardware, Original Software, Components, Advertisement and Innovation. The impact of these factors was found significant on the purchase preference of consumers while considering the Laptop purchase. The study further suggested that the marketers should work on the communication of Warranty and Insurance whereas Components must also have separate offers as per the students' requirements.

Jain & Hundal [2007] explored the factors that the people of rural areas prefer while purchasing a new mobile phone and the mobile phone service. The researchers collected the data from 1357 respondents from the rural areas of Punjab (India) by the survey questionnaire. The questionnaire includes 18 statements in order to analyze the preference towards mobile phone purchase and 18 statements for preference towards mobile phone service. Factor Analysis was applied on the data which resulted in making four factors for preference towards mobile phone purchase and five factors for preference towards mobile phone service respectively. For preference towards mobile phones, the factors were named as Convenience and Assistance, Price Consciousness, Brand Choice and Influential Persons, whereas for the mobile phone service the factors were named as Facilitating, Effectiveness, Dexterity, Relative advantage and Influential persons. The researchers suggested that more research is needed towards the rural areas because of being new emerging market for Information Technology Products. It was further suggested that marketers should adopt marketing techniques and strategies which must be aligned with the rural culture as the marketing, advertising on electronic media, print media etc was found to be insignificant because of the fact that the rural residents are less educated and they heavily rely on the suggestions and recommendations of friends, family and relatives etc.

In the light of the above reviews, it is evident that researchers are in agreement of considering Products' warranty as the sign of the quality, reliability and durability from customers' point of view and is helpful in making customers loyal to their products, increase in sales and profits from manufacturers' point of view [Lin et al. 2007, Oumlil 2008, Teng et al. 2005]. In addition to this, it was also found that customers are indifference with the choice with respect to brand and price. Both have created a tradeoff in which if customers go with the brand then they have to pay more and vice versa [Sardar 2012, Stamer, Diller 2006, Suki 2013, Walley et al., 2007]. On the other hand, while considering durable products, the researchers consider the product's warranty, brand and price along with other factors as important in order to evaluate the customer's preference, when purchasing a durable product as per their target population [Gajghate, Khorgade 2013, Jain, Hundal 2007, Mokhlis, Yaakop 2012, Pankhania, Modi 2011]. Since the IT related products are becoming a necessity from luxury, so keeping in mind the customer's tradeoff between brand and price and to the best of researcher's knowledge, no work has been done or published yet on evaluating the impact of product's warranty on the customer's preferences in Pakistani context, which is a gap that needs to be filled. Therefore, the objective of this study, as mentioned earlier, is to find out that the product's warranty influences the customers' preferences towards brand and price.

CONCEPTUAL FRAMEWORK

With an increase in the availability of substitutes and alternatives of the products, customer needs had also changed. They had started giving preference to other value added options along with the product itself [Mokhlis, Yaakop 2012]. Earlier studies had shown an agreement in evaluation of different factors that customer preferred while purchasing durable products. The findings of such studies showed that customers prefer brand, price and warranty along with the other factors while purchasing [Gajghate, Khorgade 2013, Jain, Hundal 2007, Pankhania, Modi 2011]. The researchers had considered the Product's Warranty a significant factor in addition to other factors, but none of them reported its impact on customers' preferences towards brand and price.

Stamer and Diller [2006] identified three dimensions to measure consumer preferences towards Price. These are Concern for price, Willingness to pay and Price intentions. Therefore, considering the available literature, a conceptual framework is made which will be followed in this study. It is shown in Figure 1.

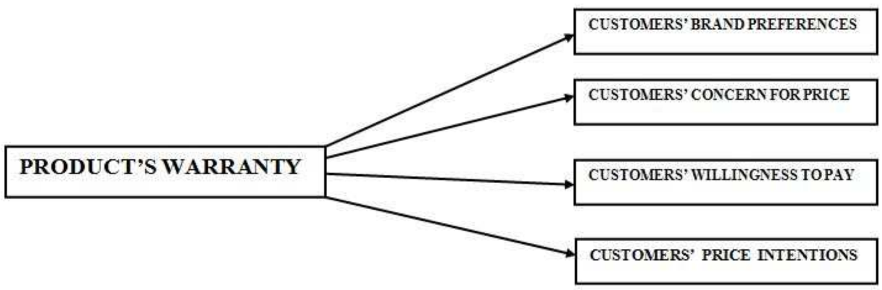

Fig. 1. Conceptual Framework of the study
Rys. 1. Schemat pracy

Hence based on the literature and proposed conceptual framework, four hypotheses were developed given as follows:

H1: Product warranty has a significant impact on Customers' Brand Preferences.

H2: Product warranty has a significant impact on Customers' Concern for price.

H3: Product warranty has a significant impact on Customers' Willingness to pay.

H4: Product warranty has a significant impact on Customers' Price intentions.

METHODOLOGY

Keeping in mind the benefits of a quantitative research [Bhat 2013], quantitative approach was selected for this study. In addition to this, considering the relationship between the variables as evident by the reviews, this study aims to identify the causal relationship between the variables. This complements the problem statement which is to study that whether product's warranty plays a significant role in customers' preferences.

For the purpose of data collection, convenience sampling technique was used. The reasons for selecting this type of technique are that it was time saving, cost saving, the researcher can have direct interaction with the respondent and large sample can easily be collected through this. Data was collected from 298 business students from a private university of Karachi. The respondents were including males and females, age ranging from less than 20 to more than 40, belongs to nuclear family or joint family, having monthly income up to PKR 50,000 to above PKR 100,000.

A structured survey questionnaire was used for data collection. This questionnaire was divided in two sections. First section was having questions for measuring the variables whereas the second section includes the questions for respondents' general information. In first section, all questions are on a five point Likert Scale ranging from 1 "Strongly Disagree" to 5 "Strongly Agree". This questionnaire was developed by adapting scales and dimensions for the dependent and independent variables.

Huysentruyt and Read [2008], identified the items by which responses for Product's Warranty were measured. Stamer and Diller (2006) identified three dimensions to measure customers' preferences towards Price. 1) Concern for Price, 2) Willingness to Pay, and 3) Price Intentions. Moreover, Singhania [2006], developed the scale to measure the respondents' preferences towards Brand.

After the development of survey instrument, questionnaire was evaluated by two panels for face and content validation. Firstly, it was evaluated by the panel of two academic experts so that it was checked that for the desired variables whether it is as per academic concepts considering the Pakistani environment. They suggested replacing the subject terminologies like Brand Loyalty with the easily understandable phrases. After incorporating the suggestion by them, it was evaluated by three IT market Professionals separately so that they can validate it as per current IT consumer market trends. After the approval from them, it was required to do a Pilot Study.

After pilot study, the instrument was distributed using Google Drive and hardcopies of questionnaire. This resulted in the successful collection of sample of 298 respondents. After data collection, Researcher used Factor Analysis and MANOVA for the analysis of data. Researchers consider these techniques as a statistical tool for explaining the most preferred customers' factors and for filtering out the least preferred scales [Gajghate, Khorgade 2013, Jain, Hundal 2007, Karjaluoto et al. 2005, Pankhania, Modi 2011].

FINDINGS AND DISCUSSION

Profile of the Respondents

Out of 298 respondents, 216 were male which constituted 72.5% of the data whereas females were only 82 (27.5%). On the other hand, 24 respondents (8.1%) were having age of 20 years or less, 199 respondents (66.8%) were having age between 21 to 25 years, 71 respondents (23.8%) were having age between 26 to 35 years whereas only four respondents (1.3%) were having age more than 36 years. The demographic characteristics of respondents summarized in table 1.

Inferential Statistics

Factor Analysis produced five factors as per literature and these five factors explained 61.423% out of total variation. The final items which were load in the five factors as made by the Factor Analysis. The component 1 was named as Brand Preferences, component 2 as Warranty, component 3 as Concern for Price, component 4 as Willingness to pay and component 5 as Price intentions, respectively. Table 2 shows the items which were load in the five respective factors. Hence five variables were made as they were named and desired.

Table 1. Profile of Respondents
Tabela 1. Profil badanych

Descriptive Profile		Frequency	Percent
Gender	Male	216	72.5
	Female	82	27.5
Age	20 years or less	24	8.1
	21 to 25 years	199	66.8
	26 to 35 years	71	23.8
	36 to 40 years	2	0.7
	41 to 45 years	1	0.3
	More than 45 years	1	0.3
Family Income PKR (Monthly)	Upto 50,000	105	35.2
	50,001 to 75,000	68	22.8
	75,001 to 100,000	47	15.8
	Above 100,000	78	26.2
Family kind	Nuclear family	153	51.3
	Joint family	145	48.7

Table 2. Factor Analysis Results Summary
Tabela 2. Wyniki analizy wskaźnikowej

	Component					
	1	2	3	4	5	Cumulative Percent
Brand is more important than any other factor while purchasing	.793					14.96%
Brand is more important than price	.713					
Brands play an important role in decision making	.698					
Warranty gives peace of mind		.771				13.78%
Protection of warranty is comforting		.766				
Won't take risk to purchase product without warranty		.691				
Prior to purchasing collect large amount of information on Price			.757			12.84%
While purchasing Consider large no of alternatives brands			.724			
Do in-depth effort to get information on consumer brands			.710			
Only pay normal price				.845		10.71%
Prepared to pay max price				.722		
Firms usually set fair prices					.783	9.72%
Very low price means low quality					.721	
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.						
a. Rotation converged in 5 iterations.						

Table 3. Multivariate Statistics Summary
Tabela 3. Analiza wieloczynnikowa

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.526	81.416[a]	4.000	293.000	.000
	Wilks' Lambda	.474	81.416[a]	4.000	293.000	.000
	Hotelling's Trace	1.111	81.416[a]	4.000	293.000	.000
	Roy's Largest Root	1.111	81.416[a]	4.000	293.000	.000
Warranty	Pillai's Trace	.143	12.200[a]	4.000	293.000	.000
	Wilks' Lambda	.857	12.200[a]	4.000	293.000	.000
	Hotelling's Trace	.167	12.200[a]	4.000	293.000	.000
	Roy's Largest Root	.167	12.200[a]	4.000	293.000	.000

Table 4. Fitness of Model
Tabela 4. Dopasowanie modelu

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	brand_preference	15.204[a]	1	15.204	30.005	.000
	concern_for_price	9.625[b]	1	9.625	19.723	.000
	willingness_to_pay	.011[c]	1	.011	.016	.900
	price_intentions	4.159[d]	1	4.159	6.865	.009
Intercept	brand_preference	33.975	1	33.975	67.049	.000
	concern_for_price	39.561	1	39.561	81.071	.000
	willingness_to_pay	68.023	1	68.023	96.381	.000
	price_intentions	47.651	1	47.651	78.653	.000
warranty	brand_preference	15.204	1	15.204	30.005	.000
	concern_for_price	9.625	1	9.625	19.723	.000
	willingness_to_pay	.011	1	.011	.016	.900
	price_intentions	4.159	1	4.159	6.865	.009
Error	brand_preference	149.988	296	.507		
	concern_for_price	144.441	296	.488		
	willingness_to_pay	208.908	296	.706		
	price_intentions	179.328	296	.606		
Total	brand_preference	4485.556	298			
	concern_for_price	4187.444	298			
	willingness_to_pay	3263.000	298			
	price_intentions	3848.000	298			
Corrected Total	brand_preference	165.192	297			
	concern_for_price	154.066	297			
	willingness_to_pay	208.919	297			
	price_intentions	183.487	297			
a. R Squared = .092 (Adjusted R Squared = .089)						
b. R Squared = .062 (Adjusted R Squared = .059)						
c. R Squared = .000 (Adjusted R Squared = -.003)						
d. R Squared = .023 (Adjusted R Squared = .019)						

Table 5. Parameter Estimates
Tabela 5. Wyliczenie paramterów

Dependent Variable	Parameter	B	Std. Error	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
brand_preference	Intercept	2.291	.280	8.188	.000	1.741	2.842
	warranty	.366	.067	5.478	.000	.235	.498
concern_for_price	Intercept	2.473	.275	9.004	.000	1.932	3.013
	warranty	.291	.066	4.441	.000	.162	.420
willingness_to_pay	Intercept	3.242	.330	9.817	.000	2.592	3.892
	warranty	-.010	.079	-.126	.900	-.165	.145
price_intentions	Intercept	2.714	.306	8.869	.000	2.112	3.316
	warranty	.191	.073	2.620	.009	.048	.335

The table 3 shows the fitness of the One Way MANOVA because of the explanation of significant variation in the Warranty. Table 5 shows that the Wilks' Lambda = .857, F (4,293) = 12.2, p < .05. Since significance value is less than .05, therefore it was concluded that there is a significant variation in dependent variables by Warranty.

Table 4 shows the models that were generated. It was found that out of four, three models were significant whereas one was found insignificant. Brand preference, concern for price, price intentions have significant impact on warranty, F (1,296) = 30.005, p <0.05; F (1,296) = 19.723, p <0.05 and F (1,296) = 6.865, p <0.05 respectively. On the other hand, willingness to pay has an insignificant impact on warranty F (1,296) = 0.016, p >0.05.

The Table 5 shows the testing of the four hypotheses which were developed earlier in the study. Four models had been generated in Table 4, having Warranty as an independent variable in all four models and brand preference, concern for price, willingness to pay and price intentions as dependent variable respectively.

By the help of Table 5, again it was found that Sig values of the 3 models having brand preference, concern for price and price intentions as dependent variables are <0.05 which stated the rejection of the Null Hypotheses and found that warranty has a significant impact on brand preference, concern for price and price intentions. In addition to this, the model in which willingness to pay was a dependent variable has shown the Sig value of 0.900, therefore in this model Null hypothesis is accepted (because sig value is > 0.05) and the impact of warranty on willingness to pay was found insignificant.

In earlier studies warranty, brand and price were identified as preferred factors but since no study reported the impact of warranty on the customers' preferences towards brand and price, therefore this study has of significance importance. It was found a significant impact of Product warranty on Customers' Brand Preferences. It was observed in the IT product market that Customers used to give preference to the Brands having warranty while purchasing IT related products. For example, since Smart Phones of HTC are available without warranty but Samsung Galaxy series and Nokia Lumia series have been offered with warranty so customers usually prefer to buy Nokia or Samsung Smart Phones.

To sum up, customers, these days, need IT related products which has a warranty but it has to be branded, offered on competitive price, have more in less price but they are not willing to pay any additional amount for that product just because of the warranty. This seems logical and is also suggested to Pakistani manufacturers and marketers.

It is suggested to the future researchers that this study needed to be done in the other regions of Pakistan as well because their preferences might be different from the Karachi. In addition to this, it is also suggested to incorporate more factors other than brand and price into the research. On the other hand, it is also suggested to apply this study on other durable products like electronic items, machinery, automobiles and motor vehicles etc. Lastly, it is also suggested to explore the dimensions of this research by dissecting the IT products category wise.

CONCLUSION

Whenever a buyer purchases a product that is of high involvement, he always thinks about the risks that are associated with the purchase specially the post purchase risks. Such post purchase risks made the background to conduct this study. Therefore, the aim of this study was to identify the significance of the Product's warranty on Customers' preferences. Dimensions were identified from the available literature and on that basis four hypotheses were developed as evident in the conceptual framework in Figure 1. After applying the One Way MANOVA, it was found that warranty has a significant impact on customers' brand preferences, concern for price and price intentions whereas insignificant impact was found on customers' willingness to pay.

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WPŁYW ISTNIENIA GWARANCJI NA ZACHOWANIE SIĘ KONSUMENTÓW: ANALIZA ODWRÓCONYCH MODELI LOGISTYCZNYCH

STRESZCZENIE. **Wstęp:** Wyroby IT stały się nierozwiązalną częścią naszego życia. W Pakistanie nie ma produkcji tych wyrobów, w związku, z czym, klienta są zmuszeni do zakupu produktów pochodzących z innych rynków. W trakcie zakupu klienci zwracają uwagę nie tylko na markę wyrobu i jego cenę, ale także na oferowaną gwarancję, która daje bezpieczeństwo w użytkowaniu produktu po zakupie.
Metody: Celem pracy było ocenienia wpływu istnienia gwarancji na preferencje zakupowe klientów w stosunku do marki i ceny produktów. Stworzono koncepcję badania na podstawie przeglądu literaturowego i następnie zebrano odpowiednie dane. Zostały one uzyskane od 298 respondentów w formie ankiety. Dane następnie poddano analizie statystycznej przy zastosowaniu Factor Analysis i One Way MANOVA.
Wyniki i wioski: Stwierdzono, że istnienie gwarancji na istotny wpływ na preferencje zakupowe na wybór marki, choć stwierdzono istotnej zależności między istnieniem gwarancji a gotowością zapłacenia za produkt wyższej ceny. Na podstawie uzyskanych wyników stwierdzono, że pakistańscy klienci oczekują branżowych wyrobów IT w konkurencyjnych cenach, posiadające gwarancję jednak z drugiej strony nie są chętni do ponoszenia dodatkowych kosztów istnienia tej gwarancji..

Słowa kluczowe: gwarancja produktu, preferencje klientów, marka, cena, odwrócone modele logistyczne.

EINFLUSS VON GARANTIE-LEISTUNGEN AUF DAS VERHALTEN DER VERBRAUCHER: ANALYSE DER REVERSIBLEN LOGISTIK-MODELLE

ZUSAMMENFASSUNG. Einleitung: IT-Produkte sind ein untrennbarer Teil unseres Lebens geworden. In Pakistan werden solche Produkte nicht hergestellt, daher sind die Kunden dazu gezwungen, die in anderen Ländern produzierten Ausrüstungen einzukaufen. Beim Einkauf von IT-Produkten nehmen die Verbraucher nicht nur Marke und Preis des jeweiligen Erzeugnisses sondern auch die angebotene Garantie-Leistung, die eine sichere Benutzung des Produktes nach dem Einkauf gewährleistet, wahr.
Methoden: Das Ziel der Arbeit war es, den Einfluss des Bestehens von Garantie-Leistungen auf die Einkaufpräferenzen der Kunden im Verhältnis zur Marke und zum Preis dieser Art Produkte zu beurteilen. Auf Grund einer Literaturrecherche wurden ein Forschungskonzept angenommen und dann entsprechende Daten erfasst. Sie wurden von 298 Respondenten in Form eines Umfrage-Bogens gewonnen. Nachfolgend wurden die Daten einer statistischen Analyse unter Anwendung von Factor Analysis und One Way MANOVA unterzogen.
Ergebnisse und Fazit: Man stellte fest, dass das Bestehen von Garantie-Leistungen die Einkaufpräferenzen und die Auswahl der Marke in einem wesentlichen Ausmaße beeinflusst, wobei man keinen wesentlichen Zusammenhang zwischen dem Bestehen der Garantie-Leistung und der Bereitschaft der Kunden zum Einkauf von Produkten zu einem durch die Garantie-Leistung bedingten, höheren Preis ermittelt hat. Auf Grund der gewonnenen Ergebnisse stellte man eindeutig fest, dass die pakistanischen Kunden das Angebot der IT-Erzeugnisse zu konkurrenzfähigen Preisen samt der Garantie gern wahrnehmen, jedoch andererseits nicht bereit sind, zusätzliche Kosten für die betreffenden Garantie-Leistungen in Kauf zu nehmen.

Codewörter: Produkt-Garantie, Kundenpräferenzen, Marke, Preis, reversible Logistik-Modelle

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RETAIL SUPPLY CHAINS AND EFFICIENCY OF RETAIL TRADE

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ABSTRACT. Background: Since in today's supply chains in particular areas (for example in the grocery sector) most power is in the hands of retail chains on which manufacturers depend, this paper analyzes the retail supply chains. The aim of this paper is to propose a new indicator of retail trade efficiency for an individual national economy. This indicator would then be used to complement the usual analyses. As large marketing systems, retail supply chains present new competition for production companies in particular states, because they can get around them or replace them with other production companies.

Methods: Concepts relating to retail supply chains are analyzed on the basis of accessible literature, and available data sources are used as the basis for a table presentation of 10 world's largest retail chains in the grocery sector, with basic remarks about their logistics and about the development of the their supply chains (basic models are described). Efficiency of the total retail trade in the selected countries is analyzed on the basis of the following indicators (a) turnover per unit of selling surface; (b) turnover per 1 employee in the retail trade. These indicators are presented in tables and graphically for the selected European countries.

Results: The performed analysis leads to the conclusion that retail trade efficiency, as measured by the realized turnover per 1 employee in the retail trade and by the realized turnover per unit of selling surface in the retail trade, is realized diversely in individual observed countries; yet there are no differences in the results between transitional and market-developed countries. However, the analysis of retail trade efficiency of entire economies of the observed states shows that there are differences between transitional and market-developed countries.

Conclusions: Thus, in order to evaluate the retail trade efficiency for the total economy in a particular country it would be necessary to also take into account the ratio between the realized gross domestic product (the GDP) and the retail turnover in the given country. This proposal is important because it would enrich the information basis for the analysis of retail trade efficiency. In that respect, further research should be focused on the analysis of this broader understanding of retail trade efficiency that is important especially for economically less developed countries (in this case the countries in transition).

Key words: retail trade, retail chain, retail supply chain, retail trade efficiency.

INTRODUCTION

Based on available literature, this paper starts from the analysis of the following relevant concepts: distributive trade, retail trade, retail chain, supply chain, retail supply chain, and foreign trade; there are also some remarks about the indicators chosen for the analysis of retail trade efficiency in a particular country.

After that, tables presenting the 10 largest retail chains in the grocery sector around the world are used to emphasize the importance of international retail chains, upon which their logistics and development of their supply chains are analyzed (basic models are described).

Then, based on the selected indicators, the efficiency of retail trade in selected European countries is analyzed. The analysis

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includes the following market-developed countries: Austria, Finland, Germany, Italy and the Netherlands. Of the countries in transition, the analysis included: Croatia, Hungary, Slovakia, the Czech Republic and Poland.

On the basis of the performed analysis, it has been observed that the evaluation of retail trade efficiency requires the taking into account not only of the efficiency of the retail level, but also of the efficiency of the retail supply chains for a particular national economy.

RETAIL TRADE AND ITS EFFICIENCY

Retail trade is an integral part of distributive trade defined as follows [SLJH 2012]:

"Distributive trade is a set of all forms of commercial activities, from the procurement of goods from the manufacturer to the delivery of these goods to final consumers. It includes the wholesale trade for its own account, agency in the wholesale trade, retail trade, and servicing and repairing of motor vehicles and motorcycles."

"Retail trade (section 47, class 45.32 and a part of groups 45.1 and 45.4 of the NKD 2007. (New Classification of Economic Activities harmonized with the NACE of the EU)) is the sale of goods to final consumers, i.e. to the population, for personal usage or for usage in the household."

In this paper, retail sale will be considered as the sale of goods and services relating to the sale of goods to the final consumer, regardless of by whom it is performed (by a business entity for which retail trade is its basic activity, or by some other business entity).

Therefore, in the wholesale trade, buyers are those receivers that use the purchased goods for further economic activities, whereas the retail trade serves the final consumer or the final user as a buyer [Lerchenmüller, 2003].

The object of our consideration is the retail company (or a retail group) that can also deal in wholesale trade. Retail chain is a company that is doing business with many retail units of the same owner and usually has a centralized decision making in terms of defining and implementing of its strategy. Some retail chains are divisions of larger corporations or holding companies [Levy and Weitz, 2007].

Retail trade is the integral part of the so-called value creation chain. That is, every product or service has its own value creation chain. In respect to the assortment with which it is in business, the retail company is an integrator of different value creation chains.

In that sense, value creation is the result of a target oriented chain of activities within and outside of the company that - depending on the point of view - is denoted as: business process, process of creation of value, or as the logistic chain, procurement chain, or supply chain [Berning, 2002], and also as "logistic network" [Mandel, 2011].

Value creation chain is especially important for the understanding of the vertical partnerships of manufacturers and trade, i.e. of the vertical system of marketing.

In today's supply chains, for example in the grocery sector, the greatest power belongs to retail chains, and manufacturers depend on them [Dujak, 2012]. When a large retailer (a retail chain) dominates in the supply chain, it is possible to use the expression "retail supply chain". However, in some are areas, supply chains are dominated by manufacturers.

Vertical marketing systems are also particularly important from the standpoint of foreign trade, because the entry of large retail chains into a country immediately opens the possibilities and needs for the development of entire supply chains, regardless of which manufacturers of goods and providers of services will become members of such channels.

In present-day conditions, processes of internationalizations and globalizations of business are developing. It is therefore important to understand foreign trade as an "economic" activity that comprises the exchange of goods and services with countries abroad, in other words as an activity that includes the complete exchange of material and non-material goods between countries" [Andrijanić, 2005].

Concentration processes in the economy develop especially through the expansion of individual companies/groups into countries other than the country of origin. Actually, internationalization of businesses operations (both of the retailer and of the manufacturer) is, along with industrial consolidation, the most important, key initiator of changes in the retail supply chain.

Anyway, the spreading of international retail chains from developed into less-developed countries creates dangerous competition that may push domiciliary manufacturers and retailers off the market, because of their inability to adjust to the new competition in a short period of time.

In that sense, especially for countries in transition, it is possible to observe problems in their economic development, because the large international retail supply chains that end in their geographical areas do not contribute sufficiently to the economic development of these countries.

There are two indicators that have been used for a long time in the efficiency analysis of the retail trade in a particular country [Lerchenmüller, 1992; Retailing in the EEA, 1996]: (a) retail turnover per 1 employee in the retail trade, and (b) retail turnover per unit of selling surface. However, for the evaluation of total efficiency and importance of retail trade in a country it would be necessary to take into consideration all activities coordinated by retail supply chains, and these activities yield different effects in different countries. It is therefore important to consider another indicator: the ratio between the realized gross domestic product (GDP) in a given country and the realized retail turnover in that country.

These analyses are of special importance for us because of the investment into the development of infrastructure in particular countries, which supports the building up and development of retail trade and of retail capacities. Although this enables the development of retail supply chains (that cross the borders of individual countries), such development need not contribute to the economic development of a particular country.

INDICATORS OF IMPORTANCE OF INTERNATIONAL RETAIL CHAINS AND BASIC REMARKS ABOUT THEIR LOGISTICS

It has already been emphasized in many research works that retail supply chains are important because of their size, because of the possibility for further expansion, and because of the introduction of new technologies. The advantages of international retail chains lie in the fact that they have concentrated their functions, so that they are much larger than the retail chains in the countries in which they operate, and they operate in a number of countries (both in and outside of Europe). So, for example, Carrefour does business in 36 countries, Metro Group in 33 countries, Tesco in 13 countries, Schwarz-Gruppe in 25 countries, Rewe Group in 13 countries, Auchan in 14 countries, and Leclerc in 6 countries [2010. The 250 Global Retailers, 2011].

More recent data for the 10 world's largest retail chains in the grocery sector are shown in Table 1. However, from the standpoint of format, i.e. the type of retail operating units, the importance lies on the retail brands of these types. The top 10 in the trade (most of them in the retail trade) in the grocery sector in the world in 2013 are presented in Table 2. Striking is the position of Amazon as the global multi-channel retailer. Although Amazon is now opening a store, it differs from those retailers that have first had only stores [Morschett, 2013].

The greatest discounters in the world in 2012 are presented in Table 3. Discount shop is a specially interesting format, regarding the connection with the manufacturers and the shares of retail brands. Therefore, discounters are becoming dominant in supply chains they manage, and they expand internationally.

Table 1. Top 10 retail chains in the extended grocery sector in the world in 2012
Tabela 1. Top 10 sieci detalicznych w handle spożywczym na świecie w 2012

No.	Company - Group	Country	Number of retail units	Total turnover in Bill. US$
1.	Walmart	USA	10.257	288,3
2.	Carrefour	France	10.316	99,2
3.	Tesco	United Kingdom	6.981	87,2
4.	Kroger	USA	3.226	80,9
5.	Scwarz-Gruppe	Germany	11.270	80,3
6.	Aldi (Aldi Nord + Aldi Süd)	Germany	10.030	72,3
7	Walgreens	USA	7.930	68,1
8.	Aeon	Japan	8.392	66,9
9.	Seven & I.	Japan	27.662	64,3
10.	Costco	USA	608	60,1

Source: Planet Retail - February 2013, according to: Lebensmittel Zeitung

Table 2. Top 10 retail brands in the world in 2013
Tabela 2. Top 10 sieci detalicznych w 2013

Rank	Retail brand	Value of the retail brand in Bill. US$
1.	Amazon	45, 7
2.	Walmart	36,2
3.	The Home Depot	18,5
4.	Ebay	17,7
5.	Tesco	16,3
6.	Ikea	12,0
7.	Target	11,9
8.	Woolworts	11,0
9.	Aldi	8,9
10.	Lowe´s	7,6

Source: Millward Brown "BrandZ", according to: Lebensmittel Zeitung

Table 3. Top 10 discounters in the world in 2012
Tabela 3. Top 10 discountów na świecie w 2012

No	Discount retail brand	Company - Group	Country	Turnover in 2011 in Mill. €	Number of discount sale units in 2011	Selling surface in 000 m^2
1.	Aldi	Aldi Gruppe	Germany	52.771	9.483	7.622
2.	Lidl	Schwarz Gruppe	Germany	50.377	9.967	8.571
3.	Neto Marken - Discount	Edeka Gruppe	Germany	13.490	4.735	3.361
4.	Penny	Rewe Group	Germany	11.789	3.701	2.569
5.	Dollar General	Dollar General Corp.	USA	11.129	10.014	6.759
6.	Dia	Dia S.A.*	Spain	11.032	6.727	2.743
7	Rema 1000	Reitan Gruppen	Norway	6.648	712	690
8.	Family Dollar	Family Dollar Stores, Inc.	USA	6.463	7.023	4.568
9.	Biedronka	JMR Jerónimo Martins Retails	Portugal	6.241	1.873	1.113
10.	Netto	Dansk Supermarked A/S	Denmark	5.426	1.160	691

** After separation from Carrefour in July 2011as an independent company*

Source: Planet Retail/LZnet - April 2012, according to: Lebensmittel Zeitung

LOGISTICS OF RETAIL CHAINS AND DEVELOPMENT OF SUPPLY CHAINS

It has already been ascertained that the retail operating unit must be observed as a point in the logistic system that is connected with previous points (wholesale trade units and manufacturers), as well as with consumers and other points that support the performing of distribution tasks (Segetlija, 1995). It has also been ascertained that the development of technical and technological possibilities is accompanied by changes in the importance of particular components of the working process, i.e. of marketing instruments, and that greater demands are especially put on logistic effects.

In fact, there is almost no function in a company that is not influenced by logistics as a cross-sectional function [Pentzinna, 2007].

The analysis of retail chains leads to conclusions about their different market effects, that is about marketing programs that condition different business models. The fact is, namely, that individual characteristics of the format of a retail operating unit also differ depending on the personality of the company. These characteristics then represent the characteristics of "the type of retail operating unit" and they amalgamate in the concept of the "business model". This individual expression then diversely determines the flows of goods and information from buyers to external partners, which are then finalized in their points of contact. These flows determine the flexibility of business models as well as the development of the structure of turnover and the structure of costs [Merkel and Heymanns, 2003].

In observing logistic solutions in supply chains managed by large retail chains, there are some interesting business models that have been examined by Th. Rudolph; these models are: global discounter (e.g. Aldi), retailer of pleasure, of contents (e.g. Tesco) and channel retailer (e.g. Walmart) [Rudolph, 2009].

Hofer [2009] has investigated the management of retail chains in the grocery sector on the examples of: (a) "slender" discounter (with an insignificant integration of logistic processes); (b) channel retailer (consumer markets, German: Verbraucher-märkte) with high integration of logistic processes; (c) the retailer of pleasure, contents (supermarkets) with high integration of logistic processes.

According to this author [Hofer, 2009], "slender" discounters follow the strategy of exploitation of leadership in costs and therefore they show strongly simplified and standardized structures with shallow and narrow assortment and only an insignificant level of services. They aim at achieving advantages in efficiency and costs through a high level of standardization and simplification of logistic processes. An important partial aspect of standardization is the offer of fast-selling articles with minimal logistic costs. The responsibility for supplies has been decentralized (on shops). Based on the high turnover frequency, on more favourable costs and on the realization of turnover with the assortment of their own brands, and also thanks to the integration backwards (through contractual partnership with manufacturers) these "slender" discounters are trying to achieve their competitive advantage.

Retailers of pleasure contents especially focus on the component of services and they follow the benefits strategies of product leaders. They enter into intensive strategic partnerships with manufacturers in such a way that they keep the control over disposal and delivery processes. Presentation of goods is buyers-oriented; it emphasizes the offered assortment of goods and services. As opposed to "slender" discounters, delivery is flexible and requires automated disposal procedures and integrated supplies management systems, where the importance lies in the exchange of information between the shop, central warehouses (logistic-distributive centres) and management.

Channel retailers have a comprehensive assortment of goods; they use the strategy of price variations in the form of price reductions, special offers and rebate actions. Since the large number of offered articles results, averagely, in a low coefficient of stock turnover, large surface shops are introduced as the most frequent format. For disposals of comprehensive assortment which is oriented towards the demand, and which is determined according to the fluctuation of sale, various models of cooperation with manufacturers have developed. Areas of cooperation include: common disposition and management of supplies, action sales, joint decisions about the positioning of particular products within the shops and on the shelves, etc. Standardized data formats and order initiation processes are used for the management of information exchange between the participants.

DEVELOPMENT OF RETAIL TRADE EFFICIENCY

Retail trade is traditionally "local" business, so that all until recently it has been possible to say that hardly any of the two compared countries have the same retail structure [Einzelhandel in Deutschland, 2000]. However, retail chains expand on international and on the global plan through concentration and internationalization processes, resulting in dramatic changes [Wortmann, 2003]. In this way, retail structures of particular countries are becoming more similar.

In analyzing the efficiency of retail trade in a particular national economy, it must be taken into account that retail trade can be an integral part of the value creation chains in which the participants are both domestic and foreign manufacturers and retailers of products - of goods and also of various services [Segetlija, 2010a].

For the created international or global supply chains, an important role is plaid by trade-marks and other forms of cooperation with production companies. Especially important are the processes of development of the globalization of procurement in retail trade. In the grocery sector, global food concerns and retail chains have become the integrators of international value chains [Stamm, 2004].

Through the development of their supply chains international retail companies are changing the relations with their suppliers in the sense of a redefinition of logistic tasks. The relations with suppliers are developing in the range from confronting interaction to close and comprehensive cooperation [Magnus, 2007].

Everything that has been said so far leads to the conclusion that the retail trade expansion processes and the processes of foreign retail chains entering particular countries have resulted in the formation of new, more efficient distribution systems, i.e. new retail supply chains.

This has prevailed over diffusion and inefficiency - characteristics of distribution systems that have, all until recently, dominated in all developing countries (and even in China and India) [Kotler et all., 2003; Kotler and Keller, 2006].

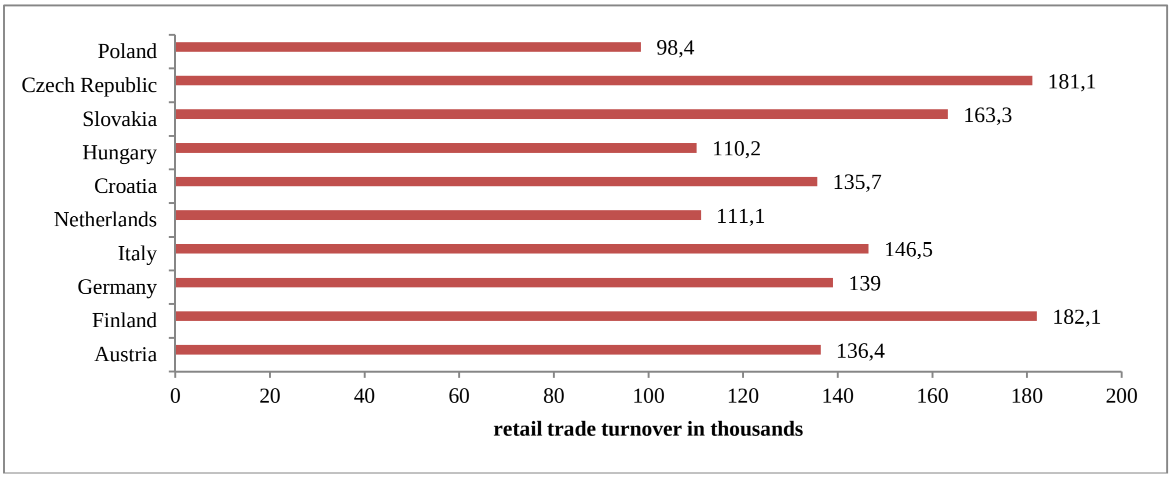
However, in some countries, especially in the so-called countries in transition, there are problems in the development of their economies, because international retail supply chains, as we have already emphasized, present new competition. Therefore, the efficiency of retail trade in the sense of utilization of capacities and of labour force may be satisfactory in particular countries, but there still remains the question of efficiency of retail trade for the entire economy of the given country.

This problem has already been identified based on the understanding of the retail trade as a "mature" sector which - in the developed world - cannot increase the total number of employed either absolutely or relatively [Segetlija, 2010b], but which is becoming the integrator of supply chains.

In this connection, we have already emphasized that new conceptions have become necessary for the explanation of changes and of the development of formats of retail operating units, concerning the value creation chain, i.e. value networks [Segetlija, 2012c]. In that sense it would be worth mentioning that there is a need for analysis that would focus especially on the tendencies of growth in the services provided by others in the value chain of the retail company, on the increase in the number of channels and on the connection with manufacturers and with consumers.

SELECTED INDICATORS OF RETAIL TRADE EFFICIENCY

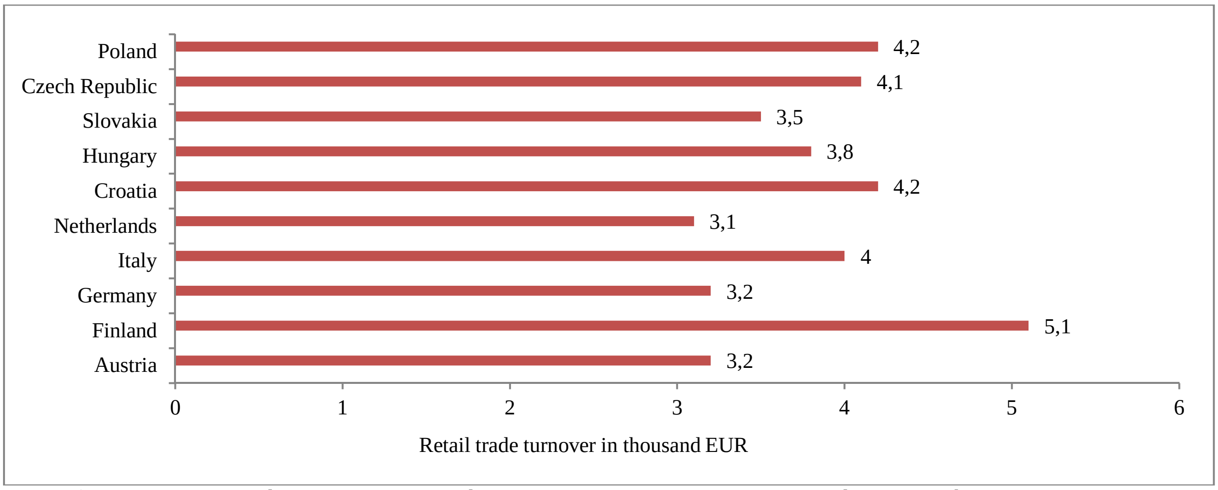
Graph 1 shows the work productivity in the retail trade of the observed European countries in 2008. Regarding different structures of turnover and of retail operating units, retail turnover per 1 employee is different in different countries. However, the Czech Republic and Slovakia, as countries in transition, do not lag behind the market-developed European countries.



Source:
a) Share of motor, wholesale and retail trades in total distributive trades in terms of turnover, Retail trade, except for motor vehicles and motorcycles; repair of objects for personal use and household, Eurostat - Statistics Database
b) Share of motor, wholesale and retail trades in total distributive trades in terms of employment, Retail trade, except for motor vehicles and motorcycles; repair of objects for personal use and household, Eurostat - Statistics Database
c) Gross domestic product as market prices, Purchasing Power Standard per Inhabitant Eurostat - Statistics Database
d) GDP per capita - Annual Data, Eurostat, Statistics Database
e) SLJH 2010, p. 396

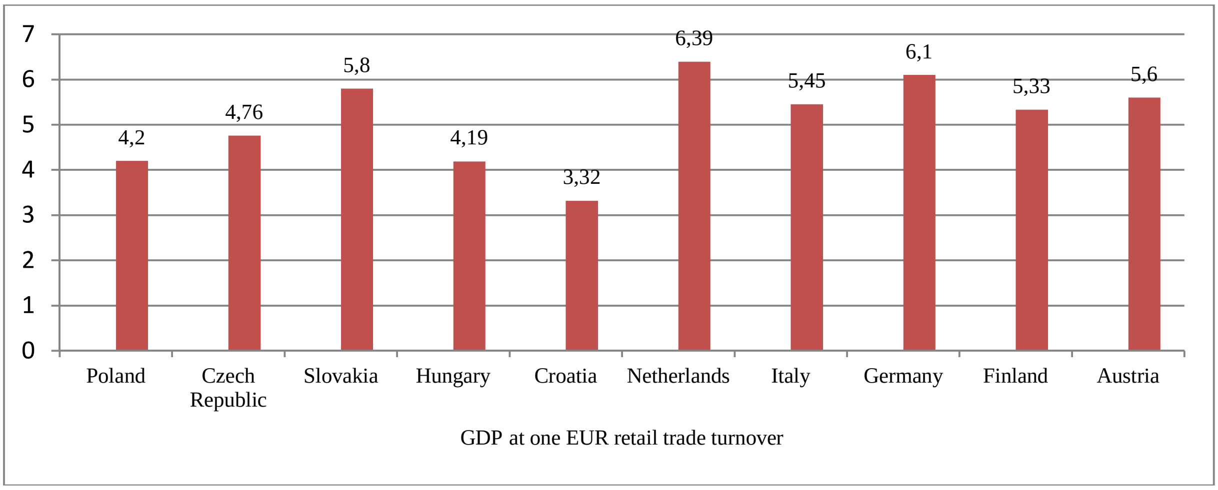
*Note: * Retail turnover for the group 47 - Retail trade, except for motor vehicles and motorcycles; repair of objects for personal use and household (under consideration of the PPS - standard (same as for the GDP). Calculation for the Republic of Croatia has been based on the exchange rate of 1 EUR= 7.30 HRK.*

Fig. 1. Retail turnover per 1 employee in selected European countries in 2008
Rys. 1. Wielkość obrotu na 1 pracownika w wybranych krajach europejskich w 2008



Source: a) Key European Retail Data 2010 Review and 2011 Forecast, Directions Magazine, Articles, June, 30th 2011
b) Gross domestic product as market prices, Purchasing Power Standard per Inhabitant Eurostat - Statistics Database
c) GDP per capita - Annual Data, Eurostat, Statistics Database
d) Population at 1 January, Most popular database tables, Eurostat

Fig. 2. Retail turnover per 1 m^2 of selling surfaces in selected European countries in 2010
Rys. 2. Wielkość obrotu na 1 m^2 powierzchni sprzedażnej w wybranych krajach europejskich w 2010



Source:
a) Eurostat Yearbook 2010, Europe in figures, pp. 98, 99
b) Share of motor, wholesale and retail trades in total distributive trades in terms of turnover, Retail trade, except for motor vehicles and motorcycles; repair of objects for personal use and household, Eurostat - Statistics Database

Fig. 3. GDP per unit of realized retail turnover in selected European countries in 2008
Rys. 3. PNB na jednostkę zrealizowanego obrotu detalicznego w wybranych krajach europejskich w 2008

Graph 2 presents the productivity of the selling surface, i.e. the turnover realized in the retail trade per 1 m2 of selling surface in selected European countries.

Graph 2 shows that the productivity of selling surface in the retail trade is the highest in Finland, Poland, Croatia and the Czech Republic, whereas in more market-developed countries the selling surface productivity is lower. The presented indicators are the result of different retail structures and models. However, all countries show the tendency of decline in the productivity of selling surfaces and of reduction of their utilization, because the retail surfaces are growing faster than the retail turnover.

Graph 3 presents the realized gross domestic product (GDP) per unit of retail turnover in 2008 in observed European countries.

Graph 3 shows that the observed transition countries realize a considerably smaller GDP per unit of retail turnover than the market-developed countries, which means that in these countries the total efficiency of retail trade is considerably smaller. Namely, retail companies from these countries expand considerably less on the international plan, and their production companies are insufficiently included in international retail chains.

CONCLUSIONS

The development of internationalization and of the globalization of business operations calls for new analyses of economic activities in particular countries. This is especially obvious in the analysis of the efficiency of retail trade in an individual country because the retail supply chains are developing internationally. The analysis of retail trade efficiency should therefore also take into the consideration its connection with the level of total economic development in a particular country.

On the basis of accessible data about the efficiency of retail trade in observed European countries, we can conclude that the retail trade in transition countries is less efficient because it realizes a smaller GDP per unit of retail turnover.

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DETALICZNE ŁAŃCUCHY DOSTAW ORAZ EFEKTYWNOŚĆ HADLU DETALICZNEGO

STRESZCZENIE. Wstęp: W obecnych czasach najistotniejszą częścią łańcuchów dostaw (szczególnie w niektórych branżach, np. spożywczej) jest jego część detaliczna. Dlatego w prezentowanej pracy, uwaga skupiona została na analizie łańcuchów dostaw detalicznych. Celem pracy jest zaproponowanie nowego wskaźnika efektywności handlu detalicznego w odniesieniu do krajowej ekonomii. Wskaźnik ten mógłby być wykorzystywany uzupełniająco do stosowanych analiz. Duże systemy marketingowe oraz łańcuchy dostaw detalicznych stanowią wyzwania dla producentów, posiadając istotną przewagę rynkową w dowolności wyboru dostawców produktów.
Metody: Poddano analizie koncepcje dotyczące detalicznych łańcuchów dostaw na podstawie dostępnej literatury. Dostępne dane źródłowe dotyczące 10 największych sieci detalicznych w sektorze spożywczym zostały zaprezentowane w formie tabelarycznej wraz z podaniem komentarzy dotyczących ich logistyki i rozwoju łańcucha dostaw. Przeanalizowano efektywność handlu detalicznego w wybranych krajach przy zastosowaniu następujących wskaźników: obrót na jednostkę powierzchni sprzedażnej oraz obrót na jednego pracownika w handlu detalicznym. Wskaźniki te zostały zaprezentowane w formie tabelarycznej oraz graficznej dla wybranych krajów europejskich.
Wyniki: Przeprowadzona analiza pozwoliła na wnioski, że efektywność handlu detalicznego, mierzona jako zrealizowany obrót na 1 zatrudnionego oraz na jednostkę powierzchni sprzedażnej, jest różna w poszczególnych analizowanych krajach. Nie jednak zauważono różnic pomiędzy krajami rozwijającymi się a krajami wysokorozwiniętymi. Niemniej, analiza efektywności handlu detalicznego w całości gospodarki analizowanych krajów wykazała różnice pomiędzy krajami rozwijającymi się a krajami wysokorozwiniętymi.
Wnioski: W celu oceny efektywności handlu detalicznego całej gospodarki w poszczególnym kraju, byłoby niezbędnym uwzględnienie również stosunku osiągniętego produktu krajowego brutto (GDP) oraz obrotu detalicznego w danym kraju. Propozycja taka jest istotna, ponieważ umożliwia wzbogacenie informacji wykorzystywanych do analizy efektywności handlu detalicznego. Dalsze badania należałoby kontynuować w kierunku analizy takiego szerszego rozumienie efektywności handlu detalicznego, co jest szczególnie istotne dla krajów słabiej rozwiniętych (krajów w okresie transformacji).

Słowa kluczowe: handel detaliczny, łańcuch detaliczny, łańcuch dostaw, efektywność handle detalicznego.

EINZELHANDEL-LIEFERKETTEN UND DIE EFFEKTIVITÄT DES EINZELHANDELS

ZUSAMMENFASSUNG. Einleitung: Heutzutage macht den meist wesentlichen Teil innerhalb von Lieferketten (insbesondere in manchen Branchen, z.B. in der Lebensmittel-Branche) deren Einzelhandel-Teil aus. Daher wurde in der Arbeit die Aufmerksamkeit auf die Analyse von Lieferketten im Einzelhandel fokussiert. Das Ziel der vorliegenden Ausarbeitung ist es, eine neue Kennziffer für die Effektivität des Einzelhandels für den Bedarf der Landeswirtschaft zu ermitteln und vorzuschlagen. Die Kennziffer könnte ergänzungsweise zu den angewendeten Analysen in Anspruch genommen werden. Große Marketing-Systeme und die Lieferketten im Einzelhandel stellen für die Produzenten riesenhafte Herausforderungen dar, indem sie eine wesentlich größere Wettbewerbsfähigkeit bei der freien Auswahl von Produkt-Lieferanten besitzen.

Methoden: Auf Grund der bestehenden Gegenstandliteratur hat man die die Lieferketten im Einzelhandel anbetreffenden Konzepte einer Analyse unterzogen. Die bestehenden, die 10 größten Einzelhandelsnetze vom Lebensmittel-Sektor anbetreffenden Bezugsquellen wurden tabellarisch mit Angabe von Kommentaren in Bezug auf ihre Logistik und die Entwicklung von Lieferketten projiziert. Es wurde dabei die Effektivität des Einzelhandels in ausgewählten Ländern unter Anwendung der folgenden Kennziffern analysiert: der Kennziffer des Umsatzes gemessen auf die Einheit der Verkaufsfläche und der Kennziffer des Umsatzes gemessen auf einen Mitarbeiter im Einzelhandel. Die Kennziffern wurden tabellarisch in Form von Graphiken für ausgewählte europäische Länder präsentiert.
Ergebnisse: Die durchgeführte Analyse ließ schlussfolgern, dass die Effektivität des Einzelhandels, gemessen als der erzielte Umsatz auf einen Mitarbeiter und auf die Einheit der Verkaufsfläche, in den einzelnen betrachteten Ländern unterschiedlich bemessen ist. Man stellte jedoch keine Unterschiede zwischen den Entwicklungs- und den hochentwickelten Ländern fest.
Fazit: Zwecks der Beurteilung der Effektivität des Einzelhandels in der ganzen Wirtschaft innerhalb der einzelnen Länder wäre es unentbehrlich, das Verhältnis des erzielten Bruttolandesproduktes (BLP) und des Einzelhandel-Umsatzes im jeweiligen Lande zu berücksichtigen. Solch ein Vorschlag ist sehr brauchbar, denn er ermöglicht die Ergänzung der für die Analyse der Effektivität des Einzelhandels in Anspruch genommenen Informationen. Die betreffenden Forschungen sollten fortgesetzt werden in Richtung einer solchen breiteren Betrachtung der Effektivität des Einzelhandels, was für die schwächer entwickelten Länder (die in einer Transformation begriffenen Länder) als besonders wesentlich zu sein scheint..

Codewörter: Einzelhandel, Einzelhandel-Kette, Einzelhandel-Lieferkette, Effektivität des Einzelhandels.

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PRODUCTION-LOGISTIC SYSTEM IN THE ASPECT OF STRATEGIES FOR PRODUCTION PLANNING AND CONTROL AND FOR LOGISTIC CUSTOMER SERVICE

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ABSTRACT. Background: The authors made multi-dimensional review of production and logistic strategies in order to prove their coherence in shaping internal and external supply chain. The paper is concluded with definition of production-logistic system as an object of modeling in transformation of business systems of manufacturing companies.

Material and methods: The paper is based on analysis of state of the art presented in the literature on the subject of production and logistics strategies. Publications of key importance were selected to identify genesis and basic assumptions of strategies and their functioning. Comparative synthesis of logistic and production strategies identified is developed with respect to authors' experience in application of predefined tools and methods characteristic for strategies identified.

Results: The result of the work conducted is consolidation of production and logistic strategies according to multi-variant customer service and original definition of production and logistic system.

Conclusions: Production system and logistic system can and should be treated as equal elements in context of material flows management in internal and external supply chains. Such approach enables modeling of both systems as coherent elements realizing selected strategy of customer service.

Key words: MRP, Lean, TOC, Agile, ECR, Quick Response, SCM, production system, logistic system.

INTRODUCTION

The goal of the following paper is to develop a synthetic classification of strategies within areas of production and logistics in order to:

- Introduce chronology to identify the moment in which the predefined solutions appeared or were developed,
- Introduce their range to define the area of application of each solution,
- Identify the level of integral integration of businesses applying the strategies predefined as well as their integration with environment.

This analysis enables the aggregation of production and logistics strategies to demonstrate their consistency in the development of internal and external supply chain. The article concludes with a definition of production and logistics system as an object of modeling in the transformation of business systems manufacturing companies.

Defining a logistics strategy and typology for solution within range of logistics requires mostly identification of place for logistic

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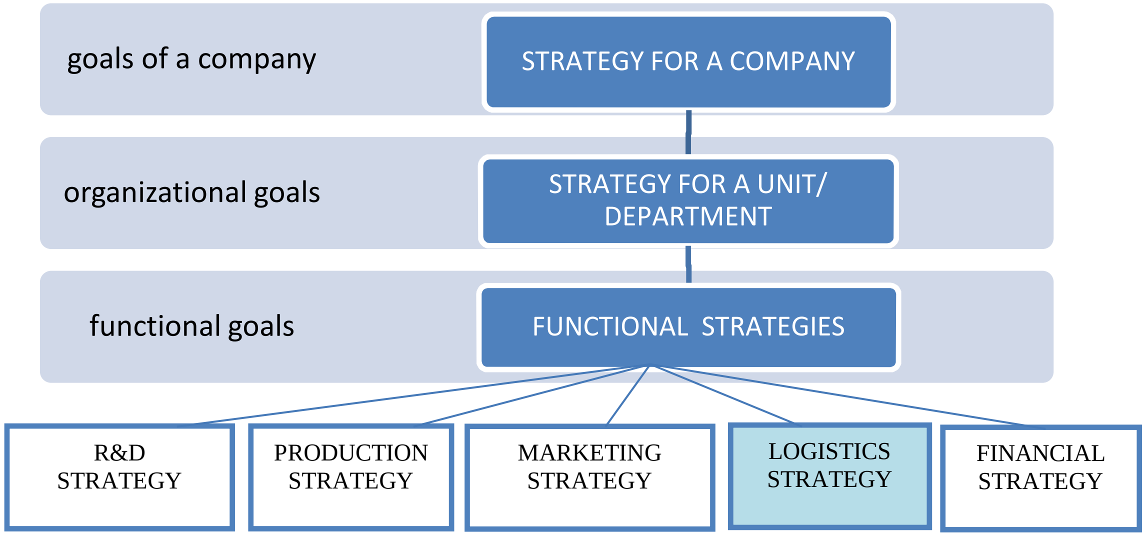
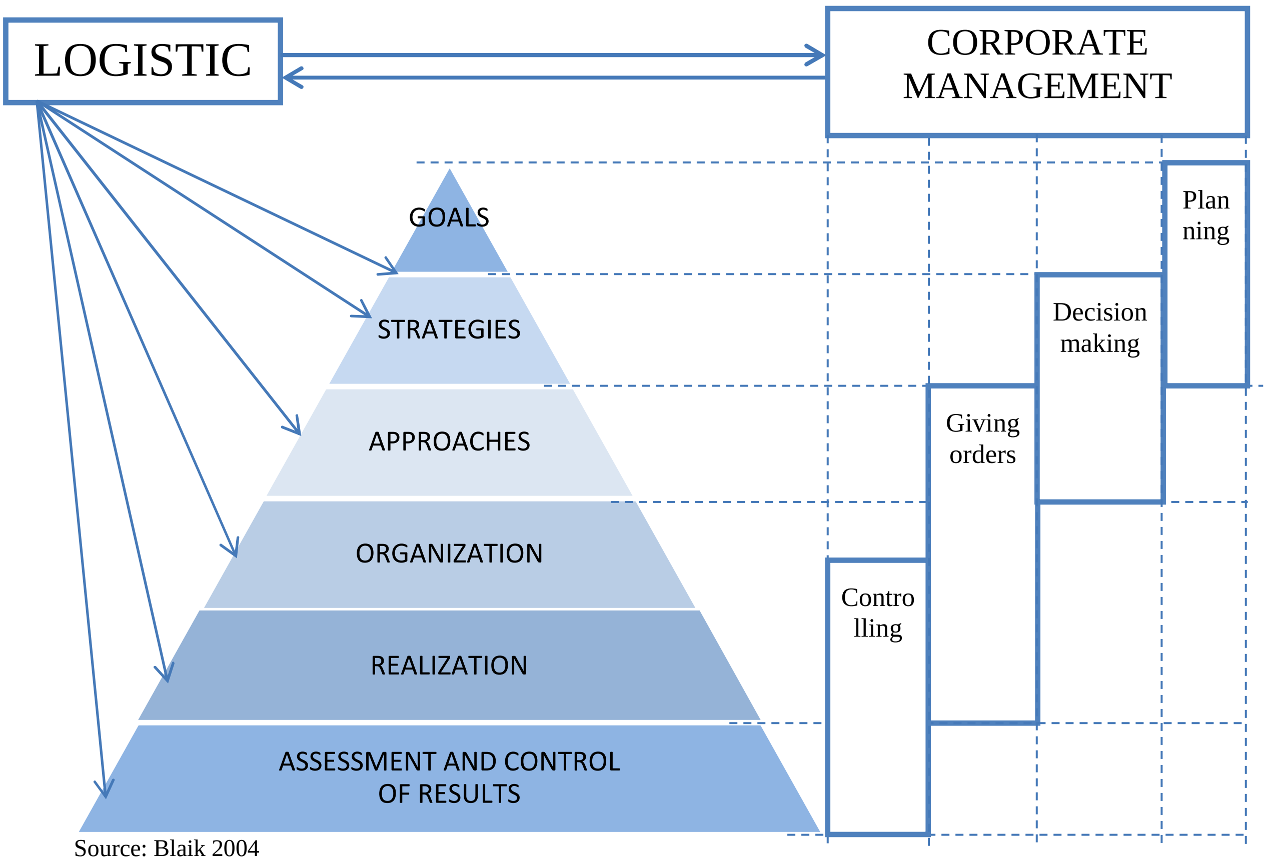
strategy in a company [Słowiński 2008]. Undoubtedly, logistics strategy is a functional solution, subordinated to global corporate strategy. The hierarchy for strategies is introduced in the figure below.



Source: Sołtysik 1996

Fig. 1. Place of logistics strategy in hierarchy of corporate strategies
Rys. 1. Miejsce strategii logistycznej w hierarchii strategii przedsiębiorstwa



Source: Blaik 2004

Fig. 2. Influence of logistics on corporate management
Rys. 2. Wpływ logistyki na zarządzanie przedsiębiorstwem

As a functional solution, logistics strategy is to support realization of global and organizational goals through optimal composition of factors crucial for customer service - i.e. quality, time, flexibility and cost [Śliwczyński 2008]. Thanks to typical for logistics integration of operations, from operational to strategic level with f.ex. keeping the deadline in transport realization a company achieves high level of customer service, influence of this functional area and strategy that defines it on global strategy is substantial [Blaik 2004], which is introduced in figure 2.

Hence, logistic strategy is on one hand a consequence of global corporate goals, on the other it influences the goals, as a performance feedback. Generally, such relation does not refer to entire company, but only to its competences and issues within the area of logistics. According to experts strategic decisions within logistics refer mostly to [Witkowski 1995, Kisperska-Moroń 2002]:

- Definition of customer service standards,
- Identification of number of and location of warehouses, distribution centers and making basic decisions concerning their equipment,
- Developing general principles of inventory management for materials and raw materials necessary to manufacture goods and provide services,
- Identification of a range of logistic services in relations with suppliers and customers and definition of a range of third party services,
- Taking some assumptions concerning IT support.

The issues are of internal character as they determine internal processes of a company (including procurements, production and sales) and of external character as well, as they define links with market environment (suppliers, co-operators, customers). The consequence of the assumption above mentioned is the conclusion that logistics strategies should on one hand refer to internal and external links, on the other however, as solutions on a lower level, offer a variety of methods, techniques and tools providing meeting predefined logistics goals.

TYPOLOGY OF LOGISTIC STRATEGIES

Attempts to systematize the functioning logistics strategies on the market and used in enterprises were undertaken repeatedly, beginning with 60-70 of XX century [Gustaffson 2006]. To build a typology of logistics strategies different criteria were used, from the most general, related to the global strategy, to the detailed, related to the organization of the various logistic subsystems.

Currently, the research is being conducted to identify trends and phenomena that affect the shape of logistics, as well as logistics and manufacturing systems strategy. The importance of logistics for companies is what makes such identification crucial, both from the point of view of practitioners, employees of enterprises, in which logistics and production processes are implemented, and scientists and researchers whose interests are related to those areas. Hence the initiatives striving for definition of state of the art both for knowledge and practice within the areas, among which BVL report is focused on trends and logistic strategies in supply chains. Report developed on the basis of 1757 surveys, confronted to 60 interviews with top managers of companies from all over the world, representing various industries [Handfield et al. 2013]. According to the report, the most often mentioned trends include [Handfield et al. 2013]:

- Customers' expectations,
- Networked economy,
- Pressure on costs,
- Globalization,
- Lack of experts,
- Volatility of markets,
- Sustainable development,
- Growing risk,
- Technology development,

with their relative importance varying over time. This variety of factors makes the company grapple not only with classical, related to costs and efficiency issues but also

take into account environmental issues, innovation, risk-sharing and many others, often associated with conflicting objectives. The logistics goals the most frequently mentioned by managers, in turn, include the following [Handfield et al. 2013]:
- Meeting customers' requirements,
- On-time deliveries,
- Green logistics,
- Delivery cycle,
- Innovation,
- CSR,
- Logistics costs,
- Logistics quality,
- Scheduling flexibility.

The way of the goals realization is a logistic strategy of a company. According to the logic developed, on the general level there are the following approaches identified, either basing on cost minimization, either on service differentiation [Penc 1996, Kisperska-Moroń 2002]:
- Substitution strategy, referring to general strategies of cost-leadership,
- Complementarity strategies, referring to strategies of differentiation and concentration.

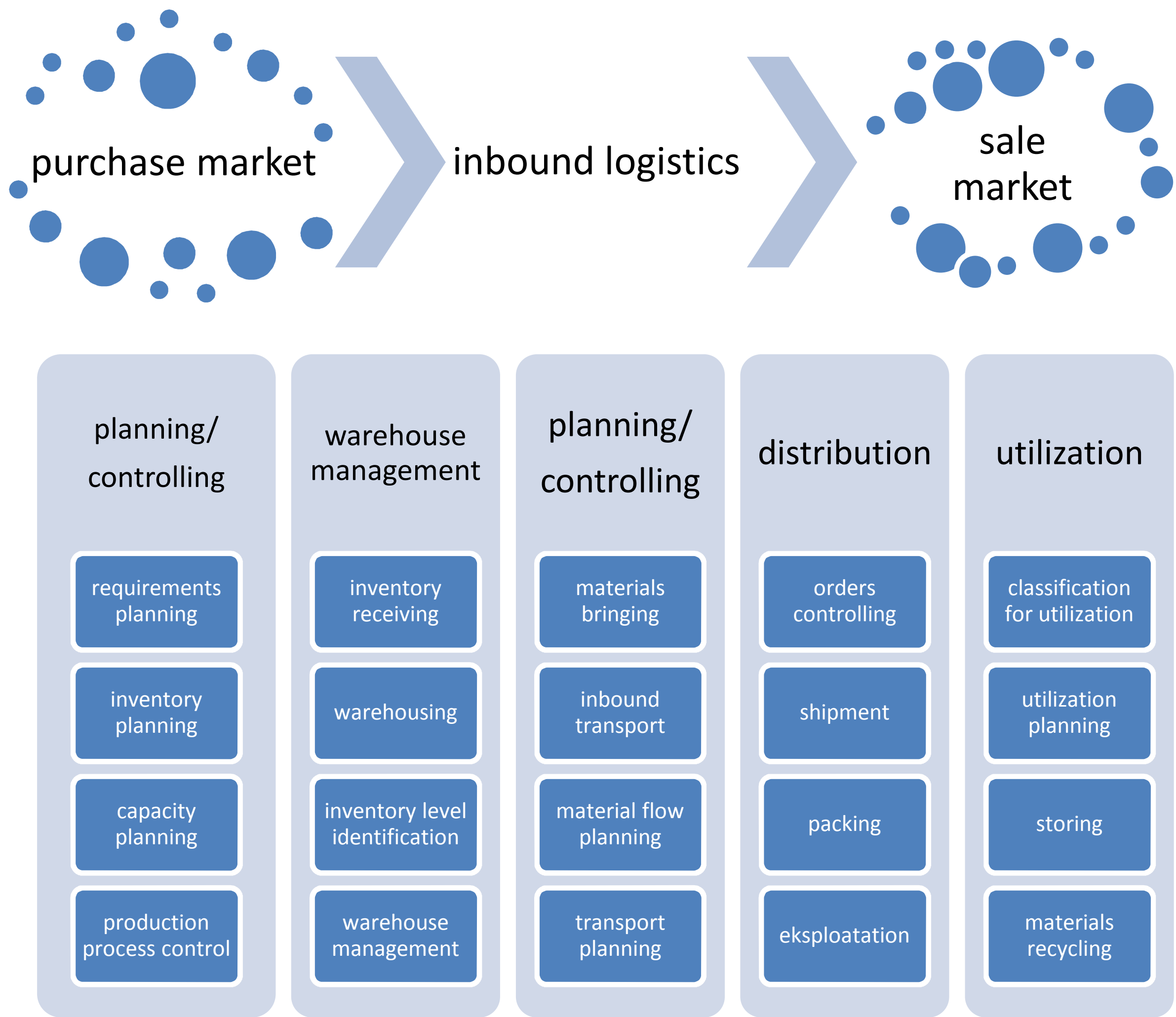
Similar conclusion and approach is presented in the works of [Bourlakis and Bourlakis 2001], [Fine and Hax 1985], [Towill and Christopher 2002].

Furthermore, the following solutions are identified in the predefined functional areas of the company [Witkowski 1995]:
- Strategy of differentiated distribution - not all products should be provided with the same level of service market. Different customers require different characteristics of the product and the various forms of sales, for example, large customers can be supplied directly by smaller regional distribution centers and small retail networks;
- strategy of rationalization - a company offers numerous kinds of products to various customers, bearing various kinds of costs. However the principle "Let's sell everything (we are able to manufacture) to anyone (willing to buy it)" should not be applied. Repeated analysis of assortment, customers and costs is required to provide knowledge on costs and profits generated by customers and companies (Pareto rule 80/20 can be of great help here);
- consolidation strategy - combining actions to achieve return-to-scale effect, f.ex. in transportation area it is recommended to combine loads to benefit from decreased unit costs. In a warehouse consolidation of inventory enables decrease in a number of warehouses, providing ability to achieve the same customer service level at a lower level of inventory;
- delay strategy -- delaying the final shape of the product to one of the last stages in the production and distribution process, or delaying changes in the location of inventory, for example, if the manufacturer of cookers moves painting process from the factory to the distribution center, it can reduce inventories. Then, he can better customize the colors to the signals coming from the stores in a given market.
- Mixed strategy - combination of assumptions taken from various strategies.

Although pure strategies allow for economies of scale and are cheap in governance, mixed strategies often produce better results in the area of cost [Słowiński 2008].

Efficiency of the solution applied depends on meeting the following two conditions:
- Logistic strategy should be consistent with other functional strategies and altogether they should create optimal combination of operations in a company,
- Logistics strategy should embrace the entire range of company's activity, including:
  - Procurement area,
  - Production area,
  - Goods distribution area,
  - Recycling, remanufacturing, utilization areas,
  - Storing processes,
  - Transport processes,

and harmonize them all in logistic aspects as it is introduced in the figure 3 [Witkowski 1995].



Source: Witkowski 1995

Fig. 3. Range of corporate logistic strategy
Rys. 3. Zakres strategii logistycznej przedsiębiorstwa

Typology of logistics strategies can also rely on the approach of their users. Bowersox and Daugherty (1987) applied this approach, using in their research American manufacturing companies (from Fortune 500 list) benefiting from logistics strategy based on process orientation, market orientation and information orientation. In turn, McGinnis and Kohn (1990) in their study also based on an analysis of U.S. companies have identified four categories of logistics strategies depending on the size and intensity of integration and coordination of logistics activities (internal and external), later (1993, 2000) identifying three main categories of strategy (intense, balanced and distributed). Kohn et al. (1990) made the analysis on the same market and identified the following factors determining strategy: customer service, integration of IT market, coordination and efficiency, which led them to the conclusion that logistic strategies differ substantially on account of global strategy and environment characteristics. Other authors for their typologies employ market-focused characteristics, such as product value [Cooper 1993], assuming that products of high value are delivered to customers directly, while for those representing lower value distribution systems are built, hence empirical research offer numerous, though sometimes consistent approaches.

In literature there is also an approach present, in which the functional logistics strategy is a method or set of methods used to achieve a particular purpose. In this perspective, logistical strategies are ways of dealing with the construction and operation of the logistics system. They provide model solutions in planning the movement of materials, conducting distribution, forming relationships with suppliers and customers. They are specific procedures for the operation characterized with certain principles of implementation and evaluation. Under this utilitarian approach the following solutions are distinguished [Pfohl 2001, Stachowiak 2010]:

- The classic strategy, based on the creation of inventories and inventory management,
- MRP (Material Requirements Planning) method of material requirements planning , building the strategic approach based on balancing the needs and available resources, and then planning the purchase of supply of the required notice, to achieve the availability of materials and the liquidity of financial resources,
- JIT (Just in Time), a set of methods and techniques based on the flexibility of the available capacity (resulting from its structure, i.e. universal , mutually substitutable resources and time buffers)
- ERP (Enterprise Resources Planning), the extension of MRP for resources across the enterprise, complex and interdependent system of planning and balancing, benefiting from IT support and nowadays functioning as a software package with a defined standard,
- SCM (Supply Chain Management), i.e. strategies that go beyond the organizational framework of the company, including supply chains and networks , configured according to a specific criterion, the efficiency (cost orientation, lean management) or flexibility (customer orientation, agile management).

In this interpretation strategies identified are to be applied either in only one of the areas of logistics, but take into account its surroundings and circumstances, or there are also those that bind all functional areas of a company, and even go beyond, integrating supply chains and networks.

Thus, literature shows differentiated approach to logistics strategies, their typology and classification, and the present study is to provide material forming the basis for publications in the field of logistics, analysis and expertise in this field, as well as the starting point for a discussion of the existing paradigms and potential directions of change.

GENESIS OF LOGISTIC STRATEGIES

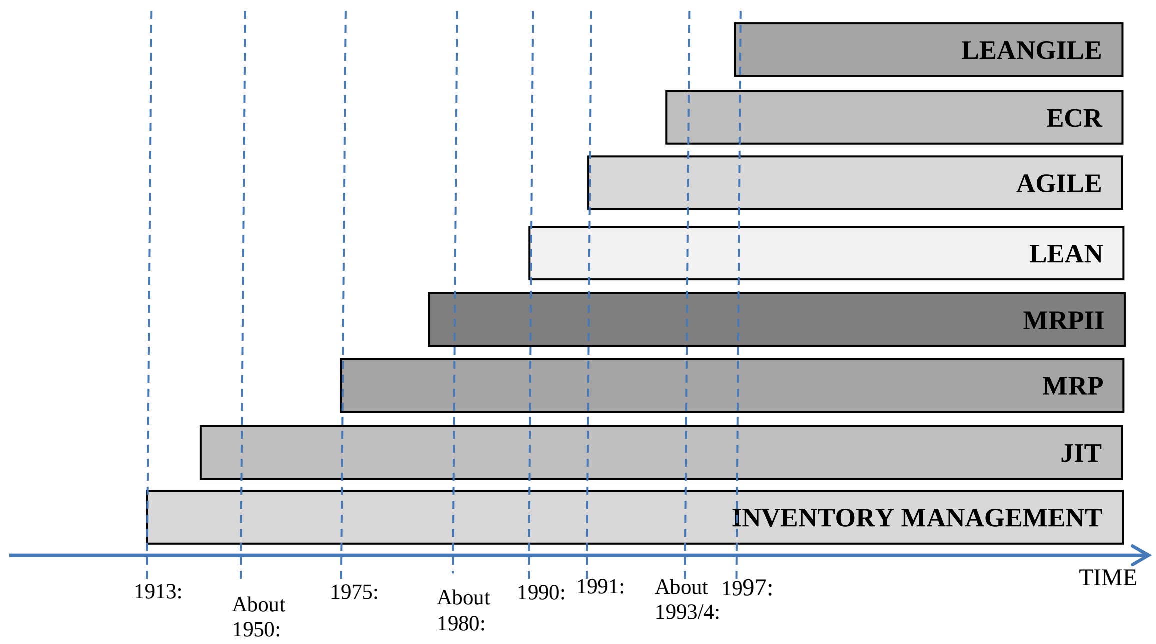
Characteristic of logistics strategies is that since they are defined, developed, they operate continuously in the market and are used by companies, so they do not disappear, but obviously the intensity of their use, represented by the number of implementation in organizations changes. Hence, it is impossible to reduce their use in time identifying the beginnings and the end, only identification of the point at which the solution appeared is possible, however it is sometimes difficult to clearly set a date for the appearance of the individual solutions, because certain approaches have evolved, paradigms, which represented, have changed gradually. Helpful in determining the age of logistics strategies are so called milestones in the development of logistics, usually in the form of projects or publications in which specific formulations, solutions, or terms they were first used. These include breakthroughs, such as:

- Ford's assembly line - solution introduced in 1913 in the Ford plant in Highland Park in the U.S. state of Michigan, has become a point of reference for the methods of mass production around the world, thereby forcing a specific organization of material flow - the creation of buffer inventory to maintain continuity of production [Pfohl 1995],
- Toyota Production System - Japanese solution, inspired by Ford's approach and supplemented by the establishment of eliminating waste policy, producing exactly on time (Just-in-Time), pull system, requiring synchronization of supply [Ohno 1995],
- ECR - Efficient Consumer Response - Effective Customer Service, solution introduced since 1993 (USA) / 1994

(Europe) by ECR Europe, aimed primarily aimed at streamlining and reducing the cost of customer service in the consumer sector by integrating the entire supply chain [Coyle 2002],

and publications:

- Material Requirements Planning, published in 1975 by Joseph Orlicky, the publication presents the essence of the MRP, with principles and guidelines of material requirements planning, approach to procurement, which is the essence of many of today's solutions in this field and an integral part of computer support systems;
- The Machine That Changed the World by James Womack, Daniel Jones and Daniel Roos, published in 1990 by MIT, presents the essence of lean manufacturing (lean production) , recognized as the biggest revolution since the Ford assembly line, forcing the integration of the environment through cooperation and coordination of the supply chain;
- 1991: The 21st Century Manufacturing Enterprise Strategy , developed by Roger Nagel and Rick Dove (Iacocca Institute) in 1991, a report on trends in the modern production and management , primarily customer orientation and flexibility in meeting its expectations and requirements , and customer integration into the flow of materials;
- Leagility : interfacing the lean and agile manufacturing paradigm in the total supply chain , in 1997 , in which the term leagility appears first, coined by J.B. Naylor , M. M. Naim and D. Berry and interpreted as a combination of agile and lean strategies; The term leagility since that time refers to a hybrid solution combining benefits from lean production paradigm and agile organization, coping with dynamic environment.



Source: own study

Fig. 4. Milestones in historical development of logistic strategies
Rys. 4. Kamienie milowe w historii rozwoju strategii logistycznych

Putting these "milestones" and related solutions to the timeline shows when various methods and strategies of logistics appeared, what are the ordinal relations between them (Fig. 4).

In addition to the milestones and key solutions for logistics strategies which these events initiated, in the diagram, there is also a solution which is an extension of a pre-existing one (MRP II - operating since the 80s of the twentieth century.) The continuity of the existence and use of the various solutions shows that none of them have been abandoned, although subjected to modifications and updates, moreover each solution introduced: a strategy or method enriched currently available composition of functional logistics strategies.

CHARACTERISTICS OF IDENTIFIED LOGISTIC STRATEGIES

Today, companies benefit from the whole spectrum of functional solutions within the logistics strategies, choosing them according to the global organizational goal, structure or expected results. The main differences in the above categories are presented in the table below.

The criteria taken into account in the table below are the purpose for which the solution has been developed, methods and tools used and the expected effects and consequences of, and generally scratched range. The method requires that the following conditions are met: planned selection and arrangement of the component activities united by a common goal, conscious and systematic in their use, the generality of the development allows for repeat steps whenever the need arises, the complexity of their activities. The term tool can be considered in two ways: a given method (or technique) can be used as a tool within the other, more complex methods, the method can be understood as a tool because of its simplicity and wide range of applications. Frequently used in the following classification: tool: the method easy to use and used in a wide range of methods in the context of more complex and while the band techniques: methods of teamwork and idea generation methods: methods that use complex tools and techniques. This table allows identification of the most important characteristics of the selected solutions - methods identified as functional logistics strategies.

Table 1. Comparison of logistic strategies
Tabela 1. Porównanie strategii logistycznych

Method/ logistics strategy	**Goal**	**Methods**	**Tools**	**Results**	**Range**
Classic strategy	Continuity of production, minimization of procurement costs, high customer service level	Creating inventory in various stages of material flow	Economic lot size, safety inventory, forecasting	Inventory distribution, capital freezing, high customer service level	A company
Material Requirements Planning (MRP)	Inventory reduction, Delivery cycle reduction	Material requirements planning, scheduling	Requirements scheduling, lot-sizing	Coordination of material requirements within dependent demand, cost reduction	A company
Manufacturing Resources Planning (MRPII)	Integration, improved efficiency	Internal integration, improved efficiency	Capacity balancing	Improved efficiency of functioning of a production system	A company
Just – in - time (JIT)	Waste elimination (time and inventory), efficiency increase,	Efficiency increase, waste elimination	TPS[1], rolling forecasting[2], kanban[3], time windows for deliveries, waste elimination (time and inventory)	Deliveries in time, team-work, cost decrease	A company

Method/ logistics strategy	Goal	Methods	Tools	Results	Range
Efficient Customer Response (ECR)	Increased efficiency of customer service, delivery time compression	Improved efficiency of material and information flows	QR[4], EDI[5], VMI[6]	Improved communication, decreased inventory level in a supply chain	A supply chain
Lean Management	Cost decrease, waste elimination	Focusing on core competencies, leaning processes	VSM[7], JIT, Open Book Management[8] and others applicable in Lean approach for supply chains[9]	Costs reduction, synchronization of material flows with demand,	A supply chain
Agile Management	Response to turbulent demand, meeting customers' requirements	Selection of resources and competencies of employees enabling them realization of processes according to customer requirements, modularization	QR, customization[10], modularization, agile intermodal transport in supply chains, EDI, tracking and tracing	Ability to meet various demands of customers	A supply chain
Leangile Management	Response to turbulent demand, cost decrease	Delayed response to market needs with proper location of decoupling point, modularization	QR, customization, proper location of decoupling point	Ability to meet various demands of customers at lower costs	A supply chain

Source: own work

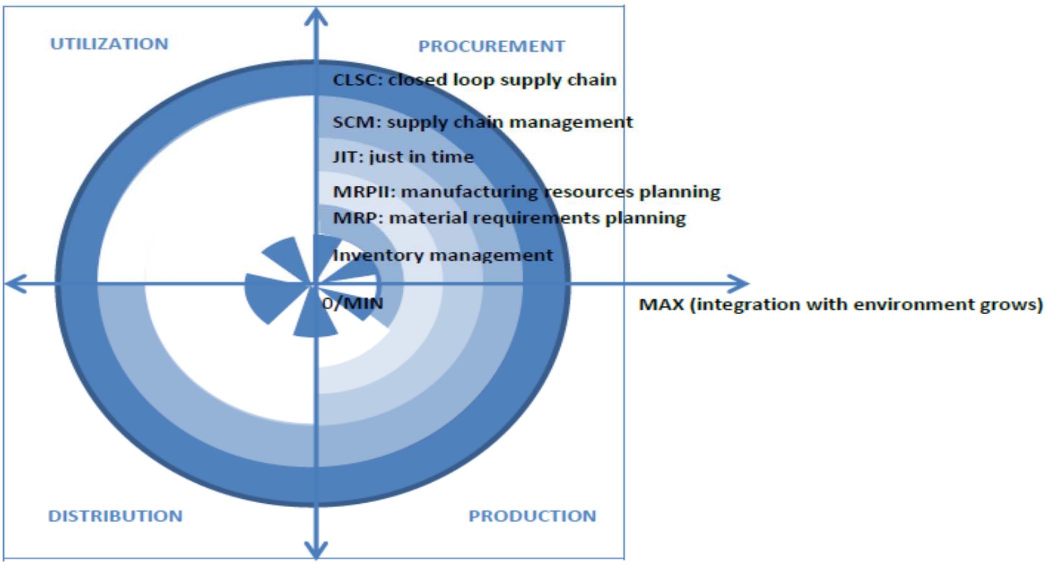
1) Toyota Production System [Ohno 1995]
2) Rolling forecasting is systematically repeated, realistic anticipation of events, achievements and conditions of enterprise functioning in a given time horizon [Pawlak 2012]
3) Kanban - Kanban is a system to control the logistical chain from a production point of view, and is not an inventory control system. Kanban was developed by Taiichi Ohno, at Toyota, to find a system to improve and maintain a high level of production. Kanban is one method through which JIT is achieved [Ohno 1988] [Durlik 1996]
4) Quick Response, QR, strategy according to which sellers and buyers cooperate to respond to customers demand as fast as possible [ECRPolska]
5) Electronic Data Interchange, EDI, exchange of data in a standard format between IT systems of commercial partners at minimum human intervention [ECRPolska]
6) Vendor Managed Inventory, VMI Suppliers monitor inventory level in a warehouse of their customers basing on sales forecasts and sales data, maintaining and developing availability of products in supply chains [ECRPolska]
7) Value Stream Mapping, The process of defining value added to a product when it is being manufactured go. Mapping is based on going upstream, from the end to the beginning and presenting both material and information flows. It is also important to include the following information on needs, requirements and processes themselves with use of the parameters such as: C/T, C/O (changeover time), EPEI (every part every interval), available time, number of operators, etc. [lean-management.pl]
8) Open Book Management, approach in which it is necessary to provide employees with information enabling understanding of enterprise functioning, the term coined by Case in [Case 1995]
9) The reader will find more in: [Womack 90]
100 Customization is adjusting an element of marketing mix (price, product, place or promotion) to individual needs of customers [Newell 1997]

APPLICATION RANGE FOR PREDEFINED STRATEGIES

The strategies and solutions in their field differ with functional scope, the scale of influencing both the company and the surroundings. It may be noted that as the introduction of new solutions in the field of logistics strategies (presented in the previous section), i.e.:

– Inventory management,
– JIT,
– MRP,
– MRPII,
– SCM - Supply Chain Management, INCLUDING Agile, Lean, ECR, Leagile,

Progressed, their territorial scope increases, from the methods that apply to only selected areas of the enterprise, to the approaches integrating the entire supply chains or networks. The following figure shows the functional scope of the solutions used in the logistics strategies broken down into the following areas: supply, production, distribution and utilization. To take into account the increasingly important area of utilization, strategies list also includes closed-loop supply (Closed Loop Supply Chain), incorporating to the classic supply chain, ending on the client and its service also an area utilization and processing (Remanufacturing) of exploited products.



Source: own study

Fig. 5. Range of application of logistic strategies
Rys. 5. Zakres stosowania strategii logistycznych

On the one hand, this approach has ecological orientation (reducing the amount of waste), on the other economic (saving resources), which makes it a sustainable strategy (based on the idea of sustainable development), also allowing to maintain continuity of contact with the client (the reader will find more in Krikke 2004 and 2005) (Fig. 5).

An additional dimension included on this chart is the degree of integration with the market, indicating a trend - the newest solution, the more it goes beyond the boundaries of the organization and strives to create chains, networks and supply loop. Hence, the idea of the figure is to show areas of application of predefined solutions (whether they are applicable in procurement, production, distribution or utilization area - or they go beyond one functional range striving for internal integration) and in the same time consider the level of external integration, with market environment (customers, supply chain partners and other stakeholders). The conclusion is, that the newer the solution, the broader its range (though inventory management refers to all the functional areas, it does not strive for integration, quite opposite, dispersion of inventories is recommended) and stronger integration with market environment. It is also important to take into consideration the fact that all of these solutions mentioned relate to the production area and the procurement area as well. Since in the area of production, logistics tasks, similar to the production strategies, include planning, coordinating and controlling the flow of materials to achieve specific system parameters - speed, economy of movement, continuity of material flows.

PRODUCTION STRATEGIES

Comparison of classical production strategy, MRPII [Heizer and Render 2007], Lean Production System [Womack et al. 1990] and a system based on Theory of Constraints [Schrangeheim et al 1990] reveals fundamental differences in the planning and organization of production flow in these concepts [Hadaś et al. 2010]. Also the QRM strategy (Quick Response Manufacturing) [Suri et al. 2010], despite its relations to ECR and Lean shows important differences compared to the generic solutions. The differences between the various strategies found in the following issues (check the Table 2.):

- implementation of the core planning activities,
- organization and material flow management,
- organization of production and the selection of the product portfolio,
- buffering mode of variability in demand and process disturbances.

Table 2. Production strategies and planning methods
Tabela 2. Przegląd strategii produkcyjnych i metod planowania

Production strategies / **Category**	**Classic**	**MRP/ MRPII**	**LEAN Production**	**TOC (DBR Solution)**	**QR Manufacturing**
	Realization of basic planning actions				
Basic planning actions	Inventory replenishment	Capacity balancing	Capacity balancing	Flow balancing	Quick paths identification
Management centralization and decentralization	Global planning on product level. Inventory decentralization	Planning centralization. Inventory centralization in a decoupling point	Flow control decentralization (local control loops).	Planning focused on bottlenecks. Flow decentralization according to FIFO	Planning centralization. Flow control decentralization according to availability of production unit
	Material flow organization and management				
Flow type	Push	Push	Pull (Kanban)	Hybrid push/pull	POLCA
Flow initiation	On input	On input	On output	According to constraints	On the level of production unit
Operations order	Priorities	According to schedule	FIFO	FIFO + schedule for critical resources	Priorities
Accepted level of flow complexity	Average	High	Small	Average to high	Small
	Organization of manufacturing units and portfolio identification				
Production form	Continuous flow (tact based) or non-continuous flow	Continuous flow (tact based) or non-continuous flow	Continuous flow (tact based)	Continuous flow (tact based) or non-continuous flow	Continuous flow (tact based)
Workshop re-organization (layout)	Not required (varied flow)	Not required (varied flow)	Required (product orientation)	Not required (varied flow accepted)	Recommended (product orientation)
Assortment portfolio	High complexity, wide assortment and variety	High complexity , wide assortment and variety	Standardized products	Complexity accepted	Lots of options, low variety of assortment
IT suport for planning	Not required	Required (MRPII)	Not required	Not required	MRPII at planning level. Flow without IT support
	Demand variety and disturbances buffering				
Buffering	Inventory buffers (buffers between stages and workstations)	Time buffers for process stages execution and inventory buffers in decoupling points	Difference: Tact time and operation cycle	Extra capacity and time in non-critical and key resources, buffers between stages	Capacity inventories

Source: own study

The traditional production strategy is based on the paradigm of the economics of scale where the lot size is subject to economic evaluation and the number of changeovers is minimized. Large production runs generate long cycles and hence high WIP inventories, as well as inventory of finished products. Inventory cache interference in the production process but the flow is in large batches and most of the time is waiting for the treatment (so-called batch and queue system). The strategy is based on identifying the location of the inventory in the system of production and logistics, optimization of their size and in consequence inventory replenishment. Hence, inventory is decentralized.

The MRPII strategy is a strategy of gradual planning and development of the idea of Material Requirement Planning (MRP I). The main idea is to combine independent demand (for finished goods) with the demand for components (dependent demand). The basic planning operation consists in the calculation of the material requirements and balancing production capacity at the levels of the product and components. Calculation of material requirements based on the structure of the product (called the Bill of Material) allows to limit the inventory at various levels of complexity of the product (by replacing the buffer time) and its concentration in the logistic decoupling point. At the same logistical point of separation (also called the order penetration point) can be positioned depending on the adopted strategy within customer service area, among others, in the warehouse of finished products, semi-finished products or raw materials.

The Lean Production strategy organizes the flow of material flows in order to achieve its continuity without queues and waiting for treatment [Liker et al. 2003]. In contrast to the traditional system, changeover is not the action avoided, but steps should be taken to minimize changeover duration by implementing well-known practices (SMED - Single Minute Exchange of Die or Single Minute Exchange or Die). The priority is to focus efforts on the elimination of waste (muda) [Ohno 1995], the most obvious manifestation is the accumulation of surplus inventory. In the lean system there are already steps taken at the design stage, which aim to balance the potential of the individual segments and make them productive machines. For this reason, the strategy requires the reorganization of the production unit (secretion of value streams and serving them specialized units responsible). The flow is more intense (without waiting for treatment), but the basis for the secretion of production units is the similarity of operations and range, and consequently its limited diversity.

Planning and control system based on TOC (Theory of Constraints) assumes batch variability with a general tendency to reduce them. Changeover process for machines is not treated as waste of time unless they relate to critical resources. Changeover of a critical resource is subject to strict limiting according to the assumption that inactivity of a critical resource is irreparable loss to the entire enterprise [Goldratt 1984]. The basic planning action is to balance the flow in order to maintain continuity of the bottleneck's identified work and control of the level of work in progress. Planning tool coordinate the flow with a critical resource is Drum - Buffer - Rope mechanism [Gardiner 1993].

Strategy for Quick Response Manufacturing (QRM) focuses its attention on shortening the total time of the contract (called Cumulate Lead Time) [Suri et al. 1998]. In the supply chain, the key is to provide the efficient flow of information from the customer to the supplier. On the other hand, on the level of production units this objective is realized by determination of the critical paths of orders (Manufacturing Critical-path Time - MCT), based on the standard critical path method (CPM). QRM strategy in many aspects is based on Lean Production, as its enrichment towards the direction of extension of the assortment and quantity of flexibility in terms of covering the demand. An example of such an extension is orientation of production units known from lean approach (Cellular Manufacturing) towards selected profitable market segments (Focused Target Market Segment - FTMS).

Further differences between production strategies can be found in the field of organization and management of material flows. According to the classic strategy material flow is initiated at the input to the system by issuing the material to the first workstation. Flow through next workstations is performed with push logic via the system until the final operation is completed. Such an organization of the flow is the reason for the large inertia of the system to the variability of assortment and low resistance to interference, which generate an increase in inventories of work in progress. In the Lean Strategy flow is initiated at the last station and then by using kanban passed further up the value stream. "TOC" Strategy in terms of flow control is, however, a specific combination of "push" and "pull" logics [Hadaś et al. 2007]. Bottleneck operation is scheduled (so called drum) and the release of the material to production is initiated with a "pull" logic (so-called "rope" in a drum - buffer - rope method). On the other hand, the flow to specific workstation which are not "bottlenecks" is implemented by "push" logic according to the FIFO priority. QRM strategy controls the flow of materials with the mechanism which is an adaptation of a kanban tool. As used herein, the tool POLCA (Paired - cell Overlapping Loops of Cards with Authorization) [Krishnamurthy et al. 2009] implements the "pull" logic allowing to control work in progress . The main difference is that the signal to the flow realization is not the need for material like in kanban, but spare capacity of the production unit.

Due to the volume of the article the authors did not characterize all categories of analysis of production strategies distinguished here, instead focusing on the features associated with material flows the most.

CONSOLIDATION OF PRODUCTION AND LOGISTIC STRATEGIES ACCORDING TO ORIENTATION TO MULTI-VARIANT CUSTOMER SERVICE

Relationships between production and logistics are traditionally very strong. In the classical approach in the case of internal material flow they are associated with the logistic support of the production floor. On the other hand, in the case of external supply chains it is related to the logistics supplies of parts and raw materials, and distribution of finished products. Contemporary business process orientation on customer service has brought another aspect of closer links between the production and logistics. Logistics orientation of the production process at the time and level of customer service has a direct impact on strategies for planning and controlling the flow of material. Particularly strong similarities (between logistics system and production) should be present in the areas of planning [Fertsch 2010]. In turn, choice of logistics strategy and specific solutions adopted in the framework of the model of logistic system is derived from the organization of the flow of materials in the area. Today, logistics is the task of synchronizing the flow of goods in the manufacturing systems with their entry to and exit from the enterprise to create the best conditions for efficient production planning and controlling [Fertsch 2009].

In the table below (see Table 4), the authors make attempts to consolidate selected strategies for production and logistics according to multi-variant orientation on customer service. With other words these are actions taken to provide internal coherence of a group or a structure and to reinforce it, as well as the result state of the actions - integration.[Bralczyk 2005].

Table 3. Consolidation of production and logistics strategies according to orientation on multi-variant customer service
Tabela 3. Konsolidacja strategii produkcyjnych i logistycznych wg. orientacji na wielowariantową obsługę klienta

Category / **Strategy**	**Planning** (on the level of products and parts)	**Controlling** (of material flows)	**Coordinating** (subject range in supply chains	**Customer-orientation** (focus on internal and external customers)	**Results measurement** (key measures and indicators)
Classic	Independent planning of inventories level for final products, parts and components, based on forecasted use (demand)	Decentralized inventory control Lots released based on economics (WIP vs. changeover sequence)	Inventories replenishment on various levels of value stream (aggregation of safety inventory for various needs and inventory localizations)	Make to inventory (MTS) at predefined service level. Inventory replenishment in supply chain (push) – availability providing (on hand)	- Customer service level - Inventory rotation - Work load for machines and employees

Category **Strategy**	**Planning** (on the level of products and parts)	**Controlling** (of material flows)	**Coordinating** (subject range in supply chains	**Customer-orientation** (focus on internal and external customers)	**Results measurement** (key measures and indicators)
MRP/ MRPII	Production planning based on orders and forecasts. Calculation of requirements for parts and components. Closed loop balancing. Potentially increased functions of planning – APS Advance Planning and Scheduling) [1]	Control on the level of parts scheduling and priorities for lots releasing, potentially increased with tracing the flow on a shop floor – MES Manufacturing Execution System	Coordination of supplies with supplies schedules. Coordination of distribution with DRPII (Distribution Resource Planning)[2]	Production according to decoupling point (order penetration point) dependent on lead time accepted by customers (CTLT – Customer Tolerance Lead Time)	- Orders on time - Conformity of schedules and their realization
LEAN /JIT	Leveling of production plan according to typical order sequences and capacity of a plant identified with a unit rhythm	Local control loops (kanban), optimization with assortment selection to value chain	Production plan forecasts (Rolling forecasting) distributed within supply chain Deliveries coordination with JIT and JIS (Just in Sequence)	Customer service buffering with inventories, replenishment in supply chain with pull logic	- Cost - Lead Time - Value added
TOC /Continuous replenishment (TOC distribution solution)	Bottlenecks load planning at final products level. Machine load planning with respect to continuity of bottleneck work (max. use)	Non-critical resources subordinated to bottleneck work pace Flow according to FIFO with monitored use of bottleneck buffer	Coordination with Drum-Buffer-Rope mechanism at the level of an enterprise. Replenishment at the level of a supply chain (Traffic Light Analogy)[3]	Customer service buffering with inventory and/or time. Inter-stage buffers dependent on complexity of material flows (VAT - Analysis) [4]	- Throughput - Inventory - Operating Expense (TOC Accounting)
ECR/QRM	Planning based on demand forecasts and orders coming from supply chain. ERP planning for final products level	Local control loops (POLCA). Optimization with resources use and Lead Time reduction	Efficient flow of information in a supply chain. Coordination of tasks with information on actual demand (flow in a value stream).	Orientation of profit bringing customers groups and providing them with fast reaction time or high service level (inventory availability)	- Complete lead time - Customer service level - Orders on time - Inventory rotation - Key resources utilization
Agile	Planning on the level of product families and modules with use of increased ERP functionalities. Project planning for new products according to (Scrum)[5] - *Release Burndown* methodology	Production streams flow planning (Sprint Planning), selecting tasks of highest priorities (Flexible resources use)	Agile logistics – logistics coordinates manufacturing and supplies within supply chain creating - *Coupled Dynamic System*	Customer service buffering with inventories or quick response to requirements Dynamic flow and resources management	Indicators defining multi-dimensional ability to change and cost of change: - FAI (Fuzzy Agiity Index)[6] -Due-date performance -Difficulty of adhe-ring to schedule of production - Capacity Utilization - (Cost of Excess capacity) - % of order delivered according to plan - Supply chain response time. - Cash-to-cash cycle time

Source: own study

1) APS - Advance Planning and Scheduling - a class of advanced IT systems which are based on ERP standard but increased with opportunity of complex planning, simulation and optimization [APICS 2008]

2) DRPII - Distribution Resource Planning - DRP increased with planning requirements to crucial resources in supply chains, i.e. warehouse space, means of transport etc. [APICS 2008]

3) Traffic Light Analogy the technique for inventory level monitoring with use of three buffer zones. Check the practical example in: [Cyplik, Hadaś, 2012]

4) VAT - Analysis is the method of classification of enterprises with material flows topography. Check the practical example in: [Hadaś , Cyplik, 2013]

5) Measures used in agile project management (Scrum)

6) Expert assessment based index developed in [Lin 2003]and applied with some changes in [Stachowiak 2004]

The analysis of production and logistics strategy has enabled their aggregation in order to demonstrate their consistency in the development of internal and external supply chain. Undoubtedly the principal platform for aggregation manufacturing and logistics strategies is the approach to manage the flow of material streams i.e. its organization, planning, and control.

DEFINITION OF PRODUCTION AND LOGISTICS SYSTEM

On the basis of the above considerations, the authors of the article formulated definition of production and logistics system as an object of modeling in the transformation of business systems of manufacturing companies.

Production system can be defined as by Eversheim (1992) as an "independent allocation of potential and resource factors for production purpose", which in addition to the elements of the technical production process, also includes organizational elements for the planning and controlling of the production process. Accordingly, it has a specific system organization that creates specific links between the elements of a production system in order to achieve the optimal factors combinations to complete the task [Kern 1980].

A production system comprises a number of elements between which there are reciprocal relations. Commonly mentioned elements are premises, humans, machines, and equipment [Löfgren 1983]. Software and procedures might be added to the listed system elements according to [Chapanis 1996]. A structural perspective of a production system can be used to describe the different system elements and their relations.

Logistics activities in manufacturing companies can be divided into three fields: procurement logistics (in-bound), production logistics (in-plant) and distribution logistics (out-bound) [Baudin 2004].

The activities of production logistics are from dock to dock, meaning all activities from the receipt of goods to the dispatch. Its main purpose is to offer an efficient logistical support for production through material planning, i.e. planning, execution and control of material flows [Bullinger et al. 1994].

Hence, efficient production logistics secures minimal inventory levels, short lead times, high flexibility of production and consistent (internal) customer orientation. Synchronization, flow and tact orientation, as well as the consideration of customer needs, are key requirements for eliminating wastes in form of excess inventory or waiting times due to material shortages [Droste et al. 2012].

Based on presented in this article deliberations the authors assume that production-logistics system is constructed as a set of elements of a production system, composed of premises, humans, machines, and equipment, software, procedures and the decision-making process, linked by mutual interrelations with a view to executing a logistics strategy.

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SYSTEM PRODUKCYJNO-LOGISTYCZNY W KONTEKŚCIE STRATEGII PLANOWANIA I STEROWANIA PRODUKCJĄ ORAZ LOGISTYCZNEJ OBSŁUGI KLIENTA

STRESZCZENIE. **Wstęp:** Autorzy dokonali wielowymiarowego przeglądu strategii produkcyjnych i logistycznych w celu wykazania ich spójności w kształtowaniu wewnętrznego i zewnętrznego łańcucha dostaw. Artykuł kończy sformułowanie definicji systemu produkcyjno-logistycznego jako obiektu modelowania w transformacji systemów biznesowych przedsiębiorstw produkcyjnych.

Metody: Artykuł oparto o analizę literaturową strategii produkcyjnych oraz logistycznych. Przeanalizowano wybrane kluczowe publikacje związane z genezą powstania strategii oraz podstawowych założeń ich funkcjonowania. Syntezę porównawczą strategii logistycznych i produkcyjnych dokonano na podstawie doświadczeń autorów w kwestii zastosowania wybranych narzędzi i metod charakterystycznych dla omawianych strategii.
Wyniki: Rezultatem prac jest konsolidacja strategii produkcyjnych i logistycznych zgodnie z orientacją na wielowariantową obsługę klienta oraz autorska definicja systemu produkcyjno-logistycznego.
Wnioski: System produkcyjny i system logistyczny można traktować jako równorzędne elementy w kontekście zarządzania przepływem strumieni materiałowych w wewnętrznych i zewnętrznych łańcuchach dostaw. Tak określone podejście pozwala modelować oba systemy jako spójne elementy realizujące wybraną strategię obsługi klienta.

Słowa kluczowe: MRP, Lean, TOC, Agile, ECR, Quick Response, SCM, system produkcyjny, system logistyczny

STRATEGIEN FÜR PRODUKTIONSPLANUNG UND -STEUERUNG UND FÜR DIE LOGISTISCHE BEDIENUNG DER KUNDEN

ZUSAMMENFASSUNG. Einleitung: Die Autoren haben eine multidimensionale Übersicht von Strategien für die Produktionsplanung und -steuerung zwecks Ermittlung deren Zusammenhangs bei der Ausgestaltung der inneren und äußeren Lieferkette vorgenommen. Der Artikel wird mit Formulierung einer Definition des produktionslogistischen Systems als eines bei der Transformation von Business-Systemen in Produktionsunternehmen wirksamen Modellierungsobjektes abgerundet.
Methoden: Die Forschung stützte man auf die Literaturrecherche im Bereich der Planungs- und Steuerungsstrategien in der Produktion. Die im Zusammenhang mit der Genese der Entstehung von Strategien und der Grundlagen ihrer Funktionsausübung stehenden Schlüsselveröffentlichungen wurden einer tiefeingehenden Analyse unterzogen. Die betreffende Vergleichsanalyse von logistischen und Produktionsstrategien wurde auf Grund von Erfahrungen der Autoren in Bezug auf die von ihnen in Anspruch genommenen Werkzeuge und auf die ausgewählten, charakteristischen für die betreffenden Strategien Methoden ermittelt.
Ergebnisse: Das Resultat der Arbeit besteht in der Konsolidierung der logistischen und Produktionsstrategien gemäß der Orientierung auf variantenreiche Kundenbedienung und der durch die Autoren ausgearbeiteten Definition des produktionslogistischen Systems.
Fazit: Produktionssysteme und logistische Systeme kann man als gleichwertige Elemente im Kontext des Managements von Materialflüssen innerhalb der inneren und äußeren Lieferketten behandeln. Das so ermittelte Herangehen an die Thematik lässt die beiden Systeme als die zusammenhängenden und die die ausgewählte Strategie des Kundenservices realisierenden Elemente modellieren.

Codewörter: MRP, Lean, TOC, Agile, ECR, Quick Response, SCM, Produktionssystem, logistisches System

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FOOD QUALITY AND SAFETY MANAGEMENT

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ABSTRACT. Ensuring quality and safety of food are nowadays the most important goals set by companies who produce and distribute it. As a result, regulations have been introduced in the European Union countries concerning the production and distribution of food as well as norms which oblige companies to implement and execute several quality management systems..

Key words: food quality, food safety, GHP, GMP, HACCP system, ISO 22000, BRC, IFS.

INTRODUCTION

The strive to ensure the safety of food has particularly intensified in the recent years. Its effect is not only technical development in the area of food production, but most importantly working out a new, systematic approach to the issue. Quality and health safety of food have become an aim whose achieving requires the commitment and high awareness of all the entities which belong to the food production chain. Simultaneously, it is necessary to determine clear rules and guidelines which set certain standards in that area. Its proper functioning should contribute to creating a consumer-friendly food product market and, in further perspective, to the improvement of the whole population's health level.

FOOD QUALITY AND SAFETY - TERMS/DEFINITIONS

In the contemporary world, the issue of food quality and safety is the object of the European Union countries', including Poland, special care.

Quality is generally considered one of the most important factors in a product's market success, particularly its long-term well-being. As Baryłko-Pikielna [1975, 1983, 1994] and Toruński [2012] show, this notion is difficult to define because of its complexity. As a result, it is not unambiguously understood, even among experts in the field [Baryłko-Pikielna et al. 1996, Toruński 2012]. The concept of quality has already found its reflection in the deliberations of philosophers. For Plato it was a certain degree of perfection. For another philosopher - Aristotle it was quality by virtue of which things are defined in a certain way. Cicero talked about it as a property of an object, while Lao Tsu was convinced that quality is something that can be constantly improved. In the early years of food science development quality used to be defined as "the lack of defects". In agriculture and quality control it is still understood in this manner [Szymonik 2004, Ożarek 2004]. For consumers, quality assessment is mainly based on visual experience, which is the basis of the purchase decision [Słowiński 2000]. It is dependent on the person, time, place, circumstances and consumer expectations [Moskowitz 1995, Oude Ophius, van Trijp

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1995]. The ISO 9000:2000 norm defines it as the ability of a product, process or system to fulfil the requirements of the customer and all the involved parties. Deming [1986], considered the creator of the modern approach to quality, defines it as the degree of homogeneity and reliability of a product at the lowest possible cost and the highest possible conformity with the market's requirements. According to Juran [1962], quality is the degree to which a certain product fulfils the needs of a given buyer (market quality), or the degree of a product's conformity with a model, template or requirements (conformity quality). Feigenbaum [1992] sees quality as an entire characteristic of a product or service (technical, execution and service level), through which it realises the consumer's expectations. Crosby, on the other hand, defines quality as conformity with the customer's requirements [Zalewski 2002, Horbaczewski 2006, Stoma 2012].

Product quality needs to be stable. A producer should aim at fulfilling basic consumer expectations concerning food, particularly ensuring its wholesomeness and safety, comfort of preparation and full sensory attractiveness immediately after production as well as during post-production storage. The ability to predict the period during which quality remains acceptable is a matter of great concern. Most current solutions are based on the assumption that changes in quality undergo a zero degree reaction and that the change to time ratio is constant in constant temperature. This approach is useful and in selected cases allows for an accurate evaluation of quality persistence. The parameters which undergo changes during storage should be examined in the course of storage tests [Baryłko - Pikielna 1995, Baryłko - Pikielna et al. 1996, Baryłko - Pikielna and Kostyra 2004]. An important element providing safe quality of food is the control of chemical remains and evaluation of the state of microbiological contamination. It is related to the potential occurrence of pathogenic bacteria, especially Salmonella, Listeria, Camphylobacter or Escherichia coli [Piskuła et al. 2011]. Thus, to provide the safety of food, microbiological criteria have been established for food in all European Union countries. They have been published in Commission Regulation (EC) no. 2073/2005 from November 15th 2005. This regulation has introduced two kinds of microbiological criteria: the food safety criterion and the hygiene criterion. Until today, the European Commission has established numerous changes in the Commission Regulation (EC) no. 2072/2005 and implemented the following regulations: 1441/2007, 365/2010, 1086/2011, 209/2013 [Ścieżyńska 2013].

Food safety is an integral part of food security [Kwasek 2013]. According to FAO food security is a situation in which all the people, all the time have constant physical, social and economical access to a sufficient amount of safe and nutritious food, which fulfils their nutritional needs and food preferences to live an active and healthy lifestyle (FAO 2009). For the consumer, however, the most important characteristic of food quality is its safety [Kwasek 2013]. Thus, the issue of safety and quality of food products has been brought up for a long time on a large scale and its significance does not raise the slightest doubt. The huge importance of these aspects in the production and distribution of food is backed by broad law regulations in the area as well as by a constant strive to improve food production and distribution processes. Several organs are responsible for food safety, particularly the European Food Safety Authority. Research activity is also an important element of food safety policy. Because community law is superior to European Union member countries' local law, national regulations have to be adjusted to current European Union acts. It is important to remind at this point that European Union regulations apply in every member country. They are taken into account in national legislation by pointing them out without citing their content, while directives are transposed into national acts of law. In Poland, the issues concerning food safety are regulated by the act from August 25th 2006 on food safety and food security [Dz.U from 2006, No. 171, pos. 1225, incl. further changes]. The act has a frame character, it comprehensively regulates conditions necessary to provide food safety on all stages of the food production chain "from the field to the table". According to this act: food safety is the entirety of conditions which need fulfilment, concerning especially: employed additives and flavourings, levels of contaminants, pesticide remains, conditions of food exposure to radiation, sensory characteristics and actions which need to be taken on all the stages of production or distribution of food in order to ensure human health and living.

The Codex Alimentarius, on the other hand, as a document which constitutes a source of norms and standards related to food, defines food safety as ensuring that food will not have any undesirable effect on the consumer's health when it is prepared for consumption and/or when it is consumed accordingly to its purpose. It simultaneously defines food hygiene as: all the conditions and actions necessary to ensure the health safety of food and its production accordingly to its original purpose.

The Codex Alimentarius determines basic rules of food hygiene within the whole food chain, thus from original production until the final consumer, which shall guarantee food safety and suitability for consumption. At the same time it imposes certain tasks in this area on governments as well as the industry and consumers. As a result, governments should conduct a policy which promotes implementing the general rules indicated by the Codex in order to:

- appropriately protect consumers from diseases and harm caused by food; the way of acting should take into account the sensitivity of particular populations or various groups within a given population;
- guarantee that food is suitable for consumption;
- maintain trust in the food which is the object of international trade; and
- introduce health education programs, which will effectively spread food hygiene rules among industry organisations and consumers.

The industry's task, on the other hand, is to:

- provide food which is safe and suitable for consumption;
- guarantee that consumers receive clear and comprehensible information in the form of labelling and other appropriate means, making it easier for them to protect the food from contamination by causal pathogens through correct storage and processing; and maintain trust in the food which is the object of international trade.

What is also emphasised is the role of consumer awareness, which should result in conforming with specific instructions and employing appropriate means of food hygiene.

Poland and other European Union countries apply Regulations of the EU legislation bodies in the area of food safety. Since January 1st 2006 all European Union member countries have common food laws which constitute the so called "Hygiene package" based on the general food law defined by the Regulation (EC) NO. 178/2002 [Kielesińska 2012, Fernández - Segovia et al. 2014]. The "Hygiene package" encompasses the 4 regulation mentioned below, which determine food hygiene rules as well as rules of conduct for appropriate authorities who supervise the food sector operators:

Regulation (EC) no. 852/2004 of the European Parliament and the Council from April 29th 2004 concerning food hygiene (it determines general rules for food sector enterprises in the area of food hygiene).

Regulation (EC) no. 882/2004 of the European Parliament and the Council from April 29th 2004 concerning official inspections carried out in order to check conformity with feed and food law as well as with rules concerning animal health and well-being (it determines general rules of conducting official inspections aimed at checking conformity with rules targeted at: preventing, eliminating or limiting acceptable levels of threat to humans - food safety in the whole food chain; guaranteeing fair practices in food trade and protection of consumer interests (along with food labelling) - trade with third countries and trade within the Union).

Regulation (EC) no. 853/2004 of the European Parliament and the Council from April 29th 2004 establishing specific laws concerning hygiene in relation to food of animal origin (it establishes laws for food sector enterprises concerning hygiene in relation to food of animal origin, which supplement the requirements included in reg. 852/2004).

Regulation (EC) no. 854/2004 of the European Parliament and the Council from April 29th 2004 establishing specific laws concerning the organisation of official inspections in relation to products of animal origin intended for consumption by humans (it is applied to feeds and products of animal origin in the area of official inspections).

These regulations clearly direct the responsibility for food safety and hygiene in the entire food chain at the food sector enterprises regardless of the position they occupy in the food production chain. Supervision over these obligations is exercised by a number of government agencies (usually by Food and Veterinary Offices) [Kielesińska 2012, Jendza 2012]. In Poland, the entities responsible for food safety at all stages of the food chain are: the State Sanitary Inspection, Veterinary Inspection, the State Plant Health and Seed Inspection, the Agricultural and Food Quality Inspection, the Trade Inspection and the Regional Fishery Inspectorates (Jendza 2012).

Regulation no. 178/2002 also constitutes the legal foundation of the Rapid Alert System for Food and Feed of the European Union, RASFF UE. The system has been working within the European Community since 1979, but it was the publication of the General Food Law that gave the RASFF legal status. The RASFF is first of all a tool for information exchange between appropriate central authorities responsible for food and feed regulation in the member countries in cases when risk for human health has been identified, thus causing the need for steps such as recalling or seizing products (Kijowski and Konieczny 2008, Leuschner et al. 2013). The hazardous food product warning network as part of the RASFF UE in Poland is administered by the Chief Sanitary Inspector.

QUALITY MANAGEMENT SYSTEMS

Regulations have been introduced in the European Union countries and others around the world concerning the production and distribution of food. Law norms have also been introduced according to which there is an obligation to implement and apply some quality management systems [Codex Alimentarius, Leonkiewicz 2005, Morkis 2006, Nowicki and Sikora 2012, Kielesińska 2012, Skrzypek 2012]. With reference to the food industry, obligatory and non-obligatory (voluntary) systems can be mentioned.

Obligatory quality management systems

Obligatory quality management systems include:

- GHP (Good Hygienic Practice)
- GMP (Good Manufacturing Practice)
- HACCP (Hazard Analysis and Critical Control Point) (Morkis 2006, Janus and Kijowski 2007, Skowron 2008, Kielesińska 2012, Popis 2013).

In Poland, the obligation to implement and apply Good Hygienic Practice and Good Manufacturing Practice has been effective since July 20th 2000, while the obligation to implement and apply the HACCP system - since May 1st 2004.

GHP and GMP include initial requirements necessary to develop and implement the HACCP system. The implementation of these rules is carried out at the stage of food production, storage and quality control. Respecting these rules can constitute the basis for the implementation of food safety management systems [Gorris 2005, Morkis 2006, Janus and Kijowski 2007, Nowicki and Sikora 2012, Popis 2013].

Good Hygiene Practice (GHP) determines the actions which need to be taken and the hygienic conditions which need to be fulfilled and controlled at every stage of production and or distribution to ensure the health safety of food. GHP includes procedures and instructions concerning the execution of hygienic processes in the facility, which will particularly determine: the frequency and time of washing and disinfection of production space, production equipment, personnel, the frequency and scope of personnel training in the GHP area as well as protection against pests [Turlejska 2003, Morkis 2006, Janus and Kijowski 2007, Nowicki and Sikora 2012, Popis 2013].

Good Manufacturing Practice (GMP) determines the actions which need to be taken and the conditions which need to be fulfilled for the production of food as well as materials and products intended for contact with food to be carried out in a way which ensures appropriate health safety of food according to its intended use [Morkis 2005, Janus, Kijowski 2007]. GMP encompasses every aspect of food production beginning with the main assumptions concerning the facilities: construction, technical and technological, through the requirements applied to raw materials, personnel, machines (equipment), all the way to the production process itself (procedures and practices as well as methods) and then to the storage and distribution of the manufactured product. GMP requires every element of food production to be defined in advance and specified resources to be delivered in an appropriate amount, in an appropriate place and appropriate time as well as to be used accordingly to their intended use. This practically means developing written procedures and instructions for the production process and requirements for the production process base such as obtaining raw materials, buildings and production surroundings, machines and devices, washing and disinfection, storage, transport and distribution; personnel, training, protection against pests. These clauses should be included in the Manufacturing Books [Turlejska 2003, Janus and Kijowski 2007, Nowicki and Sikora 2012, Popis 2013, Kafetzopoulos and Gotzami 2014].

The Hazard Analysis and Critical Control Point system (HACCP) is an independent food health safety management system which is specific for the food sector [Morkis 2006, McMeekin et al. 2006, Janus and Kijowski 2007, Fabisz - Kijowska and Kijowski 2008, Nowicki and Sikora 2012, Popis 2013]. The implementation of the HACCP system in production facilities which manufacture and distribute food should be preceded by introducing both GMP and GHP rules [Morkis 2006, Janus and Kijowski 2007, Fabisz - Kijowska and Kijowski 2008, Nowicki and Sikora 2012, Popis 2013]. The HACCP is a food control system required by the EU law in member countries, it ensures appropriate hazard identification and assessment as well as control at every stage of food production and distribution. Its aim is to identify risk and prevent problems related to health quality. It is executed through applying control methods and monitoring points considered critical in the conducted processes which are significant for consumer health. Sources of hazard may include events or factors: biological, chemical or physical, which have appeared during food production. The HACCP system is considered the most effective tool which allows to guarantee that food will not become polluted or contaminated and will be safe for the consumer. It is a proactive system which puts the emphasis on prevention instead of quality inspection [Janus and Kijowski 2007, Malinowska 2012, Nowicki and Sikora 2012, Szymańska - Brałkowska 2012, Kafetzopoulos et al. 2013].

Non-obligatory quality management systems

Non-obligatory (voluntary in the unified market of the European Union) quality management systems, which can be applied in food industry enterprises include:

- Total Quality management (TQM),
- Quality Management System according to ISO 9000 series norms (ISO 9001),
- Food safety management system according to the ISO 22000 norm,
- World Class Manufacturing (WCM),
- Quality Assurance Control Points (QACP),
- International Food Standard (IFS),
- Global Standard Food (BRC),
- Proprietary Enterprise Quality Management System
- GlobalGAP (Morkis 2006, Popis 2013).

Total Quality Management (TQM) is a management method based on the engagement and cooperation of all employees and utilising all the accessible material resources of a given facility to achieve its optimal functioning as well as customer satisfaction. TQM is not directed at food safety, but instead at economical or organisational effects because the main aim of the system is achieving customer satisfaction, ensuring long-term success for the enterprise and bringing benefits to organisation members as well as the society. TQM can be explained in the following way:

- Total - every person in the company is committed to broadly-understood quality (if only possible, so are the customers and suppliers)
- Quality - customer expectations are entirely fulfilled
- Management - managers at every level, especially the highest, support and actively engage in implementing a pro quality corporate culture.

ISO 9000 is the name given to a family of norms developed to provide guidelines on the basis of which a quality management system can be effectively implemented and maintained.

The ISO 9000 norm family includes three norms:

- ISO 9001 "Quality management systems - requirements". The basic, international norm of the 9000 series, which includes requirements for the implementation and certifications of such systems and is the foundation on the basis of which certification is carried out.
- ISO 9000 "Quality management systems. Fundamentals and vocabulary" constitutes an introduction to norms concerning quality management. It describes the basics of quality management systems and defines the terms used in these norms.
- ISO 9004 norm "Quality management systems. Guidelines for performance improvements" contains guidelines concerning improving a quality management system. It is helpful when maintaining a quality management system.

The ISO 9001 norm contains requirements for a quality management system. It is one of the most popular standards compliance with which is confirmed by external certifications. The number of ISO 9001 certificates issued worldwide is incomparably larger than that of other kinds of certificates concerning management systems. The ISO 9001 norm is applicable to every organisation irrespectively of its size and type. Every organisation which wishes to keep pace with the customers and present a good level of management and customer service as well as take care of its future development can find a useful tool in a Quality Management System based on the ISO 9001 norm. Apart from enterprises, quality management systems are nowadays commonly introduced in offices, hospitals, schools, police stations and other public as well as private institutions.

Norm EN ISO 22000:2005 Food safety management systems - Requirements for any organisation in the food chain was published in 2005. In 2006, on the other hand, its Polish version was created: PN-EN ISO 22000:2006 Food safety management systems - Requirements for any organisation in the food chain. This norm's structure is close to norm PN-EN ISO 9001:2009 "Quality management systems - Requirements" and to norm PN-EN ISO 14001:2005 "Environmental management systems - Specification with guidance for use". The ISO 22000 norm is supplemented by norms: PKN-ISO/TS 22003:2007 "Food safety management systems - Requirements for units conducting audit and certification of food safety management systems" and norm PN-EN ISO 22005:2007 "Traceability in the food and feed chain - General principles and basic requirements for system design and implementation [Wysokińska - Senkus 2010].

The aim of the international ISO 22000 norm is to harmonise the requirements concerning food safety management of enterprises in the food chain on a global level. It is particularly helpful to enterprises which are attempting to achieve a coherent and integrated food safety management system [Fabisz-Kijowska and Kijowski 2008, Nowicki and Sikora 2012, Fernández - Segovia et al. 2014].

The international norm determines the requirements concerning a food safety management system for an organisation in the food manufacturers' chain, which has to prove its ability to control threats to food safety in order to ensure that the food is safe while consumed by people. The ISO 22000 norm defines food safety as "assurance that food will not cause harm to the consumer when it is prepared and/or eaten according to its intended use". According to the ISO 22000 norm, an organisation shall establish, document, implement and maintain an effective food management system and update it when necessary accordingly to the international norm requirements.

The ISO 22000 norm requires the organisation to reach an adequate hygienic standard, necessary to ensure food safety through effective planning, establishment and implementation of actions including: PRP (prerequisite programs), OPRP (operational prerequisite programs) and/or the HACCP Plan - necessary to manufacture safe products [Frgemand and Pietrasik 2006, Słowińska 2006, Mokrosińska 2006, Fabisz - Kijowska and Kijowski 2006, Fabisz - Kijowska and Kijowski 2008, Skowron 2008].

The international ISO 22000:2005 norm constitutes the foundation for the development, implementation and certification of a food safety management system. The normative approach to the issue of safety assurance which it employs simultaneously carries the universality characteristic due to which it can be applied in all enterprises operating in the food industry regardless of their size [Fabisz - Kijowska and Kijowski 2008, Skowron 2008].

World Class Manufacturing (WCM) is an enterprise management system. Its aim is to manufacture products which meet world standards and present the best manufacturing class. The result of this is the best world class manufacturing in the field of product quality, price, quickness and reliability of delivery, flexibility and innovation.

Quality Assurance Control Points (QACP) is a system which ensures appropriate food quality. It can be based on the HACCP system. Analogical methods and procedures are used for those systems. The HACCP, however, only concerns health safety, while the QACP is a broader system encompassing the entire product quality assurance (Janus and Kijowski 2007).

International Food Standard (IFS) has been developed for the purposes of auditing suppliers who cooperate with networks of so called private label manufacturers. The main aim of the IFS standard is to confirm whether the supplier is capable of delivering a safe product compliant with valid law regulations and norms. Furthermore, the IFS introduces uniform requirements and transparency in the supply chain (of raw materials and the final product). The IFS standard is based on the principles of a quality management system as well as the HACCP system and is supported by the expectations for prerequisite programs, that is the set of Good Manufacturing Practices - GMP, Good Hygienic Practices - GMP and Good Laboratory Practices - GLP. The IFS also follows the guidelines of the Global Food Safety Initiative (CIES), an organisation associating key, global companies in the food market [Słowińska 2008, Kielesińska 2012, Nowicki and Sikora 2012, Popis 2013, http://www.iso.org.pl/miedzynarodowe-standardy-zywnosci-ifs].

The BRC Food Standard determines the requirements which a producer and a supplier should fulfil in order to ensure the health safety of food as well as proper hygienic and production conditions. The Food Standard requires the company to introduce the HACCP protocol, an effective and currently documented quality management system and constant control of appropriate norms concerning products, processes, personnel and environment protection. Numerous advantages result from possessing the BRC Food Standard Certificate for the certified enterprise as well as its associates. It is a vast document, at the same time focused on safety, quality and legal aspects of an operation and it also has clear principles based on the HACCP protocol. The BRC norms are based on a standardised system of reports and documents precisely matched to their requirements. Moreover, the whole model is complementary to already existing quality management systems such as ISO 9001 or HACCP and the rules of GMP and GHP [Słowińska 2008, Kielesińska 2012, Nowicki and Sikora 2012, Popis 2013, http://www.iso.org.pl/brc-food1].

A proprietary Enterprise Quality Management System is implemented by some food industry enterprises, especially those with foreign capital. Such demands are made by mother companies to unify the management system.

BRC Global Standard - Food establishes requirements for manufacturers of processed food, basic products delivered as brand name retail products, brand name food products or food and product ingredients for gastronomy, catering and food manufacturers. The certification applies to products created and stored on premise. The standards do not apply to wholesale, import or distribution and storage outside of the company's premises [Popis 2013, http://www.iso.org.pl/brc-food1].

SUMMARY

The methods, recommendations or guidelines presented here only constitute a part of a broad spectrum of solutions targeted at achieving high quality of manufactured products. Irrespectively of which one we choose, it is necessary to remember that quality control is by definition a conscious effort of an enterprise regarding the issue of the quality of goods or service and the essential share of responsibility rests upon the management. In fact, good quality is not a matter of coincidence, but a result of planned and coordinated actions of all the departments encompassing design, engineering and technical work, quality production preparation and its planning, product manufacturing standards and personal requirements as well as staff training and improvement. Meanwhile, the aim is to eliminate all the negative factors which can negatively affect the quality of obtained products.

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http://www.iso.org.pl/brc-food1

ZARZĄDZANIE JAKOŚCIĄ I BEZPIECZEŃSTWEM ŻYWNOŚCI

STRESZCZENIE. Zapewnienie jakości i bezpieczeństwa żywności są to obecnie najważniejsze cele jakie stawiają sobie przedsiębiorstwa zajmujące się produkcją i obrotem żywności. Dlatego w krajach Unii Europejskiej wprowadzono regulacje prawne dotyczące produkcji i obrotu żywnością a także unormowania prawne wprowadzające obowiązek wdrożenia i stosowania niektórych systemów zarządzania jakością..

Słowa kluczowe: jakość żywności, bezpieczeństwo żywności, GHP, GMP, system HACCP, ISO 22000, BRC, IFS

QUALITÄTS- UND SICHERHEITSMANAGEMENT VON LEBENSMITTELN

ZUSAMMENFASSUNG. Qualitäts- und Sicherheitsmanagement von Lebensmitteln stellt heutzutage eines der wichtigsten Ziele, die vor den lebensmittelherstellenden und -umsetzenden Unternehmen gestellt wird, dar. Daher wurden in den EU-Ländern Rechtsregulationen bezügl. Lebensmittelherstellung und -umsetzung sowie die Rechtsnormierungen, die die Pflicht der Einführung und Anwendung von ausgewählten Qualitätsmanagement-Systemen obligatorisch machen, eingeführt.

Codewörter: Lebensmittel-Qualität, Lebensmittel-Sicherheit, GHP, GMP, HACCP-System, ISO 22000, BRC, IFS

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INTERMODAL TRANSPORT IN EUROPE - OPPORTUNITIES THROUGH INNOVATION

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ABSTRACT. Background: Freight transport volume in ton-km in OECD countries will grow considerably up to 150 to 230 % in 2050 compared to 2010. Although the EU policy aims to shift 30% of road freight over 300 km to other modes such as rail or waterborne transport by 2030 the recent trends show a stable modal split of road at approx. 75%. Conventional intermodal transport on the major European routes has shown a steady but only limited organic growth through recent years. Therefore, new innovative concepts for intermodal transport and for the shift from road to rail are needed.

Methods: Definitions of intermodal transport have been clarified and the development of combined transport in Europe and in Germany and Poland in particular has been analyzed on the basis of available data sources. New innovative concepts for intermodal transport have been identified on the basis of desk research, recent relevant projects (RETRACK, SCANDRIA, Rail Baltica) and market intelligence.

Results: The analysis leads to the conclusion that new innovative concepts in intermodal transport comprise new forms of organization as well as new technologies and new routes. The following three innovations to facilitate the shift from road to rail by intermodal transport are being introduced and discussed: multimodal operation of ocean carriers in maritime hinterland transportation, innovative handling technologies for non-crane able trainers and freight corridors for long distance intermodal transport within the TEN-T network and on the Europe-Asia corridor.

Conclusions: Further accelerated growth in the shift from road to rail through intermodal transport requires new innovative concepts beyond the traditional combined transport in Western Europe. Three promising innovative concepts have been introduced. Further research is needed and should be focused on financial and economic appraisal as well as on the effectiveness of state intervention policies.

Key words: Intermodal Transport Markets, Multimodal Transport, Combined Transport; Freight Corridors, Container Transport, Non-crane able trailers, Innovation.

INTRODUCTION

Forecasts for freight transport show that freight transport and road transport in particular will grow considerably. In OECD countries freight transport volume in tonne-km will grow up to 150 to 230 % in 2050 compared to 2010, in Non-OECD countries up to 250 to 550 % in the same period. (OECD / ITF, 2012, p. 8) According to OECD / ITF [2012] the general trend may be towards a higher share in use of road vehicles since this provides for more flexibility in terms of delivery and uses relatively cheaper infrastructure than rail.

Considering the bottlenecks in road infrastructure existing already today and the ecological impacts of transport, ever increasing road transport is seen critically and calls for a wider use of rail and ship on the main haul and in combined transport solutions. But recent statistics according to (European Commission, 2013, p. 110) show no real turn but a stable share of road transport of approx. 75% in the modal split in EU - 27 countries [European Commission, 2013]. For

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comparison: In Germany the share of road transport in land freight transport in tonne-km was 67% in 2001, 65% in 2010 and 66% in 2011, while in Poland the road transport share was 62%, 81% and 79% in the same periods [European Commission, 2013].

Accordingly an actual objective of the European Union transport policy is to shift 30% of road freight over 300 km to other modes such as rail or waterborne transport by 2030, and more than 50% by 2050, facilitated by efficient and green freight corridors [European Commission, 2011]. "In longer distances, options for road decarbonisation are more limited, and freight multimodality has to become economically attractive for shippers. Efficient co-modality is needed. The EU needs specially developed freight corridors optimised in terms of energy use and emissions, minimising environmental impacts, but also attractive for their reliability, limited congestion and low operating and administrative costs" [(European Commission, 2011].

Intermodal transport solutions which combine and use all modes optimally can contribute significantly to higher efficiency and attractiveness of the overall transport system and to the ease of the road infrastructure. Measures to support intermodal transport are consistent with the EU policy, which aims to strengthen combined transport in Europe and to establish green transport corridors [The Federal Government, 2008].

INTERMODAL TRANSPORT - DEFINITIONS AND MARKETS

In order to clarify the variety of different terms the following definitions will be used in the further course of this paper:

Intermodal Transport is "the movement of goods in one and the same loading unit or road vehicle, which uses successively two or more modes of transport without handling the goods themselves in changing modes" [UN ECE, 2001]. Loading units are intermodal transport units as containers, swap bodies and crane able semi-trailers. Combined Transport is a sub-category of this term and "is an intermodal transport where the major part of the European journey is by rail, inland waterways or sea and any initial and/or final legs carried out by road are as short as possible." Combined transport is therefore used, when road transport is substituted by rail or ship on parts of the transport route [UN ECE, 2001]. Combined transport can be accompanied transport (e.g. complete motor vehicles with drivers on low-floor railcars as rolling motorway or on ferries) or unaccompanied transport (loading units on rail or ship).

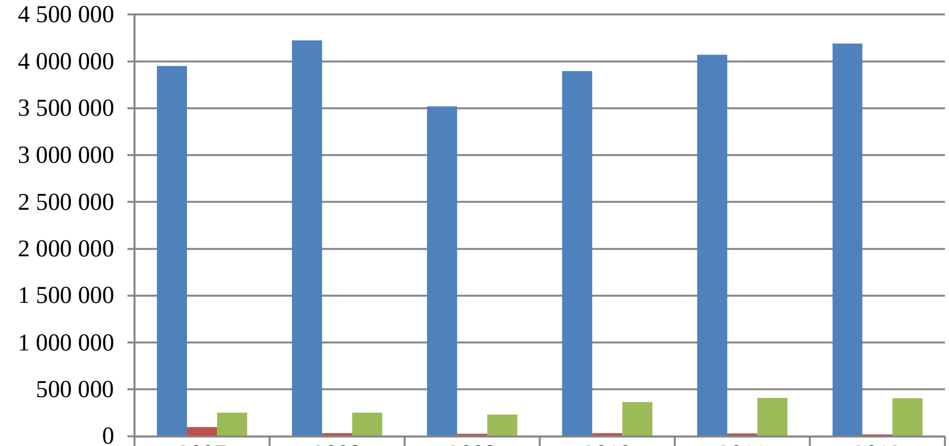
Different from these technical terms the term "Multimodal Transport" is a legal term and is used for "the door-to-door movement of goods under the responsibility of a single transport operator known as a Multimodal Transport Operator (MTO) on one transport document." [UNCTAD, 2014] Provisions for Multimodal transport documents came into force in 1992 [UNCTAD, 1992]. Multimodal documents are the FIATA Bill of Lading or the MULTIDOC 95 and serve as documents of title and are bankable in documentary credits. If the terms of payments require documentary credits, exporters using multimodal documents may benefit from earlier payment and decreasing capital costs. In this case the point of delivery may be shifted from ports to inland points, e.g. if the term of delivery "FCA Free Carrier" (inland terminal) and a FIATA Bill of Lading is agreed upon as bankable document.

From the definitions it can be derived that not every intermodal transport needs to be a multimodal transport, e.g. a door-to-door container transport can be covered by several segmented contracts. Actually in Continental Europe the share of door-to-door- contracts in seaborne container transport (i.e. carriers' haulage contracts) can be estimated at 20 % to 30% only. Merchant haulage documents for the pre- and on carriage and a separate port-to-port-bill of lading issued by the ocean carrier for the sea leg prevail. Also multimodal transport needs not to be intermodal, in case no loading units are being used (e.g. heavy lifts and project cargo).

Intermodal markets

We can distinguish between two major intermodal markets. One is the seaborne trade and its corresponding pre- and on-carriage from and to the seaports hinterland. Here the ISO maritime containers owned or leased by ocean carriers prevail. The second market is the continental intermodal transport of unaccompanied crane able semi-trailers and swap bodies owned by forwarders. In this continental market on longer distances also ISO maritime containers and "Euro-pallet-wide" containers are applied, usually provided by railways or leasing companies. Accompanied semitrailers with trucks are carried on special flat railcars by so-called "rolling motorways". They play nowadays a niche role in case of road traffic restrictions only.

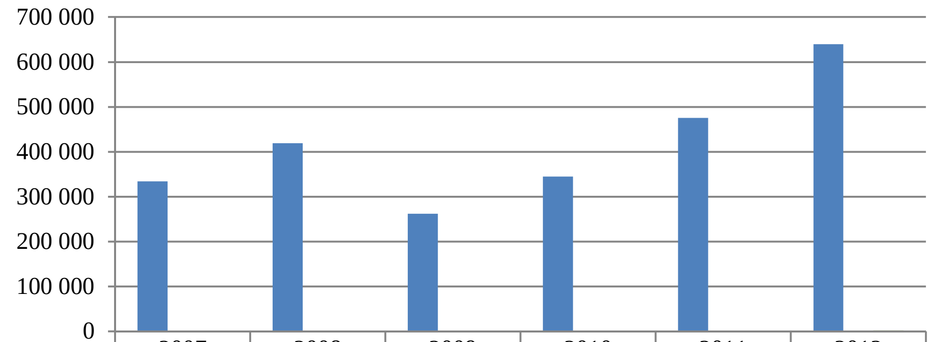
Table 1. Annual number of empty and loaded intermodal transport units carried on railways in FR Germany
Tabela 1. Ilość pustych i pełnych jednostek transport intermodalnego zrealizowanych przez koleje FR Germany



	2007	2008	2009	2010	2011	2012
containers and swap bodies	3 952 433	4 223 321	3 518 950	3 895 724	4 069 957	4 191 420
road vehicles (accompanied)	95 881	33 489	26 962	31 758	29 422	19 327
semi-trailers (unaccompanied)	249 808	253 041	230 636	365 472	410 077	403 739

Source: Eurostat, 2014

Table 2. Annual number of empty and loaded intermodal transport units carried on railways in Poland
Tabela 2. Ilość pustych i pełnych jednostek transport intermodalnego zrealizowanych przez oleje w Polsce



	2007	2008	2009	2010	2011	2012
containers and swap bodies	333 835	419 285	261 787	344 538	475 460	639 936
road vehicles (accompanied)	0	12	2	7	7	1
semi-trailers (unaccompanied)	0	0	1	30	109	2 004

Source: Eurostat, 2014

Concerning intermodal transport by rail in Germany the table illustrates that containers and swap bodies dominate the market with approx. 90% share of all loading units. The development trend of containers and swap bodies shows a modest growth only what can be explained by the high level of containerization achieved already. Nowadays shipping lines offer more than 30 types of containers for almost every type of commodity.

The combined transport of accompanied road vehicles shows a negative trend. Rolling motorways were successful in Alp crossing traffics and through state interventions only.

Slow but continuous growth in combined transport of semi-trailers in Germany is an indicator for further potentials in this segment.

In Poland the development of intermodal transport is in a development phase and much more dynamic.

The container traffic by rail almost doubled between 2007 and 2012. This is a sign of the increasing container traffic via Polish ports on-carried to the industrial hinterlands in Poland. The combined transport of accompanied road vehicles plays no role whereas the combined transport of unaccompanied semi-trailers is in its initial phase.

Considering all European Union (28) countries a steady but modest growth of intermodal transport of 3.7 per cent per annum can be observed between 2004 and 2012. (calculated according to [Eurostat, 2014]) In order to achieve the EU policies objectives through better co-modality of all modes of transport in general and by strengthening intermodal transport in particular, innovations - additionally to the organic growth - are needed: new organizational concepts, new technologies and new routes with new intermodal products. Although national and EU transport policy may support these innovations in their initial phase, in the longer run they need to be competitive without state subsidies. Innovation trends will be introduced for the seaborne as well as for the continental intermodal markets in the following.

SEABORNE CONTAINER TRANSPORT: ECONOMIES OF SCALE AND MULTIMODALITY

Containerization is a sea battle, fought and won ashore.

Although since 2008 there are signs of maturation of container traffic [Rodrigue, 2014] there is still room for organic growth. Because up to two third of costs in container transport are caused by landside operations, the hinterland transport is a major playing field for rationalization and growth. The following trends shall be discussed in brief:

Hinterland hubs

Ever bigger ships are the main factor for ports to look for opportunities to ensure fast and flexible terminal handling within limited time windows. To establish hinterland terminals and hubs which serve as centres for sorting, consolidation and distribution of containers and railcars is one strategy which is followed by terminal operators and container carriers [Brügelmann, 2012]. Frequent container shuttle trains between port and hinterland hub facilitate intermodal transport.

Hinterland distribution centres

Although there are no reliable statistics available there are indications that the share of containers stuffed or stripped in ports is still very high because ports often function as consolidation and distribution centres for overseas commodities. 57 % of all containers imported via Port of Hamburg and on-carried by trucks stay in the city of Hamburg or in the surrounding region [DESTATIS, 2014]. Very often the reason is that the container cargo is stripped and stored in distribution centres within this region and delivered according to demand later to the final points of destination within Germany and Europe as conventional truck load. These long traditions in supply chains are questioned more and more as availability and costs of labour force and of real estate have become more challenging in port regions during recent years. The shift of European and regional distribution centres into hinterland is a trend which could be observed in the Netherlands first (concept of Distriparks) and is gaining importance in Germany also (e.g. in Berlin-Brandenburg region [Wagener, 2008]). This trend strengthens the shift from conventional cargo on trucks towards containers on rail.

When will sea carriers go really multimodal?

Considering the low level of carriers pre- and on-carriage in maritime containers' hinterland traffic the question may be raised why sea carriers tend to deploy their containers on the sea leg only and why they are reluctant to act as a Multimodal Operator who would integrate the land leg into a full service package. As major reasons may be considered:

– the focus of vessel owning ocean carriers on high market shares in ocean transport and on selling container vessels capacity,
– the strong market position of seaborne forwarders as 3PL (3PL = Third Party Logistics Provider, i.e. logistics provider which organizes the logistics chain on behalf of the shipper but does not own transport equipment necessarily) which organize the logistics chain on behalf of the shippers and which benefit from organizing hinterland carriage,
– the imbalances of container flows and the sophisticated container logistics necessary in the case of controlling hinterland transport,
– the investments into a hinterland system and into assets which would be necessary in the case of establishing a real multimodal system (including terminals, depots, dedicated shuttle trains, forwarding services, etc.).

On the other hand there are arguments for the engagement of ocean carriers in hinterland traffic as real Multimodal Transport Operators. Reasons among others are:

– the possibility to control hinterland routes and to direct container flows to certain hub ports instead of the need to pick up cargo in several ports. Economy of scale in ocean shipping can cross-subsidize increasing inland transport costs because of fewer ports served. Examples are grid tariffs and port equalization schemes applied by ocean carriers in inland tariffs [Biebig, et al., 2008].
– the direct contact to major industrial shippers and the possibility to generate the sea freight necessary without the influence of intermediaries.
– a possible control and higher productivity in container logistics hence often for sales reasons empty containers are positioned to the hinterland free of charge, even in the case of merchant haulage.

Indeed there are signs that major shipping lines tend to establish an inland terminal network (owned, partner, joint venture) stepwise and to offer genuine door-to-door-multimodal transport. The result is a higher concentration of container volumes on certain hinterland routes, in control of the ocean carriers and a corresponding higher share of rail and barge transport. This results in lower pre-and on-carriage costs per rail in comparison to single truck loads. An example is the intermodal split in the Rotterdam hinterland traffic of the Maersk shipping line. In the case of merchant haulage the split is 65 % truck, 27% barge and 9% rail whereas the intermodal split in the case of carriers' haulage is 25 % truck only, 42 % barge and 32 % rail [Gibson, 2008]. We can assume that a higher share of carriers' haulage will contribute to the shift from road to rail decisively. The ever increasing ships' sizes and the cost pressure are the driving forces for ocean carriers to exploit productivity potentials still existing in the hinterland through comprehensive control of container logistics and the use of high capacity and low costs shuttle trains and barge services to and from inland hubs.

CONTINENTAL INTERMODAL TRANSPORT: INNOVATIVE TECHNOLOGIES FOR NON-CRANE ABLE TRAILERS

Continental road transport is dominated by semi-trailers, carrying 66 % of the transport volume. But only 2 % of these semi-trailers are equipped for vertical handling and can be used for unaccompanied intermodal transport.

Overall at present only 15% of all road units (semi-trailers, containers, swapbodies etc.) can participate in the unaccompanied intermodal transport [Teßmann, 2012].

A new intermodal product based on a technology for handling and transportation of non-crane able semitrailers would open the huge market of rail transport for conventional semi-trailers which are by far prevailing, especially in the Eastern and Southern European countries. Quite a variety of innovative technologies have been developed during the last years, but almost none could exceed pilot stage or was fit for the market. Also the rolling motorway for rail transportation of accompanied trucks and trailers could survive in niche markets and with state interventions only. But with the expanding distances within the new EU (28) countries, with increasing costs of road transport and with the pressure to reduce greenhouse emissions the need for technological innovations in rail transport which adapts railcars and terminals better to the needs of their potential clients in road transportation is ever growing.

Indeed now several innovative technologies are ready for market entry or are implemented already. Without being comprehensive the following technologies for handling and unaccompanied rail transport of non-crane able trailers shall be mentioned in brief (in alphabetical order):

- Cargo-Beamer: pulls crane able trays with semi-trailers on special wagons. Trays can be loaded vertically by conventional cranes or reach stackers or horizontally on special terminals. Pilot connections are implemented in Germany.
- ISU: semi-trailer is lifted with additional spreader vertically into pocket wagon. The ISU-technology is implemented as a bridge technology for low volume traffic.
- MegaSwing: is a rotatable and moveable waggon, needs no special terminal, only electric supply. Pilot trains were successful.
- Mobiler: special loading unit is pulled from truck on the wagon horizontally. The Mobiler technology is used for in house industrial shuttle connections.
- Modalohr: semi-trailers on low floor and articulated wagon, special terminals needed. The Modalohr-system has been implemented in high volume, special shuttle train connections successfully.

A recent study compared different technologies by a multi-criteria analysis for their application within the North-South corridor via the German capital region Berlin-Brandenburg [Wagener&Herbst Management Consultants GmbH, 2013]. Which technology is fitted most for a certain market depends on the type and volume of traffic mainly. For the initial low volume phase the ISU technology is appropriate. MegaSwing and Cargo Beamer can serve both low volume and high volume trades, also in mixed trains. The Modalohr-system is efficient in particular in long distance high volume trades with special shuttle trains and special terminals. The Modalohr system has been working since 2003 on the 175 km Autoroute Ferroviaire Alpine (AFA) between France and Italy with 5 trains daily and since 2007 on the 1,050 km route between Luxembourg and Perpignan (Southern France) with up to 4 trains daily [Metz, 2014].

A comparison between the combined transportation of crane able semi-trailers and the transportation of non-crane able semitrailers showed that the conventional unaccompanied combined transport of crane able semitrailers can offer lower total system costs. On the relation Cologne - Milano (825 km) the total system costs for conventional combined transport were 580 € per semi-trailer and for the second best, the Modalohr system 759 € per semi-trailer [Mertel, 2013]. But to assume that the innovative horizontal technologies are not competitive would be a too far going conclusion. Actually, there seems to be a hen and egg problem. The conventional combined transport operators are ready to open a regular service if there is no risk of utilization. Therefore private company trains are preferred since there is no risk for the operator at all. The small amount of crane able semitrailers makes it difficult for the operators to start a public train unless there is a high demand already, often caused by traffic limitations (e.g. in the Alp crossing traffic). Because of the much higher market share of non-crane able semitrailers the risk for operators for this type of trailers can be considered as much lower. Indeed the experiences of the Autoroute Ferroviaire Alpine (AFA) with the Modalohr system between Aiton (F) and Orbassano (I) via the Mont Cenis tunnel show that since 2003 more than 200,000 semi-trailers have been carried successfully and that after an extension of the gauge in 2012 to GB 1 the possible carriage of 4 m corner height trailers caused a significant increase of this type of trailer to 50% of the total amount. Interestingly there was no single crane able semitrailer on these trains [Metz, 2014].

Obviously the new technologies serve a different market and do not cannibalize the conventional combined transport. A stated preference survey among forwarders and road carriers showed that road carriers would be willing to adjust their business model to horizontal loading technologies on the one hand but are reluctant to leave their semi-trailers out of their control on the other hand [Truschkin, 2013]. Because transport costs beside punctuality and reliability are the most important factor for the modal choice, pricing instruments are considered as the most effective means to promote the shift of non-crane able semi-trailers from road to rail [Truschkin, 2013].

For the implementation of a high volume intermodal system for non-crane able semi-trailers the following success factors can be considered as important:

- shuttle trains over long distances with high frequencies,
- investments into infrastructure, availability of sufficient rail time table capacity and clearance from technical barriers in order to ensure standard gauge G1or G2,
- available base load in the initial phase,
- strict neutral operator with a full service package (optional pre- and on-carriage),
- financial capability of the operator to overcome initial phase,
- full control and real time information e.g. through GPS based telematics solutions,
- punctuality and reliability of train services
- competitive price in comparison to road transport,
- complementary state intervention, e.g. through toll fees or traffic limitations in environmentally sensitive areas.

SERVING ALL: FREIGHT CORRIDORS FOR LONG DISTANCE INTERMODAL TRANSPORT

Because of additional loading and unloading costs at transhipment points between road and rail or ship, the intermodal transport requires an economic minimum distance between two transhipment terminals. Depending on the operational concept this minimum distance is regarded as between 300 and 500 km, a distance roughly above a day-trucking. In principle the longer the rail route the more competitive intermodal transport becomes against pure road transport.

But over longer distances obstacles in the interoperability of national rail systems hamper the long distance intermodal transport and are therefore a major action field for the EU transport policy. The regulatory framework for establishing interoperable and efficient rail corridors between EU member countries and third countries was established with the EU Regulation No. 913/2010 [European Commission, 2010]. For important rail freight corridors executive and management boards were established to coordinate freight corridor implementation plans which among others include co-ordination of investments and traffic management provisions.

The Alp crossing route between ARA (Antwerpen, Rotterdam, Amsterdam) ports via Germany to Italy is the most important route for intermodal rail transport in the EU.

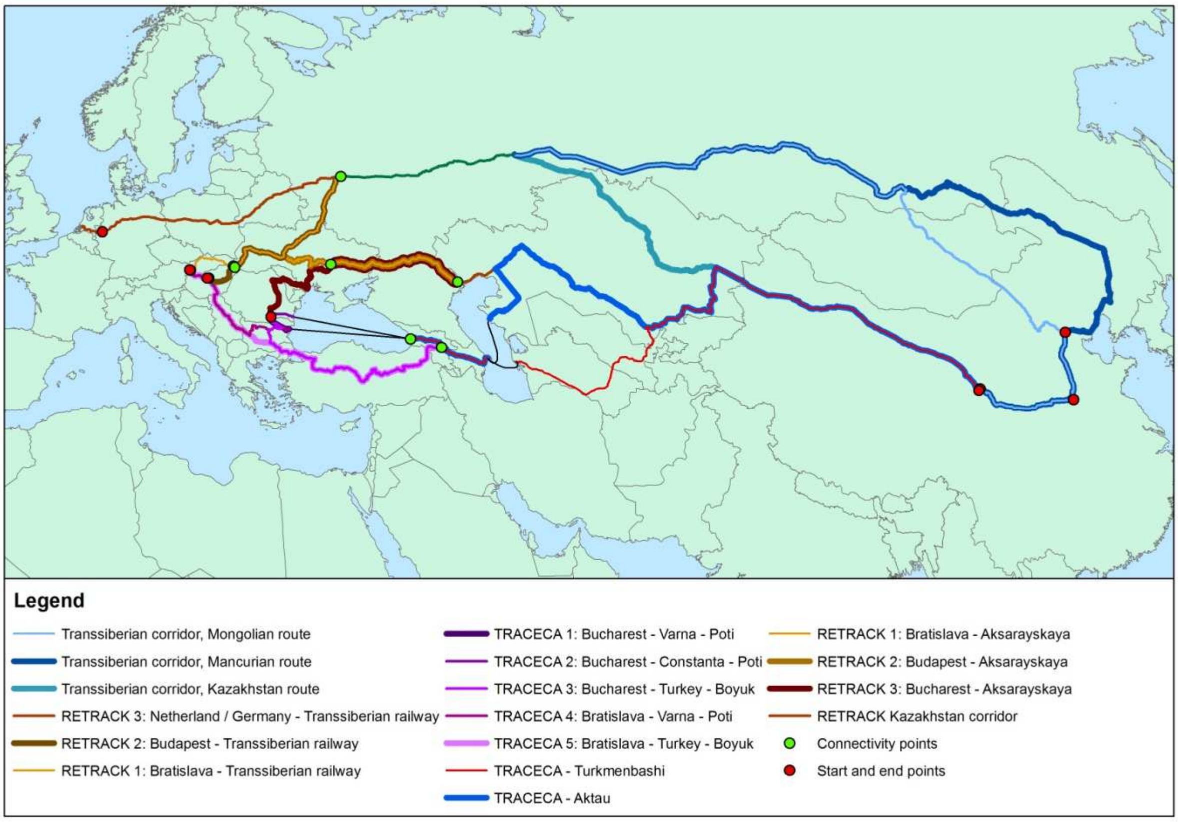
With the EU membership of new member countries in South-East Europe and Central Europe new opportunities but also challenges for long distance intermodal transport emerge. The East-West-Corridor from BENELUX via Germany and Poland to the Baltic States and to White Russia / Russia and further on to China will become a major freight corridor within the coming years. The North Sea Baltic Corridor is an important part of the TEN-T corridor network and will receive EU co-funding for infrastructure investments (for TEN-T corridors see [European Commission, 2014]). The most important project within this corridor is "Rail Baltica", a European standard gauge railway between Tallinn, Riga, Kaunas and

North-Eastern Poland. (European Commission, 2014) This standard gauge rail track will open new chances for rail freight in general but also for trailer transport on railcars. When "Rail Baltia" is implemented there will be substantial advantages for intermodal transport in comparison to road transport.

Table 3. Routing options Berlin - Kaunas (Rail Baltica)
Tabela 3. Opcje tras Berlin - Kaunas (Rail Baltica)

Option	**Route**	**Distance (km)**	**Time (hrs)**	**Costs (€)**	**CO2-Emmission (kg)**
Road Truck / Semitrailer	Berlin-Frankfurt(Oder)-Poznan-Plock-Suwalki-Maijampole-Kaunas	974 (all road)	30	995	760
Road/Ferry Truck / Semitrailer on Ship	Berlin-Sassnitz-Klaipeda-Kaunas	1,068 (318 km road D +535 km ferry +215 km road LT)	29.5	1,137	535
Road/Rail via Rail Baltica Truck / Semitrailer on Railcar	Berlin - FV Großbeeren-Warschau - Kaunas	1,021 (23 km road, 998 km rail)	30	625	337

Source: Wagener, 2011



Source: Davydenko, 2012

Map. 1 Rail corridors between Europe and China
Mapa. 1. Korytarze kolejowe pomiędzy Europą i Chinami

Table 4. Comparison of Freight Costs and Lead Times for one 20' - Container (< 16.5 tons)
Tabela 4. Porównanie kosztów przewozu i czasów dla kontenera 20' (< 16.5 ton)

Route Duisburg (D) – Lanzhou (PRC)	Km	**Single Waggon Load**		**Block Train**	
		USD	Days	USD	Days
TransSib-Kazakh route	9,118	6,730	28	3,200	18
TransSib-Mogolian route	12,028	6,705	38	4,700	22
TransSib -Manchurian route	13,055	6,705	39	4,600	20

Source: Davydenko, 2012

A model calculation shows that road/rail transport of one semitrailer via Rail Baltica would need the same transit time but would save up to 37% of costs and 56% CO_2-emmission, compared to pure road transport (price basis 2011).

Concerning the rail freight corridors between Europe and China the RETRACK project of the EU investigated different routes and identified opportunities and bottlenecks. Map 1 illustrates possible routes between the relation of Duisburg (D) and Lanzhou (PRC). Among the TRACECA corridor and the RETRACK (Central) corridor, the TransSib corridor with the routes via the Transsibirian Railway proved to be the most competitive between Germany and China.

On this corridor several technical barriers between different rail systems both in technical but also in operational terms exist. Two different railtrack systems (1,435/1,520 mm) require transhipment or changes of boogies at border crossings between European and Russian as well as between Chinese and Russian systems. Non-electrified, single track rail tracks, several different electrification system (AC and DC), different signalling and train control systems and different maximum train lengths between 600 m (in PL) and 1000 m (in RU) are technical barriers which complicate inter-operation on this intercontinental route. But railway companies work on facilitating traffic on this corridor, e.g. RZD through the project "TransSib in 7 days".

Among the different TransSib routing options the TranSib - Kazakh route is the most competitive one.

In comparison to sea freight the rail transport from China to Europe via TransSib offers a lower transit time at a higher price. The price level (index) from Shanghai/Bejing to Moscow for sea freight to rail freight is as 3 to 5. The lead times (days) terminal to terminal from Shanghai/Bejing to Moscow are sea freight / rail freight as 33-40 days to 10-12 days. Therefore the TransSib route enables to offer a new intermodal product (with triple price for one third of transit time compared to sea freight) which serves a niche market for high value and time sensitive cargo originating or destined from / for Chinese inland places, preferably in the Western and Northern parts of China [Davydenko, 2012]. The operation of through going block trains instead of single waggon traffic is a very precondition for efficient transport on this route. Because an 80% utilization of trains is needed, closed company trains dominate instead of open public trains. Main clients are shippers of electronics (from China to Europe) and of automotive parts (from Europe to China). For example, Schenker Rail has operated more than 200 trains for BMW from Germany to the fabrication plant in Shenyang in China [Albert, 2013].

It will be a challenge for this Europe-China container transport system to establish efficient container logistics which solves imbalances in trade flows and to develop public train concepts. Also technical and commercial interoperability is an objective which requires a harmonized legal framework (COTIF / SMGS) and solutions for technical interoperability, e.g. through multi-systems locomotives. The experiences with the corridor management gained within the EU should be considered if they are appropriate also for Pan-European corridors.

SUMMARY AND CONCLUSION

To sum up, intermodal transport needs a re-thinking if a more than organic growth is aimed for. Opportunities for further growth base on organizational and technological innovations as well as on new routes with new intermodal products. Concerning organization the establishment of inland distribution centres and hinterland hubs as well as the expansion of carriers' haulage by shipping lines would facilitate rail solutions within intermodal transport. New innovative technologies for rail transport of non-crane able semi-trailers would open this huge market for intermodal transport. Long distance freight corridors, in particular on the North -Sea Baltic and Europe Asia Corridors through Germany and Poland, open new routes for intermodal transport and enable to offer new products with a different price/time-ratio compared to unimodal transport. Further research is needed and should be focused on financial and economic appraisal of different variants of the innovations as well as on the effectiveness of state intervention policies to promote intermodal transport.

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Intermodaler Verkehr in Europa - Chancen durch Innovation

TRANSPORT INTERMODALNY W EUROPIE - INNOWACYJNE SZANSE JEGO ROZWOJU

STRESZCZENIE. **Wstęp:** Wolumen przewozów towarowych liczony w tono-km wzrośnie w krajach OECD do roku 2050 w porównaniu do roku 2010 od 150 do 230%. Pomimo tego, że Unia Europejska dąży do tego, aby 30% transportu drogowego, realizowanego na dystansach dłuższych niż 300 km, przesunąć do roku 2030 do strefy transportu kolejowego i morskiego, najnowsze trendy rozwojowe w tym zakresie wskazują raczej na stabilny rozkład statystyczny udziału transportu drogowego w całym wolumenie przewozów towarowych, kształtujący się na poziomie 75%. Konwencjonalny transport intermodalny w obrębie najważniejszych, europejskich ciągów komunikacyjnych wskazuje w ostatnich latach na jego stały, aczkolwiek ograniczony w swej dynamice wzrost. Z tego też względu istnieje konieczność opracowania nowych, innowacyjnych koncepcji rozwiązań w sferze transportu intermodalnego, skutkującego przeniesieniem możliwie dużego wolumenu towarów z transportu drogowego na transport kolejowy.
Metody: W artykule zdefiniowano warianty rozwiązań dla transportu intermodalnego oraz przeanalizowano w oparciu o istniejące statystyczne źródła i bazy danych trendy rozwojowe w zakresie transportu kombinowanego w Niemczech i w Polsce. Na bazie zrealizowanych w ramach najnowszych, istotnych dla istoty badań projektów (RETRACK, SCANDRIA, Rail Baltica) oraz w oparciu o własne rozpoznanie rynku określono innowacyjne koncepcje rozwoju transportu intermodalnego.
Wyniki: Przedmiotowa analiza prowadzi do konstatacji, że nowe, innowacyjne koncepcje w zakresie transportu intermodalnego dotyczą zarówno nowych form organizacyjnych, zastosowania nowoczesnych technologii, jak również wytyczenia nowych korytarzy transportowych. Przedstawiono i poddano dyskusji trzy opisane w artykule, innowacyjne rozwiązania dla potrzeb realizacji przełożenia w ramach transportu intermodalnego przepływu towarów z drogi na szyny, które to rozwiązania będą wspierały rozwój przez spedytorów morskich multimodalnego transportu na ciągach komunikacyjnych od portów w głąb kontynentu, ponadto powstawanie innowacyjnych technologii w zakresie przeładunku naczep siodłowych, nieprzystosowanych do przeładunku przy pomocą dźwigów i suwnic, jak również do wytyczania korytarzy transportowych dla realizacji transportów intermodalnych na obszarze sieci TEN -T i korytarza Europa - Azja.

Wnioski: Większa dynamika wzrostu w zakresie przekładania punktu ciężkości z transportu drogowego na transport kolejowy za sprawą komunikacji intermodalnej wymaga wdrożenia nowych, innowacyjnych koncepcji, które wyjdą poza przyjęte i stosowane w Europie zachodniej, tradycyjne rozwiązania w zakresie tradycyjnego transportu kombinowanego. W artykule przedstawiono trzy wybrane, innowacyjne koncepcje tego typu rozwiązań. Wskazano na konieczność kontynuacji badań, szczególnie w zakresie nie tylko pogłębionej, jednostkowej oraz ogólnoekonomicznej oceny zaproponowanych rozwiązań, ale również pod względem skuteczności przedsięwzięć, realizowanych przez poszczególne państwa w ramach kształtowania określonej polityki transportowej.

Słowa kluczowe: transport intermodalny, transport multimodalny, transport kombinowany, korytarz transportowy, transport kontenerowy, naczepy siodłowe bez możliwości przeładunku przy pomocy urządzeń dźwigowych, innowacje

INTERMODALER VERKEHR IN EUROPA - CHANCEN DURCH INNOVATION

ZUSAMMENFASSUNG. Einleitung: Das Gütertransportaufkommen in Tonnen-km wird in den OECD-Ländern erheblich bis zu 150 bis 230% im Jahr 2050 im Vergleich zu 2010 wachsen Obwohl die EU-Politik darauf abzielt, 30% des Straßengüterverkehrs über 300 km bis 2030 auf andere Verkehrsträger wie Eisenbahn oder Schiff zu verlagern, zeigen die jüngsten Entwicklungen einen eher stabilen Modal Split Anteil des Straßenverkehrs bei ca. 75%. Der konventionelle intermodale Verkehr auf den wichtigsten europäischen Strecken zeigt ein stetiges, aber nur ein begrenztes organisches Wachstum den letzten Jahren. Neue, innovative Konzepte für den intermodalen Verkehr und für die Verlagerung von der Straße auf die Schiene sind daher notwendig.
Methode: Die Varianten des intermodalen Verkehrs wurden definiert und die Entwicklung des kombinierten Verkehrs in Europa und in Deutschland und Polen auf der Grundlage der verfügbaren statistischen Datenquellen analysiert. Neue, innovative Konzepte für den intermodalen Verkehr wurden auf Basis Sekundärforschung, der jüngsten relevanten Projekte (RETRACK, SCANDRIA, Rail Baltica) und eigener Marktkenntnis identifiziert.
Ergebnisse: Die Analyse führt zu dem Ergebnis, dass neue innovative Konzepte im intermodalen Verkehr sowohl neue Organisationsformen als auch neue Technologien sowie neue Routen betreffen. Die folgenden, drei Innovationen, welche die Verlagerung von der Straße auf die Schiene durch intermodalen Transport begünstigen, werden vorgestellt und diskutiert: multimodale Beförderung durch Reeder in maritimen Hinterlandverkehr, innovative Technologien für den Umschlag nichtkranbarer Sattelauflieger und die Entwicklung von Güterverkehrskorridoren für den intermodalen Verkehr innerhalb des TEN -T-Netzes und im Europa-Asien-Korridor.
Schlussfolgerungen: Ein beschleunigtes Wachstum in der Verlagerung von der Straße auf die Schiene durch den intermodalen Verkehr erfordert neue innovative Konzepte, die über den traditionellen kombinierten Verkehr in Westeuropa hinausgehen. Drei ausgewählte, innovative Konzepte werden hierfür vorgestellt. Weitere Forschung ist notwendig und sollte insbesondere die vertiefte einzel- und gesamtwirtschaftliche Bewertung der Konzepte betreffen sowie die Wirksamkeit staatlicher verkehrspolitische Maßnahmen.

Codewörter: Intermodaler Transport, Multimodal Transport, Kombinierter Verkehr; Frachtkorridor, Containertransport, Nichtkranbare Sattelauflieger, Innovation.

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ANALYSIS OF PACKERS' WORKLOAD ON THE PACKING LINE – A CASE STUDY

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ABSTRACT. Background: One of the elements of the logistics system is the subsystem of production, which is a system composed of physical elements such as machinery and equipment, tools, and (most importantly) people. In addition, systems dependent on the human operator are particularly prone to problems related to: discomfort, ensuring production quality and increases in training costs and absenteeism.

Material and methods: The study was conducted in an establishment in the furniture industry, in the product packing department. The system under assessment included a position located at the conveyor belt. The aim of the study was to evaluate the load and the risk of musculoskeletal discomfort (MSD's) among workers and conduct an analysis of risk factors. For the evaluation method, the Ovako Working posture Analysing System (OWAS) was used. The evaluated activities related to the sequential packing of furniture in positions located at the conveyor belt.

Results: The result was 7 tasks qualifying for action category (AC) 1, 4 tasks for AC 2 and 5 activities for AC 4. The main risk factors influencing the negative assessment of posture were keeping the back sloped and twisted, work in a standing position and shifting weight onto one leg.

Conclusions and recommendations: On each of the evaluated positions where AC 4 occurred, employees back and legs were particularly vulnerable while retrieving elements. Corrective action in these positions should be carried out as soon as possible. Ergonomic intervention should be linked to: reorganizing positions with particular emphasis on retrieving items as well as the storage of packed products; introduction of employee rotation on such positions to ensure load variation of the musculoskeletal system. After making changes on the test positions, reassessment with the OWAS method is recommended in order to verify the effectiveness of the changes.

Key words: OWAS, workload, ergonomics, risk, MSD's.

INTRODUCTION

One of the elements of the logistics system is the subsystem of production, in which the basic elements (resources) of each of the working process are: the people, the means of work and work items [Słowiński 2008]. In turn, production systems are defined as a complex system of physical elements such as machinery and equipment, tools and (most importantly) people. Employees in the manufacturing system are "internal consumers" and the system must be designed to meet their needs. At the same time, the production system must produce goods that meet the needs of "external consumers ". In terms of health and safety, the production system is designed to meet the needs of both internal and external consumers [Black 2007]. In addition, production systems dependent on the human operator are particularly prone to problems related to: discomfort, ensuring production quality and increased training costs and absenteeism [Kasvi et al. 2000].

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Work performed by a person is accompanied by physical exertion, which can cause the appearance of musculoskeletal discomfort (MSD's) among employees [Vieira, Kumar 2004, Wang et al. 2014] in the form of health problems [Lasota 2001, Lasota 2008a, Lasota 2008b]. Studies have shown that the posture of the employee at work, range of motion, strength, repetition and duration must be taken into account when categorizing the level of physical activity [Kumar 1994]. The posture and movements of the employee during operation are important variables that must be taken into account in considering the safety of the work, as they are the two most important factors that determine the burden of the employee. The posture of the employee can be influenced by factors such as task accomplished, work, tools and their design and anthropometric characteristics [Vieira, Kumar 2004].

Research techniques proposed to estimate the level of discomfort and load profiles associated with employees taking different postures during labour can be divided into two groups - observational techniques and those based on devices. In the case of observation techniques, assessment of the angular deviation of body segments from the neutral position is achieved by means of visual observation. In contrast, techniques based on instruments involve continuous monitoring of posture performed by devices connected to the worker. Due to the lack of interference in the labour process, low cost and ease of use, observational techniques are more commonly used in industry [Genaidy et al. 1994].

Observational methods used to assess postural load of the employee include: Ovako Working posture Analysing System (OWAS) [Karhu et al. 1977], Rapid Upper Limb Assessment (RULA) [McAtamney, Corlett 1993], Rapid Entire Body Assessment (REBA) [Hignett, McAtamney 2000, Lasota 2006], Muscle Fatigue Assessment Method (MFA) [Rodges 1997] and Rapid Posture Evaluation (EPR - Evaluación Postural Rápida) [Guélaud et al. 1975]. It is important to note that they have been developed for different purposes and are therefore used under different workplace conditions [Kilbom 1994]. Each technique has its own operator classification system, which differs from other techniques; this may cause variance in the final result of the load of the operator, depending which technique was used.

Since the publication of scientific studies have shown its usefulness in assessing the posture of a worker while working in different environments such as warehouses [Torres, Vina 2012], construction [Li, Lee 1999], the poultry industry [Scott, Lambe 1996], operation and maintenance of boats [Joode et al. 1997], beverages distribution centres [Wright, Haslam 1999], metalworking [Gonzalez et al. 2003], wood [Jones, Kumar 2007], fish processing [Quansah 2005], the steel industry, electronics, automotive and chemical industries [Kee, Karwowski 2007, Lasota 2013, Lasota 2013b, Lasota, Ścigaj 2013, Lasota 2014, Muthukumar et al. 2014, Sesek et al. 2004, Wang et al. 2014], etc.

Modern production systems featuring assembly lines and packing lines are often equipped with a conveyor belt for transport. The performance of such a system is not determined solely by the technical subsystem, but also by the human subsystem. From an ergonomic point of view, a key element affecting workers and the efficiency of workflow is that of improper positions taken during work. In particular, this can be affected by excessive load. Discomfort in the human system can lead to problems associated with the provision of production, quality and an increase in costs related to sickness absence due to the negative impact of work on the health of workers. Hence, an essential element of ergonomic assessments is the detection of risks that require ergonomic intervention to improve the efficiency of the system.

This study focuses on one case relating to the packaging of furniture for positions located at the conveyor belt (Figure 1, Figure 2), which allowed for a detailed investigation on the interaction of employees with each element of the task. Due to the fact that employees perform the work manually, a set of methods was used including: interview, task analysis and OWAS, which is recognized as one of the simplest techniques of observation and in conjunction with the observation method enables fast performance evaluation and assessment of the level of ergonomic intervention associated with the risk of MSDs.

The aim of the study was to evaluate the workload and the risk of MSD's in the packaging of the product and the analysis of risk factors using the OWAS method.

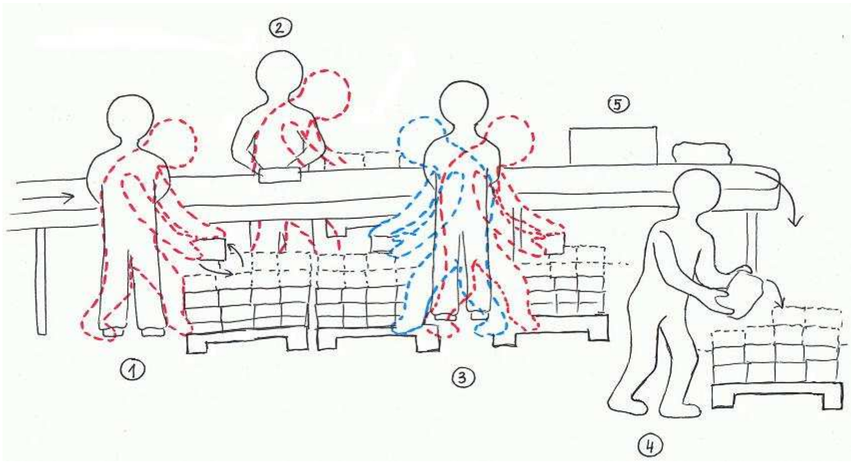

Fig. 1. The packing line - front view
Rys. 1. Linia pakowania - widok z przodu

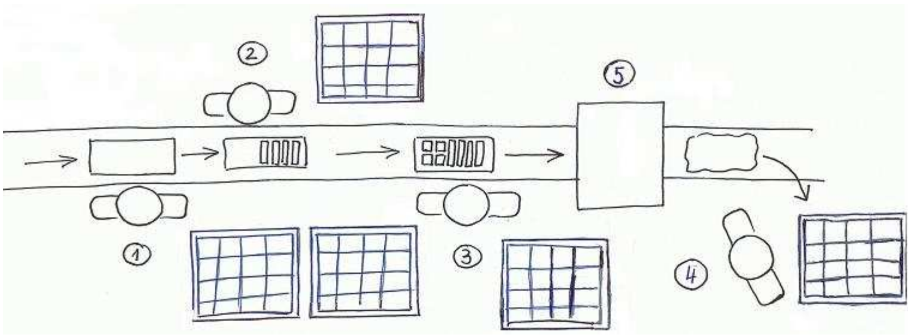

Fig. 2 The packing line - top view
Rys. 2. Linia pakowania - widok z góry

RESEARCH DESIGN AND METHODS

Research design

This case study was carried out in the packaging section of an enterprise in the furniture industry located in western Poland. The study was limited to the packaging of a table as a final product. The evaluated system consisted of 4 stations located at the conveyor belt. Work took place in a standing position, in three shifts with a working time of 8 hours per shift. The sample consisted of 12 men with a mean age of 28.5 years, standard deviation (SD = 4.5) and years of service 9.9 (4.6) years.

Process and Task Description

The work consisted of the sequential placement of individual elements of the furniture on the conveyor belt, according to the technological card developed by the technologist. The table packaging process was conducted in four stages in the following sequence: first the top was placed on the conveyor, followed by the legs, then fittings and boxes of screws. Once arranged, the elements enter a thermo-sealing machine whose function is to shrink wrap the furniture. The packaged product was then removed from the belt and laid on a pallet. Each employee on the packaging line was responsible for the quality of component placement, controlled by the correct placement of its predecessor.

Data Collection

Several techniques have been used to collect data in this study: observation, interviews, task analysis and postural evaluation.

Observations, interviews and task analysis

Observations of the tasks carried out by employees were preceded by an interview with the manager and employees to understand the process of work and activities performed by employees. A hierarchical task analysis [Annett 2004] was used to identify the activities performed by the Packers. Four tasks were identified in the activities performed by employees (Table 1 - Table 4).

Table 1. OWAS rating for position no. 1 - setting down the tabletop
Tabela 1. Ocena OWAS na stanowisku nr 1 - umieszczanie blatu

No.	Operation	Position code for body segment				AC
		Back	Arms	Legs	Load	
1	Obtaining	4	1	5	1	4
2	Visual inspection	1	1	2	1	1
3	Setting down	2	1	2	1	2

Table 2. OWAS rating for position no. 2 - laying down the legs
Tabela 2. Ocena OWAS na stanowisku nr 2 - układanie nóg

No.	Operation	Position code for body segment				AC
		Back	Arms	Legs	Load	
1	Obtaining	4	1	5	1	4
2	Visual inspection	1	1	2	1	1
3	Setting down	2	1	2	1	2

Table 3. OWAS rating for position no. 3 - placement of fittings
Tabela 3. Ocena OWAS na stanowisku nr 3 - umieszczanie okuć

No.	Operation	Position code for body segment				AC
		Back	Arms	Legs	Load	
1	Visual inspection	1	1	2	1	1
2	Obtaining fittings	4	1	5	1	4
3	Placing fittings	1	1	2	1	1
4	Obtaining box	4	1	5	1	4
5	Packing to box	1	1	2	1	1

Table 4. OWAS rating for position no. 4 - depositing to pallet
Tabela 4. Ocena OWAS na stanowisku nr 4 - odkładanie na paletę

No.	Operation	Position code for body segment				AC
		Back	Arms	Legs	Load	
1	Visual inspection	2	1	2	1	2
2	Obtaining	2	1	3	1	2
3	Transfer	1	1	7	1	1
4	Depositing	4	1	5	1	4
5	Return	1	1	7	1	1

The OWAS Method and postural evaluation

The OWAS method was developed by Finnish authors in the Oy Ovako Company [Karhu et al. 1977] and has been disseminated in many countries. The method was developed to assess the risk of exposure to MSD's associated with the posture of the employee while working. The method comprehensively considers the issue, based on an observation technique whilst performing the work. The approach takes into account the posture taken by the operator during operation by highlighting the following body segments: the trunk (back), arms, legs, and measuring the external load in kilograms, which has a significant impact on risk. The basis for the assessment of exposure to MSD's is the degree of the total load on the body with regard to posture and the external load. The OWAS method is focused on the identification of problems and corrective actions which finds its expression in terms of evaluation. The main objective of the assessment, therefore, is to make possible the disclosure and correction of undesirable operations.

In this method, the model distinguishes three segments of the human body, which may take different postures and external loads. The OWAS method takes into account the load derived from four factors:

- Back position (four coded items: 1 - straight/ upright, 2 - bent forward, 3 - straight and twisted, 4 - bent and twisted),
- Position of the arms (three codes : 1 - both arms below shoulder height, 2 - one arm above shoulder height, 3 - both arms above shoulder height),
- Position of the legs (seven items: 1 - sitting position, 2 - standing on both legs, knees straight, 3 - standing with one leg extended, knees straight, 4 - standing with two bent knees, 5 - standing on one bent knee, 6 - kneeling on one or both knees, 7 - walking or moving),
- External load in kg (three codes: 1 - less than 10kg, 2 - from 10 to 20kg, 3 - over 20kg).

The total load code for the operator is comprised of the codes for the position of the back, the position of the arms, legs and the position of the external load, thus creating a four-digit code. Their combination creates categories describing the assessment of the risk of exposure to MSD's and categories of actions (AC) necessary to improve the working conditions on the test bench. The authors singled out:

- AC 1 - No risk: Normal posture, with no particular adverse effect on the musculoskeletal system. Intervention is not required.
- AC 2 - Low risk: Working posture has a slight detrimental effect on the musculoskeletal system, there is a light load, immediate intervention is not required, but the ergonomic adjustment should be taken into account in future actions.
- AC 3 - Medium risk: Working posture has a significant detrimental effect on the musculoskeletal system; ergonomic intervention should be carried out as soon as possible.
- AC 4 - High risk: Working posture has a very high detrimental effect on the musculoskeletal system; ergonomic intervention is required immediately.

Positions taken by the operators were assessed during routine daily work. In turn, positions taken by each of the workers were evaluated several times. The most unfavourable positions taken by the Packers were taken into account.

RESULTS AND DISCUTION

In position no.1 (Table 1) in which the employee placed the table top on the belt, three worker postures were rated. In the case of collection of the tabletop, exposure to MSD's was very high; AC 4, which requires urgent ergonomic intervention. Such a high rating was associated with both tilting and twisting of the back, with the weight transferred onto one leg bent at the knee. In the case of the visual inspection stage, the risk was assessed as low, AC1, and does not require intervention. In contrast, placement of the tabletop on the conveyor belt was associated with medium risk, AC2 which may entails the need to make changes to the position. For the evaluated position, the most vulnerable segment of the body to injuries arising was the back, which was usually leaning forward and bent and twisted at the same time.

In position no. 2 (Table 2) - stacking of the legs - three tasks were distinguished. Obtaining the legs for the table from the palette was associated with a high risk of MSD's, AC 4, which requires immediate intervention. The employee obtains the items whilst turning and leaning back and moving the weight onto one leg, which was bent at the knee joint. During visual inspection, the posture of the worker was correct: no risk, AC1. In contrast, placing the legs on the table whilst on the conveyor belt qualified for AC 2, medium risk, due to forward tilting of the trunk.

In position 3 (Table 3) the employee placed fittings. Five distinct worker postures were identified. Obtaining fittings and boxes with screws were associated with a high risk, AC4 - intervention required immediately. Incorrect posture was caused by twisting while leaning back and transfer of weight onto one leg, which was bent at the knee joint. The posture of the worker in the other three actions was correct: no risk, AC 1, which does not require an ergonomic intervention.

In position no. 4 (Table 4) five worker postures were evaluated. In the case of the action of depositing the packed piece on the pallet, exposure to MSD's was very high; AC 4, which requires immediately ergonomic intervention. This procedure was associated with tilting and twisting of the back while the weight was transferred onto one leg bent at the knee. In the case of two tasks: taking items from the conveyor belt and the visual inspection of the packaged product, the risk of MSD's was classified as medium; AC 2. In turn, the transfer of the packed product and returning for another packed product was characterized by minimal exposure to MSD's, AC 1 - intervention is not required. The most vulnerable segment of the body to injuries arising was the back, which was tilted forwards during the inspection of the packaged product, obtaining items from the conveyor belt and depositing them on the pallet located on the trough. An incorrect posture was also taken by the lower limbs while downloading the product and setting it down on a pallet.

When assessing the packaging process, which took place on the following positions located at the conveyor belt, only 7 of the 16 activities evaluated were found not to be associated with the risk of MSD's - AC 1. In contrast, four tasks were associated with medium risk, AC 2, which means that the positions need to be changed. The main reason was excessive forward tilting of the back. There were no activities qualifying for AC3. In contrast, 5 of the 16 activities were related to very high risk, AC 4, which requires immediate intervention. The AC 4 rated positions included 4 tasks for obtaining components and one concerning the depositing of the packed table onto the palette.

It was observed that in all activities, the load was below 10kg and employees maintained arms below the shoulders all the time. Incorrect posture was taken by the back and lower limbs. In the case of the back, incorrect posture was observed in 9 out of 16 cases. Workers backs were excessively tilted and / or twisted, especially when obtaining items from the pallet. In the case of the legs, incorrect posture was also noted in 6 cases: body weight was transferred onto one leg, either upright or bent at the knee. Incorrect leg posture affected retrieving items from the palette and placing the packaged product on the pallet.

The main cause of the irregularity of postures of employees is believed to lie in incorrect job planning. Packaged items were on pallets, in which the initial height of the working plane was about 1.3 m, but over time decreased to approximately 0.2m, causing the appearance of awkward postures. Positions were not equipped with any technical measures that would allow the adjustment of the height of the pallet. Furthermore, in positions 1, 2 and 3 pallets are located behind the worker, causing twisting of the torso and bending, especially significant in the case of obtaining items from the lower layers. Such placement of pallets was probably "more convenient" for an additional person whose task was to replenish empty space on the pallets with successive portions of the pack.

CONLUSIONS AND RECOMENDATIONS

An important element in production systems, apart from the physical elements, is the human factor. This factor significantly affects performance, cost and quality [Istota inżynierii produkcji 2012]. The improvement of manufacturing systems should not only cover the technical sphere, but also the realm associated with the environment and ergonomics. The aim of this study was to assess the level of exposure to MSD's in the packing of a product using the OWAS method.

Of the 16 postures evaluated, the results were:
- AC 1 - 7 operations,
- AC 2 - 4 operations,
- AC 4 - 5 operations.

The main risk factors influencing the negative assessment of posture were:
- Maintaining a sloping and twisted back;
- Working in a standing position;
- Transfer of the body weight onto one leg.

Work on the test bench was associated with a significant exposure of workers to health problems, hence changes to the positions should be carried out. Production engineers and specialists in the field of health and safety should pay particular attention to the organization of the packaging process and in particular the deployment of individual components subject to packaging. Ergonomic intervention should be related to:
- Reorganization of positions, with particular emphasis on retrieve items as well as the storage of packaged products,
- The introduction of a system of rotation of employees in order to ensure the variability of the workload.

After making changes on the test bench reassessment with the OWAS method is recommended in order to verify the effectiveness of the changes.

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ANALIZA OBCIĄŻENIA PRACĄ PAKOWACZY PRACUJĄCYCH NA LINI POTOKOWEJ - STUDIUM PRZYPADKU

STRESZCZENIE. **Wstęp:** Jednym z elementów systemu logistycznego jest podsystem produkcji, który jest układem złożonym z elementów fizycznych takich jak: maszyny i urządzenia, narzędzia pracy, i (co najważniejsze) ludzi. Ponadto systemy zależne od człowieka-operatora są szczególnie podatne na problemy związane z: uciążliwościami, zapewnieniem produkcji, jakości i ze wzrostem kosztów szkolenia i nieobecności w pracy.
Materiał i metody: Badanie przeprowadzono w zakładzie przemysłu meblarskiego na dziale pakowania wyrobów. W skład ocenianego systemu wchodziły stanowiska zlokalizowane przy taśmie transportującej. Celem pracy była ocena obciążenia i ryzyka wystąpienia zaburzeń mięśniowo-szkieletowych (MSDs) u pracowników, analiza czynników ryzyka. Do oceny zastosowano metodę Ovako Working posture Analysing System (OWAS). Oceniono czynności związane z sekwencyjnym pakowaniem mebla na stanowiskach zlokalizowanych przy taśmie transportującej.
Wyniki: Do kategorii działań (KD) 1 zakwalifikowano 7 czynności, KD 2 - 4 czynności, KD 4 - 5 czynność. Głównymi czynnikami ryzyka wpływającymi na negatywną ocenę pozycji podczas pracy były: utrzymywanie pleców pochylonych i skręconych, praca w pozycji stojącej, przenoszenie ciężaru ciała na jedną nogę.
Wnioski i rekomendacje: Na każdym z ocenianych stanowisk wystąpiła KD 4, szczególnie narażone były plecy i nogi pracowników podczas pobierania elementów stąd działania korekcyjne na stanowiskach powinny być przeprowadzone najszybciej jak to możliwe. Interwencja ergonomiczna powinna być związana z: przeorganizowaniem stanowisk ze szczególnym uwzględnieniem pobierania elementów jak również składowania zapakowanych wyrobów; wprowadzeniem systemu rotacji pracowników na stanowiskach w celu zapewnienia zmienności obciążenia układu mięśniowo-szkieletowego. Po dokonaniu zmian na badanym stanowisku zaleca się ponowną ocenę metodą OWAS w celu weryfikacji skuteczności wprowadzonych zmian.

Słowa kluczowe: OWAS, obciążenie pracą, ergonomia, ryzyko, MSDs.

ANALYSE DER ARBEITSBELASTUNG VON PACKERN AM FLIESSBAND - EINE FALLSTUDIE

ZUSAMMENFASSUNG. Einleitung: Einer der Bestandteile eines Logistiksystems ist das Subsystem der Produktion, welches aus physischen Elementen besteht, wie: Maschinen und Geräten, Arbeitswerkzeugen, und (was am wichtigsten erscheint) aus Menschen. Darüber hinaus sind die von menschlichem Operator abhängigen Systeme besonders anfällig für Probleme verbunden mit arbeitsmä?igen Beschwerlichkeiten, mit Sicherstellung der Produktion und Qualität sowie mit steigenden Schulungskosten und unterschiedlich bedingter Abwesenheit von Mitarbeitern am Arbeitsplatz.
Material und Methoden: Die Untersuchung wurde in der Verpackungsabteilung eines Möbelproduktionsbetriebs durchgeführt. Bestandteile des bewerteten Systems waren Arbeitsstellen am Fließband. Das Ziel der Untersuchung war die Prüfung der Belastung und des Risikos von Muskel-Skelett-Krankheiten (MSDs) bei den Mitarbeitern und die Analyse von Risikofaktoren. Zur Beurteilung wurde die OWAS-Methode (Ovako Working posture Analysing System) angewendet. Beurteilt wurden alle Tätigkeiten beim sequenziellen Verpacken von Möbelstücken am Förderband.
Ergebnisse: In der Maßnahmenklasse (KD) 1 wurden 7 Tätigkeiten, KD 2 - 4 Tätigkeiten, KD 4 - 5 Tätigkeiten ermittelt. Die Hauptrisikofaktoren, die die negative Bewertung der Körper-Haltung bei der Arbeit beeinflussten, waren: gebeugter und gekrümmter Rücken, Arbeit im Stehen, Übertragung der Körperlast auf ein Bein.

Schlussfolgerungen und Empfehlungen: An jeder Arbeitsstelle kam KD 4 vor, besonders gefährdet waren beim Entnehmen von einzelnen Elementen der Rücken und die Beine der Mitarbeiter. Daher sollten die Korrektionsmaßnahmen an den Arbeitsstellen schnellstmöglich vorgenommen werden. Die ergonomische Intervention sollte Folgendes umfassen: die Umgestaltung der Arbeitsstellen mit einer besonderen Berücksichtigung der Entnahme von Elementen sowie der Lagerung fertiger Erzeugnisse und Einführung eines Arbeitsstellenwechselsystems für die Mitarbeiter zur Variierung der Belastung des Muskel-Skelett-Systems. Nachdem Änderungen in den untersuchten Stellen vorgenommen worden sind, wird eine erneute Untersuchung nach der OWAS-Methode empfohlen, um die Effektivität der eingeführten Veränderungen zu verifizieren.

Codewörter: OWAS, Arbeitsbelastung, Ergonomie, Risiko, Muskel-Skelett-Krankheiten, MSDs

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RECENT TRENDS IN PACKAGING SYSTEMS FOR PHARMACEUTICAL PRODUCTS

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ABSTRACT. Background: In recent years, pharmaceutical packaging market was one of the fastest growing areas of the packaging industry. At the same time the packaging manufacturers put high demands on quality and safety.
Methods: Review of innovations in packaging systems for pharmaceutical products was made including newest information of researches and achievements of recent years.
Results and conclusion: Observed in recent years the development of pharmaceutical packaging market expanded due to with the huge technological advances that allow introduction of new packaging. Also, in this study presented intelligent packaging in pharmacy and innovation in child-resistance packaging.

Key words: pharmacy, packaging, intelligent packaging.

INTRODUCTION

Pharmaceutical packaging may be defined as the science, art and technology of enclosing or protecting products for distribution, storage, sale and usage including printed material, employed in the finishing of a pharmaceutical product [Mehta et al., 2012]. According to World Health Organization (WHO), global pharmaceuticals market is worth US$300 billion a year, a figure expected to rise to US$400 billion within three years. The 10 largest drugs companies control over one-third of this market, several with sales of more than US$10 billion a year and profit margins of about 30%. Six are based in the United States and four in Europe. It is predicted that North and South America, Europe and Japan will continue to account for a full 85% of the global pharmaceuticals market well into the 21st century. Also, the development of the pharmaceutical market has led to the growth of the market for medicinal product packaging. In 2010, the value of the global pharmaceutical packaging market amounted to USD 47,8 billion. According to the data provided by Global Business Intelligence Research, until 2017 it should increase by 7,3% per year on average, and by the end of the forecasted period, it should approach the amount of USD 80 billion. Although the packaging for the medical and pharmaceutical sector constitutes only a small part of the world packaging industry (about 5% of production), due to the dynamic development of this sector in the last few years, medicinal and pharmaceutical packaging is becoming one of the driving forces behind the growth of the whole packaging industry. Because of the unchangeable demand for drugs, the pharmaceutical packaging industry is highly resistant to macroeconomic factors. Therefore, it is a particularly attractive niche that has been penetrated relatively superficially [Mrówczyński, 2011].

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The use of packaging systems not only intended for passive protection against humidity, light and oxygen, but also designed to improve the overall quality characteristics of their contents, e.g. to extend shelf-life and enhance safety, is a well-known concept for medical products [Rooney, 1995, Vermeiren et. al. 1999, Ahvenainen, 2003]. The packaging for medicinal products has to satisfy certain requirements. Above all, the packaging is designed to protect the product against the external effects of all actions that may change the properties of the product, e.g. humidity, light, oxygen, temperature and changes in temperature. Moreover, its role is to protect the product against biological contamination and mechanical damage, as well as enable the correct information and identification of the product. The type of packaging and the materials used have to be chosen in such a way as to exclude the adverse effect of the packaging on the product (through chemical reactions, the rinse of packaging materials, or absorptions). The safety aspect must also work reversely, i.e. the product cannot have negative effect on the packaging; it cannot change the properties of the packaging and affect its protective function [Dobrucka, 2012]. Moreover, packaging should give clear identification of the product at all stages. The life of the patient may depend upon rapid and correct identification in emergencies. Packaging also serves as a mean to identify the manufacturer of the product. Besides, packaging should carry the information on the correct usage of dosage forms, their contents, their provenance, side-effects and warnings [Chirag et al., 2012]. Package should assist in patient compliance [Aulton, 2005, Mehta, 2001].

Also, packaging is also of great importance during the examinations of the stability of medicinal products in various conditions related to temperature and humidity, performed in line with GMP requirements. The scope of examination includes the packaging of a given product. Thus, the stability of the drug in given packaging in various climatic conditions is an indicator of safety and quality, very important both to the manufacturing company and the patient.

INTELLIGENT PHARMACEUTICAL PACKAGING

Constant innovations in the pharmaceuticals themselves (such as prefilled syringes, blow fill seal vials, powder applications and others) also hale a direct impact on the packaging. Traditionally, the majority of medicines (51%) have been taken orally by tablets or capsules, which are either packed in blister packs (very common In Europe and Asia) or fed into plastic pharmaceutical bottles (especially in the USA). Powders, pastilles and liquids also make up part of the oral medicine intake. However, other methods for taking medicines are now becoming more Widery used. These include parenteral or intravenous (29%), inhalation (17%), and transdermal (3%) methods. Oral tablets themselves are also now available in a wide range of different shapes and sizes. These changes have made a big impact on the packaging industry and there is an increasing need to provide tailored, individual packaging solutions, which guarantee the effectiveness of medicines [Kunal et al., 2012]. For this reason, one of the packaging that has been introduced in the pharmaceutical industry is intelligent packaging. At present, this packaging system is growing rapidly. In pharmacy, intelligent packaging is designed to facilitate communication within the whole medicinal product chain, as well as to ensure its better quality and safety. The role of the intelligent drug packaging is also to increase the effectiveness of the taken drug, which has a direct effect on the improvement of the patients' health and brings considerable savings. An example of this type of packaging is system based on conductive ink on a carton board based blister inlay, which is connected to a cellular module embedded in the package. This enables the tracking of one pill at the time on removal from the blister, whereby data is sent to the cellular module and then forwarded wirelessly, even instantaneously if required, using GSM or GPRS cellular networks, to electronic health record systems. This allows real-time tracking and intervention by a physician and also enables physicians to make timely changes to patients' medication. The principal benefits derive from the numerous possibilities that this solution provides to healthcare service providers:

sending voice-call reminders or text messages (SMS) to patients, or making personal visits when important prescribed medication has not been taken in time. Another type of intelligent solution is packaging system, designed for topical treatments. This technology measures the right amount of topical cream or ointment to simplify the application process. Besides, this system allows patients to scan a digitally embedded watermark in the packaging with their smartphones to access extra product information.

In the pharmaceutical market there is also the "talking packaging". There are for patients who have problems with regularity in the use of drugs. System the "TalkPack" can be invisibly integrated into any printed image on any packaging material. This technology needs a special scanning pen. The method used by "TalkPack" is not limited to the packaging material but can be used by any printed material. No other composite elements are used which could influence the recycling qualities. A special pen-shaped reader is used to retrieve the stored information and to replay it as audio files. Talk Pack does not require any RFID or microchips; the dot code is simply printed on top of images and texts using a special varnish. This technology can be used with all printing technologies and package types. For example, NFC (Near Field Communication) tags can be added to any packaging so a consumer could touch the code on the packaging with their NFC-enabled mobile phone to download text, audio or web page product information, which can be played back on his handset. The medical and pharmaceutical industry could use the technology to display detailed information and instructions in a small area.

The huge changes relate to aerosols. In the pharmaceutical market there are systems of aerosols with indicators of dose. One example is nebulizer designed to operate in-line with standard ventilator circuits and mechanical ventilators. This system is operated without changing patient ventilator parameters. Besides, this nebulizer is refilled without interrupting ventilation. In order to remind the patient about the dose or to take the drug, special packaging was introduced to the market. It has a special closing equipped with electronic microcircuits, which strictly monitors the date and time of each opening and closing of the packaging. The packaging closing is equipped with an LCD screen, which shows the number of the drug doses administered within 24 hours, as well as the time that has elapsed since the last pill was taken. All the actions connected with opening and closing the packaging are saved, and later they can be read and analysed during a medical appointment. This solution makes it possible to determine whether the patient complied with the chosen therapy, as well as to assess its effects. Another type, the Slide Pack packaging, ensures that the medicinal product is not separated from its packaging and it constitutes its integral part. Moreover, the packaging ensures that both the blister pack with pills and the patient information leaflet are packed together and are easily available to the client. In order to open the packaging, you grab the shorter sides of the rectangular box and pull out the compartments. From one side, you pull out the blister pack with pills/capsules, while from the other - the patient information leaflet, from which the patient can read the application instructions at any time.

As the pre-filled syringes become more popular on the pharmaceutical market, the packaging with a security mechanism has been introduced. The mechanism prevents injuries, and it is integrated with the safety label [MedPack, 2011]. It is related to the fact that the pre-filled syringe contains a needle, which poses the risk of an accidental prick with an already contaminated needle. In the new pre-filled syringe, next to the needle there is a special mechanism - Needle Trap, thanks to which the patient may administer the drug independently, without running the risk of microbiological contamination. Moreover, to reduce the possibility of microbial contamination and the risk of disease transmission dry as hepatitis or HIV developed new syringe design. This syringe turns dark red after use and warning doctors and patients that it may be contaminated. The ABC Syringe is impregnated with an ink that's sensitive to carbon dioxide and then sealed in a protective atmosphere so that it remains transparent until it is ready for use. After the seal is broken, the shell of the syringe starts to turn a dark red, alerting both doctors to the risk that the syringe may already have been used.

INNOVATION IN CHILD-RESISTANCE PACKAGING

Since its introduction in the late 60s and early 70s, child-resistant packaging has led to a significant reduction in the number of children admitted to hospital for accidentally ingesting poisonous substances. However, recent statistics show accidental poisoning is still a serious problem worldwide, even in heavily regulated, developed countries.

USA was the first country in the world that introduced the requirement of securing the child of chemical substances and drugs. To be able to say that the packaging is sufficiently well protected against children, at least 85% of the 200 children tested could not cope with opening the package within 5 minutes of testing. The result is positive if at least 85% of the children did not open the package (opened less than 8 for packaging unit doses of pharmaceutical products) during the first test, and if at least 80% of the children did not open the package (opened less than 8 for packaging unit doses of pharmaceutical products) during the first and second attempt. An article published in 2011 in the Journal of Pediatrics reported the number of children admitted to hospital in the US after swallowing inappropriate medication has been increasing in recent years. The most popular used packaging to protect the child is close to a 'push - turn "or " squeeze- turn ". This type of closure requires the use of two hands to open the package . Many pharmaceutical companies in the world conduct research on packaging safe for children. One example is blisters with the necessary puncture resistance and specialized peelability to meet both American standards and European testing criteria. Broad range of lidding structures that suit all opening mechanisms: push-through, peel-push, peel-open and tear-open. Also, one of the pharmaceutical companies introduced printed tear indicator, accompanied by text explaining how to open it as opposed to other packaging options on the market which use a notch to signify where to tear open the sachet. The level of child resistance can be further increased by incorporating Amcor's tear system with "fold first" or "squeeze first" instructions. Child resistant packaging must strike a balance between being too hard for children to open but easy enough for invalids and the elderly to access.

Spray products, both cosmetic and pharmaceutical, are particularly challenging for packaging designers to protect against curious children. A spray top is much easier and more intuitive for a child's mind to grasp than a screw-top bottle. In recent years, sliding lock systems have become popular for many spray cans. Developed specifically for a new anesthetic spray being launched by a major US pharmaceutical company, the design's opening mechanism requires a tab to be pushed at the same time as the cap is being twisted, an action that requires the wrist and fingers to work together, something that is beyond most young children.

SUMMARY

Packaging in the pharmaceutical industry has gone through major changes in the past decade. This is undoubtedly due to the fact that they are placed high demands. The advent of new drug delivery systems and the development of new biochemical compounds have resulted in a need not only for enhanced protection against factors such as moisture, light, oxygen and mechanical forces, but also for packaging forms to play a more integral role in the drug delivery process.

The protective and safety function of the product gains a special meaning here and it must be guaranteed in each type of packaging used, with no exceptions. However, the wide range of materials used in the pharmaceutical packaging industry does not impose any limitations on the manufacturers, and the dynamic development of the plastic industry leads to new opportunities and solutions related to packaging. Therefore, the innovations that are now inventions will soon be generally accessible, and they will be replaced with other novelties. Everything that is being created aims at achieving the highest product quality and thus the safety of the potential patient.

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NOWE ROZWIĄZANIA W SYSTEMACH PAKOWANIA PRODUKTÓW FARMACEUTYCZNYCH

STRESZCZENIE. **Wstęp:** W ostatnich latach rynek opakowań farmaceutycznych należał do najszybciej rozwijających się obszarów przemysłu opakowaniowego. Jednocześnie wyznaczał producentom opakowań duże wymagania w zakresie jakości i bezpieczeństwa.
Metody: Przegląd innowacji w systemach pakowania dla produktów farmaceutycznych został dokonany z uwzględnieniem nowości ostatnich lat.
Wyniki i podsumowanie: Obserwowany na przestrzeni ostatnich lat rozwój rynku opakowań farmaceutycznych związany jest przede wszystkim z ogromnym postępem technologicznym, który umożliwia wprowadzenie na rynek nowych opakowań. W związku z tym, w pracy przedstawiono inteligentne opakowania dla farmacji oraz innowacje w opakowaniach chroniących przed niepożądanym otwarciem przez dzieci.

Słowa kluczowe: farmacja, opakowanie, opakowania inteligentne.

NEUE LÖSUNGEN IN VERPACKUNGEN FÜR PHARMAZEUTISCHE PRODUKTE

ZUSAMMENFASSUNG. Einleitung: In den letzten Jahren war der Markt für pharmazeutische Verpackungen einer der am schnellsten wachsenden Bereiche der Verpackungsindustrie. Gleichzeitig hat er den Verpackungsherstellern hohe Anforderungen an Qualität und Sicherheit gestellt.
Methoden: Es ist eine Übersicht von Innovationen innerhalb der Verpackungen für pharmazeutische Produkte unter Berücksichtigung der Neuheiten der letzten Jahre gemacht worden.
Ergebnissen und Fazit: Die in den letzten Jahren auf dem Markt für fharmazeutische Verpackungen beobachtete Entwicklung ist in erster Linie mit den großen technologischen Fortschritten, die die Einführung von neuen Verpackungen ermöglichen, verbunden. Im Zusammenhang damit wurden intelligente Verpackungen für die pharmazeutische Industrie sowie innovative Lösungen in Verpackungen, die vor unbefugtem Öffnen durch die Kinder zu schützen vermögen, dargestellt.

Codewörter: Pharmazie, Verpackung, intelligente Verpackungen

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APPLYING ROBUST RANKING METHOD IN TWO PHASE FUZZY OPTIMIZATION LINEAR PROGRAMMING PROBLEMS (FOLPP)

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ABSTRACT. Background: This paper explores the solutions to the fuzzy optimization linear program problems (FOLPP) where some parameters are fuzzy numbers. In practice, there are many problems in which all decision parameters are fuzzy numbers, and such problems are usually solved by either probabilistic programming or multi-objective programming methods.

Methods: In this paper, using the concept of comparison of fuzzy numbers, a very effective method is introduced for solving these problems. This paper extends linear programming based problem in fuzzy environment. With the problem assumptions, the optimal solution can still be theoretically solved using the two phase simplex based method in fuzzy environment. To handle the fuzzy decision variables can be initially generated and then solved and improved sequentially using the fuzzy decision approach by introducing robust ranking technique.

Results and conclusions: The model is illustrated with an application and a post optimal analysis approach is obtained. The proposed procedure was programmed with MATLAB (R2009a) version software for plotting the four dimensional slice diagram to the application. Finally, numerical example is presented to illustrate the effectiveness of the theoretical results, and to gain additional managerial insights.

Key words: Decision making, Fuzzy Optimization Linear programming (FLOP), Two phase method, Post optimal analysis.

INTRODUCTION

Over the last few years, more and more manufacturers had applied the optimization technique most frequently in linear programming to solve real-world problems and there it is important to introduce new tools in the approach that allow the model to fit into the real world as much as possible. Any linear programming model representing real-world situations involves a lot of parameters whose values are assigned by experts' opinion, and in the conventional approach, they are required to fix an exact value to the aforementioned parameters. However, both experts and the decision maker frequently do not precisely know the value of those parameters. If exact values are suggested these are only statistical inference from past data and their stability is doubtful, so the parameters of the problem are usually defined by the decision maker in an uncertain space. Therefore, it is useful to consider the knowledge of experts' opinion about the parameters as fuzzy data. Fuzzy data helps the decision maker to take the decision in open ended space; since the market is volatile it is very difficult to take the optimum decision of the decision parameters. In the mean time fuzzy related data helps for obtaining the optimal solution and then the post optimal solution gives the managerial implications for the given problem.

Two significant questions may be found in these kinds of problems: how to handle the

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relationship between the fuzzy parameters, and how to find the optimal values for the fuzzy multi-objective function. The answer is related to the problem of ranking fuzzy numbers.

In fuzzy decision making problems, the concept of optimizing the decision was introduced by Bellman and Zadeh [1970]. Zimmerman [1978] presented a fuzzy approach to multi-objective linear programming problems in his classical paper. Lai and Hwang [1992] considered the situations where all parameters are in fuzzy number. Lai and Huang [1992] assume that the parameters have a triangular possibility distribution. Gani et al. [2009] introduce fuzzy linear programming problem based on L-R fuzzy number. Jimenez et al. [2005] propose a method for solving linear programming problems where all coefficients are, in general, fuzzy numbers and using linear ranking technique. Bazaar et al. [1990] and Nasseri et al. [2005] define linear programming problems with fuzzy numbers and simplex method is used for finding the optimal solution of the fuzzy problem. Rangarajan and Solairaju [2010] compute improved fuzzy optimal Hungarian assignment problems with fuzzy numbers by applying robust ranking techniques to transform the fuzzy assignment problem to a crisp one. Pattnaik [2012] presented a fuzzy approach to several linear and nonlinear inventory models. Swarup et al. [2006] explain the method to obtain sensitivity analysis or post optimality analysis of the different parameters in the linear programming problems.

In fact, in order to make linear programming more effective, the uncertainties that happen in the real world cannot be neglected. Those uncertainties are usually associated with per unit cost of the product, product supply, customer demand and so on. Looking at the property of representing the preference relationship in fuzzy terms, ranking methods can be classified into two approaches. One of them associates, by means of different functions, each fuzzy number to a single of the real line and then a total crisp order relationship between fuzzy numbers is established. The other approach ranks fuzzy numbers by means of a fuzzy relationship. It allows decision maker to present his preference in a gradual way, which in a linear programming problem allows it to be handled with different degrees of satisfaction of constraints. This paper considers fuzzy multi-objective linear programming problems whose parameters are fuzzy numbers but whose decision variables are crisp. The aim of this paper is to introduce robust ranking technique for defuzzifying the fuzzy parameters and then sensitivity analysis for the requirement vector in the constraint function is also performed that permits the interactive participation of decision maker in all steps of decision process, expressing his opinions in linguistic terms for managerial insights. The major techniques used in the above research articles are summarized in Table 1. In the present scenario the market is totally uncertain so it is very difficult to take the decision for the exact cost of the product. For avoiding this type of unusual difficulties the optimum solution can be obtained in fuzzy decision space.

Table 1. Major Characteristics of Fuzzy Optimization Linear Programming (FOLP) Models on Selected Researches
Tabela 1. Cechy charakterystyczne modeli optymalizacji liniowej w wybranych opracowaniach

Author(s) and Published Year	**Structure of the Model**	**Fuzzy Number**	**Objective Model**	**Model Type**	**Ranking Function**	**Sensitivity Study**
Zimmermann (1978) [16]	Fuzzy	Triangular	Single	Cost	Linear	No
Maleki et al. (2000) [9]	Fuzzy	Trapezoidal	Multi	Profit	Linear	No
Jimenez et al. (2005) [5]	Fuzzy	Triangular	Multi	Cost	Linear	No
Nasseri et al. (2005) [10]	Fuzzy	Trapezoidal	Multi	Profit	Linear	No
Buckly et al. (2000) [3]	Fuzzy	Triangular	Multi	Profit	Linear	No
Present Paper (2014)	Fuzzy	Trapezoidal	Multi	Profit	Robust	Yes

The remainder of this paper is organized as follows. In Section 2, it is introduced fuzzy numbers and some of the results of applying arithmetic on them. Assumptions, notations and definitions are provided for the development of the model. In Section 3, it is introduced Robust' ranking technique for solving fuzzy number linear programming problems. In Section 4, a linear programming problem with fuzzy variables is proposed and in Section 5 it is explained a fuzzy version of the simplex algorithm of two phase method for solving this problem. An application is presented to illustrate the development of the model in Section 6. The sensitivity analysis is carried out in Section 7 to observe the changes in the optimal solution. Finally Section 8 deals with the summary and the concluding remarks.

PRELIMINARIES

It is reviewed that the fundamental notation of fuzzy set theory initiated by Bellman and Zadeh [2]. Below it is given definitions taken from Zimmerman [16].

Definition 2.1 *Fuzzy sets*

If X is a collection of objects denoted generally by x, then a fuzzy set $\tilde{A}$ in X is defined as a set of ordered pairs $\tilde{A} = \{(x, \mu_{\tilde{A}}(x))/x\epsilon X\}$, where $\mu_{\tilde{A}}(x)$ is called the membership function for the fuzzy set$\tilde{A}$. The membership function maps each element of X to a membership value between 0 and 1.

Definition 2.2 *Support of a fuzzy set*

The support of a fuzzy set $\tilde{A}$ is the set of all points x in X such that $\mu_{\tilde{A}}(x) > 0$. That is $support\ (\tilde{A}) = \{x/\mu_{\tilde{A}}(x) > 0\}$.

Definition 2.3 $\alpha -$ *level of fuzzy set*

The $\alpha -$ cut (or) $\alpha -$ level set of a fuzzy set $\tilde{A}$ is a set consisting of those elements of the universe X whose membership values exceed the threshold level α. That is $\tilde{A}_\alpha = \{x/\mu_{\tilde{A}}(x) \geq \alpha\}$.

Definition 2.4 *Convex fuzzy set*

A fuzzy set $\tilde{A}$ is convex if, $\mu_{\tilde{A}}\big(\lambda x_1 + (1 - \lambda x_2) \geq min(\mu_{\tilde{A}}(x_1), \mu_{\tilde{A}}(x_2)\big), x_1, x_2 \epsilon X$ and $\lambda\epsilon[0,1]$. Alternatively, a fuzzy set is convex, if all $\alpha -$level sets are convex.

Definition 2.5 *Convex normalized fuzzy set*

A fuzzy number $\tilde{A}$ is a convex normalized fuzzy set on the real line R such that it exists at least one $x_0 \epsilon R$ with $\mu_{\tilde{A}}(x_0) = 1$ and $\mu_{\tilde{A}}(x)$ is piecewise continuous.

Definition 2.6 *Trapezoidal fuzzy numbers*

Among the various fuzzy numbers, triangular and trapezoidal fuzzy numbers are of the most important. Note that, in this study only trapezoidal fuzzy numbers are considered. A fuzzy number is a trapezoidal fuzzy number if the membership function of its be in the following function of it being in the following form:

Any trapezoidal fuzzy number by $\tilde{a} = (a^L, a^U, \alpha, \beta)$, where the support of $\tilde{a}$ is $(a^L - \alpha, a^U + \beta)$ and the modal set of $\tilde{a}$ is $[a^L, a^U]$. Let *F(R)* is the set of trapezoidal fuzzy numbers.

Definition 2.7 *Arithmetic on fuzzy numbers*

Let $\tilde{a} = (a^L, a^U, \alpha, \beta)$ and $\tilde{b} = (b^L, b^U, \gamma, \theta)$ be two trapezoidal fuzzy numbers and $x\epsilon R$. Then, the results of applying fuzzy arithmetic on the trapezoidal fuzzy numbers as shown in the following:
Image of $\tilde{a}: -\tilde{a} = (-a^U, -a^L, \beta, \alpha)$
Addition: $\tilde{a} + \tilde{b} = (a^L + b^L, a^U + b^U, \alpha + \gamma, \beta + \theta)$
Scalar Multiplication: $x > 0,\ x\tilde{a} = (xa^L, xa^U, x\alpha, x\beta)$ and $x < 0,\ x\tilde{a} = (xa^U, xa^L, -x\alpha, -x\beta)$

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Image of $\widetilde{a}$: $-\widetilde{a} = (-a^U, -a^L, \beta, \alpha)$
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Scalar Multiplication: $x > 0,\ x\widetilde{a} = (xa^L, xa^U, x\alpha, x\beta)$ and $x < 0,\ x\widetilde{a} = (xa^U, xa^L, -x\alpha, -x\beta)$

RANKING FUNCTION

A convenient method for comparing of the fuzzy numbers is by use of ranking functions. A ranking function is a map from *F(R)* into the real line. The orders on *F(R)* are:

$\tilde{a} \geq \tilde{b}$ if and only if $\Re(\tilde{a}) \geq \Re(\tilde{b})$

$\tilde{a} > \tilde{b}$ if and only if $\Re(\tilde{a}) > \Re(\tilde{b})$

$\tilde{a} = \tilde{b}$ if and only if $\Re(\tilde{a}) = \Re(\tilde{b})$

Where, $\tilde{a}\ and\ \tilde{b}$ are in F *(R)*. It is obvious that $\tilde{a} \leq \tilde{b}$ if and only if $\tilde{b} \geq \tilde{a}$. Since there are many ranking function for comparing fuzzy numbers but robust ranking function is applied. Robust's ranking technique satisfies compensation, linearity and additive properties and provides results which are consistent with human intuition. Give a convex fuzzy number $\tilde{a}$, the Robust's Ranking index is defined by

$$\Re(\tilde{a}) = \int_0^1 0.5(a_\alpha^L, a_\alpha^U)d\alpha,$$

where (a^L, a^U) is the α- level cut of the fuzzy number $\tilde{a}$.

In this paper this method for ranking the objective values. The robust ranking index $\Re(\tilde{a})$ gives the representative value of the fuzzy number $\tilde{a}$. It satisfies the linearity and additive property.

FUZZY OPTIMIZATION LINEAR PROGRAMMING PROBLEMS (FOLPP)

However, when formulating a mathematical programming problem which closely describes and represents a real-world decision situation, various factors of the real world system should be reflected in the description of objective functions and constraints involve many parameters whose possible values may assigned by experts. In the conventional approaches, such parameters are required to be fixed at some values in an experimental and subjective manner through the experts' understanding of the nature of the parameters in the problem-formulation process.

It must be observed that, in most real-world situations, the possible values of these parameters are often only imprecisely known to the experts. With this observation in mind, it would be certainly more appropriate to interpret the experts' understanding of the parameters as fuzzy numerical data which can be represented by means of fuzzy sets of the real line known as fuzzy numbers.

Definition 4.1 *Linear programming*

A linear programming (LP) problem is defined as:
$Max\ z = cx$
$s.t.\ Ax = b$
$x \geq 0$
Where, $c = (c_{1,} c_2, \ldots \ldots . . c_n)$, $b = (b_1, b_2, \ldots \ldots b_m)^T$, and $A = [a_{ij}]_{m \times n}$.

In the above problem, all of the parameters are crisp. Now, if some of the parameters be fuzzy numbers then fuzzy linear programming is obtained which is defined in the next section.

Definition 4.2 *Fuzzy linear programming*

Suppose that in the linear programming problem some parameters be fuzzy numbers. Hence, it is possible that some coefficients of the problem in the objective function, technical coefficients the right hand side coefficients or decision making variables be fuzzy number Maleki [2002], Maleki et al. [2000], Rommelfanger et al. [1989] and Verdegay [1984]. Here, the linear programming problems with fuzzy numbers in the objective function.

Definition 4.3 *Fuzzy number linear programming*

A fuzzy number linear programming (FLP) problem is defined as follows:

$Max\ \tilde{z} = \tilde{c}x$

$s.t.\ Ax = b$

$x \geq 0$

where, $b\epsilon R^m$, $x\epsilon R^n$, $A\epsilon R^{m\times n}$, $\tilde{c}^T\epsilon((F(R))^n$, and $\Re$ is a Robust ranking function.

Definition 4.4 *Fuzzy feasible solution*

The vector $x\epsilon R^n$ is a feasible solution to FLP if and only if x satisfies the constraints of the problem.

Definition 4.5 *Fuzzy optimal solution*

A feasible solution x^* is an optimal solution for FLP, if for all feasible solution x for FLP, then $\tilde{c}x^* \geq \tilde{c}x$.

Definition 4.6 *Fuzzy basic feasible solution*

The basic feasible solution for FLP problems is defined as: Consider the system $Ax = b$ and $x \geq 0$, where A is an $m \times n$ matrix and b is an m vector. Now, suppose that $rank(A, b) = rank(A) = m$. Partition after possibly rearranging the columns of A as $[B, N]$ where $B,\ m \times m$, is nonsingular. It is obvious that $rank(B) = m$. The point $x = (x_B^T, x_N^T)^T$ where, $x_B = B^{-1}b$, $x_N = 0$ is called a basic solution of the system. If $x_B \geq 0$, then x is called a basic feasible solution (BFS) of the system. Here *B* is called the basic matrix and *N* is called the non basic matrix.

A FUZZY VERSION OF SIMPLEX ALGORITHM FOR TWO PHASE METHOD

In the first phase of this method, the sum of the artificial variables is minimized subject to the given constraints (known as auxiliary fuzzy linear programming problem, FLP) to get the fuzzy basic feasible solution to the original FLP. Second phase then optimizes the original objective function starting with the fuzzy basic feasible solution obtained at the end of phase I. The iterative procedure of the fuzzy algorithm may be summarize as follows.

Step-1 Express the problem in the standard form and check whether there exists a starting fuzzy basic feasible solution.

- If there is a ready starting fuzzy basic feasible solution, go to Phase II.
- If there does not exist a ready starting fuzzy basic feasible solution, go on to the next step.

Phase-I

Step-2 Add the artificial variable to the left side of each of the equations corresponding to constraints of the type $\geq$ or $=$. However addition of these artificial variables causes violation of the corresponding constraints. Therefore, we would like to get rid of these variables and would not allow them to appear in the final solution. This is achieved by assigning (-1) in the objective function.

Step-3 Solve the modified FLP by simplex method, until any one of the three cases may arise.

1. No artificial variable appears in the basis and the optimality conditions are satisfied, then the current solution is an optimal basic feasible solution.
2. At least one artificial variable is present in the basis with zero value. In such a case the current optimum basic feasible solution is degenerate.
3. At least one artificial variable is present in the basis with a positive value. In such a case, the given FLP does not possess a fuzzy optimal basic feasible solution. The given problem is said to have a fuzzy pseudo-optimum basic feasible solution.

Phase-II

Step-4 Consider the optimum basic feasible solution of *Phase-I* as a starting basic feasible solution for the original FLPP. Assign actual coefficients to the variables in the objective function and a value zero to the artificial variables that appear at zero value in the final simplex table of *Phase-I*.

APPLICATION

In this section the application of fuzzy version simplex algorithm solution to FLP has been presented. This application is the diet problem for pigs.

Diet Problem

A farmer has three products P_1, P_2 and P_3 which he plans to mix together to feed his pigs. He knows the pigs require a certain amount of food F_1 and F_2 available, per gram of P_1, P_2 and P_3. The approximate time, in hours, each P_i spends in each F_j is given in Table 2.

Also, each pig should have approximately at least 54 units of F_1 and approximately at least 60 units of F_2, per day. The costs of P_1, P_2 and P_3 vary slightly from day to day but the average costs are: (1) 8¢ per gram of P_1; (2) P_2 is 9¢ per gram; and (3) 10¢ per gram for P_3.

The farmer wants to know how many grams of P_1, P_2 and P_3 he should mix together each day, so his pigs will get the approximate minimum, to minimize his costs.

Table 2. Times of product P_i is in department D_j
Tabela 2. Okres pobytu produktu P_i w dziale D_j

Product	D1	D2
P1	2.5	5
P2	4.5	3
P3	5	10

Since all selling price numbers given are uncertain, the FLP model is formulated. The Trapezoidal fuzzy number for each value given is obtained. So, the FLP is given by:

Min $\tilde{z} = (6,8,9,10)x_1 + (6,9,10,11)x_2 + (9,10,12,13)x_3$

Such that
$2.5x_1 + 4.5x_2 + 5x_3 \geq 54$
$5x_1 + 3x_2 + 10x_3 \geq 60$
$\forall\, x_1, x_2, x_3 \geq 0$

Solution
$\min(-\tilde{z}) = max\tilde{z}'$
Max $\tilde{z}' = -(6,8,9,10)x_1 - (6,9,10,11)x_2 - (9,10,12,13)x_3$
$2.5x_1 + 4.5x_2 + 5x_3 - x_4 + A_1 = 54$
$5x_1 + 3x_2 + 10x_3 - x_5 + A_2 = 60$

Table 3. Optimal Values for the Proposed Fuzzy Linear Programming Model (Phase-I)
Tabela 3. Optymalne wartości proponowanego modelu programowania liniowego (Faza I)

$\tilde{C}_j$			(0,0,0,0)	(0,0,0,0)	(0,0,0,0)	(0,0,0,0)	(0,0,0,0)	-1	**-1**	**Min ratio**
$\tilde{C}_B$	$\tilde{Y}_B$	$\tilde{X}_B$	$\tilde{y}_1$	$\tilde{y}_2$	$\tilde{y}_3$	$\tilde{y}_4$	$\tilde{y}_5$	$\tilde{y}_6$	$\tilde{y}_7$	
-1	$\tilde{y}_6$	54	2.5	4.5	5	-1	0	1	0	10.8
-1	$\tilde{y}_7$	60	5	3	$\boxed{10}$	0	-1	0	1	6→
$\tilde{z}_j$		-114	-7.5	-7.5	-15↑	1	1	(0,0,0,0)	(0,0,0,0)	$\tilde{\Delta}_j$
$\tilde{C}_B$	$\tilde{Y}_B$	$\tilde{X}_B$	$\tilde{y}_1$	$\tilde{y}_2$	$\tilde{y}_3$	$\tilde{y}_4$	$\tilde{y}_5$	$\tilde{y}_6$	$\tilde{y}_7$	**Min ratio**
-1	$\tilde{y}_6$	24	0	$\boxed{3}$	0	-1	5/10	1	-5/10	8→
(0,0,0,0)	$\tilde{y}_3$	6	5/10	3/10	1	0	-1/10	0	1/10	20
$\tilde{z}_j$		-24	(0,0,0,0)	-3↑	(0,0,0,0)	1	-5/10	(0,0,0,0,)	-1/2	$\tilde{\Delta}_j$
$\tilde{C}_B$	$\tilde{Y}_B$	$\tilde{X}_B$	$\tilde{y}_1$	$\tilde{y}_2$	$\tilde{y}_3$	$\tilde{y}_4$	$\tilde{y}_5$	$\tilde{y}_6$	$\tilde{y}_7$	**Min ratio**
(0,0,0,0)	$\tilde{y}_2$	8	0	1	0	$\frac{-1}{3}$	$\frac{5}{30}$	1/3	-5/30	-
(0,0,0,0)	$\tilde{y}_3$	36/10	5/10	0	1	$\frac{1}{10}$	$\frac{-3}{20}$	-1/10	3/20	-
$\tilde{z}_j$		(0,0,0,0)	(0,0,0,0)	(0,0,0,0)	(0,0,0,0)	(0,0,0,0)	(0,0,0,0)	1	1	$\tilde{\Delta}_j \geq 0$

Table 4. Optimal Solution of the LPP (Phase-II)

Tabela 4. Optymalne rozwiązanie LPP (Faza II)

$\widetilde{\boldsymbol{C}}_{\boldsymbol{j}}$			(-10,-9,-8,-6)	(-11,-10,-9,-6)	(-13,-12,-10,-9)	(0,0,0,0)	(0,0,0,0)	**Min ratio**
$\widetilde{\boldsymbol{C}}_{\boldsymbol{B}}$	$\widetilde{\boldsymbol{Y}}_{\boldsymbol{B}}$	$\widetilde{\boldsymbol{X}}_{\boldsymbol{B}}$	$\widetilde{\boldsymbol{y}}_{\boldsymbol{1}}$	$\widetilde{\boldsymbol{y}}_{\boldsymbol{2}}$	$\widetilde{\boldsymbol{y}}_{\boldsymbol{3}}$	$\widetilde{\boldsymbol{y}}_{\boldsymbol{4}}$	$\widetilde{\boldsymbol{y}}_{\boldsymbol{5}}$	
(-11,-10,-9,-6)	$\tilde{y}_2$	8	0	1	0	$\frac{-1}{3}$	$\frac{5}{30}$	-
(-13,-12,-10,-9)	$\tilde{y}_3$	36/10	5/10	0	1	$\frac{1}{10}$	$\frac{-3}{20}$	-
$\tilde{z}_j$		8(-11,-10,-9,-6) +36/10 (-13,-12.-10,-9)≈ $-312/10\approx$-31.2	5/10(-13,-12,-10,-9)+(6,8,9,10) ≈ 2.75	(0,0,0,0)	(0,0,0,0)	-1/3(-11,-10,-9,-6)+1/10(-13,-12,-10,-9) ≈ 27.17	5/30(-11,-10,-9,-6)-3/20(-13,-12,-10,-9) ≈ 0.15	$\tilde{\Delta}_j \geq 0$

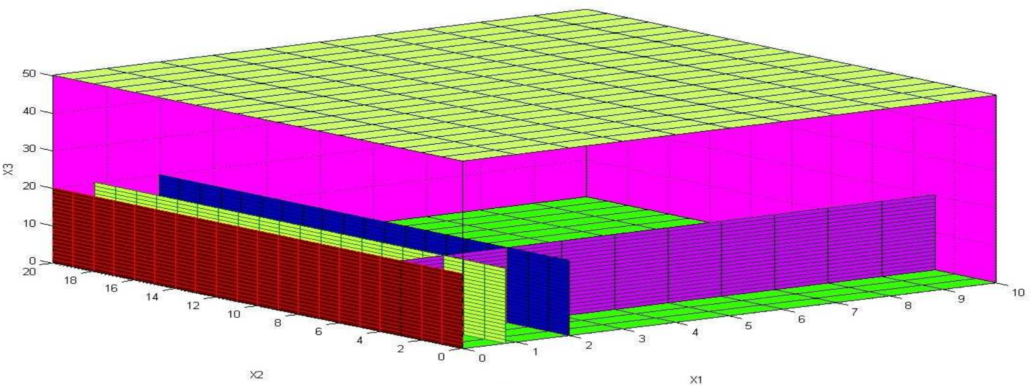

Fig. 1. Dimensional Slice and Mesh plot of Fuzzy Total Cost $z(x_{1,}x_2,x_3\ ),\ x_1,x_2 and\ x_3$.
Rys. 1. Warstwy przestrzenne oraz siatka kosztu całkowitego $z(x_{1,}x_2,x_3\ ),\ x_1,x_2\ i\ x_3$.

Table 3 and Table 4 derive the fuzzy optimal solution of the given problem using simplex method of two phase of FOLP. In the solution procedure the robust ranking method is used for defuzzifying the fuzzy numbers but other procedures are remaining same as for the crisp method for obtaining the optimal solution by Two Phase method of LP. In crisp LP model the optimal total cost is Rs. 108 but in FOLP model the optimal total cost is Rs. 31.2 with identical solution of the decision variables both for crisp LP and fuzzy OLP. The optimal total cost in fuzzy space is less than that of the crisp LP model so it is advisable and acceptable to apply fuzzy logic for obtaining the optimum decision in an uncertain market.

From Table 3 and Table 4 it is found that the fuzzy optimal solutions are $\tilde{x}_1 = 0, \tilde{x}_2 = 8, \tilde{x}_3 = 3.6\ and\ \tilde{z} = 31.2$. Fig. 1 shows the four dimensional slice and mesh plot of fuzzy total profit $\tilde{z}(\tilde{x}_1,\tilde{x}_2,\tilde{x}_3), \tilde{x}_1,\ \tilde{x}_2\ and\ \tilde{x}_3$.

SENSITIVITY ANALYSIS

Discrete variation in b

The investigations that deal with changes in the optimum solutions due to discrete variations in the parameter b_i is called sensitivity analysis. Consider the fuzzy linear programming problem

Let the component b_k of the vector **b** be changed to $b_k + \Delta b_k$, hence range of Δb_k, so that the optimum solution $\widetilde{\boldsymbol{X}}_B^*$ also remains feasible is $\underset{b_{ik}>0}{\text{Max}}\left\{\frac{-\tilde{x}_{\boldsymbol{Bi}}}{b_{\boldsymbol{ik}}}\right\} \leq \Delta b_k \leq \underset{b_{jk}<0}{\text{Min}}\left\{\frac{-\tilde{x}_{\boldsymbol{Bj}}}{b_{\boldsymbol{jk}}}\right\}$

From the Table 3 we observe $\tilde{\boldsymbol{x}}_B = [\,8{,}3.6\,]$ and $\boldsymbol{B}^{-1} = [\tilde{y}_6, \tilde{y}_7] = \begin{bmatrix} \frac{1}{3} & \frac{-5}{30} \\ \frac{-1}{10} & \frac{3}{20} \end{bmatrix}$. The individual effects of changes in $b_1 and\, b_2$ where $\boldsymbol{b} = [\, b_1\ b_2\,]$ such that the optimality of the basic feasible solution is not violated, are given by $\underset{b_{ik}>0}{\text{Max}}\left\{\frac{-\tilde{x}_{Bi}}{b_{ik}}\right\} \le \Delta b_k \le \underset{b_{jk}<0}{\text{Min}}\left\{\frac{-\tilde{x}_{Bj}}{b_{jk}}\right\}$. $\underset{b_{11}>0}{\text{Max}}\left\{\frac{-8}{\frac{1}{3}}\right\} \le \Delta b_1 \le \underset{b_{21}<0}{\text{Min}}\left\{\frac{-3.6}{\frac{-1}{10}}\right\} = -24 \le \Delta b_1 \le 36$ and $\underset{b_{22}>0}{\text{Max}}\left\{\frac{-3.6}{\frac{3}{20}}\right\} \le \Delta b_2 \le \underset{b_{12}<0}{\text{Min}}\left\{\frac{-8}{\frac{-5}{30}}\right\} = -24 \le \Delta b_2 \le 48$.

Hence, $-24 \le \Delta b_1 \le 36$ and $-24 \le \Delta b_2 \le 48$. Now, since $b_1 = 6\, and\, b_2 = 10,$ the required range of variation is $30 \le b_1 \le 90$ and $36 \le b_2 \le 108$. It implies that in fuzzy decision space the requirement value has the limit 30 units to 90 units for the first constraint and has the limit 36 units to 108 units for the second constraint for obtaining the optimal solution of the given LP model. It gives the managerial implications for taking the optimum decision with the bounded values of the requirement vector of the FLP model.

CONCLUSIONS

The main contribution of this paper is to formulate a linear programming problem with fuzzy parameters and defuzzifying the fuzzy parameters by using robust ranking technique. Based on the optimal solution it allows taking a decision interactively with the decision maker in fuzzy decision space. The decision maker also has additional information about the availability of the violation of requirement vector in the constraints, and about the compatibility of the cost of the solution with his wishes for the values of the objective function which extend the classical LP models with no sensitivity analysis in the past. By using fuzzy theory and robust ranking approach, individual firm's cost strategies are examined and the optimal solutions with sensitivity analysis for obtaining the managerial implications in fuzzy environment are derived. These analysis of the results are established which present a number of managerial insights into the economic behavior of the firms, and can serve as the basis for empirical study in the future study.

Thus, there are possible extensions to improve this present model. The decision maker can intervene in all the steps of the decision process which makes this approach very useful to be applied in a lot of real-world problems where the information is uncertain with nonrandom, like general management, project management, marketing and production management.

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ZASTOSOWANIE ODPORNOŚCIOWEJ METODY RANKINGOWEJ W PROBLEMACH 2-FAZOWYCH ROZMYTEJ OPTYMALIZACJI LINIOWEJ (FOLPP)

STRESZCZENIE. **Wstęp:** Praca analizuje rozwiązanie problemów rozmytej optymalizacji liniowej (FOLPP) w przypadku, gdy niektóre parametry to liczby rozmyte. W praktyce, istnieje wiele problemów, w których wszystkie parametry decyzyjne są liczbami rozmytymi. Takie problemy są rozwiązywane zazwyczaj przy pomocy programów probalistycznych lub wieloobiektowych metod programistycznych.
Metody: W pracy, poprzez zastosowanie koncepcji porównania liczb rozmytych, przedstawiono efektywną metodę rozwiązywania omawianych problemów. Problem programowania linowego został oparty na środowisku rozmytym. Przy przyjętych założeniach, optymalne rozwiązanie może być teoretycznie osiągnięte poprzez zastosowanie 2-fazowej metody simplex w środowisku rozmytym. W celu podjęcia decyzji rozmytej, zmienne mogą być wpierw wygenerowane, następnie rozwiązane i poprawione sekwencyjnie poprzez zastosowanie podejścia decyzji rozmytej i techniki odpornościowej metody rankingowej.
Wyniki i wnioski: Wypracowany model został przedstawiony za pomocą aplikacji, zastosowano analizę optymalizacyjną. Proponowana procedura została zaprogramowana przy pomocy MATLAB (R2009a) w celu otrzymania 4-wymiarowego wykresu. Następnie zaprezentowano przykład liczbowy w celu przybliżenia efektywności teoretycznych rezultatów pracy oraz uzyskania dodatkowego spojrzenia na problem.

Słowa kluczowe: podejmowanie decyzji, rozmyta optymalizacja liniowa (FOLP), metoda 2-fazowa, analiza optymalizacyjna.

ANWENDUNG VON WIDERSTANDSFÄHIGER RANGREIHEN-METHODE IN DEN 2-PHASEN-FRAGESTELLUNGEN DER UNSCHARFEN LINEAREN OPTIMIERUNG (FOLPP)

ZUSAMMENFASSUNG. Einleitung: Die Arbeit setzt sich mit Lösungen der unscharfen linearen Optimierung im Falle, wenn manche Parameter unscharfe Mengen darstellen, auseinander. In Wirklichkeit gibt es viele Problemstellungen, in denen alle entscheidungstragenden Parameter unscharfe Mengen sind. Solche Problemstellungen werden gewöhnlich anhand proballistischer Programme oder mithilfe von objektorientierten Programmierungsmethoden gelöst.

Methoden: In der Arbeit stellte man eine effektive Methode für die Lösung der betreffenden Probleme durch die Anwendung eines auf den Vergleich von unscharfen Mengen hinzielenden Konzeptes dar. Die Problemstellung der linearen Programmierung stützte man auf das Fuzzy-Medium. In den angenommenen Fällen kann theoretisch eine optimale Lösung durch die Anwendung der 2-Phasen-Simplex-Methode im unscharfen Medium erzielt werden. Für das Treffen einer unscharfen Entscheidung können die Variablen erst einmal generiert, ferner gelöst und dann sequenziell verbessert werden, insbesondere durch die Inanspruchnahme der an der unscharfen Entscheidung, sowie an der widerstandsfähigen Rangreihenmethode orientierten Verfahren.

Ergebnisse und Fazit: Das ausgearbeitete Modell wurde anhand eines Anwendungskonzeptes, in dem eine Optimierungsanalyse zur Geltung kam, dargestellt. Das vorgeschlagene Anwendungsverfahren wurde anhand von MATLAB (R2009a) zwecks Erzielung eines 4D-Diagramms programmiert. Ferner präsentierte man ein zahlenmäßiges Beispiel zwecks Projizierung der Effektivität der theoretischen Ergebnisse der Arbeit, sowie zwecks einer zusätzlichen Wahrnehmung des betreffenden Problems.

Codewörter: Entscheidungstreffen, unscharfe lineare Optimierung (FOLP), 2-Phasen-Methode, Optimierungsanalyse.

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DETERMINATION OF OBJECTIVES FOR URBAN FREIGHT POLICY

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ABSTRACT. Background: Decisions regarding strategic planning of urban freight transport very often are based on superficial assumptions inadequately reflecting the actual character of encountered challenges. The trend may be observed to adapt isolated solutions without supporting measures and verification of expected outcomes. Selected urban freight solutions have a significant potential to alleviate transport related problems, but they require unorthodox approach beyond standard traffic planning and road management. City's current planning experience must be taken into account to plan an optimized sequence of actions.

Method: Due to complexity of the problem and specific decision making factors the analytic network process ANP was selected to determine relevant objective of the urban freight policy. Gdynia was selected as the subject for modeling with a review of the current freight planning practice as a first step. Then, classification of policy objective and their prerequisites were identified supported with descriptive feasibility assessment. This allowed for a development of the ANP decision-making model.

Results: Considered objectives for urban freight policy were identified were optimization, reduction and transfer. After verifying relevant decision factors optimization was selected as the most feasible option for Gdynia. Other alternatives were rated around four times lower with a slight prevalence of reduction over transfer. Such ranking reflects current planning practice and availability of transferable experiences. Despite the indicative results, it must be stressed that urban freight planning should be based on the long term methodical approach not to exclude any emerging possibilities.

Key words: urban freight policy, urban logistics, transport policy, multi-criteria decision making, analytic network process.

INTRODUCTION

Planning of urban freight activities remains a challenge for the most of municipalities across Europe. There is a growing concern about side effects of economic growth manifested in the form of a negative impact of transport on the urban environment and the growing demand for investments. Despite several successful and inspiring examples of practical solutions implementation planning of such measures requests a special attention. It is important to provide municipalities with the decision support method to start an evaluation of possible measures and policy options.

The aim of this paper was to develop a methodology for assessment of urban freight policy objectives with regards to the city current freight planning experience. Objective of the method was to provide a ranking of preselected policy objectives. This methodology was intended as the first step for in-depth planning resulting in implementation of operational solutions. The decision model was elaborated with the multi-criteria Analytic Network Process ANP method. To achieve practical results Gdynia was selected as a case-study. The paper is organized into 5 sections. Section 1 identifies challenges in urban freight planning providing an overview of high-level objectives. Section 2 introduces a methodology

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for urban freight self-assessment, which gives background assumptions for the model. In Section 3 a classification of urban freight policy objectives was provided. Section 4 contains the ANP model structure and results and section 5 is the summary

CHALLENGES IN URBAN FREIGHT TRANSPORT POLICY MAKING

In recent years there is a strong trend for coordinated actions towards urban mobility planning reflecting all aspects of this issue [COM(2013) 913]. The general objective is to achieve sustainable urban mobility by overcoming fragmented approach with standards of planning and evaluation. However, urban freight planning seems to be neglected in those efforts so far. Urban freight is vital for growing urban communities due to increasing demand and complexity of services. This is not followed by implementation of strategic planned measures based at city transport system analysis and stakeholders involvement. Thus, few cities have a comprehensive urban logistics strategy. Cities lack knowledge about logistics chains and their users' requirements. Survey among cities in Sweden revealed, that 43% don't spend any time working on freight transport despite 65% identify freight transport as an area of concern [Lindholm 2012]. Majority of urban logistics operations are carried out by private operators, with only small share of municipal services like waste removal or road maintenance etc. Private operators carry their businesses without purposeful dialogue with city authorities. However, when given a chance to cooperate towards problem solving and optimisation of every-day activities, operators are often keen to work co-operatively to implement solutions satisfying both private and public partners. The cooperation is crucial for implementation of applicable solutions for urban freight.

Without stable policy framework it is difficult for operators or retailers to see a clear business case to get involved and make investments required to change their urban logistics operations [SWD(2013) 524]. Clear strategies for managing urban freight are needed primarily on local level. Strategies must set clear objectives and measures to achieve them. To improve urban logistics in the long term better definitions, data collection, monitoring and evaluation is required. To achieve the goal of planning sustainability, strategic considerations of urban freight policy should be identified. They can be then translated into objectives and measures. Primary set of such considerations includes: [Tanguchi, et. al, 2004]:

- mobility - an ability to move the goods,
- sustainability - in utilization of existing resources i.e.: transport infrastructure, space, funds,
- livability - provision of optimal living quality for city inhabitants.

These factors may be broken down into more detailed issues:

1. Mobility:
   - provision of access to every form of economic activity within a city,
   - consideration of requirements of different urban freight transport users and stakeholders (retail, services, production, constructions etc.),
   - ability for a modal choice - as far as possible from economic and technical point of view,
   - support for innovative in urban supply chain management and transport services.

2. Sustainability:
   - access management to designated areas or infrastructure elements according to their purpose and technical standards,
   - reduction of extensive utilization of infrastructure leading to its premature deterioration,
   - using the transportation infrastructure to shape economic and spatial development processes,
   - implementation of advanced technologies (ITS) to improves efficiency of urban logistics processes,
   - inclusion of all transport externalities into regulatory policy.

3. Livability:
   - reduction of CO_2, noise and other emissions from freight transport,

- rationalisation of available city space design to achieve convenient access to services, leisure education for all users,
- improvement of traffic safety.

REVIEV OF THE EXISTING FREIGHT PLANNIG PRACTICE

One of the main factors restricting effective urban freight planning is absence of the proper planning procedure based on credible data. It is important to precisely evaluate the degree to which freight issues are addressed by existing or envisaged measures within planning documents. This identifies where the starting point in terms of strategic urban freight planning is. Overview of freight related problems and existing methods of addressing them is required for construction of multicriteria model for identification of strategic objectives of urban freight traffic policy. This can be achieved in three steps:

- Freight self-assessment - commodity flow characteristics, urban freight system characteristics and limitations, users of the system and their needs [NHCRP 2007].
- Definition of freight planning stage - on the basis of freight self-assessment, it will be possible to describe if freight planning is in the basic or advanced phase. Understanding this provides an opportunity to better define objectives of freight planning policy, with rational targets and activities reflecting real problems and available resources.
- Definition of strategic objectives by identification of measures and clustering them according to possible impacts and complexity level. It is important to have in mind the freight planning stage and results of freight self-assessment to choose appropriate set of measures.

The main purpose of self-assessment is to evaluate current level of understanding of freight issues and their presence in relevant policies to document was already has been done. It does not substitute the comprehensive urban freight profile, but provides a starting point for enhancing or creating urban freight transport policy. Different questions may be asked or issues addressed. Table 1 presents short overview of possible questions regarding city, freight stakeholders and organization responsible for planning [NHCRP 2007].

Table 1. Selected questions for urban freight self-assessment
Tabela 1. Wybrane pytania do oceny stanu wiedzy odnośnie miejskiego transportu ładunków

Self-assesement questions - city freight system
What is the nature of freight flows in the city - what is the share of internal and passing through flows?
What are the main freight terminals and what modes of transport do they serve?
Is the city a transportation hub and what is it catchment area - what are the key freight routes across the city and region?
What is the importance of freight related activities to local economy, ie. how many jobs is related to transport activities?
What conflicts or externalisties are related to freight transport - where to they arise?
Are there major freight related problems known to transport operators?
Self-assesement questions - urban freight stakeholders
What other institutions may be involved in urban freight planning?
What are the largest bussiness in terms of freight movements? What mode of transport does they use and does it have direct impact on the urban transportation system?
Are the main logistic chains identified in terms of type of cargo and flow direction?
Were the freight stakeholders given an opportunity to express their needs and concerns? What aspects of urban transportation systems they would like to be improved?
Has the private sector participated in urban freight policy planning? Are there organisations of shippers, retailers etc. involved in freight?
Self-assesement questions - planning organisation
What freight planning efforts were already undertaken?
What freight-related investments has been made?
What staff is involved into different urban freight related activities - planning, monitoring etc.?
What kind of data is accesible?
Is there a political support for urban freight measures?

Answers to those questions would be rather qualitative than quantitative. More detailed analysis should be performed during specific measure implementation planning. Detailed procedure for selection of urban freight measures on the operational level was described in [Kaszubowski 2014]. Self-assessment provides information about system's weakest areas, impacts of transport activities and the level of freight competence within responsible organisation. As a result, current freight planning stage may be described in one of two ways: basic or advanced. Table 2 provides a description of these categories [NHCRP 2007].

Table 2. Description of basic and advanced urban freight planning stages
Tabela 2. Opis podstawowego i zaawansowanego poziomu planowania odnośnie miejskiego transportu ładunków

Freight planning stage	Characteristics
Basic Urban freight issues are handled as a part of general regalatory system relying on standard measures applicable to all users, no targeted or specific problem related actions are undertaken	– scattered or no urban freight related planning activities – limited reliabe data sources – little or no interaction with private sector (i.e:shippers, retailers) – limited knowledge of specific freight needs – urban freight is neglected as a part of larger investments carried by city
Advanced Urban freight starts to emerge as an planning issue or problem area, however there is no integration at the planning level with related strategic documents	– some urban freight related activities has been planned and implemented – initial interaction with private sector as a part of specific project – basic understanding about urban freight relation to the city economic base – urban freight initiatives start to form with local leaders

Table 3. Objectives in Sustainable Urban Transport Plan for Gdynia
Tabela 3. Cele Zrównoważonego Planu Transportu Miejskiego w Gdyni

Measure	Appears	Significance 1-5
Planning for cycling infrastructure	X	4
Planning for walking infrastructure	-	-
Measures to encourage low carbon vehicles	-	-
New ITS systems, traffic management to reduce congestion, encourage mode shift to public transport	x	5
New rail and/or tram system	X	4
Bus rapid transit or extensive bus priority measures	X	3
Public transport related measures, including improved interchanges and park and ride.	X	4
Measures to manage negative impacts of freight	X	1
Access management, shared space, reallocation of space to pedestrians	-	-
Mobility management	X	2
Road safety measures	X	4
Measures to improve travellers' personal security (reduced risk of attack/robbery) especially for PT users, pedestrians and cyclists.	X	3
Parking management	X	4
Maximum (limited) parking standards for new buildings	X	3
Speed management and traffic calming	-	-
Integration of planning on a scale of the city and metropolitan area	X	3
Reduction of transport needs	X	2
Modernization of public transport rolling stock	X	4
Information systems for travellers	X	4

Urban freight self assessment for Gdynia was conducted with the above described methodology. Sustainable Urban Transport Plan 2008 - 2015 was used as a reference. It is a generalization of the city's Transport Policy adopted in 1998. Range of SUTP's objectives were verified according to their area of influence and perceived significance (Table 3). It is an adaptation of the Sustainable Urban Mobility Plan review template used in the Civitas projects evaluation.

SUTP analysis indicates that the plan is oriented towards public transport effectiveness, introduction of traffic management systems and road safety measures. Only one measure concerns urban freight and managing its negative impacts like pollution, noise and intrusion. Detailed verification of this measure reveals that there is no deeper understanding of the urban freight characteristics and stakeholders requirements. Delivery optimization envisaged in the SUPT is based on the vehicle flows modifications rather supply chain management with regard to local market potential and actors involvement. No cooperation was planned with local stakeholders during the development phase hampering measure feasibility. However, main freight generators (seaport) and related problems with transit HGV traffic are properly highlighted. On the positive side one of the sub-tasks is to examine local delivery structure, receivers' location and population characteristics.

Consequently, urban freight planning stage in Gdynia may be described as basic. There is limited knowledge about supply chains characteristics and actors' needs, insufficient reliable data sources and scarce interaction with private sector. However, urban logistics is not completely neglected as awareness of freight related problems is growing among decision makers and residents. This gives an opportunity to introduce new concepts and embed urban logistics into planning practice.

IDENTIFICATION OF POLICY OBJECTIVES AND RELATED MEASURES

European Commission addressed urban freight in various documents and strategies so far. However, only recently this issue is considered as an integral part of sustainable mobility planning process. According to the latest Urban Mobility Package [SWD (2013) 524] on the basis of best practice review particular attention should be paid at the following areas:

- management of urban freight demand,
- modal shift,
- efficiency improvement,
- improved vehicles and fuels.

Management of urban freight demand may be achieved twofold: by proper land use planning at the city level and by consumers and operators introducing new schemes of ordering and deliveries. There is a mutual relationship between freight transport measures and land use planning, where the latter relates to all intervention that change the use of space. Such actions require consistent policy over a long period of and a holistic approach that takes into account the demand for urban freight transport generated through planning decisions and the needs of the freight industry.

Modal shift requires cross-sector actions integrating infrastructure, technology and regulation measures. Urban freight is dominated by road transport as most suitable for last-mile delivery. Under specific conditions selected cargo flows show a potential to be shifted to other modes of transport or at least other types of vehicle more suitable for operations in dense urban environment. This requires city authorities to provide right policy framework conditions to make these solutions economical viable, even if they deliver overall improvements from the operational point of view.

Efficiency improvement is the most challenging task in urban logistics. It may be considered as the reference for all planned actions. Efficiency is often limited by inadequate infrastructure provision, supply chain structure, poor service quality other factors. In addition, barriers tend to overlap making it difficult to find one common solution. Close cooperation between all involved actors is crucial due to diversity of problems and possible solutions, which should be feasible for implementation without negative impacts on business stability.

Urban freight has a substantial potential for improvement in vehicles and fuels. Operational characteristics of urban deliveries favor introduction of electric, hybrid or gas fuelled vehicles making urban logistics quieter and cleaner. The density and frequency of operations make urban areas attractive place for alternative fuel projects. Implementation of new technologies requires long-term legislative support to guide investments and technology development. New technologies would be attractive for potential users only when capital investments provide an opportunity for cost reduction and operational savings.

Successful identification of urban freight policy objectives requires a good overall understanding of the stakeholders involved in the city distribution. Stakeholders are defined as individuals or group of individuals that are able to influence the objectives of an organisation or who can be influenced themselves. In the urban freight policy context five groups of stakeholders may be identified [Macharis, Verlinde 2012]:

– shippers,
– receivers,
– logistic service providers,
– local authorities,
– citizens.

These stakeholders interact in different fields where transport operations take place, like public space, transport market and traffic. They also have different objectives related to these fields, indirectly defining the scope of urban freight policy. Figure 1 presents stakeholders, their fields of interaction and objectives [Macharis, Verlinde 2012].

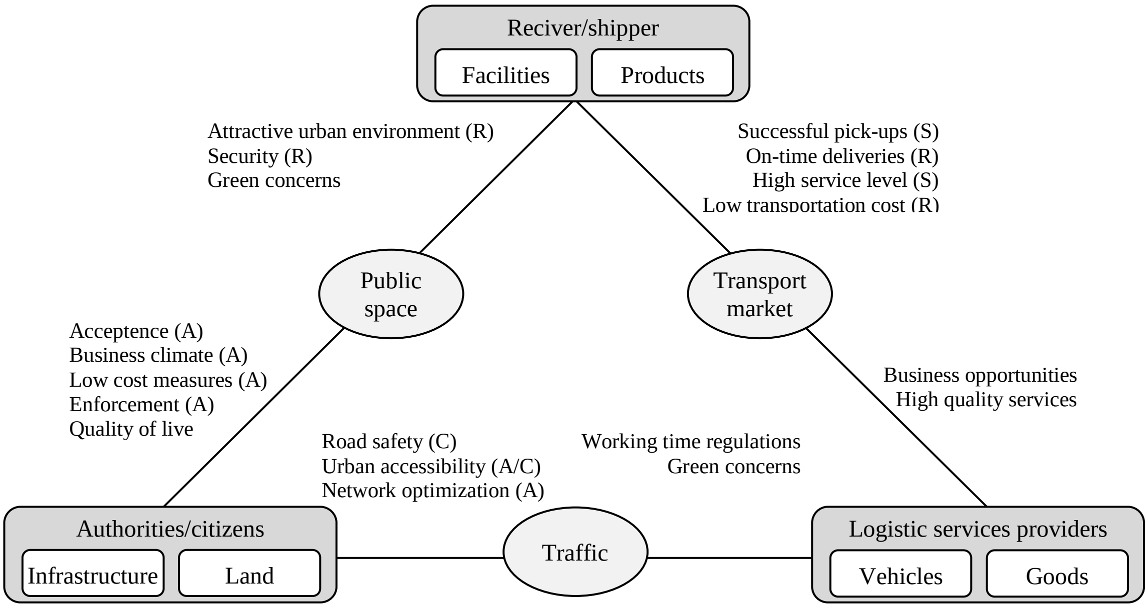

Fig. 1. Urban freight stakeholders and their objectives
Rys. 1. Cele podmiotów zaangażowanych w miejski transport ładunków

Analysis of issues regarding urban freight management on strategic level confirms the importance of proper definition of objectives. In this paper three functional objectives for urban freight policy were proposed together with corresponding sets of measures. Intention behind this selection was to create relatively homogenous groups reflecting major challenges in urban freight management. Another purpose of this categorization was to group the measures according to their complexity and implementation effort. As well as assessed interconnections between objectives and measures. The latter corresponds to a situation, when an advanced measure can't be implemented without meeting some preconditions provided by foregoing measures. An example may be delivery by electric vehicles, included into transfer objective. This measure requires supporting regulatory framework like low emission zone or pedestrian area in the city center or special permission to operation regardless existing time windows [Dziekan et. al, 2013]. Feasibility and complexity of selected objectives will be examined separately as a part of multicriteria decision model. Three groups of functional objectives are:

1. Optimization - of freight vehicles flows and demand for infrastructure; it requires traffic management, regulatory framework for different vehicle classes, access restrictions to selected areas, delivery zones etc. Main objective is to alleviate negative impacts of freight traffic on the affected communities and to induce changes in the characteristics of logistic service providers operations.
2. Reduction - of excessive demand for freight movements; problems may have multiple reasons originating in city spatial patterns, management of logistics chains, infrastructure provision or local economy

characteristics. This requires more sophisticated actions involving wide array of stakeholders and long-term planning based on business-case feasibility.

3. Transfer - shift of urban freight flows to more sustainable modes were applicable (rail or waterborne) or introduction of new vehicle types for road transport (electric, LPG).

Table 4 presents three objectives with main areas of implementation and measures assigned [Munuzuri et. al. 2005, Russo, Comi 2010, Lindholm 2010, DG MOVE 2012]. It should be noted that this classification is not exclusive and some measures may be interpreted as falling into more than one category. For example, night delivery schemes as introduced under PIEK certification programme contribute to freight optimization as a regulatory measure by avoiding peak hours. However, there is also potential to reduce demand for freight movements by bundling deliveries into one larger vehicle instead of few small deliveries. Selection of implementation areas was based on existing measures review:

– infrastructure, both linear and nodal,
– regulation/planning - measures related to governance of transport system and planning principles, like access regulations, HGV road network or planning the location of objects with high-transport demand,
– ITS (transport telematics) - this class includes among others traffic information systems, route optimisation software, vehicle capacity management systems,
– technical equipment - measures related to vehicles and loading units when applicable.

Table 4. Objectives and measures of urban freight policy
Tabela 4. Cele i narzędzia zarządzania miejskim transportem ładunków

Area of implementation	Objective		
	Optimization	Reduction	Transfer
Infrastructure	– provision of sufficient quantity of well designed delivery spaces – reduction of free parking spaces to improve freight vehicle flow on selected streets – use or public parking spaces or other restricted areas (taxi stops, bus lanes) – mini-warehouses – provision of delivery spaces in private or commercial buildings – buffer parking for HGV scheduled for a construction site or other delivery place	– city terminals/city consolidation centers – urban delivery schemes for shippers and receivers – construction consolidation centers	– utilization of existing rail or waterborne terminals as a transfer/consolidation hubs
Regulation/ planning	– access according to weight, length or other vehicle parameters – access to pedestrian zones – double parking short time restrictions – closing the center for private traffic – paid access to selected areas – adequate rotation in delivery zones – night deliveries – harmonization of regulations, also at regional level – delivery time windows – carrier classification – freight zone classification – street classification, dedicated roads for HGV traffic – limitation of loading and unloading times – signalling of truck routes	– location of freight high-demand facilities next to a transport infrastructure of high capacity – zoning of activities – service and delivery plans – relocation of freight generators according to urban renewal – safeguarding of rail-connected & water-connected sites for future use	– low emission zones/environmental zones
ITS	– access control – delivery zones monitoring – automatic toll systems – weight-in-motion for HGV – traffic management	– order processing and delivery/pick-up bundling and scheduling	
Technical equipment	– on line load zone reservation – vehicle navigation and fleet management systems (AVL/AVM)		– electric vehicles/hybrid vehicles – LPG vehicles – bikes, etc.

PRIORITIZATION OF URBAN FREIGHT POLICY OBJECTIVES IN GDYNIA

Multicriteria model for prioritization of urban freight policy objectives was elaborated with the analytic network process ANP method. ANP was developed as a generalization of analytic hierarchy process (AHP) method introduced by Thomas L. Saaty. Both methods share the same approach of paired comparison on a common criterion with a ratio scale. ANP provides a comprehensive framework for the analysis of complex decision problems in economy, investment, governmental, transportation and other sectors. It allows to include all the factors and criteria, both tangible and intangible, that have bearing on selecting the optimal solution among given alternatives. In contrary to hierarchical AHP method, ANP allows to both interactions and feedback within elements and clusters. Feedback approach renders complex relations within the structure of decision criteria.

ANP method has many applications in transportation and management sector. It was used for transport project selection and prioritization [Ivanović et. al. 2012, Onut 2011, Dikmen et al. 2007, Macura et. al 2011]. There are applications for risk assessment and decision analysis [Ergu et. al 2011], information system project selection [Liang 2008], R&D project selection [Mohanty 2005] and many others.

ANP procedure is described in [Saaty 2009]. There are several variations of decision-making frameworks of this method. Despite this each must provide set of alternatives, criteria grouped into clusters and a network of connections reflecting interactions between elements. Alternatives of the urban freight policy functional objectives were defined in previous chapter as optimization, reduction and transfer. Decision criteria were derived from examination of existing measures implementation and selected indicators of freight strategy effectiveness [Hensher 2000]. Subsequently the criteria were clustered according to freight related domains of the urban transport planning [Ruesch 2012] and strategic planning methodology [Köbl 2008]. Conclusions from evaluation of selected urban freight measures were incorporated into the decision making structure [Kaszubowski 2012].

Rating the relevance of alternatives on selected criteria was executed in accordance to the results of freight assessment in Gdynia and the implementation characteristics for urban freight policy objectives (table 8). General feasibility assessment of objectives (tables 5,6,7) was also examined. The set of verification criteria was designed to reflect major concerns of involved stakeholders when validating urban freight policy objectives. Suggested criteria for objectives assessment are:

- availability of good practices with thorough evaluation,
- transfer potential reflecting local authorities powers,
- ability to serve as a basis for more advanced measures,
- level of possible integration with existing measures,
- up-scaling potential.

The procedure would be descriptive in nature, corresponding with previously mentioned urban freight self-assessment method. Three objectives identified before were examined with above mentioned criteria with four grade scale: lower, moderate, good and high. Main question was the practicability of each objective for implementation within a policy system characteristic for the most Polish cities. For more transparency, also areas of implementation as presented in Table 4 were included to identify these with highest potential. Tables 5, 6 and 7 present analysis results with regards to mobility, sustainability and livability. This approach was intended to maintain the link between general policy considerations and objectives.

To summarize results of the objective feasibility analysis list of characteristics for each of the objectives was drawn and presented in table 8. This recapitulation would be used for creation of the multicriteria decision model.

Table 5. Feasibility of objectives regarding the Mobility general objective
Tabela 5. Ocena oddziaływania celów funkcjonlanych na realizację postualtu zapewnienia mobilności

	Feasibility for urban freight policy general objective: Mobility		
	Optimization	Reduction	Transfer
Infrastructure	high	moderate	lower
Regulation/planning	high	moderate	lower
ITS	good	lower	-
Technical equipment	moderate	-	moderate

Source: own elaboration

Table 6. Feasibility of functional objectives regarding the Sustainability general objective
Tabela 6. Ocena oddziaływania celów funkcjonlanych na realizację postualtu zapewnienia zrównoważonego wykorzystania dostępnych zasobów

	Feasibility for urban freight policy general objective: Sustainability		
	Optimization	Reduction	Transfer
Infrastructure	high	moderate	lower
Regulation/planning	high	lower	lower
ITS	good	lower	-
Technical equipment	lower	-	moderate

Source: own elaboration

Table 7. Feasibility of functional objectives regarding the Liveability general objective
Tabela 7. Ocena oddziaływania celów funkcjonlanych na realizację postulatu ochrony standardu życia mieszkańców

	Feasibility for urban freight policy general objective: Liveability		
	Optimization	Reduction	Transfer
Infrastructure	good	moderate	lower
Regulation/planning	high	high	moderate
ITS	moderate	lower	-
Technical equipment	lower	-	moderate

Source: own elaboration

Table 8. Summary of general characteristics of urban freight policy objectives
Tabela 8 Zestawienie głównych cech dla analizowanych celów zarządzania miejskim transportem ładunków

Objectives		
Optimization	Reduction	Transfer
– significant number of evaluated examples – relatively easy to integrate with existing measures – cost-effective – immediate results for regulatory measures – high level of public acceptance regarding reduced traffic intensity, noise and other emissions – limited stakeholder involvement required – limited impact on supply chains structure and freight demand factor – concerns freight traffic than rather logistics issues – useful as a basis for more complex measures – suitable to start competition in logistics industry in terms of new technology and systems – suitable for up-scaling	– high potential for supply chains redesign, but interaction with market proves challenging – proper business case in required for financial feasibility – few successful examples without external support – close cooperation of stakeholders is required, both private and public – dedicated private partner with clear business concept is essential – public involvement is often required in terms of regulatory framework, – for UCC's implementation only the exemptions and regulations that are not exclusive – for regulatory measures effects may be deferred, especially for planning, zoning etc. – planning measures must outreach the transportation issues only – potential for implementation innovative technology solutions	– for infrastructure: location-specific solutions with limited transferability potential – limited number of examples – detailed planning and ax-ante evaluation necessary – requires strong regulatory support, also on the national level – measures must be implemented as a part of complex concept with a well designed system of supporting actions – private sector involvement is essential – technology solutions must be proven and based on sound business case

Source: own elaboration

Figure 2 presents the structure of an analytic network process model created in accordance to previously identified conditions. It consists of the alternatives cluster and five criteria clusters: transport system, planning requirements, economy, environment and society. ANP method allows to assign weights to clusters as well as to derive the weight of cluster's elements with respect to the alternatives. It is important to identify the importance of the clusters because final priorities do depend on that. For the presented model weights for clusters are: planning requirements (0,293), transport system (0,250), economic development (0,217), society (0,130), environment (0,11). This reflects basic planning stage of urban freight policy in Gdynia, where a thorough approach is crucial placing high requirements for the planning system.

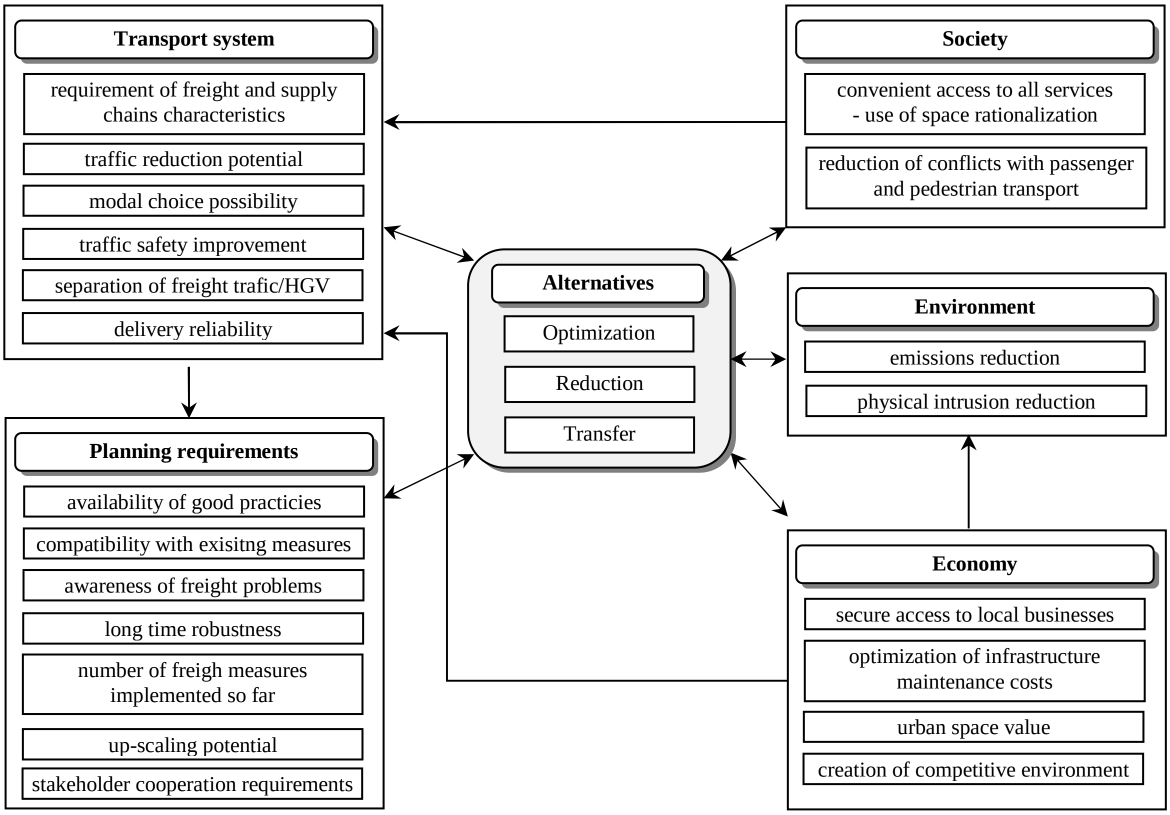

Fig. 2. Multicriteria model for classification of urban freight management objectives in Gdynia
Rys. 2. Wielokryterialny model decyzyjny dla klasyfikacji celów zarządzania transportem ładunków na przykładzie Gdyni

Synthesized judgments reveal final ranking of alternatives for urban freight policy in Gdynia with regards to previously identified baseline situation. Priorities of alternatives in direct and normalized form are:

- Optimization 0,677726 (1,000000),
- Reduction 0,184776 (0,272641),
- Transfer 0,137499 (0,202883).

To illustrate a background of the final result part of the supermatrix from the SuperDecision application was presented. It is a weighted matrix of feedback link between criteria and alternatives including cluster weights. It describes the importance of criteria with regards to implementation characteristics of three objectives.

Table 9. Weighted super-matrix for priorities with respect to alternatives
Tabela9. Ważona macierz wag nadanych poszczególnym kryteriom w odniesieniu do alternatyw

Cluster	**Criterion**	**Optimization**	**Reduction**	**Transfer**
Economic Development	Securing access for local businesses	0,1153	0,1237	0,0902
	Infrastructure maintenance cost	0,0637	0,0459	0,0676
	Increased value of urban space	0,0257	0,0332	0,0451
	Creation of competitive environment	0,0126	0,0146	0,0145
Environment	Reduction of emissions	0,0906	0,0870	0,0906
	Reduced physical intrusion	0,0181	0,0217	0,0181
Planning requirements	Availability of good practicies	0,0226	0,0133	0,0144
	Compatibility with existing measures	0,0245	0,0310	0,0238
	Awareness of freight problems	0,0954	0,0261	0,0386
	Long time robustness	0,0589	0,0282	0,0210
	Number of freight measures	0,0215	0,0680	0,0594
	Stakeholder cooperation	0,0592	0,1159	0,1260
	Up-scaling potential	0,0114	0,0109	0,0104
Society	Convenient acces to all services	0,1087	0,0978	0,0870
	Reduced conflicts with passenger and pedestrain transport	0,0217	0,0326	0,0435
Transport system	Requirement of freight and supply chains characteristics	0,0182	0,0848	0,0144
	General traffic reduction	0,0646	0,0601	0,0659
	Modal choice possibility	0,0125	0,0164	0,0225
	Overall traffic safety improvement	0,0347	0,0288	0,0409
	Separation of freight traffic/HGV	0,0886	0,0362	0,0799
	Delivery reliability	0,0315	0,0238	0,0264
		Σ 1,000	**Σ 1,000**	**Σ 1,000**

Source: own elaboration

CONCLUSIONS

The aim of this paper was to choose the rank urban freight policy objectives for Gdynia with a developed multicriteria model. The approach was intended as the first step in planning procedure towards selection of applicable set of practical measures. Selection of optimization objective was influenced by several analyzed factors, both external and internal in relation to current situation in Gdynia. Due to initial stage of urban freight planning in Gdynia and scarce transferable examples from Poland effort should be made first to thoroughly examine the freight system from the logistics point of view. It requires different approach than the traffic management systems implementation which is well advanced in Gdynia. Currently introduced systems would of course benefit perspective urban freight solutions. Logistic solutions indicate another factor, that is high requirements for stakeholder participation in preparation and implementation phase. Most measures included into optimization objective may be introduced by the city as a part of regulatory system. Reduction of demand for goods and transfer for less-intrusive types of transport involves deeper interaction with supply chains structure and economic processes. This is not a common attitude within existing planning system, but indispensable for more advanced urban freight solution demanding with solid business case and private sector cooperation. It is advisable to approach these objectives with a solid experience from previous actions to plan more sophisticated measures aiming at more complex problems. Further research should be aimed at development of guidelines for inclusion of urban freight traffic management into city's sustainable transport planning as a standard procedure meshing with other fields of planning.

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OKREŚLENIE CELÓW POLITYKI ZARZĄDZANIA MIEJSKIM TRANSPORTEM ŁADUNKÓW

STRESZCZENIE. **Wstęp:** Decyzje dotyczące planowania strategicznego transportu miejskiego towarowego są często oparte na założeniach nieodzwierciedlających aktualną sytuację i charakter napotkanych wyzwań. Można zaobserwować pewien trend przystosowywania pojedynczych rozwiązań bez pomocy środków wspierających oraz bez weryfikacji oczekiwanych rezultatów. Wybrane rozwiązania transportu miejskiego towarowego posiadają znaczny potencjał łagodzenia problemów transportowych, ale ich zastosowanie wymaga niekonwencjonalnego podejścia wychodzącego poza granice standardowego zarządzania i planowania ruchu drogowego. W procesie planowania poszczególnych działań należy uwzględnić dotychczasowe doświadczenia planistyczne danego miasta.

Metody: Ze względu na kompleksowość problemu i specyficzność czynników wpływających na podejmowaną decyzję, sieciowy proces analityczny ANP został wybrany dla określenia istotnych celów polityki transportu towarowego miasta. Gdynia została wybrana jako miasto poddane analizie. Jako pierwszy krok przeprowadzono przegląd obecnie stosowanych metod planistycznych w obszarze transportu towarowego. Następnie przeprowadzono klasyfikację celów polityki oraz ich warunków wstępnych wraz z opisową oceną ich wykonywalności. To pozwoliło na opracowanie modelu decyzyjnego ANP.

Wyniki: Zidentyfikowane cele polityki transportu towarowego miejskiego to optymalizacja, redukcja i transfer. Po zweryfikowaniu czynników wpływających na podejmowane decyzje, wybrano optymalizację, jako opcję najbardziej wykonywalną dla Gdyni. Inne możliwości oceniono czterokrotnie niżej, z lekką przewagą redukcji nad transferem. Taki ranking odzwierciedla aktualne praktyki planistyczne oraz dostępność doświadczeń związanych z transferem. Pomimo uzyskanych wyników, należy podkreślić, że planowanie miejskiego transportu towarowego powinno być oparte na długoterminowym metodologicznym podejściu bez wykluczenia żadnej z pojawiających się możliwości.

Słowa kluczowe: polityka transportu towarowego miejskiego, logistyka miejska, polityka transportowa, wielokryteriowe podejmowanie decyzji, analityczny proces sieciowy

ZIELSETZUNG DER POLITIK FÜR DIE AUSGESTALTUNG DES STÄDTISCHEN TRANSPORTVERKEHRS

ZUSAMMENFASSUNG. Einleitung: Die die strategische Planung innerhalb des städtischen Transportverkehrs anbetreffenden Entscheidungen stützen auf die Annahmen, die kaum aktuelle Situation widerspiegeln und Charakter begegneter Herausforderungen wahrnehmen. Man beobachtet einen Trend der Anpassung von einzelnen Lösungen jedoch ohne die Inanspruchnahme von unterstützenden Mitteln und ohne Verifizierung der zu erwartenden Resultate. Ausgewählte Lösungen innerhalb des städtischen Transportverkehrs besitzen ein bedeutendes Potenzial für die Milderung von Transportproblemen, allerdings deren Anwendung bedarf eines unkonventionellen Herangehens, das über die Grenzen der standardmäßigen Management und Planung des Straßenverkehrs hinausgeht. Daher müssen im Prozeß der Verplanung von eizelnen Aktivitäten die bisherigen planungsrelevanten Erfahrungen einer Stadt berücksichtigt werden.

Methoden: Angesichts der Komplexität des Problems und der Eigenart von Einflußfaktoren beim Entscheidungstreffen wurde der analytische ANP-Netzprozeß für die Bestimmung von wesentlichen Zielsetzungen für die Ausgestaltung der Politik für den städtischen Transportverkehr in Anspruch genommen. Die Stadt Gdynia wurde für die betreffende Analyse ausgewählt. Einleitungsmäßig führte man einen Überblick über die gegenwärtig angewendeten Planungsverfahren innerhalb des Transportverkehrs durch. Demzufolge hat man eine Klassifizierung der Zielsetzungen und deren Voraussetzungen samt einer Bewertung ihrer Ausfürbarkeit vorgenommen. Dies lag der Bearbeitung des ANP-Entscheidungsmodells zugrunde.

Ergebnisse und Fazit: Die in diesem Rahmen ermittelten Zielsetzungen der Politik des städtischen Transportverkehrs sind Optimierung, Reduktion und Transfer. Nach der Verifizierung der Einflußfaktoren beim Entscheidungstreffen wurde gerade die Zielsetzung der Optimierung, als die meist in Gdynia ausführbare Option, ausgewählt. Andere Möglichkeiten hat man vierfach niedriger bewertet, mit einem leichten Übergewicht der Reduktion dem Transfer gegenüber. Eine solche Abstufung widerspiegelt die gegenwärtigen Planungsverfahren und die Verfügbarkeit der mit dem Transfer zusammenhängenden Erfahrungen. Abgesehen von den Ergebnissen sei hervorzuheben, dass die Planung des städtischen Transportverkehrs auf ein zeitlich kontinuierliches, methodologisches Herangehen, ohne die alternativen, in Erscheinung tretenden Möglichkeiten auszuschließen, gestützt werden soll.

Codewörter: Politik des städtischen Transportverkehrs, Stadt-Logistik, Transportpolitik, Mehrkriterien-Entscheidungstreffen, der analytische Netzprozeß

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THE APPLICATION OF RFID IN WAREHOUSE PROCESS: CASE STUDY OF CONSUMER PRODUCT MANUFACTURER IN THAILAND

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ABSTRACT. Background: This warehouse has three main problems: poor accuracy of inventory location, long cycle time of receiving process and non-real time empty storage location. Therefore, the objective of this research is to improve the process in the warehouse by applying radio frequency identification (RFID) technology.
Methods: There are four steps in this research. First of all, the current of the receiving process and the picking process are studied. Second is to give the guideline for RFID application. Third is to implement of RFID system in this warehouse. The last one is to compare the result of the current process and the proposed process.
Results and conclusions: The passive ultra high frequency (UHF) RFID is selected for used in this warehouse. The RFID readers are attached on forklift trucks, the warehouse entrance and loading dock area. The system used RFID tags in two forms: one form used to identify pallets and another to indicate the locations of shelves on which pallets are stored. After using RFID system in this warehouse, the results showed that the accuracy of inventory location increased from 78.2% to 100%. The cycle time reduces from 66 minutes to 47 minutes which is down to 28.79%. . Moreover, the empty storage location are known real time.

Key words: RFID, Warehouse, Receiving process, Picking process.

INTRODUCTION

Warehouse management is one important activity of supply chain management. There are four main activities in the warehouse processes [Rouwenhorst et al., 2000]. The receiving process is the first process encountered by an arriving product. The products may be check and wait for transportation to the next process. Second activity is the storage process that products are placed in storage locations. Third, the picking process is a process of retrieving products from warehouse storage locations to satisfy customer orders. The last one is the shipping process that orders are checked, packed and eventually loaded the carrier. The efficiency of a warehouse depends on how efficiently it can perform the activities.

In warehouse of consumer product manufacturer, it is very difficult to management. The complexity of warehouse management depends on the number storage keeping unit (SKU), quantities of each SKU and the number of orders received and shipping. This warehouse has three main problems: poor accuracy of inventory location, long cycle time of receiving process and non-real time empty storage location. It is necessary to improve warehouse management efficiency and decrease error rates.

Radio Frequency Identification or RFID is the technology which uses radio frequency to identify objects and transfer data by the wireless non-contact and it can be automatically tracked and traced on each

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product item or pallet by using the RFID tag. RFID technology consists of an antenna, RFID reader and RFID tag. When the RFID tag passes through the field of the scanning antenna, it detects the activation signal from the antenna and it transmits the information on its microchip to be picked up by the scanning antenna. RFID tags can be read in a wide variety of circumstances, where barcodes or other optically read technologies are useless and it is developed for collecting and tagging data will help managing warehouse data more effectively.

Therefore, the objective of this research is to improve the process in the warehouse by applying RFID technology.

The remainder of this paper is organized as follows. The related literatures are reviewed in section 2. In section 3, the methodology of this research is explained. In section 4, the results of the methodology are proposed. The last section is conclusion and recommend.

LITERATURE REVIEW

In the past decades, RFID technologies have attached considerable attentions [Sarac et al., 2008] Currently, RFID is an importance technology for revolutionizing a wide range of applications including supply chain management [James et al., 2013]. RFID can apply in different parts of supply chain such as warehouse management, transportation management, production scheduling, order management, inventory management and asset management systems [Banks et al., 2007].

The RFID system consists of three components: reader, tag and host computer [Sulaiman et al., 2012]. The tag is the part that collects real time data and then transmits that data via radio waves. The tags usually have two parts, a small chip and an antenna. Information is stored and processed by the chip while the antenna is used to receive and transmit information. RFID tags can be either passive or active tag. An active tag has a small battery on board and is activated when in the presence of an RFID reader. A passive tag is cheaper and smaller because it has no battery. The information is read by an RFID reader when a tag passes by it. The reader can track the tag's movement in real time and pass its digital identity and other relevant information to a computer system.

There are many researches in field of RFID. For example, Spekman and Sweenry [2006] presented a comprehensive overview of RFID technology. The goal is to provide insights regarding the implementation and use of RFID by focusing on its advantages and its problem. Schultae et al. [2006] presented that the RFID-based navigation and position system shall support wood carriers to cut back on unproductive times in the forest by localizing woodpiles in a more efficient way. Janke et al. [2007] proposed the German logistics company that has successfully implemented and tested a system to backtrack goods dispatched through the transport chains of two large food suppliers. Wang et al., [2010] proposed a digital warehouse management system in the tobacco industry based on RFID technology. Cyplik and Patecki [2011] compared the possibilities of applications of identification methods based on RFID and RTLS (Real Time Location Systems) in certain economic conditions. Zhu et al., [2012] provided an overview of the current state of RFID application in different industries and its impact on business operations. Dwivedi et al., [2013] studied the factors affecting the use of RFID systems and user satisfaction in a library context by empirically testing relevant constructs from DeLone and McLean's IS Success Model. Liu et al., [2013] viewed the RFID technology as an operation strategy to ensure food safety, and proposed three pricing decision models according to different operation strategies and market situations. Fan et al. [2014] considered the situation of a retailer subject to inventory inaccuracies stemming from shrinkage problems. They apply a newsvendor model to analyze how to reduce inventory shrinkage problems by deploying RFID.

METHODOLOGY

The methodology of this research is shown in figure 1.

First of all, the general information of an existing warehouse such as receiving process and picking process are studied by using 3G principles. The first G is Genba or the actual place. The second G is Genbutsu or the actual thing. The last one is Genjitsu or Genshou or the actual situation. Moreover, the cycle time of receiving process and the accuracy of inventory location are collected. Second, the fundamental level of RFID is studied. For example, what is RFID? How do the parts fit? After that, the RFID system of this warehouse is designed. Third, the RFID system is implemented in this warehouse. After that, the RFID system is tested. The last step, after the RFID system is used, the cycle time of receiving process and the accuracy of inventory location are collected. Next, the data are compared between before and after using RFID.

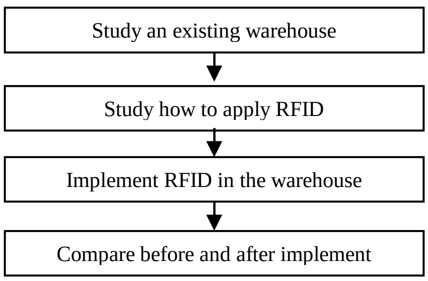

Fig. 1. The methodology of this research
Rys. 1. Metodologia badań

RESULTS

The general information of an existing warehouse

This factory manufactures consumer product such as toothpaste, washing powder and hand soap. After the goods are produced, they are transported to the warehouse. This factory has two warehouses. One warehouse is next to the production line that is not considered in this research. The other one is far from the factory that storage the export product. The distance between the factory and this warehouse is approximate 4 kilometers. The finished goods are transported from the factory to this warehouse by truck which contains 10 pallets per trip. Figure 2 shows the existing of receiving process in this warehouse. The information of the receiving process used paper-based; therefore, it is not real-time. In the storage process, this warehouse used the random storage policy that allows the storage location for a particular product to change or float overtime. Moreover, the picking process is shows in figure 3.

However, this warehouse has three main problems. The first problem is the long cycle time of receiving process that the cycle time of receiving process (10 pallets per trip) is 66 minutes per trip. The second problem is the poor accuracy of inventory location which the accuracy of inventory location is 72.87%. The last problem is the non-real time empty storage location which effect to the quantitative of storage location for the finished goods and the time for finding the storage location. Therefore, the RFID system is selected to improve warehouse management efficiency and reduce error rates.

The guideline for the application of RFID

The RFID system consists of three components. The first component is the antenna. This research selects the passive ultra high frequency (UHF) RFID base on EPC class 1 Gen1 standard for this warehouse because it is inexpensive price and not require power source to operate. The second component is RFID tags. Two forms of RFID tags are selected to use in this warehouse. First form is called a pallet tag that is used to identify pallets (figure 4). Another is called a location tag that is used to indicate the locations of shelves on which pallets are stored (figure 5).

The last component is RFID reader. There are three forms of the RFID readers. The first form is the desktop reader (figure 6) that is used in production line to generate data to RFID tag before attach to finished goods pallet. The second form (figure 7) is RFID reader and antenna which mounted on the warehouse entrance and loading dock. It can be automatically traced on each finished goods pallet to be moving pass. The last one (figure 8) is the reader which mounted on forklift trucks with antenna and touch screen computer. This reader can read both pallet tag and location tag for verifying the correct location of shelves.

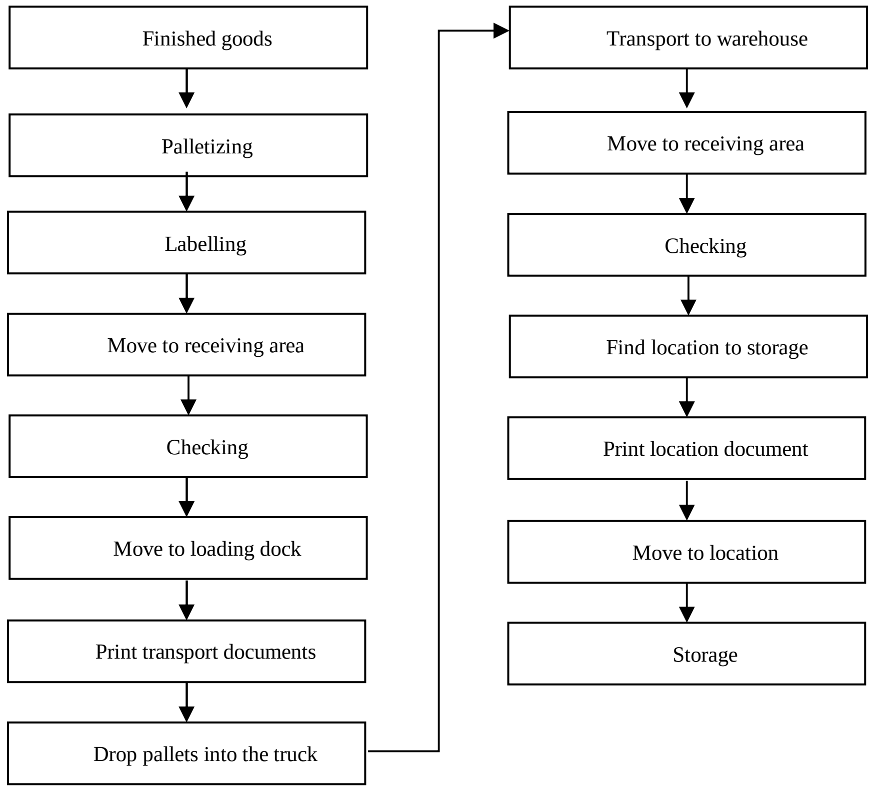

Fig. 2. The receiving process
Rys. 2. Przebieg procesu odbioru

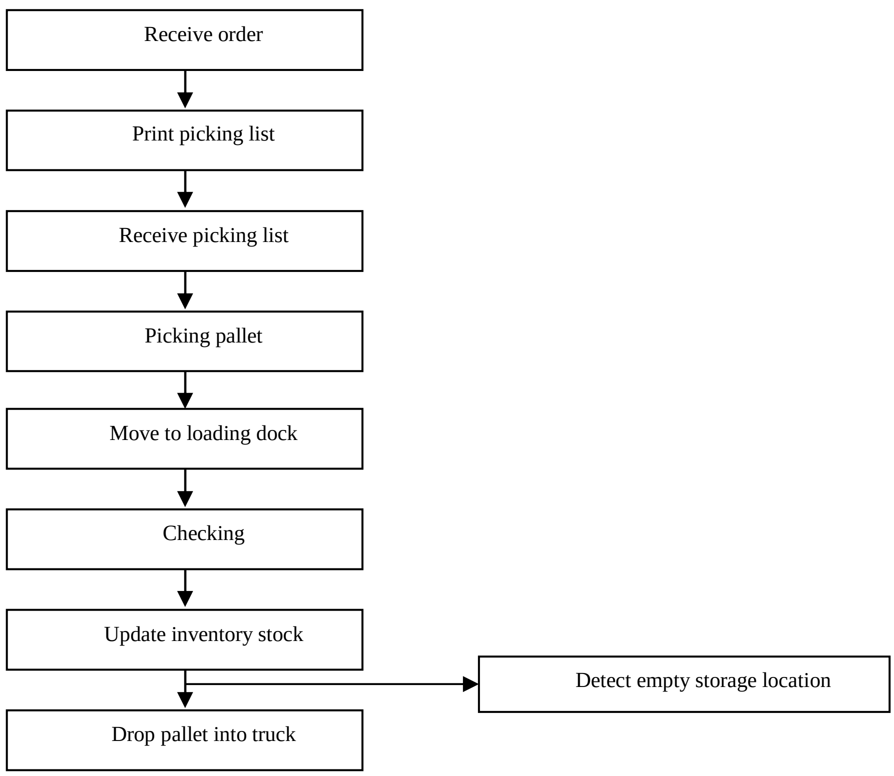

Fig. 3. The picking process
Rys. 3. Proces podjęcia

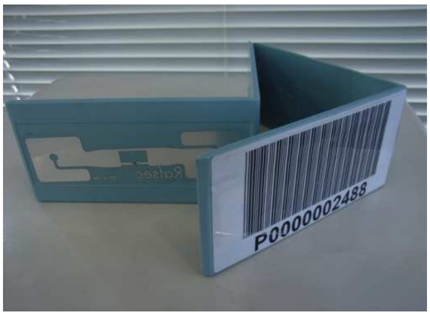

Fig. 4. Pallet tag
Rys. 4. Tag na palecie

Fig. 5. Location tag
Rys. 5. Tag lokalizacji

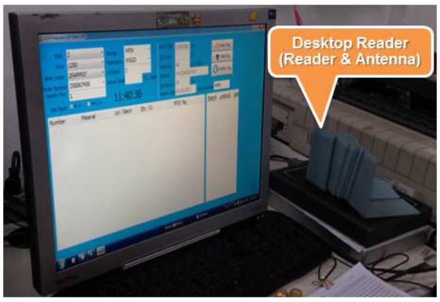

Fig. 6. Desktop reader
Rys. 6. Czytnik

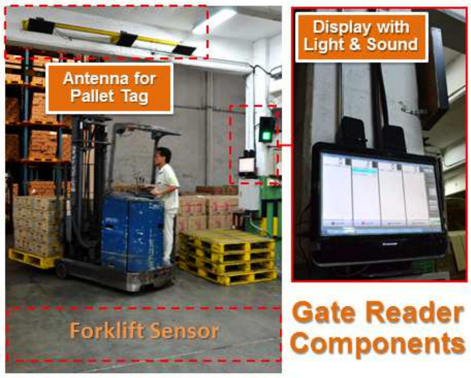

Fig. 7. Gate reader and antenna
Rys. 7. Czytnik na bramce i antena

Fig. 8. Reader which mounted on the Forklift truck
Rys. 8. Czytnik zamontowany na wózku widłowym

The implementation of RFID in the warehouse

Integrating RFID technology into warehouse process, based on the analysis of the current processes, the receiving process is changed after using RFID system to be the receiving process in Figure 9.

From the figure 9, after the finished good is produced, production data is linked to the RFID tags which attach to each pallet. Warehouse staff will know the number of pallet which is transport to the warehouse. Therefore, they will prepare the storage location. The first gate reader where is installed between end of production line and warehouse can be automatically traced on each finished goods pallet to be moving pass to specify the destination warehouse. The second gate reader where is installed at shipping area can be traced on each pallet to be moving pass and specify automatically the location in the destination warehouse and drop pallets into the truck. When transport pallets to the destination warehouse, RFID tag which attach to each pallets is read by forklift reader and show the location to be stored on a touch screen computer which mounted on the forklift truck. The forklift truck moves pallet to the location and stores while location tag is read to verify by forklift reader.

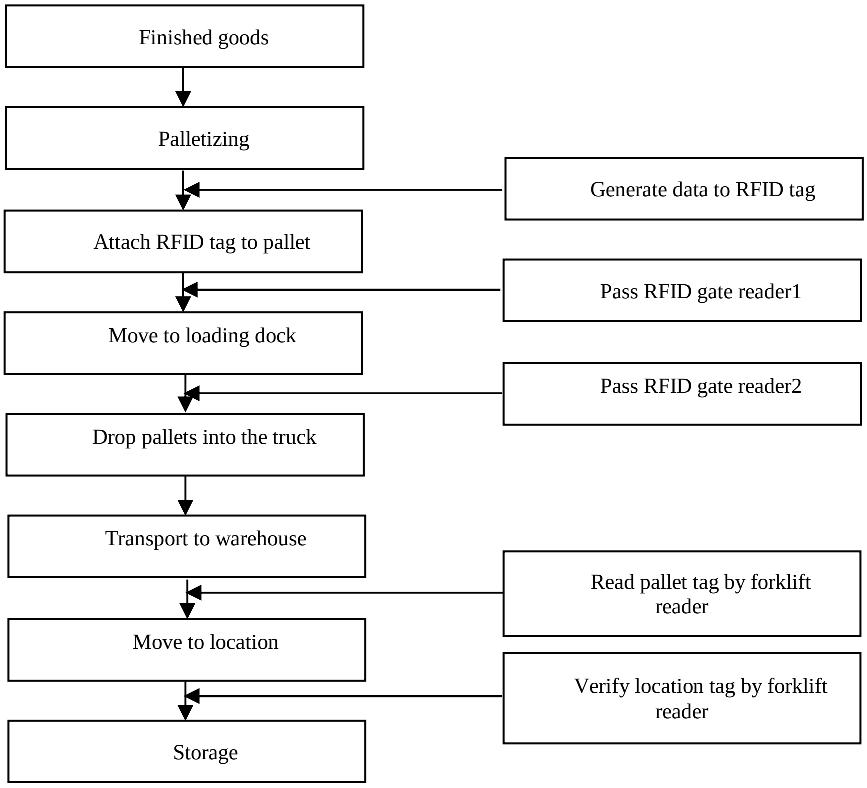

Fig. 9. The receiving process after using RFID system
Rys. 9. Proces odbioru po użyciu systemu RFID

Moreover, the picking process is changed after using RFID system which is shown in figure 10.

From the figure 10, the picking list is shown in the touch screen monitor. After that, the staff will pick the pallet by reading both pallet tag and location tag. Therefore, the inventory stock and empty storage location are updated real time. Next, the pallet is moved to the loading dock. All pallets are checked and dropped into the truck. This process can improve the storage location management which the empty storage location can use in the receiving process real time.

The comparison before and after RFID implementation

After implement RFID system, the data is collected. The results are shown in table 1.

From the table 1, the implement RFID in the receiving process can help to solve the problems. The average total cycle time of receiving process is reduced by 28.79%. The accuracy of inventory location is 100%. Moreover, the empty storage locations are known real time, so it help to save time to find the empty storage location.

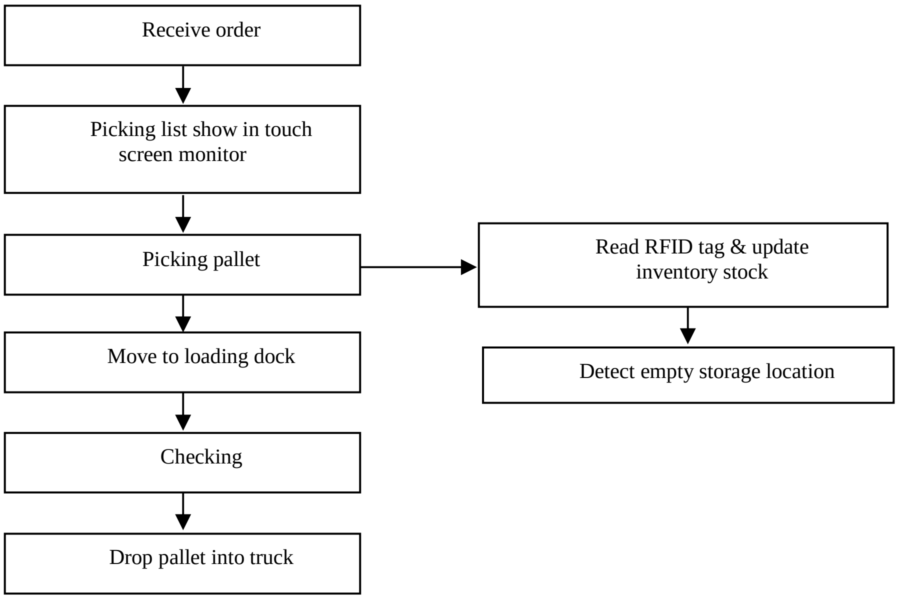

Fig. 10. The picking process after using RFID system
Rys. 10. Proces podjęcia po użyciu systemu RFID

Table 1 Comparison before and after RFID implementation
Tabela 1. Porównanie przed i po wdrożeniu RFID

Items	Before RFID implementation	After RFID implement	Difference
The average total cycle time of receiving process (10 pallets per trip)	66 minutes per trip	47 minutes per trip	28.79%.
The accuracy of inventory location	72.8 %	100%	27.2%
The empty storage location information	Non-real time (wait for warehouse staff input the data)	Real time	

CONCLUSION AND RECOMMEND

The objective of this research is to improve the process in the warehouse by using RFID technology. This warehouse has three significant problems. The first problem is an inaccuracy of inventory location that the accuracy of inventory location is 72.8 percent. The second problem is long cycle time of receiving process that the average total cycle time is 66 minutes per trip while one trip is 10 pallets. The last problem is a non-real time empty storage location. After the RFID system is implemented, the accuracy of inventory location is improved from 78.2% to 100%. The cycle time is decreased by 28.79% or 19 minutes. Moreover, the empty storage location are known real time.

However, this research focuses only one warehouse that far from the factory; therefore, it has gap to improve other warehouse of the factory.

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ZASTOSOWANIE APLIKACJI RFID W PROCESIE MAGAZYNOWYM - STUDIUM PRZYPADKU U PRODUCENTA WYROBÓW KONSUMENCKICH W TAJLANDII

STRESZCZENIE. **Wstęp**: W analizowanym magazynie występowały trzy podstawowe problemy: słaby poziom dokładności określenia miejsca składowania, długi okres cyklu pozyskiwania oraz brak bieżącej informacji o pustych miejscach składowania. Celem tej pracy było poprawienie procesu w omawianym magazynie poprzez wprowadzenie technologii RFID.

Metody: Badania przeprowadzono w czterech etapach. Pierwszym etapem było przeanalizowanie istniejącej sytuacji. Drugim - przekazanie wytycznym dla wprowadzenia technologii RFID. Trzecim - wdrożenie systemu FRID w analizowanym magazynie. Ostatnim etapem było porównanie wyników aktualnego procesu z proponowanym. Wybrano pasywną ultra wysoką częstotliwość (UHF) RFID do stosowania w danym przypadku. Czytniki RFID zostały przymocowane do wózków widłowych, na wejściu do magazynu oraz na polu załadowczym. Tagi RFID były używane w dwóch wersjach: do identyfikacji palet oraz do identyfikacji miejsc składowania towaru na regałach.

Wyniki i wnioski: Po wprowadzeniu technologii RFID, trafność danych dotyczących lokalizacji towaru w magazynie wzrosła z 78,2% do 100%. Cykl roboczy został zredukowany z 66 minut d o47 minut, czyli 28,79%. Jednocześnie uzyskano informację o pustych miejscach składowania.

Słowa kluczowe: RFID, magazyn, proces odbioru, proces pobrania

Sooksaksun N., Sudsertsin S., 2014, The application of RFID in warehouse process: case study of consumer product manufacturer in Thailand. LogForum 10 (4), 423-431.
URL: http://www.logforum.net/vol10/issue4/no6

DIE ANWENDUNG VON RFID-VERFAHREN IN LAGERPROZESSEN - STUDIENFALL BEIM HERSTELLER VON KONSUMERZEUGNISSEN IN THAILAND

ZUSAMMENFASSUNG. Einleitung: Innerhalb des analysierten Lagers traten drei Hauptprobleme auf: fehlende Präzision bei der Identifikation eines Lagerplatzes, lange Zeit für Kommissionierung und Warenausführung und fehlende Information über die freien Lagerplätze. Das Ziel der Arbeit war es, die Prozesse im betreffenden Lager mit Hilfe der RFID-Technologie zu verbessern.

Methoden: Die Untersuchungen vor Ort wurden in vier Etappen durchgeführt. Innerhalb der ersten Etappe hat man die bestehende Situation analysiert. Innerhalb der zweiten - erfolgte die Bereitstellung von Richtlinien für die Einführung der RFID-Technologie. In der dritten Etappe - die Einführung des RFID-Systems im analysierten Lager. In der letzten Etappe hat man einen Vergleich der Ergebnisse des herkömmlichen Prozesses mit denen des vorgeschlagenen Systems vorgenommen. Es wurde eine passive Ultra-Hochfrequenz (UHF) RFID für den betreffenden Anwendungsfall ausgewählt. Die RFID-Leser wurden an Gabelstapler befestigt, ferner am Lagereingang und innerhalb der Verladefläche positioniert. Die RFID-Tags wurden in zweierlei Versionen in Anspruch genommen: als die Version für die Identifikation von Paletten und als die Version für die Identifikation von Lagerplätzen im Regalfach.

Ergebnisse und Fazit: In Folge der Einführung der RFID-Technologie ist die Daten- Effizienz hinsichtlich der effektiven Warenidentifikation im Lager von 78,2% auf 100% angestiegen. Der Arbeitszyklus wurde von 66 auf 47 Minuten, das heißt um 28,79%, reduziert. Gleichzeitig gewann man die Information über die freien Lagerplätze.

Codewörter: RFID, Lager, Entnahme-Prozeß, Aufnahme-Prozeß

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PRODUCT RETURNS MANAGEMENT IN THE CLOTHING INDUSTRY IN POLAND

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ABSTRACT. Background: The aim of this study is to identify and define on the basis of the literature the principal external and organizational factors and check to what extent they affect the efficiency of returns management as well as any resultant savings. The author proposes a conceptual model which correlates the results of returns management as well as savings with the main determinants identified on the basis of the literature. Then, in the operationalisation phase of the model, the dependent and independent variables were defined in the form of constructs. In accordance with the adopted model, individual constructs were measured based on standardised interviews.

Materials and methods: The results of returns management and any savings generated by this process are affected by certain determinants which are described in the literature. The adopted model included external factors, such as the cooperation of retailers with logistics operators and suppliers, the exchange of information in the supply chain, and organizational behaviour (experience of employees); as well as organizational factors related to the flow of information and IT systems. Due to financial and organisational restrictions, the originally planned representative sample of retail chains was limited to the regions of Wielkopolska and Lubuskie. In the end, 105 interviews were analysed.

Results: The results obtained in the research sample confirm assumptions about the possible potential savings that can be achieved as a result of appropriately conducted corporate policies in the area of reverse logistics. A correlation was also revealed between the experience and competencies of staff and the efficiency of returns management.

Conclusions: Research into the factors affecting the efficiency of returns management and any savings resulting from returns management policies have not been conducted in Poland to date. The present study contributes to the growing trend of research into the logistics of product returns. It emphasises the role of cooperation in the supply chain, the experience and competencies of employees and the importance of computerization of the process as well as the impact of those factors on the efficiency of returns management and any potential savings.

Key words: logistics management, supply chains, returns handlings, retailers, reverse logistics.

INTRODUCTION

Studies relating to the factors which affect the results of returns management and the savings resulting from a returns management policy have not been conducted in Poland so far (This article is part of a project of National Science Center 4228/B/H03/2011/40). This study contributes to the growing trend of research into reverse logistics, and emphasises in this respect the role of retailers as well as cooperation in the supply chain (An earlier version of this paper was submitted at the "International Conference on Management, Leadership and Governance - ICMLG 2014" Wellesley, Massachussets USA, 20-21 March 2014).

From the point of view of competitiveness of enterprise, undertaking actions in field of reverse logistics is important for several reasons: profit margins are shrinking; sales managers are increasingly more sensitive to the costs of maintaining inventory (including unsold goods); and opportunity costs appear, as do the possibilities of recovering the value

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of returned products [Daugherty, Richey, Genchev and Chen, 2005].

In economic and management sciences, which focus on the study of enterprises, it is common practice to formulate models, the purpose of which is to lead to a better understanding of the socio-economic reality [Dyduch, 2008]. Management theorists attempt to capture the relationships between the influence of certain factors on selected indicators which reflect the performance of business operations or, in a narrower sense, a specific area of business operations. In practice, this involves searching for relationships between predefined explanatory variables and a dependent variable or variables; these relationships take the form of hypotheses.

RESEARCH ENVIRONMENT AND HYPOTHESIS DEVELOPMENT

The aim of this study is to define, on the basis of the literature, the principal external and organisational factors; as well as checking which of them affect the results of returns management and the savings which may be obtained in this respect. The study consists of four stages:

1. Proposing a conceptual model which correlates the results of returns management and any savings obtained with the principal determinants identified on the basis of the literature;
2. Operationalizing the model - defining the explanatory variables and the response variables in the form of constructs;
3. Measuring the individual constructs according to the adopted model on the basis of standardised interviews;
4. Results and discussion.

The results of a returns management process and any savings in this area are influenced by certain determinants which have been described in the literature. The adopted model includes external factors (cooperation between a retailer and both a logistics operator and a supplier, as well as information exchange in the supply chain), organisational behaviour (the experience of employees) and organisational factors (flow of information in IT systems).

These factors are not directly observable. They have been described by means of 6 constructs, each of which consists of components included in the questionnaire. Selected measurement tools were used in this study, which were applied and published in reputable logistics journals. The tools were found to be credible and reliable. Each of the analysed dimensions (contracts) was converted into the form of statements which denoted the occurrence of each individual dimension and to which the respondents reacted. Below is a list of the constructs in an operationalized form, i.e. in the form of questionnaire questions.

Explanatory variables:

- exchange of information in the supply chain,
- collaboration with suppliers and logistics operators,
- degree of computerisation of the product returns process and the IT used by a corporation,
- experience of employees.

Response variables:

- results of product returns management,
- savings.

RESULTS OF PRODUCT RETURNS MANAGEMENT

Company policies in respect of reverse logistics are often treated superficially by managers. Over the years, management practice and studies conducted in this field made it possible to identify the most important expectations of company management as well as the ways of measuring performance in this area. Corporate policies and practice can take the form of reverse logistics handling programmes [Daugherty, Autry, & Ellinger, 2001]. Constructing a tool for measuring the extent to which the targets of returns handling have been met makes it possible to assess the efficiency and effectiveness of actions undertaken in this field. The results of returns management include factors related to customer services, but also cost factors related to value recovery, profitability and inventory.

A tool constructed in this way captures the essence of both management and the implementation of a returns policy [Autry, 2005].

SAVINGS

As an economic category savings are usually considered in the context of household budgets, as cash or money deposited in a bank account as an investment. In this analysis savings are treated as a tendency to reduce waste in logistics as well as a chance to lower costs and reduce unnecessary spending. A measure of savings understood in this way consists of statements referring to employees' perception of savings in respect of reverse logistics [Jack, Powers, Skinner, 2010, Skinner, Bryant, Richey, 2008].

COOPERATION IN THE SUPPLY CHAIN

The first group of hypotheses is related to the assumption that closer cooperation in the supply chain (specified in the study as the relationship between a retailer and a supplier) is positively correlated with the results of returns management and any resultant savings.

In the study two dimensions of cooperation in the supply chain were adopted: exchanging information plus cooperating with suppliers and operators. Such an approach, even though the notions partially overlap as information exchange is a manifestation of close cooperation, is treated as a separate construct which relates mainly to information regarding inventory. This is due to the assumption that exchanging information about the level of products is less expensive than physically transferring them.

Cooperation with suppliers and operators is based on exchanging information. In the literature it is accepted that there is a correlation between information exchange and an increase in a company's economic performance [Daugherty et al., 2005]. Typically, cooperation in respect of information exchange is connected with such issues as production planning, inventory and pricing levels, sales data and delivery information [Sandberg, 2007; after: Olorunnivo, Li, 2010]. Information exchange in these areas usually results in a greater transparency of operations in the supply chain, cost reductions, better inventory results and increased sales (Olorunniwo and Li, 2010). Cooperation on an operational level is the most commonly described form of partnership [Whipple, Russell, 2007; after: Olorunnivo, Li, 2010].

The cooperation of retailers with suppliers and logistics operators has been presented in the form of such attributes as well-defined objectives, scope of cooperation and the responsibilities involved, common arrangements in respect of planning and forecasting, long-term contracts, commonly agreed performance indicators, as well as sharing risks and benefits with partners.

Information exchange in the supply chain (in this study specified as the relationship of a retailer with a supplier and logistics operator)

H1 Information exchange is positively correlated with
H1A the results of the returns management process and
H1B the resultant savings

H2 Cooperation with suppliers and logistics operators is positively correlated with
H2A the results of the returns management process and
H2B savings.

THE DEGREE OF COMPUTERISATION IN HANDLING RETURNS AND THE USE OF INFORMATION TECHNOLOGY

Today, information technology is indispensable for enterprises and their partners in the supply chain. New technologies improve the performance of enterprises on every level [Bharadwaj, 2000]. Companies use different systems, data formats and software, and share data with business partners can be very beneficial [Olorunniwo, Li, 2010].

An information system (IS) can be described in respect of the following categories:

- Capability, measured by means of accuracy and availability of information;
- Compatibility, referring to user-friendliness and technologies which enable automation, bar codes, EDI and RFID [Daugherty, Myers, Richey, 2002].

Empirical studies confirmed that the use of IT in logistics is crucial to the performance of logistics management [Closs, Savitskie, 2003 after: Olorunnivo, Le 2010]. It has been assumed that the results of returns management and any potential savings are related to the degree of computerisation of returns handling; and that potential savings are related to the degree of computerisation of returns handling and using IT solutions by an organisation.

On this basis the following hypothesis have been formulated:

H3 Using information systems in returns handling is positively correlated with
H3A the results of returns management and
H3B the resultant savings

EMPLOYEES AND IMPROVING THEIR COMPETENCES

People, with their skills, knowledge and experience, are a fundamental resource of enterprises. In the adopted model it is assumed that in terms of the results of returns management an important role is played by such elements as managerial skills; including organisation and control, team collaboration, as well as the continuous professional development of employees. Such an approach was proposed by [Ho, 2012]. Thus, another relationship has been included in the analysis:

H4 Employees' experience in handling returns is positively correlated with
H4A the results of returns management and
H4B the resultant savings

METHODS AND RESEARCH SAMPLE

The study involved retail corporations in the clothing industry. In clothing chains the leaders are manufacturers or distributors. A brand in the clothing market is a value which is often worth hundreds of thousands of dollars. Equally important is efficient logistics. In a clothing chain, goods are transferred from a central warehouse to the shops, as well as between shops. Depending on the customer segment and target group, enterprises in the clothing industry form networks either at the retail or wholesale level. Thus, two categories of chains can be distinguished:

- In the first category the leader is the company responsible for designing and manufacturing clothes as well as selling them under various brands which form a network with suppliers. These are usually highly integrated enterprises, connected by a shared strategy, capital and other resources, including manufacturing and logistics facilities
- The second model is based on a design and retail company, which manages a domestic or international brand and organises a network of companies under a franchise agreement or a chain of stores of its own. In the clothing sector there are international enterprises which transfer the sales of the entire group to a country and create subsidiaries which are responsible for the distribution in a given market, for example through a sales office. Franchise chains in the clothing industry are usually not closely integrated.

This study analyses shops - retail outlets which belong to a retail chain (ownership status was not taken into account). There are several reasons behind the choice of clothing chains (franchises or affiliated retail outlets) for the analysis. In such chains it is extremely important to adjust the stocks of seasonal products between warehouses and shops, including unsold goods which a retailer (distributor) has the right to return due to seasonal changes (spring/summer, autumn/winter).

In retail chains there are sometimes deliveries which do not comply with orders, the shelf stock may be too large, sales forecasts may turn out to be too optimistic, or an unprofitable outlet in a certain location is closed down, which means that any unsold goods have to be transferred to other shops.

A questionnaire was designed based on the literature and interviews with the personnel of retail chains. After conducting a pilot study (12 questionnaires), the aim of which was to eliminate any ambiguities so that the respondents would not have any doubts as to the meaning of the questions, the research proper began. Due to financial and organisational constraints, the research sample was restricted to stores from the Wielkopolska and Lubuskie region. Data were collected by students of Domestic and International Logistics at Poznań University of Economics. Finally 105 interviews have been included in the analysis (See also exploratory research: Jeszka A.M., 2014, Returns management in the supply chain. LogForum 10 (3), 295-304).

Quantitative research was conducted on a sample of retail chains operating in the clothing industry in Poland based on a retailers directory. For financial reasons the geographical scope of the study was restricted to the regions of Wielkopolska and Lubuskie. The study focused on shopping centres as this is where retail chains most frequently are located. The sample included large shopping centres in Poznań, Gorzów Wielkopolski and Zielona Góra. The study took into account the number of retail points in relation to the number of inhabitants, where the ratio was 7:1. From a statistical point of view, random sampling was used. This made it possible to determine the characteristics of the subject of research, which was specified as a study of the whole class of entities described, i.e. clothing retail chains operating in Poland (The entire research report [Jeszka, 2014]). This is an example of using triangulation and mixed methods in social research. The findings of this research refer to the research sample and as such are a case study as understood by [Miles, Huberman, 1994].

Taking into account the objectives of the study, standardised interviews were conducted with senior management staff representing the analysed retail chains. The research tool was an interview questionnaire. The study was conducted in March and April 2013. The study carried out on a sample of store managers of retail chains revealed diversified opinions among the managerial staff on various aspects of returns management.

In the study some hypotheses were tested which can be divided into two groups: the first two hypotheses are related to cooperation in the supply chain and concern its relationship with the results of returns management and savings. The next two hypotheses are related to the computerisation of returns handling, the IT tools used by a company as well as the experience of management and employees in the area of handling product returns, and concern the influence of these variables on performance and savings.

Figure 1 presents the conceptual model.

Cooperation in the supply chain is a concept that has been discussed for a number of years. The best known and most widely used projects such as ECR, CPFR and VMI are mainly used in the FMCG sector. So far, the issue of cooperation between suppliers, logistics operators and retailers in the clothing sector has not attracted a great deal of interest.

A frequently used measure of a reliability of a construct is Cronbach's alpha, which determines the consistency of the items included in a given scale. In other words, it determines to what extent the items included in a given factor are similar to one another, and whether they relate to the same phenomenon - the same theoretical construct. The value of the alpha coefficient above 0.7 indicates that the scale is correct and confirms a correct construction of an indicator. The measure of the reliability of a Cronbach's alpha scale based on the correlation values between items should be higher than 0.6. Otherwise the predictions of the variables are weak and they cannot be fully trusted.

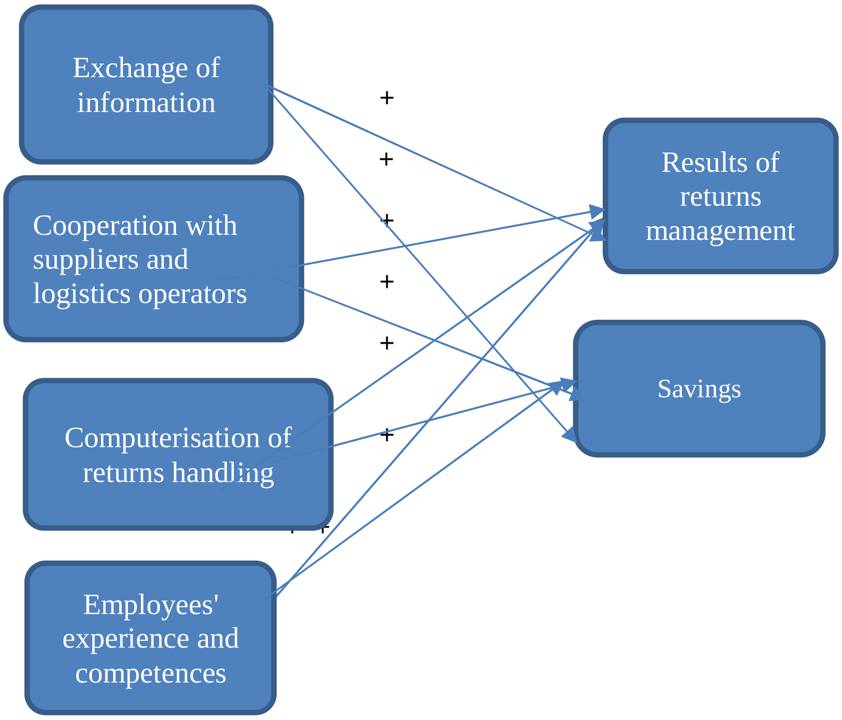

Fig. 1. A graphic representation of the conceptual model
Rys. 1. Graficzne przedstawienie koncepcji

Table 1. Exchange of information
Tabela 1. Wymiana informacji

	Statements	Median	Average
Exchange of information; Strongly disagree = 1 Strongly agree = 5 (Olorunniwo and Li, 2010) Cronbach's alpha 0.99	1. Accuracy of the information we exchange	3	3.2
	2. Access to the database	3	2.7
	3. Use of inventory data available on the Internet	3	2.8
	4. Access to information from the warehouse	3	2.8
	5. Trust between partners	3	3.2

Table 2. Cooperation with suppliers and logistics operators
Tabela 2. Współpraca z dostawcami i operatorami logistycznymi

	Statements	Median	Average
Cooperation with suppliers and logistics operators; Strongly disagree = 1 Strongly agree = 5 (Olorunniwo and Li, 2010) Cronbach's alpha 0.858	1. Long-term contracts	3	3.3
	2. Well-defined goals, scope and responsibilities within cooperation	3	3.1
	3. Common arrangements for planning and forecasting	3	2.9
	4. Commonly agreed performance indicators	3	2.8
	5. Sharing risks and benefits with partners	3	2.6

Table 3. Degree of computerisation of returns handling
Tabela 3. Poziom komputeryzacji obsługi zwrotów

	Statements	Median	Average
Please indicate: The IT system in our company permits; 1 = strongly disagree 5 = strongly agree (Olorunniwo & Li, 2010) Cronbach's alpha 0.82	1. Passing information to all units of the company	4	3.7
	2. Prompt handling of return procedures	4	3.8
	3. Effective planning of returns	4	3.6
	4. Effective handling of return operations on a daily basis	4	3.7
	5. The system is integrated with suppliers and customers	4	3.5
	6. Monitoring what happens to returned products	4	3.2

Table 4. Employees' experience and competences
Tabela 4. Doświadczenie i umiejętności pracowników

	Statements	Median	Average
Experience and competences (Ho, 2012); 1 = very low 5 = very high Cronbach's alpha 0.824	1. Experienced and competent staff	4	4.4
	2. Competent management	5	4.5
	3. Skilled advisers and trainers	4	3.9
	4. Support from senior management	4	4.0
	5. Cooperation in a team	5	4.5
	6. Sufficient number of staff	4	4.0

Table 5. Savings
Tabela 5. Oszczędności

	Statements	Median	Average
Savings (Jack, Powers, & Skinner, 2010); 1 = strongly disagree 5 = strongly agree Cronbach's alpha 0.67	1. We save a lot because of our returns operations	3	3.2
	2. Our returns policy improves our cost position relative to competitors	3	3.3
	3. Our reverse logistics programme results in considerable savings	3	3.2
	4. Our returns methods incur lower costs relating to compliance with environmental regulations	3	3.3

Table 6. Results of product returns management
Tabela 6. Rezultaty zarządzania zwrotami produktów

	Statements	Median	Average
Results of product returns management; Poor = 1 Excellent = 5 (Autry, 2005) Cronbach's alpha 0.58	1. Improved customer relations	4	4.0
	2. Reduced costs	3	3.4
	3. Value recovery	3	3.4
	4. Reduced inventory	3	3.3
	5. Increased profitability	3	3.3

The above data in tables 1-5 refer to savings which can be achieved by undertaking active measures in the area of reverse logistics. Savings are usually talked about in the context of money deposited in bank savings accounts. In this case they are used as a measuring tool which consists of the four statements listed in the table 6.

RESEARCH FINDINGS

Based on a correlation analysis at the level p<0.05 the following significant correlations can be observed: those between cooperation with suppliers and logistics operators and savings (correlation coefficient R=0.2); between computerisation of returns handling and savings (R=0.3); as well as between the experience and competences of employees and savings (R=0.6). Staff experience and competences are also correlated with the results of returns management at the level of R=0.19. Thus, hypotheses H2B, H3B, H4A and H4B have been confirmed; whereas hypotheses H1A and H1B as well as H2A and H3A have been rejected.

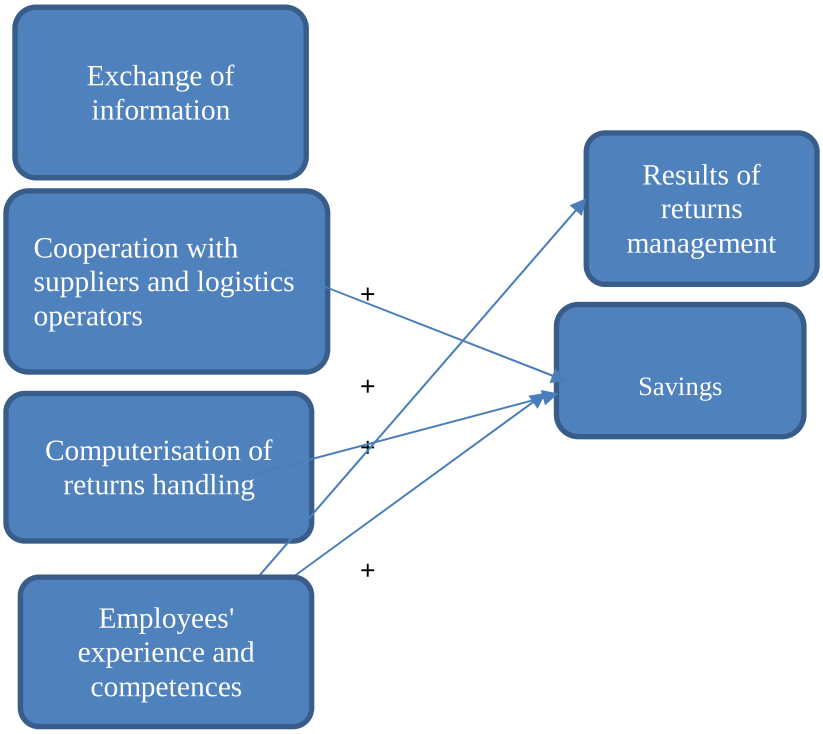

Fig. 2. Empirical model
Rys. 2. Model doświadczalny

Based on the findings obtained in the analysed sample, the predictions relating to potential savings which could be achieved by retail enterprises through implementing appropriate reverse logistics policies have been corroborated. An important role in this respect is played by the experience and competences of staff in terms of reverse logistics as well as the extent to which the process of handling returned products is computerised. There is also a correlation between potential savings and the cooperation of a retailer with suppliers and logistics operators. These findings show that automating the process of product returns does not result in better customer relations, cost reductions, value recovery, reduced inventory or improved profitability. It is quite striking that no correlation was discovered between the computerisation of the returns process, the flow of information or the cooperation of partners in the supply chain and the results of product returns management. Reverse logistics continues to be perceived by practitioners as something not worthy of attention. The process of handling product returns is usually neither monitored nor subjected to analyses which, as the findings show, are only made possible by adequate computerisation and exchanging information with suppliers and logistics operators. Often suppliers manifest their opportunism by disposing of goods through selling the largest possible volume of merchandise to retailers and leaving to them all the issues related to dealing with surplus goods or price reduction policies. This process is controllable and measurable but there is no will to cooperate or to share benefits.

LIMITATIONS

Most empirical studies refer to a segment of the market or a particular group of companies. So it was in this case. The sample was narrowed down to clothing retail chains in two provinces in Poland.

Methodologically, the study was based on a questionnaire survey and the analysis is strongly based on the perceptions of the respondents. This was due to two factors: the complexity and the amount of data collected, and in particular the confidentiality of data that we guaranteed in the course of the study. The research study outcomes are used as measures of perceived performance results. Hard data in the form of financial results could reveal other relationships and connections. Future studies ought to take this into account.

This study focused on describing a state of affairs and making a diagnosis but it did not take into account changes over time. Future research ought to conduct an analysis over a period of time and include different industries.

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ZARZĄDZANIE ZWROTAMI W BRANŻY ODZIEŻOWEJ W POLSCE

STRESZCZENIE. **Wstęp:** Celem niniejszego studium było zdefiniowanie na podstawie literatury głównych czynników (zewnętrznych i organizacyjnych) i sprawdzenie, które z nich wpływają na efektywność zarządzania procesem zwrotów produktów oraz oszczędności, które z tego tytułu można uzyskać. Zaproponowano model koncepcyjny, który wiąże korelacyjnie wyniki zarządzania procesem zwrotów produktów oraz oszczędności z wyłonionymi na podstawie literatury głównymi determinantami. Następnie w fazie operacjonalizacji modelu – zdefiniowano zmienne objaśniające i zmiennych objaśniane w postaci konstruktów. Dokonano pomiaru poszczególnych konstruktów zgodnie z przyjętym modelem na podstawie wywiadów standaryzowanych.

Materiał i metody: Teoretycy zarządzania podejmują próby uchwycenia zależności pomiędzy wpływem określonych czynników na wybrane wskaźniki odzwierciedlające miary efektywności prowadzonej działalności lub w węższym ujęciu – określonego obszaru tejże działalności. Na wyniki zarządzania procesem zwrotów produktów i oszczędności w tym zakresie wpływ mają określone i opisane w literaturze determinanty, w modelu ujęto: zewnętrzne czynniki tj. współpraca detalisty z operatorem logistycznym i dostawcą oraz wymiana informacji w łańcuchu dostaw, zachowania organizacyjne (doświadczenie pracowników,) oraz czynniki organizacyjne tzn. związane z przepływem informacji system IT. Planowaną reprezentatywną próbę sieci handlowych ze względów finansowych oraz organizacyjnych ograniczono do województwa Wielkopolskiego i Lubuskiego. Ostatecznie analizie poddano 105 wywiadów.

Wyniki: Studia w zakresie czynników mających wpływ na efektywność zarządzania procesem zwrotów produktów i oszczędności wynikających z polityki zarządzania zwrotami nie były dotąd przeprowadzane w Polsce. Przeprowadzone studium wnosi wkład w rozwijający się nurt badań nad logistyką zwrotów i podkreśla rolę detalistów oraz współpracy w łańcuchu dostaw w tym zakresie. Na podstawie wyników w badanej próbie potwierdziły się przypuszczenia na temat możliwych potencjalnych oszczędności uzyskiwanych dzięki odpowiednio prowadzonej przez korporacje handlowe polityce w zakresie logistyki zwrotów. Występuje także zależność między współpracą detalisty z operatorami logistycznymi i dostawcą a możliwością uzyskania oszczędności.

Słowa kluczowe: zarządzanie logistyczne, łańcuch dostaw, obsługa zwrotów, detaliści, logistyka zwrotna

RETOUREN-MANAGEMENT IN DER BEKLEIDUNGSINDUSTRIE IN POLEN

ZUSAMMENFASSUNG. Einleitung: Das Ziel des vorliegenden Forschungsstudiums war es, auf Grund des Gegenstandsliteratur die wichtigsten (äußeren und organisatorischen) Einflußfaktoren zu definieren sowie zu prüfen, welche von ihnen die Effizienz des Managements von Retouren-Prozessen und die damit zu erzielenden Kostenersparungen positiv beeinflussen. Es wurde ein Konzeptmodell, welches die Ergebnisse des Managements des Rücksendungs-Prozesses mit den in der betreffenden Literatur ermittelten, wichtigsten Determinanten korrelationsmäßig verbindet, vorgeschlagen. Ferner hat man in der Phase der Operationalisierung des Modells die erschließenden Variablen und die Erschließung von Variablen in Form von Konstrukten definiert. Es wurde dabei gemäß dem angenommenen Modell und auf Grund der standardisierten Umfragen eine Bewertung der einzelnen Konstrukten vorgenommen.

Material und Methoden: Viele Management-Theoretiker versuchen, die Abhängigkeiten innerhalb des Einflusses bestimmter Indikatoren auf ausgewählte Kennziffern zu ermitteln. Die Indikatoren widerspiegeln Masstäbe der Effizienz der wirtschaftlichen Tätigkeit oder im engeren Sinne die Effizienz eines bestimmten Bereichs der betreffenden Aktivität. Die Ergebnisse eines effizienten Retouren-Managements und die daraus resultierenden Ersparnisse werden von bestimmten, in der Literatur abgehandelten Determinanten beeinflusst. Im betreffenden Modell gehören dazu: die äußeren Einflußfaktoren, dh. Kooperation des Einzelhändlers mit Logistik-Dienstleistern und Informationsaustausch innerhalb der Lieferkette, organisatorische Verhaltensweisen (Erfahrung der Mitarbeiter) sowie die mit dem IT-System und dem Informationsfluss zusammenhängenden Einflußfaktoren. Die vorgeplante, repräsentative Losgröße der zu untersuchenden Handelsnetze wurde aus finanziellen Gründen auf die Großpolnische und die Lebuser Wojewodschaften eingeschränkt. Letztendlich hat man 105 Umfragen einer Analyse unterzogen.

Ergebnisse: Bisher wurden in Polen keine Forschungsstudien in Bezug auf die Faktoren, die die Effizienz des Retouren-Managements und der daraus resultierenden, mit der Politik des Retouren-Managements zusammenhängenden Ersparnissen, durchgeführt. Das betreffende Forschungsstudium leistet hiermit einen Beitrag zur Entwicklung der Forschungen zur Retouren-Logistik sowie hebt die Rolle von Einzelhändlern und deren Kooperation innerhalb der Lieferkette auf diesem Gebiet hervor. Die Ergebnisse der Erforschung innerhalb der untersuchten Losgröße ließen die Annahmen bezüglich der potenziellen, dank der gezielt von den interessierten Handelsnetzen betriebenen Politik des Retouren-Managements und der Retouren-Logistik zu erzielenden Ersparnissen bestätigen. Es bestehen ferner die Zusammenhänge zwischen der Kooperation des Einzelhändlers mit Logistik-Dienstleistern und der Möglichkeit der Erzielung wesentlicher Ersparnisse.

Codewörter: Logistik-Management, Lieferkette, Bedienung von Retouren, Einzelhändler, Retouren-Logistik

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ICT COMPETENCIES IN LOGISTICS TRAINING - INTERNATIONAL VIEW

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ABSTRACT. Background: Today's business reality requires employees to continuously develop their professional competence and to keep requalifying in the face of structural unemployment risk. The need for staying up to date on ICT technologies brings into focus the competence that logistics trainers and teachers should demonstrate to be able to teach the human resources in demand by the European economy.

Material and methods: A study into the level of competence required to be able to deliver trainings with the use of ICT tools was conducted among experienced practitioners (trainers and teachers) from Germany, Italy and Poland. The study had a form of a questionnaire survey made available on the project's website. Electronic data has been subject to a statistical analysis with the application of descriptive statistics tools.

Results: The respondents from all the countries agreed that teachers and trainers should demonstrate ICT competencies at the application level. Some differences in this opinion transpired in the course of a detailed analysis of the levels required for each competency.

Conclusions: The results of the survey into which competencies should be given the highest regard differed from country to country. These differences can be attributed to the role of ICT tools in logistics vocational trainings. The respondents from Germany and Poland are focused on the quality of training materials and on their delivery. Italian trainers attach the greatest importance to communication and cooperation with the trainees.

Key words: ICT, e-learning, lifelong learning, competence level.

INTRODUCTION

According to the Lisbon strategy, the European economy is expected to become the most competitive economy in the world. It implies the need for continuous learning, aimed at enhancing the intellectual potential of societies - this is the idea behind the concept of lifelong learning. Since the second half of the '90s lifelong learning has moved to a central position among the EU policies are concerned. It started to be perceived as a vital tool for enhancing competitiveness in Europe's knowledge-based economy. Rising educational aspirations and access to various form of lifelong learning were intended to promote social cohesion in ever-more diversified societies of the EU member states [Holford 2008].

In the context of the need for lifelong learning and the number of students being on the decline, e-learning seems very promising as a form of education - both in Poland and globally [Wodecki 2010]. Lifelong learning requires new technological solutions. Half of the society can't just go back to school and work through paper textbooks.

With its universality, the Internet seems to show the greatest potential as far as supplying

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knowledge is concerned [Cellary 2012]. On top of that, the surveys indicate that school leavers (including university graduates) are ill-equipped to enter the labour market. Hence competencies are a much more valid point of reference for the employers, not a diploma.

It testified to the need for professional lifelong learning [Iwanicka 2012].

The study conducted by the authors indicates that acquiring new skills is viewed by many entrepreneurs as a source of competitive advantage. Customer requirements keep evolving, competition grows ever-stronger nowadays. Unique skills of employees are becoming a more and more valuable asset, enabling companies to provide unique services and innovative products and, in consequence, to expand their customer base. Knowledge helps entrepreneurs to become more efficient. It translates into a growth in demand for their products and services. [Ahrend, Diamond, Webber, 2010].

ICT IN EDUCATION

ICT is an abbreviation of information and communications technology [Webb, Cox 2004]. ICT skills are a staple in professional and everyday life today. Education is no different. Information technologies are growing in importance. Their application in education is referred to as e-learning (a specific type of distance education). Literature on the subject matter abounds with various definitions of e-learning. It is predicated on the fact that e-learning is multi-faced and can be viewed from many angles. There are two basic perspectives for approaching e-learning: didactic and technological. This paper draws on the definition formulated by M. Hyla. E-learning is thus construed as: "all the activities supporting the training process, based on ICT" [Hyla 2007]. The use of ICT in the didactic process requires specialized tools, which allow for [Berdowska, 2010]:

- Displaying the course content over the Internet,
- Organizing the didactic process, recruiting and reporting,
- Creating accounts for individual users (for progress tracking),
- Tracking progress and time spent on studying,
- Communication between the course participants,
- Keeping the finances in check.

These functionalities are performed with the use of ICT tools and can be of full use provided that their users know how to handle them. Access to these tools and user skills are what determines belonging to the "information society". If the above are in short supply, it is referred to as "information poverty", "information apartheid" and "digital divide" [Selwyn 2003]. The importance of ICT tools in the life of individuals and societies is on the increase probably due to the development of the so-called "social software" and Web 2.0. The idea of creating social software can be traced back to the '60s. This is when computers came into play in the context of user knowledge and experience sharing. Tools enhancing communication through a world-wide net have been developed over the years - such as Usenet, mailing lists or the software for real time discussions. Over the past years we have been observing a rapid development of what is referred to as social software. Market tendencies have been accompanied with technological solutions which enable ever-more sophisticated ways of communicating over the internet.

A shift in the functioning of internet users - namely from information recipients to the creators of user-generated content along with the relevant support technologies have been bundled together into an umbrella term of Web 2.0. This term is suggestive of the blend of the tradition of world-wide web and its new "quality" [Alexander 2006].

The reason behind this phenomenon is the application of management support IT tools and the target group. The term Enterprise 2.0 has been coined in reference to Web 2.0. Enterprise 2.0 describes the entities which use the internet in their daily operations. This activity is diversified: browsing offers, trends, competition analysis, sales, marketing, product testing, product development [Blue Coat 2008].

The use of ICT tools in education is no longer a matter of making it more appealing, but a real requirement that the educational service providers are faced with. It entails a change in the approach towards the organization of training sessions, creating materials and knowledge assessment. As is the case with each and every change, it is met with reluctance and a disbelief in its efficiency. Which factors contribute to a reluctant approach towards ICT in education [Mumtaz 2000]:

- lack of teaching experience with ICT,
- lack of on-site support for teachers using technology,
- lack of ICT specialist teachers to teach students computer skills,
- lack of computer availability,
- lack of time required to successfully integrate technology into the curriculum,
- lack of financial support.

In the analysis of above mentioned factors the focus was on the first three. In view of the amount of time which has lapsed since the survey referred to in this paper, the remaining factors have been eliminated to a large extent. Common access to technology and falling prices of both devices and internet rates are no longer barriers to development. A problem yet to address is the shortage of fully qualified trainers and teachers who would be able to use ICT tools to boost the efficiency of delivered training sessions.

SURVEY METHODOLOGY

Referring to the conclusions drawn at the end of the previous chapter the employees of the Poznan School of Logistics undertook to conduct a survey into the competence which logistics teachers and trainers should demonstrate to be able to put ICT tools to an effective use in their training sessions. The consultations with trainers and teachers have given rise to an idea of a more complex venture, however. The Poznań School of Logistics was the coordinator of Logistics Open Training for Engineering Competence (lot4eng.com), project co-funded by the European Commission within the framework of the Transfer of Innovation strand of the Lifelong Learning Programme - Leonardo da Vinci subprogramme. Lot4eng.com intends to provide high-quality e-learning materials best matched to the current market demand and dedicated to improving managerial and engineering competence of beneficiaries (employees of logistic, manufacturing, distribution companies) that are at risk of having competence gap, which would be also a complement to a competence framework for logistics teachers and trainers who bear the responsibility for up-to-date training programmes. In this sense, there will be also designed a completely customized methodological e-learning module improving teachers' and trainers' competence in using innovative ICT technologies, including Web 2.0 technology, in vocational logistic training.

In the first stage of the study a group of experts (employees of training companies and trainers with wide experience under their belt) from Germany, Italy and Poland created a set of 15 competencies required for conducting trainings with the use of ICT tools:

1. Main characteristics of the digital community (web2.0 and new learning paradigms),
2. Factors ensuring effective online teaching in the context of school education and professional training,
3. Basics on Course Management System (CMS), Learning Management System (LMS), Virtual Learning Environment (VLE),
4. Technologies for preparing electronic content: learning scenario, technical scenario, scenario implementation,
5. Web-based environment for e-learning and related teaching models,
6. Didactical digital materials and Learning Objects in SCORM standards,
7. Web2.0 tools to share didactic materials (ex. slideshare, teachertube, etc),
8. Internet, web2.0 technologies and tools (google, youtube, wikipedia, fb, linked-in, vimeo, etc),
9. Tools for digital and social communication: messenger, skype, forums, wiki blogging, podcasting,

collaborating, social networking, multimedia sharing, social tagging etc.,
10. Search, modify, re-use digital didactic resources available on the net for rapid learning,
11. Manage and moderate a community/group of e-learners,
12. Assessment of training needs and effective evaluation of acquired knowledge through e-learning platform tools,
13. Methods and software for developing multimedia didactic material for online trainings,
14. Delivery and monitoring of e-trainings,
15. Effective communication and cooperation in a Web 2.0 environment.

The second stage of works consisted in preparing an electronic survey which asked respondents to define the level of competence that teachers and trainers should demonstrate. The level of competence was measured based on Bloom taxonomy.

Table 1. Bloom Taxonomy
Tabela 1. Taksonomia Blooma

Level	Competences
Evaluation	You can pass judgment on something.
Synthesis	You can create something new as a result of analysis.
Analysis	You can break something down.
Application	You can take something from one context and use it in another.
Comprehension	You understand what you know.
Knowledge	You know something.

Source: [Crowe, Dirks, Wenderoth 2008]

The present analysis is based on datasets which are derived from online questionnaires filled by respondents from each of the three countries. The number of respondents was as follows:
- Germany: n = 21
- Italy: n = 20
- Poland: n = 48

Each respondent was presented with 15 responses, corresponding to the number of competences. The above described datasets have been used for further analyses aimed to respond to the questionnaire objectives described below. For geographic context of survey's results, additional variables were calculated as the result of aggregation of all competences levels.

Statistical analyses were based on basic principles of descriptive statistics, namely calculation of absolute and relative frequencies for each level of competence on the taxonomy proposed (knowledge, comprehension, application, analysis, synthesis and evaluation, respectively, from the lowest to the highest), as well as sum of frequencies of responses of higher versus lower levels. Mode values are given when significant to the interpretation of results on a particular competence.

GEOGRAPHIC CONTEXT OF SURVEY'S RESULTS

GERMANY

German respondents show a prevalence of responses where application is the most frequent answer: in particular, it is so in 9 out of 15 questions/competences. Overall, the histograms are quite balanced as to the distribution of frequencies for each level of the taxonomy, and of the tendencies towards higher levels (analysis, synthesis and evaluation) versus lower levels (application, comprehension and knowledge).

The competences where a more advanced level of knowledge (shown in table 2) is required - according to the taxonomy on which the questionnaires were based - are, in particular, ICT_10 "Search, modify, re-use digital didactic resources available on the net for rapid learning", and ICT_14 "Delivery and monitoring of e-trainings". On the first question, almost 30% of responses were directed towards the need to possess the skills at the most advanced level, evaluation, while the second most frequent response was synthesis (together with application), and analysis got 16% of the responses. For competence ICT_14, regarding the delivery and monitoring of e-trainings, 24% of the responses again were directed towards the need to possess the skills at the evaluation level, while synthesis and analysis got 34%

altogether (and thus the first three levels of the taxonomy were well above 50% of all responses).

Also, for competence ICT_5 "Web-based environment for e-learning and related teaching models" and ICT_6 "Didactical digital materials and Learning Objects in SCORM standards", 56% of the responses were within the first three levels of the taxonomy (evaluation, synthesis, analysis), indicating that these are two competences that German respondents request to be taught at a fairly high level.

Table 2. The competences required at the highest level according to German respondents
Tabela 2. Najbardziej wymagające kompetencje ICT zdaniem niemieckich respondentów

DE_2_ICT	Factors ensuring effective online teaching in the context of school education and professional training.
DE_4_ICT	Technologies for preparing electronic contents: learning scenario, technical scenario, scenario implementation
DE_5_ICT	Web-based environment for e-learning and related teaching models
DE_6_ICT	Didactical digital materials and Learning Objects in SCORM standards
DE_10_ICT	Search, modify, re-use digital didactic resources available on the net for rapid learning
DE_14_ICT	Delivery and monitoring of e-trainings

Source: Own study

ITALY

As for Germany, the most frequent response by Italian respondents across all questions (competencies) is application, with the exceptions of ICT_6 "Didactical digital materials and Learning Objects in SCORM standards", ICT_10 "Search, modify, re-use digital didactic resources available on the net for rapid learning" and ICT_15 "Effective communication and cooperation in a Web 2.0 environment", where they express the need to have a competence at a knowledge, analysis and evaluation level respectively. The competences for which the respondents tend to require a higher level on the taxonomy are discussed below.

Table 3. The competences required at the highest level according to Italian respondents
Tabela 3. Najbardziej wymagające kompetencje ICT zdaniem włoskich respondentów

IT_7_ICT	Web2.0 tools to share didactic materials (ex. slideshare, teachertube, etc)
IT_8_ICT	Internet, web2.0 technologies and tools (google, youtube, wikipedia, fb, linked-in, vimeo, etc)
IT_9_ICT	Tools for digital and social communication: messenger, skype, forums, wiki blogging, podcasting, collaborating, social networking, multimedia sharing, social tagging etc.
IT_15_ICT	Effective communication and cooperation in a Web 2.0 environment.

Source: Own study

In particular, respondents think that competence ICT_7 "Web2.0 tools to share didactic materials (ex. slideshare, teachertube, etc)" is required to be taught at an advanced level (evaluation, synthesis and analysis cumulatively get 52% of the responses); the same first three levels of the taxonomy get 57% of the total responses for the competence ICT_8 "Internet, web2.0 technologies and tools (google, youtube, wikipedia, fb, linked-in, vimeo, etc)", although for both cases the most frequent response is application.

Competence ICT_9 "Tools for digital and social communication: messenger, skype, forums, wiki blogging, podcasting, collaborating, social networking, multimedia sharing, social tagging etc.", too, receives a cumulative frequency of the first three levels of the taxonomy which is above 50% (53%). This competence is somewhat similar to the ICT_8 one, indicating that Italian respondents think that the social networking tools are of much importance among ICT competences for the logistics employees.

It can also be noticed how for competence ICT_15 "Effective communication and cooperation in a Web 2.0 environment", the evaluation level is the most frequent response, getting 27% of the total responses (the first three levels on the taxonomy are worth 50% of the responses).

POLAND

The most frequent response by Polish respondents across all questions (competencies) is application (the only exception is ICT_12 "Assessment of training needs and effective evaluation of acquired knowledge through e-learning platform tools", where they express the need to have a competence at an evaluation level). Other competencies that require a higher level on the taxonomy are presented in table 4.

Table 4. The competences required at the highest level according to Polish respondents
Tabela 4. Najbardziej wymagające kompetencje ICT zdaniem polskich respondentów

PL_1_ICT	Main characteristics of the digital community (web2.0 and new learning paradigms)
PL_2_ICT	Factors ensuring effective online teaching in the context of school education and professional training.
PL_10_ICT	Search, modify, re-use digital didactic resources available on the net for rapid learning
PL_11_ICT	Manage and moderate a community/group of e-learners
PL_12_ICT	Assessment of training needs and effective evaluation of acquired knowledge through e-learning platform tools.

Source: Own study

In particular, competence ICT_12 "Assessment of training needs and effective evaluation of acquired knowledge through e-learning platform tools" shows a cumulative frequency of 59% of responses in the first three levels of the taxonomy (evaluation, synthesis, analysis). The need to possess this competence at the most advanced level, evaluation, is worth alone 30% of the responses. Besides, competence ICT_10 "Search, modify, re-use digital didactic resources available on the net for rapid learning" is also strongly requested, as the most frequent response is the evaluation level and the cumulative frequency of the evaluation, synthesis and analysis levels is 58%.

Competence ICT_2 "Factors ensuring effective online teaching in the context of school education and professional training" receives, like ICT_10 "Search, modify, re-use digital didactic resources available on the net for rapid learning" the evaluation level as the most frequent response. Competences ICT_2, ICT_1 "Main characteristics of the digital community (web2.0 and new learning paradigms)" and ICT_11 "Manage and moderate a community/group of e-learners" exhibit a cumulative frequency of the evaluation, synthesis and analysis levels slightly above 50%.

CONCLUSIONS

Analysing responses of German respondents it is possible to notice that with the exception of competence ICT_1 (showing most frequent responses on the knowledge and analysis levels) and other competencies on high levels (particularly evaluation and analysis), the cumulative frequencies are centred around the average level of application and the surrounding levels of analysis and comprehension. This is confirmed by the fact that in 8 out of 15 cases (competences), the cumulative frequency of the lowest three levels (knowledge, comprehension, and application) are higher than the cumulative frequency of the highest three levels (analysis, synthesis, and evaluation); in 7 out of 15 cases we have the opposite situation, where the cumulative frequency of the highest three levels is higher than the cumulative frequency of the lowest three levels.

However, differently from Germany, Italian respondents tend to indicate that competences are to be taught at the "low" levels of the taxonomy. The histograms show a general preference for the responses knowledge, comprehension, and application for most of the questions/competences. In fact, in 10 out of 15 questions/competences, the cumulative frequencies for the lower levels of the taxonomy (knowledge, comprehension, and application) are higher than the cumulative frequencies for the higher levels (analysis, synthesis, and evaluation). This indicates that the view of Italian respondents on the competences required in the field of logistics are of a more "practical" level, where employees need to apply - and sometimes simply know and comprehend - the basic elements for each competence.

Polish respondents exhibit on average a preference for lower levels of the taxonomy: in 10 out of 15 questions (competences), the average mean of relative frequencies on the lowest three levels (knowledge, comprehension, and application) is higher than the average mean of relative frequencies on the highest three levels (analysis, synthesis, and evaluation).

The exceptions are competencies ICT_1, ICT_2, ICT_10, ICT_11, and ICT_12.

This indicates that respondents in this country think that the ICT competencies for logistics employees are to be taught at an intermediate level of the taxonomy, a level at which they can apply and understand knowledge and not necessarily be able to analyse, synthesize and evaluate the principles of each of the 15 competences listed, with the above mentioned exception.

To sum up, the survey leads to two basic conclusions. At first glance the perception of ICT competence requirements among logistics teachers and trainers is rather uniform irrespective of the country. The most expected competence level is application. On the one hand, it corroborates the existence of a barrier to the proliferation of ICT tools (as mentioned in the literature part) and, on the other hand, on what the trainers expect from these tools. In their opinion the tools needn't be a basis in all aspects of training sessions, but rather a supporting element, to be used and implemented during sessions. The second conclusion pertained to which competencies are required at the highest level. In this area the respondents from various countries were not unanimous. Only two competencies were the same (ICT_2 and ICT_10 in the case of Poland and Germany). In the case of Germany and Poland emphasis will be on creating and delivering materials to the trainees. In Italy the highest regard was given to the organization of functionalities related to communication and collaboration within Web 2.0.

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KOMPETENCJE ICT W SZKOLENIACH LOGISTYCZNYCH - SPOJRZENIE MIĘDZYNARODOWE

STRESZCZENIE. **Wstęp:** Wymagania stawiane przez współczesną gospodarkę pracownikom dotyczące ciągłego rozwoju kompetencji zawodowych jak również konieczności przekwalifikowania się w sytuacji zagrożenia bezrobociem strukturalnym wymagają uczenia się przez całe życie. To z kolei w dobie ciągle rosnącego zainteresowania technologiami informacyjnymi (ICT) nakazuje się zastanowić jakimi kompetencjami powinni dysponować trenerzy i szkoleniowcy z obszaru logistyki aby skutecznie dokształcać kadry niezbędne europejskiej gospodarce.

Metody: Badania poziomu kompetencji wymaganego w realizacji szkoleń z wykorzystaniem narzędzi ICT przeprowadzono wśród doświadczonych praktyków (trenerów i szkoleniowców) z Niemiec, Włoch i Polski. Badanie

przeprowadzono za pomocą kwestionariusza ankiety udostępnianego za pośrednictwem strony internetowej projektu. Zebrane dane w formie elektronicznej poddano analizie statystycznej przy wykorzystaniu narzędzi statystyki opisowej.
Wyniki: Respondenci ze wszy kich krajów zgodnie wskazują, że kompetencje ICT trenerów i szkoleniowców powinny być najczęściej na poziomie stosować. Różnice dostrzec może jednak w szczegółowej analizie wymaganego poziomu dla poszczególnych kompetencji.
Wnioski: Różnic w wynikach pochodzących z poszczególnych krajów w określaniu, jakie kompetencje ICT są wymagane na najwyższym poziomie należy upatrywać w roli, jaką mają spełnić narzędzia ICT w szkoleniach zawodowych w obszarze logistyki. Respondenci z Niemiec i Polski skupiają się, na jakości materiałów szkoleniowych oraz sposobie ich dostarczania. Włoscy szkoleniowcy wskazują, że najistotniejsze jest wykorzystanie narzędzi wspomagających wzajemną komunikację i współpracę z uczestnikami szkoleń.

Słowa kluczowe: ICT, e-learning, uczenie przez całe życie, poziom kompetencji

ICT-KOMPETENZEN IN DEN LOGISTIKSCHULUNGEN - INTERNATIONALE PERSPEKTIVE

ZUSAMMENFASSUNG. Einleitung: Die Anforderungen der heutigen Wirtschaft an Arbeitnehmer in Bezug auf die kontinuierliche Entwicklung von Berufsqualifikationen sowie die Notwendigkeit der Umschulung bei Gefahr einer strukturellen Arbeitslosigkeit erfordern lebenslanges Lernen. Das stetig wachsende Interesse an Informations- und Kommunikationstechnologien (ICT) bedarf es wiederum, sich zu überlegen, über welche Kompetenzen die Ausbildungskräfte im Bereich Logistik verfügen sollen, um die notwendigen Arbeitskräfte für die europäische Wirtschaft erfolgreich weiterbilden zu können.
Methoden: Die Untersuchungen des Kompetenzniveaus, das zur Durchführung von Schulungen mit der Anwendung von den IKT-Werkzeugen erforderlich ist, wurden unter den erfahrenen Praktikern (Ausbildungskräften) aus Deutschland, Italien und Polen durchgeführt. Die Untersuchung wurde mit Hilfe eines elektronischen Fragebogens durchgeführt, welcher auf der Webseite des Projektes zur Verfügung gestellt wurde. Die erfassten Daten wurden einer statistischen Analyse unter Anwendung von Werkzeugen der deskriptiven Statistik unterzogen.
Ergebnisse: Die Befragten aus allen Ländern weisen ausdrücklich darauf hin, dass die IKT-Kompetenzen der Ausbildungskräfte in den meisten Fällen auf dem Niveau der Anwendung (application) zurechtkommen sollen. Die Unterschiede sind jedoch in einer detaillierten Analyse des Niveaus für die einzelnen Kompetenzen zu beobachten.
Fazit: Die Unterschiede in den Ergebnissen aus den einzelnen Ländern bei der Festlegung, welche IKT-Kompetenzen auf dem höchsten Niveau erfordert werden, sind in der Rolle zu sehen, welche die IKT-Werkzeuge in den Berufsschulungen im Bereich Logistik zu erfüllen haben. Die Befragten aus Deutschland und Polen konzentrieren sich auf die Qualität der Schulungsmaterialien sowie auf deren Lieferungsart. Die italienischen Ausbildungskräfte weisen darauf hin, dass der Einsatz von Werkzeugen zur Unterstützung der gegenseitigen Kommunikation und Zusammenarbeit mit Schulungsteilnehmern am wichtigsten ist.

Codewörter: IKT, E-Learning, lebenslanges Lernen, Kompetenzniveau

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