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E-LOGISTICS AND M-LOGISTICS IN INFORMATION ECONOMY

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ABSTRACT. **Background:** The purpose of this article is to study the concepts of electronic and mobile logistics as components of the information economy within which the effective management of relevant information flows can be performed today.
Materials: The article is based on the available recent scientific-theoretical and professional practical research and publications. Introduction to these studies and publications allowed to conclude the diversity, importance and relevance of the proposed in this work problem and the existence of the understudied aspects.
Results: This article proposes author definition of m-logistics as part of an information logistics, describes the aspects of its functioning and demonstrates its place in information economy.
Conclusion: This work may be a starting point for further research in the field of e-logistics and m-logistics. For example, there is a need for the development and introduction of modern economic and mathematical methods and models by which the effective information management in modern business environment can be performed.

Key words: e-logistics, m-logistics, information flow, information economy.

INTRODUCTION

Today's global economy is called post-industrial or information, in particular due to its turning from simple data about something into full-value product which can bring additional revenue to the company (firm). Information economy is a type of economy where productivity and competitiveness of economic agents depend largely on their ability to generate, manage and effectively use the information based on knowledge [Malyk 2013]. The basis for the information economy can be considered information and communication technologies and tools, rapid development and availability of which led to the emergence of electronic (or digital) economy, in the context of which electronic business (or e-business) operates.

E-business includes: e-commerce, e-advertising, e-marketing, electronic banking, electronic auctions etc. In these types of business activity the adjective "electronic" indicates that these activities are carried out strictly in electronic (digital) form using the Internet, mobile connection etc. Previously, sites of enterprises (companies) were similar to business cards where one could read, for example, the history of the company, its management, contacts, activities, list of products which the company produced and sold. In site development more attention was paid to its design than to functional content. Today the websites of the companies in the sphere of e-business are much more complex, where the consumer can perform a number of actions without resorting to the company employees' assistance. For example, the consumer can fully independently order the products and pay for them on the company site

with the help of Internet-banking - carry out a number of banking transactions without visiting the bank, etc.

Each year, mobile communication devices are becoming more powerful, which predetermines the use of complex software applications. As a result, the line between PC (laptop) and mobile device is erased - in particular, on a tablet (or smartphone) one can work with e-mail, take photos and videos, read and edit documents, create drawings, business presentations, etc. In addition, continuous improvement and development of mobile communication technologies allows one to be constantly connected to the Internet at high speed sufficient for performing actions described above. In this case we can talk about the mobile business (m-business), which includes m-commerce, m-banking etc.

The use of innovative devices and technologies in the analysis, processing, transmission of information facilitates simplification, accelerating and reducing the cost of traditional business processes. However, relevant remains the problem of information management the essence of which lies in active providing of full and reliable information in the right place at minimum cost for its receiving with the aim of taking the relevant sufficient decisions by the consumer or company management. When the company cooperates with partners (customers, suppliers, carriers, banks and others), between them there is an exchange of information, which is organized in the form of the respective flows. Managing such flows belongs to the sphere of logistics within which electronic and mobile logistics can be isolated.

The concepts of e-logistics and m-logistics are quite new. A great number of works of scientists and specialists are devoted to various aspects of functioning of e-logistics. But there are no systematic investigations about m-logistics. Therefore, there is a need to fill this gap.

INFORMATION, ELECTRONIC AND MOBILE LOGISTICS: GENERAL ASPECTS OF FUNCTIONING

In "traditional" logistics the main is the material flow, others are accompanying it. According to the nature of information economy not only goods can be profitable, but also information. That is why, in our view, on the one hand we can talk about implementation of information as a good with material flow. On the other hand we can talk about the dyad of material and information flows which complement each other and become the main flows in the context of the information economy.

Material flow management is carried out within various types of logistics: purchasing, warehousing, marketing etc. And information flow management is made within information logistics. There are different interpretations of information logistics, after examination of which the following conclusion can be drawn. Some authors refer to the sphere of influence of information logistics only information systems of the company and everything connected with their functioning, others - managing information (information flows accompanying material flows). Let us assume that the information logistics of the company is a subsystem of the company management that organizes information flows affecting the results of the company logistics operations [Skitsko 2014].

Information logistics occurred before the information economy, not alongside with it. Information logistics appeared together with the concept of logistics, because the need for information support of processes in moving the material flow has always existed. In our opinion, now information logistics is one of the main types of logistics and perhaps the main one. In particular, due to the fact that with the development of information and communication tools and technologies and increasing importance of information there are constant changes in information logistics to a greater extent than in other types of logistics. And these changes predetermine changes in other traditional forms of logistics (e.g. purchase, storage, sale, etc.) and the emergence of new types of logistics. With

the development of internet and spread of the use of electronic presentation of information within information logistics e-logistics occurred.

Now there is no universally accepted (defined by regulatory documents) definition of e-logistics notion. Various scientists offer their own definition in their research practices. However, the common feature of these definitions is that almost in all of them the word "Internet" can be found. In particular, e-logistics is called Internet-Enabled Logistics [Gunasekaran, Ngai, Cheng 2007]. However, the use of the Internet itself in logistics processes does not mean that logistics becomes electronic. E-logistics is essentially a complex entity (system), which includes manufacturers (distributors), logistics centers, resellers, carriers, consumers among which there is an electronic exchange of data via the Internet with the help of mobile (wireless) and wired communication technologies with the aim to, in particular, reduce data errors, improve efficiency in decision-making and more.

Electronic logistics (e-logistics) is a management subsystem for forecasting, planning, decision making, coordination and control of electronic information flows through information and communication systems and technologies with application of mathematical methods and models (in agreement with material, service, financial flows and the flow of intellectual manpower) at the macro-, meso-, microeconomic levels [Skitsko 2014].

To the functions of e-logistics we can refer, in particular, the following [Skitsko 2014]:
- formation of information environment in which interact the participants of the logistics chain of goods supply;
- definition of characteristics of electronic information flows;
- formation of requirements and needs to the companies which provide information and communication services and corresponding connection;
- organization of the use of international standards of products identification;
- maintenance of correct and reliable operation, development of information system of the company;

- collection, analysis, storage, transformation and organization of information transfer in electronic form;
- selection of the necessary data for management decision making.

Methodical basis of electronic logistics is its international standards, development of which is currently carried out in the following areas [Bukreev, 2006, Barcik, Jakubiec, 2012]: barcoding of products; Electronic Data Interchange - EDI; Global Data Synchronization Network - GDSN; Electronic Product Code - EPC. In addition, it is necessary to maintain and develop (constantly update) hardware and software of electronic logistics system participants in order to improve their competitiveness by improving quality of service and reduce the cost of logistics processes etc.

Mobile tools and technology are innovations the use of which on one side has become commonplace in business and everyday life, on the other hand - they are constantly evolving, requiring corresponding changes in building business processes, new knowledge and skills of people, hardware and software upgrade and so on. Today people use smartphones or tablets not only for communication (mobile connection, email, social networks, etc.), entertainment (online games, television, etc.) and receiving information available on the Internet, but also for buying goods in online stores or through auctions, ordering and purchasing air, train or bus tickets, tickets to concerts or theater, performing banking operations and more. The penetration of mobile devices and technologies in business processes and everyday life of people will only increase each year. In particular, in press release [World's largest online…, June 08, 2015] showed a clear dependence of the increase of online purchases on increasing the spread of smartphones and tablets. Besides, today in Britain 59% of online purchases are made through mobile devices, in the US - 45%, in Germany - 24% [World's largest online…, June 08, 2015].

The development of online trading leads to the development of other areas, including logistics, banking, and so on. As an example, let us consider the development of cooperation

of express delivery and its clients. Previously, the sender and recipient could learn about the movement of the parcels only by telephone. Later the companies began offering the service of SMS notification as for location of the parcel on its way to final destination. Then there appeared the opportunity to track the parcel by its unique number on the company site. Only computer (a laptop) and Internet connection were needed for this. Then the connection was only wired. Now there is opportunity to track the parcel in a mobile app which is installed on a smartphone or tablet with the use of wireless mobile technology. The use of such innovations predetermines the following: the communication of logistics services consumer (recipient of the parcel) and the company staff is minimized; comprehensive and timely information as for the parcel location allows the recipient to plan their daily schedule more rationally etc. In addition, information asymmetry in the processes of delivery is reduced due to the opportunity of almost equal access to information by all participants of the logistic chain.

Wide spread of mobile devices and technologies requires accurate information flows management. Such management can be carried out within the e-logistics, but according to the modern trends of technologies development it would be more appropriate to talk about the emergence of the concept of mobile logistics.

In our opinion, m-logistics is a subsystem of e-logistics as for forecasting, planning, decision making, coordination and control of electronic information flows that occur and are formed with the use of mobile devices (smartphones, tablets, etc.). On a mobile device one can work with information via SMS, special mobile application and / or using optimized "traditional" (full) website.

Special mobile application requires its installation on user's device. It should also be easy and simple, should not require many actions from the consumer for getting the necessary information, use the least possible RAM volume (this affects the speed of both the application and the mobile device as a whole). Mobile apps actually replace the common website providing additional functions unavailable from the computer or laptop. For example, the mobile application can store the barcode of the loyalty card, so the customer does not have to carry a number of plastic cards - he only needs to launch the app on a smartphone. On the other hand it is not necessary to create a mobile application the development of which may be very expensive. It is enough to optimize the common web site for work on a mobile device, which primarily lies in simplification of visual presentation of information (pictures, videos, additional effects and features, etc.). The requirements to mobile applications can be applied to a simplified version of the web site.

Methodical basis for mobile logistics can be methodological basis of electronic logistics (see above), where the main place is occupied by bar coding and electronic data exchange. Currently when purchasing electronic tickets to the cinema or theater a consumer receives a unique linear bar code that is read at the entrance to the hall with special devices from smartphone or tablet screen. Besides, transport tickets can contain two-dimensional bar code, which is also read from device screen. In these cases, there is no need to print tickets. In our view, barcoding any information through mobile applications is quite prospective. For example, while making order in a mobile internet-store the client may get a corresponding bar code of the order so not to remember the information about the order needed while receiving the goods at pickup point or automated parcel terminal. The client may just provide the bar code (which will be scanned by a special device) for confirmation. In addition, such coding should reduce the number of possible errors in the data exchange and time of receiving the order.

In our opinion, the mobile logistics should perform the following functions:
- to facilitate the forming of general information environment in which interact the participants of the logistics system with the aim of receiving information in any part of Earth where there is mobile connection and Internet;
- to specify characteristics of electronic information flows;

− to state the requirements which are included in the TT (technical task) on development of mobile apps with the help of which the participants of the logistics system communicate;
− to state the requirements as for optimization of the "traditional" web site for its fast view on mobile devices;
− to select data and forms of their representation in mobile apps and on the optimized web site for management decisions making;
− to constantly monitor the development of mobile tools and technology and adapt the used mobile apps to the current customers' needs etc.

Specifying mobile logistics as a separate sphere of economic activity predetermines the necessity to determine its place in the information economy (see Fig. 1). Mobile logistics on the one hand is part of e-logistics, on the other - of m-business. M-business functions within the mobile economy, by which we can understand the following. Mobile economy is part of the information economy, in which economic activity is carried out only by mobile means and technology. Mobile economy is part of the e-economy, within which operates the e-business, which includes e-logistics. E-economy functions not only within the information economy, but within information logistics as well, and mobile economy - within e- economy and e-logistics.
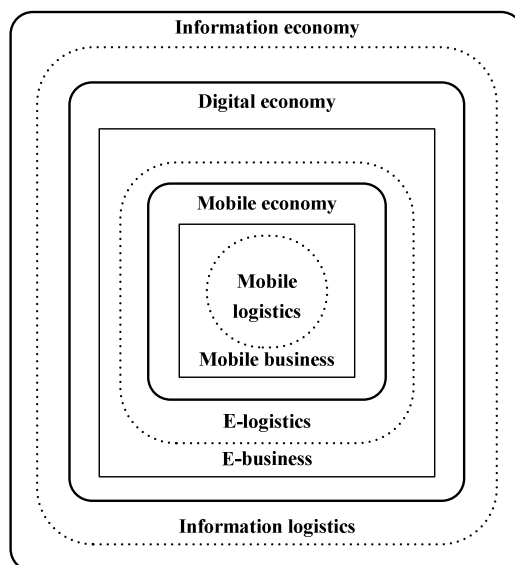
Source: own study

Fig. 1. Conceptual model of the information economy
Rys. 1. Model koncepcyjny ekonomii informacji

INFORMATION FLOWS AS THE MAIN CONSTITUENT OF E-LOGISTICS AND M-LOGISTICS: THE ESSENCE, PROBLEMS OF MANAGEMENT AND MODELING

The peculiarity of the current stage of economic development in business is the coexistence and development of the traditional production (physical production of goods consumed by us in the real physical world and which can be touched by hand, performing physical works or services - repair, cleaning, hairdressing, etc.) and innovations, related primarily to the process of generating, sharing, storage, destruction of information as well as analysis, management and information flow modeling. All the more information in business has electronic (digital) form replacing paper media. Due to this almost immediate exchange of considerable volume of information is possible among companies via Internet and mobile networks in modern business. This stipulates the reduction of time on performing some business processes and final result may

be achieved faster. The exchange of information in e-business may be performed in the context of the following forms (models) of interaction [Adamczewski, 2001, Barcik, Jakubiec, 2012, Shemet, 2012]:

- B2B (business-to-business). In this model there is interaction among the companies (enterprises, legal entities) with the aim to obtain various benefits. The final consumer (a physical person) of these companies is absent in this model, and the consumer of the products (goods, works or services) of one company is other company. Besides, in this model the exchange of information or selling information products is also carried out. Functioning of the B2B model today is performed with the help of various specialized trading platforms on the Internet.
- B2C (business-to-customer). In this model the company interacts with its end consumer. That is why the company (legal person) sells the goods, performs works or provides the services to a person (physical person). B2? models include Internet stores, Internet banking, selling transport, theatre or concert tickets etc. In our opinion, this model is most widely spread in e-commerce, therefore it requires most attention from the point of view of scientific theoretical and practical research of various aspects of its functioning.
- C2C (customer-to-customer). In this model people (physical persons) interact with each other with the help of various communication means and technology. The functioning of C2C model is currently performed through Internet auctions, classifieds etc., where such sites are the intermediaries between the buyers and sellers.
- C2B (customer-to-business). This model is relatively new. In this model opinions or ideas of the end consumers expressed by various means, in particular, on various Internet forums, social media, email etc. considerably influence the products making (their characteristics, features, price etc.) by the producer.
- B2G (business-to-government). In this model the company interacts with the state administrative organs. To this model of interaction may be referred in particular state procurement via Internet.

- C2G (customer-to-government). In this model there is interaction between a person and state administrative organs. To this model may be referred in particular the electronic submission of income declaration via the site of the tax service or email.
- G2B (government-to-business), G2C (government-to-customer). In these models state administrative organs provide the companies (enterprises) and physical persons with information services via Internet.

In each of these models one of the main places is occupied by information. Information is not something that exists in isolation, by itself. Information is subjective [Aphanasenko, Borisova, 2012], it represents data about something. In e-business one can always find the source of information, outline the ways and means of its transfer, specify the persons it is meant for, i.e. the circle of its consumers. The growth of the importance of information for companies, consumers, state administrative organs will only grow every year. This is connected, for example, with the following [Bowersox, Closs, 1996]: the consumers recognized the usefulness and convenience of possession of relevant information concerning the current state of their order, presence of the remains in warehouses, delivery schedules and payments, etc. as part of logistic service; the managers of the companies paid attention to the fact that well organized exchange of information on the supply chain reduces the need for material and human resources; information increases flexibility in deciding on the effective use of enterprise resources and more.

As we said earlier, information management (management of information flows) in e-business is carried out within the e-logistics and m-logistics. In each of the above mentioned models of e-business the limits of e-logistics and m-logistics will be different. As an example, let us consider the operation of a typical Internet store as main representative of e-business (B2C model). The criterion of an effective online store is, of course, its profit, the presence and growth of which is impossible without the complete satisfaction of its (store) customers. However, stiff competition between online stores causes

extensive research of the buyers' actions, their preferences, selection criteria of both goods and shops and so on. In particular, the major factor for consumers in their choice of online store, except for the price and quality of goods, is fast and damageless delivery of the orders (which relates to traditional logistics sphere).

In addition, we believe that buyer's choice of the online store is also significantly impacted by how easily it is possible to make an order on the site or in the mobile application and receive confirmation of its execution (within the scope of e-logistics and m-logistics).
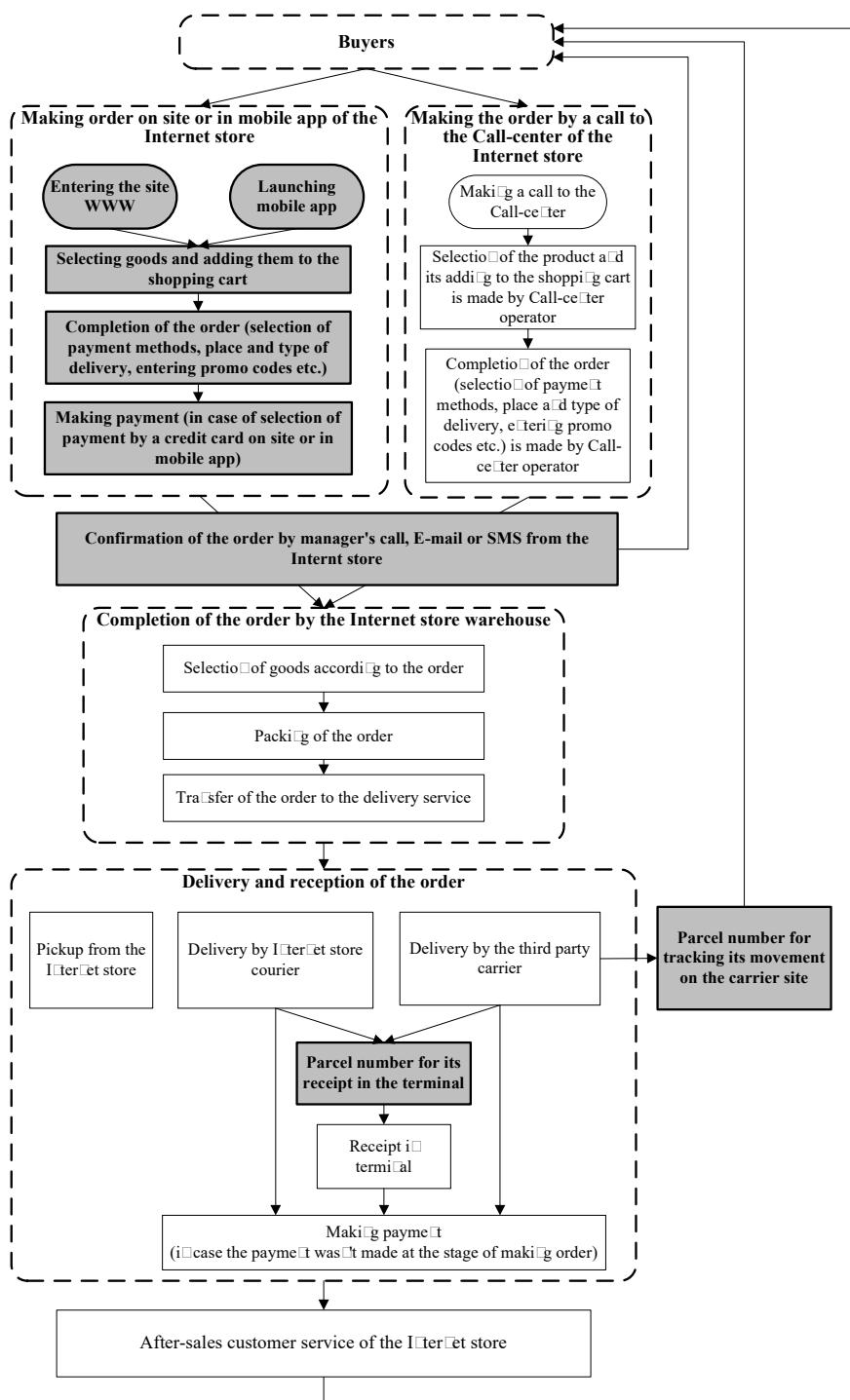
Source: own study

Fig. 2. The conceptual block diagram of the interaction of buyers and Internet store
Rys. 2. Koncepcyjny schemat blokowy oddziaływań pomiędzy kupującymi i sklepem internetowym

Fig. 2 shows the actions of the buyer and units of the online store while the buyer is making purchases. The painted (gray) rectangles and ovals in this picture demonstrate the limits of e-logistics and m-logistics influence. In this case they are the same. This confirms the idea we expressed at the beginning of this article that the boundaries between computers (laptops) and mobile devices are erased. Some processes of executing the order by the warehouse of the online store and delivery which are not marked in the picture also refer to e-logistics and/or m-logistics. By making flowcharts of the actions of participants of other forms (models) of interaction in e-business we can make the corresponding conclusions.

The need for information flows (in particular, the electronic flows) management is due to the fact that their movement corresponds to the operation of actual business processes. On one hand business processes form the information flows, on the other - the effective functioning of business processes is difficult without a proper functioning of information flows. For management of information flows in e-logistics and m-logistics can be used various methods and models of analysis and design [Korablev, 2011, Rodkina, 2001]: graphic; network modeling; graphic analysis; method of functional-operational analysis; method of schemes of information connections; method of requisites and others. These models allow, in particular, to identify a number of irregularities in the traffic of information flows, which include [Milutina]: scattering, storage, rejection, source exhaustion, interruption of the flow of information or absence of the part of way for its traffic. Using models of information flows in the form of charts, graphs or networks we can determine structural (organizational) aspects of information flows. However, only with such models it is difficult to identify quantitative and qualitative characteristics of information flows and solve the problem of forecasting of information flows. In this case, one can use economic and mathematical models that are built, for example, on the basis of tools of theory of fuzzy sets and fuzzy logic, artificial neural networks, genetic algorithms, coevolution, synergy and so on.

CONCLUSIONS

The rapid development of information and communication tools and technologies led to the emergence of companies of new generation that are pure innovational or combine tradition and innovation, and that carry out their activities on the Internet and mobile networks. One of the main components of such companies' activity is information that in the context of the information economy is a commodity that can be profitable. So it requires careful attention from the point of view of management and modeling which can be performed within e-logistics and m-logistics.

In this work the author definition of m-logistics as the constituent part of information logistics is given, its aspects of functioning are described and its place in information economy is shown. The concept of "m-logistics" is almost out of use now, but the need for its occurrence is obvious. In our view, the development of the concept of m-logistics and related areas of research should be of interest not only for Internet stores shopping, commercial banks, etc., but also for the companies in Multilevel marketing (MLM).

This work may be a starting point for further research in the field of e-logistics and m-logistics. For example, there is a need for the development and implementation of modern economic and mathematical methods and models by which one may perform the effective information management.

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World's largest online retail markets to double in size in the next three years [press release], June 08, 2015, http://www.occstrategy.co.uk/news-and-media/2015/06/google-paypal-research-press-release

E-LOGISTYKA ORAZ M-LOGISTYKA W EKONOMII INFORMACJI

STRESZCZENIE. **Wstęp:** Celem pracy jest przeanalizowanie różnych koncepcji elektronicznej oraz mobilnej logistyki, jako części składowych ekonomii informacji, w obrębie, której mogą być realizowane efektywne zarządzanie przepływem informacji.
Materiały: Praca opiera sie na dostępnych ostatnio publikowanych pracach i publikacjach o charakterze zarówno teoretycznym jak i praktycznym. Wstęp do tych studiów pozwala na stwierdzić złożoność jak i istotność obranego do analizy tematu badawczego jak również małej ilości dotychczas przeprowadzonych prac w tym temacie.
Wyniki: Została zaproponowana autorska definicja m-logistyki, jako części logistyki informacji, opisane aspekty jej funkcjonowania oraz zaprezentowane jej miejsce w ekonomii informacji.
Wnioski: Praca ta może być punktem startu dalszych badań w obszarze e-logistyki oraz m-logistyki. Stwierdzono potrzebę opracowania i wdrożenia nowoczesnych metod i modeli ekonomicznych i matematycznych dla celów pomiaru efektywnego zarządzania informacją we współczesnym środowisku biznesowym.

Słowa kluczowe: e-logistyka, m-logistyka, przepływ informacji, ekonomia informacji

E-LOGISTIK UND M-LOGISTIK IN DER INFORMATIONSÖKO-NOMIE

ZUSAMMENFASSUNG. Einleitung: Das Ziel der Arbeit ist Analyse unterschiedlicher Konzepte für elektronische und mobile Logistik (E- und M-Logistik) als relevante Bestandteile der Informationsökonomie, innerhalb deren das Management des Informationsflusses effektiv betrieben werden kann.

Materialien: Die Arbeit stützt sich auf die zugänglichen, letztens publizierten Forschungsarbeiten und Veröffentlichungen sowohl theoretischen als auch praktischen Charakters. Die Einleitungsbetrachtung lässt die Komplexität und die Relevanz des dieser Analyse unterzogenen Forschungsthemas sowie eines Mangels von dazu unternommenen Forschungsaktivitäten feststellen.

Ergebnisse: Es wurde eine Autorendefinition der M-Logistik als eines Bestandteiles der Informationslogistik vorgeschlagen, Aspekte deren Funktionsausübung beschrieben und ihr Rang innerhalb der Informationsökonomie projiziert.

Fazit: Die vorliegende Arbeit kann ein Ausgangspunkt für weitere Forschungen im Bereich der E-und M-Logistik werden. Es wurde Notwendigkeit der Bearbeitung und Einführung von modernen Methoden sowie mathematischen und ökonomischen Modellen zwecks der Bewertung eines effizienten Informationsmanagements innerhalb des gegenwärtigen Business-Umfeldes festgestellt.

Codewörter: E-Logistik, M-Logistik, Informationsfluss, Informationökonomie

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STRATEGIC VEHICLE FLEET MANAGEMENT - THE REPLACEMENT 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 third one of a series of three papers that the author dedicates to the strategic vehicle fleet management topic.

Material and methods: The paper discusses ways of building replacement strategies for companies' fleets of vehicles. It means deciding for how long to exploit particular vehicles in a fleet (the fleet replacement problem - FR). The essence of this problem lies in the minimization of vehicle / fleet exploitation costs by balancing ownership and utilization costs and taking into account budget limitations. In the paper an original mathematical model (an optimization method) allowing for the FR 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 that there exist optimal exploitation periods of particular vehicles in a fleet. However, combination of them gives a replacement plan for an entire fleet violating budget constraints. But it is possible to adjust individual age to replacement of particular vehicles to fulfill budget constraints without losing economical optimality of a developed replacement plan for an entire fleet.

Conclusions: The paper is the last one of a series of three papers that the author dedicated to the strategic vehicle fleet management topic including the following managerial decision problems: MAKE-or-BUY, sizing / composition and replacement.

Key words: management, optimization, fleet, vehicle, transport, replacement.

"If you can afford to operate an old fleet you can afford to operate a less old one!" - Paul T. Lauria

INTRODUCTION

The decision for how long to exploit particular vehicles in a fleet or when to dispose / replace them and by what type of a brand new or used vehicles, including selection of vehicles investment / acquisition option (e.g. to buy on cash, credit, lease or rent), is called a fleet replacement (FR) problem.

The FR problem can be considered on a level of single vehicles or on a level of entire fleets. It makes a significant difference in the way budget limitations are taken into account. Budget limitations mean available funds that can be spent on replacements of vehicles within a given time period (e.g. fiscal year). When single vehicles are considered budget limitations can be skipped or they just simply can't be taken into account since budgets are defined on a fleet level, not on a level of single

vehicles. In contradiction, whereas entire fleets are considered budget limitations are crucial when developing replacement plans.

On a single vehicle level of considerations the essence of the FR problem is to exploit vehicles not too short and not too long. Too short exploitation periods result in high vehicle ownership costs, whereas too long exploitation periods result in high vehicle utilization costs. High ownership costs a caused by a steep decrease in a vehicles' residual value (RV) in early years of their exploitation life. High utilization costs a caused by technical condition deterioration and increased downtimes associated with it. While on an entire fleet level of considerations the essence of the FR problem is not to cause capital investment surges in time. It requires adjustments of an individual optimal age to replacement of particular vehicles in a fleet keeping capital investments within a predefined, reasonable range (budget limitations). The possibility of adjustment of an individual optimal age to replacement of particular vehicles is supported by relatively flat total (or unit) exploitation costs function around an optimal age to replacement being the decision variable.

THE METHOD FOR SOLVING THE FR PROBLEM

Methods for solving the FR problem can be divided into the preventive and the failure based ones [Eilon, King, Hutchinson 1966; Glasser 1969; Jardine, Buzacott 1985]. But in the case of the preventive replacement methods it is necessary to define time to replacement, which is obvious in the case of the failure based methods since it is just a moment of a failure. There are two ways of defining that time (an exploitation period) when using the preventive based methods. They are: age based replacement [Glasser 1969] and group replacement [Nakagawa 1984]. Considering vehicles, including trucks, the preventive age

based replacement methods can be applied. Instead of an age a cumulative utilization, e.g. mileage can be used as well.

Regardless if an age of a vehicle (an exploitation period) or a cumulative utilization (mileage) is used the general aim when planning replacement is to minimize overall exploitation costs, usually discounted ones. The majority of replacement methods are based on a comparison (a minimization of a sum that means balancing) of decreasing with time ownership costs (often depreciation costs only) and increasing with time utilization (operational and maintenance) costs [Britten 1971; Christer, Goodbody 1980]. As the author proved [Redmer 2009], while vehicles, especially trucks, are considered it is important to minimize unit (e.g. per one kilometer), discounted exploitation costs instead of a total exploitation costs (e.g. annual ones). It is caused by a decreasing with time utilization intensity of such vehicles.

The general drawback of the existing solution methods for the FR problem is that they assume a constant utilization of equipment, including vehicles, during its operational lifetime [Hartman 1999]. Moreover, the methods are focused on searching for an optimal, from the mathematical point of view, solutions. It results in replacement plans requiring varying with time investments, e.g. year-to-year. While in practice it is always better to avoid any expenditure surges.

As a result a generic formula for calculating the age to replacement a^r_i of particular vehicles i (i = 1, 2, 3, …, I) in a fleet, the age that minimizes the average unit discounted fleet exploitation costs UDC_{avr} and allows for fulfilling budget limitations in particular fiscal years fy (fy = 1, 2, 3, …) can be written as follows:

$$UDC_{avr}(a^r) = \frac{\displaystyle\sum_{i=1}^{I}\sum_{j=1}^{J} \frac{CE_{ij} - GBV_i \cdot d_{ij} \cdot TR + UC_{F_{ij}}(a_{ij}) + UC_{V_{ij}}(a_{ij}) \cdot UI_{ij}(a_{ij}) + FP_{ij}(a_{ij}=a_i^r) - RV_{ij}(a_{ij}=a_i^r)}{(1+r)^j}}{\displaystyle\sum_{i=1}^{I}\sum_{j=1}^{J} UI_{ij}(a_{ij})}$$

under the condition:

$$B_{fy}^{\min} \le \sum_{i=1}^{I} \sum_{j=12\cdot(fy-1)+1}^{12\cdot fy} \left[CE_{ij} - GBV_i \cdot d_{ij} \cdot TR + FP_{ij}(a_{ij}=a_i^r) - RV_{ij}(a_{ij}=a_i^r) \right] \le B_{fy}^{\max}$$

where:

$UDC_{avr}(a^r)$	average unit discounted fleet exploitation costs when replacing vehicles i in a fleet at the age of a_i^r [monetary unit – m.u./km],
i	particular vehicles in a fleet; $i = 1, 2, 3, \ldots I$ [–],
j	particular periods of analysis (e.g. months); $j = 1, 2, 3, \ldots J$ [time unit – t.u.],
a_{ij}	age of vehicle i in particular period of analysis j; $a_{ij} \in \langle$initial vehicle age when put into a fleet, $a_i^r \rangle$ [t.u.],
a_i^r	age of vehicle i to replacement – DECISION VARIABLES [t.u.],
CE_{ij}	total capital expenditures associated with acquisition of vehicle i incurred in particular periods of analysis j, e.g. leasing payments [m.u./t.u.],
$FP_{ij}(a_{ij}=a_i^r)$	final payment associated with acquisition of vehicle i incurred in the last period j of its exploitation when $a_{ij} = a_i^r$ [m.u.],
GBV_i	Gross Book Value of vehicle i (e.g. net price) [m.u.], being a basis for depreciation expenses calculation,
d_{ij}	depreciation rate of vehicle i in particular periods of analysis j [-/t.u.],
TR	tax rate [-],
$UC_{Fij}(a_{ij})$	utilization fixed costs of vehicle i at the age of a_{ij} in particular periods of analysis j [m.u./t.u.], including costs associated with a vehicle only (e.g. without driver's salary): – road taxes, – insurance, – permanent licenses,
$UC_{Vij}(a_{ij})$	utilization unit variable costs of vehicle i at the age of a_{ij} in particular periods of analysis j [m.u./km], including: – fuel, – maintenance (e.g. labor, spare parts, downtime, …), – tires, – one-time licenses, – parking, – phone calls, – tolls (for roads, tunnels, bridges, ferries, …),
$UI_{ij}(a_{ij})$	utilization intensity (mileage) of vehicle i at the age of a_{ij} in particular periods of analysis j [km/t.u.],
$RV_i(a_{ij}=a_i^r)$	residual (market) or scrap value of vehicle i in the last period j of its exploitation when $a_{ij} = a_i^r$ [m.u.],
r	discount factor [-/t.u.],
$B^{min/max}_{fy}$	fleet investment budget limitations (min / max) in particular fiscal years fy; $fy = 1, 2, 3, \ldots$ [m.u./fy].

THE CASE STUDY
- SOLVING THE FR PROBLEM
IN POLISH CIRCUMSTANCES

Let's consider a fleet composed of 20 EURO5 semi-trucks (truck-tractors) heaving Gross Book Value of 325000 Polish zlotys each (1 zloty = 3.8 USD = 4.0 EUR - the exchange rate dated 16.04.2015 by the National Bank of Poland), and leased as a brand new ones 4.5 years ago (being currently at the age of 54 months). The leasing, that is a 5-year long financial one, lasts within the next 6 months with no final payments. The leasing monthly payments are constant and equal to 6000 zlotys. Vehicles are depreciated under the rate of 17% annually that gives the 86-month depreciation period. The company, that is a non-transportation company operating the analyzed fleet for international transports, pays tax at the rate of 19%.

The following parameters: fixed utilization costs, variable utilization costs, residual value and utilization intensity, characterizing particular vehicles, vary with time of their exploitation. Moreover, since particular vehicles are utilized with different intensity their variable utilization costs changes with time under different rates. Average values of the particular parameters are as follows (assuming a straight line changes with time):
- annual fixed utilization costs for a brand new vehicle equal to 18000 zlotys and decrease with time (by 3.0% per year),
- unit variable utilization costs for a brand new vehicle equal to 2.1 zlotys per kilometer and increase with time differently for particular vehicles (see Table 1),
- utilization intensity (monthly mileage) is different for particular vehicles (see Table 1) and decreases with time (by 2.5% per year),
- residual value of a vehicle at the end of the leasing period (for 5-year old vehicle) equals to 50% of its GBV and decrease further with time (by 5.0% per year).

Assumed values of the age to replacement a^r_i for all vehicles in the fleet are 5 at minimum to 10 years at maximum (60 to 120 months).

Table 1. Parameters heaving individual values for particular vehicles
Tabela 1. Parametry posiadające indywidualne wartości dla każdego z pojazdów

Vehicle i	Monthly mileage for a brand new vehicles	Variable utilization costs' annual increases
	[km/month]	[%/year]
1	8000	1,7%
2	8200	1,7%
3	8400	1,7%
4	8600	1,8%
5	8800	1,8%
6	9000	1,8%
7	9200	1,9%
8	9400	1,9%
9	9600	1,9%
10	9800	2,0%
11	10000	2,0%
12	10200	2,0%
13	10400	2,2%
14	10600	2,2%
15	10800	2,2%
16	11000	2,3%
17	11200	2,3%
18	11400	2,3%
19	11600	2,4%
20	11800	2,4%

Using the proposed above mathematical model of the FR problem, the above described data and a professional solver for the MS Excel the problem has been solved.

Two different solutions of the problem have been found. The solutions named "optimal" and "smooth" one. The optimal solution means a replacement plan constructed based on the optimal age to replacement calculated separately for each one vehicle in the fleet. In this solution the budget constraint has been relaxed (skipped). The smooth solution means a replacement plan constructed based on the age to replacement calculated for particular vehicles in the fleet simultaneously (at the same time) trying to keep investment expenditures in the range of 0 to 800 000 zlotys per year (the budget).

The results are presented in Fig. 1 and Table 2.

Table 2. Selected solutions of the analyzed FR problem
Tabela 2. Wybrane rozwiązania analizowanego problemu wymiany taboru

Vehicle *i*	Age to replacement of vehicle *i* – a^r_i [month]	
	Smooth solution	**Optimal solution**
1	101	96
2	101	96
3	77	89
4	77	89
5	60	89
6	69	83
7	101	83
8	89	83
9	101	78
10	101	78
11	120	78
12	63	73
13	89	73
14	120	73
15	69	69
16	101	69
17	60	69
18	63	69
19	77	65
20	63	62
Average age to replacement – a^r_i [month]	**85**	**78**
Average unit fleet exploitation costs – $UDC_{avr}(a^r)$ [zloty/km]		
discounted (*r* = 1.3% per year)	**1.54**	**1.53**
not discounted	**2.65**	**2.63**
Average discounted total annual fleet exploitation costs [million zloty/year]	**3.30**	**3.30**
Average discounted total annual net fleet investments [million zloty/year]	**0.46**	**0.40**
Average total annual fleet mileage [million km/year]	**2.20**	**2.20**

Source: author's research
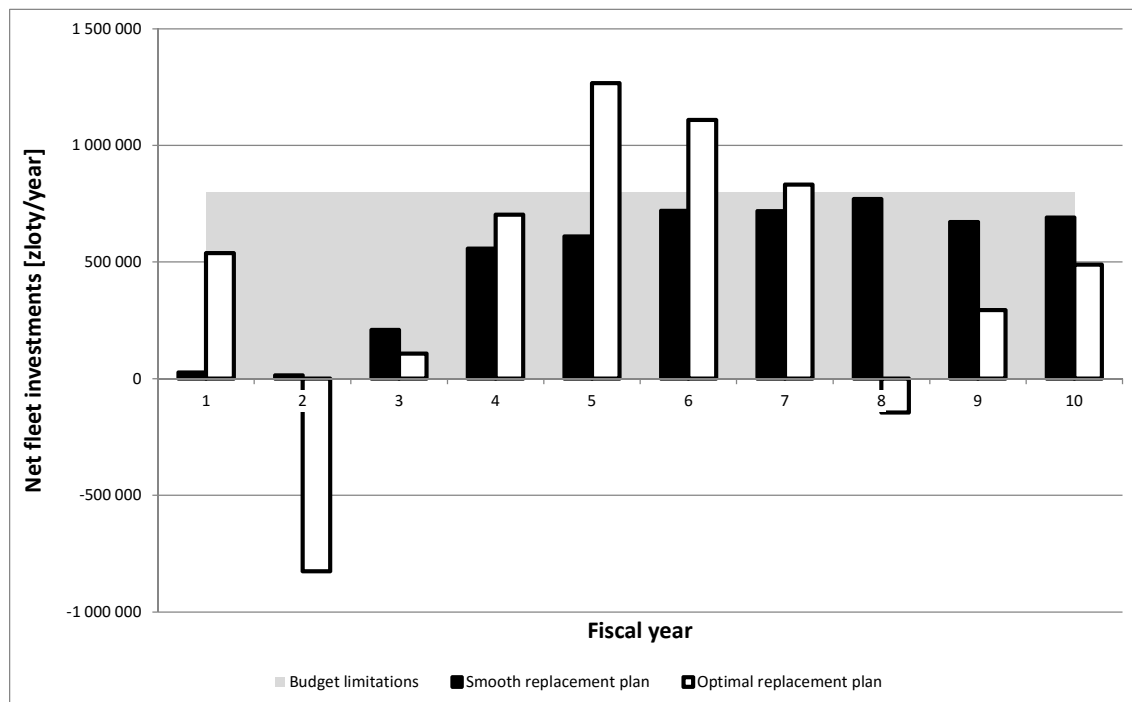
Source: author's research

Fig. 1. The net fleet investments in comparison to the available budget for fleet replacement
Rys. 1. Wydatki inwestycyjne netto w stosunku do założonego budżetu na wymianę floty

As it is shown in Table 2 both solutions are very similar, equally good, when taking into account the average unit fleet exploitation costs they result in (less than 1% difference). Moreover, the average age to replacement is similar in both solutions as well. It is around 7 years of exploitation to the moment of replacement (based on the optimal solution 6.5 years and on the smooth one 7.1 years - precisely). The significant difference is when taking into account budget limitations and net fleet investments the both solutions result in within particular fiscal years. The net fleet investments are defined as a difference between funds that according to a given FR problem solution (a replacement plan) have to be spent on vehicles' purchases (e.g. leasing payments) less all possible allowances (e.g. depreciation resulting in a tax shield and a residual value resulting in incomes when selling a vehicle). Fig. 1 proves that the optimal solution from the budget limitations point of view is a significantly worse solution for the company operating analyzed fleet than the smooth one. The optimal solution results in the net fleet investments varying much from year to year within the range of minus 825 000 to plus 1 267 000 zlotys per one fiscal year. Moreover, this solution requires high expenditures in the first one fiscal year (538 000 zlotys). On the contrary, the smooth solution does not cause capital investment surges in time, requires small expenditures in the first three fiscal years (83 000 zlotys on average) and the expenditures in the further years are relatively flat (within the range of 558 000 to 770 000 zlotys per year).

CONCLUSIONS

Summarizing not only presented above considerations of the FR problem, but also two other, important strategic fleet management problems that are the Make-or-Buy (MoB) and the fleet sizing / composition (FS/FC) discussed in the two previously published by the author papers (Redmer 2014; Redmer 2015), one can draw the fallowing conclusions:
− The FR problem: the best (in this case a smooth one meaning relatively flat capital investments in particular fiscal years) solution of the problem is very similar to its other solutions (e.g. an optimal one meaning combination of the optimal ages to replacement of particular vehicles in a fleet) resulting in very equal average unit fleet exploitation costs and average age of vehicles to replacement; best solution of the problem can match budget limitations on fleet investments while it is a problem in other solutions; best solution of the problem requires lower expenditures in the first years of a replacement plan than other solutions; best solution does not cause capital fleet investment surges in time while other solutions do.
− The FS/FC problem: best (in this case an optimal one meaning appropriate number of vehicles of particular types in a fleet) solution of the problem can be significantly better than its other solutions (e.g. a smooth meaning the same number of vehicles of particular types in a fleet, or a random ones) resulting in a higher utilization of a fleet that is always the most economical; the total size of a fleet in best solution can be higher than in other solutions of the problem but better fitted; best solution of the problem results in a low number of vehicle types in a fleet, that is easier to manage; best solution (fleet composition) is sensitive to any changes in vehicle types in a fleet that decreases the fleet utilization ratio.
− The MoB problem: best (in this case an optimal one) solution of the problem can result in a significant reduction of the total transportation costs; usually a mix of the MAKE and the BUY options constitute the best solution; sometimes, solution based mostly on the MAKE option can also reduce total transportation costs, however such a solution requires significant investments and is very risky; less risky, requiring lower investments seems to be solution based on the MAKE option but putting into a fleet used vehicles only; best solution is relatively sensitive to changes (increases) of the unit operating costs of company's "own" vehicles reducing significantly any savings the MAKE option can result in; when the MAKE option is going to be applied there is always a risk

associated with an ineffective utilization of company's "own" fleet.

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STRATEGICZNE ZARZĄDZANIE TABOREM SAMOCHODOWYM - PROBLEM WYMIANY

STRESZCZENIE. **Wstęp**: Floty pojazdów stanowią podstawowy środek produkcji w transporcie. Prawidłowe zarządzanie nimi jest zatem kluczowe dla wszystkich firm realizujących przewozy. Niniejszy artykuł jest trzecim z serii trzech, jakie autor chce poświęcić tematyce strategicznego zarządzania taborem samochodowym.
Metody: W artykule omówiono sposoby kształtowania strategii wymiany flot samochodowych przedsiębiorstw. To znaczy ustalenia, jak długo poszczególne pojazdy we flocie mają być eksploatowane (problem wymiany - FR). Istota problemu leży w minimalizacji kosztów eksploatacji pojazdu / floty poprzez znalezienie równowagi pomiędzy kosztami posiadani a kosztami użytkowania z uwzględnieniem ograniczeń budżetowych. W artykule zaproponowano autorską, matematyczną metodę (model optymalizacyjny) pozwalającą na prowadzenie analiz typu FR.
Rezultaty: W artykule zaprezentowano zastosowanie opracowanej metody na rzeczywistym przykładzie problemu decyzyjnego w warunkach polskich oraz uzyskane rezultaty. Rezultaty te pokazały, że istnieje optymalny okres eksploatacji każdego z pojazdów we flocie. Jednak kombinacja tych okresów daje plan wymiany dla całej floty niespełniający ograniczeń budżetowych. Jest jednak możliwe dostosowanie indywidualnych okresów eksploatacji poszczególnych pojazdów we flocie tak, by spełnić ograniczenia budżetowe i jednocześnie zachować optymalność / efektywność ekonomiczną uzyskanego rozwiązania, planu wymiany dla całej floty.
Wnioski: Niniejszy artykuł jest ostatnim z serii trzech, które autor poświęcił tematyce strategicznego zarządzania taborem samochodowym z uwzględnieniem takich menedżerskich problemów decyzyjnych, jak: MAKE-or-BUY, liczebność / kompozycja i wymiana floty.

Słowa kluczowe: zarządzanie, optymalizacja, flota, pojazd, transport, wymiana.

STRATEGISCHES FAHRZEUGFLOTTENMANAGEMENT - DAS PROBLEM DES FLOTTENERSATZES

ZUSAMMENFASSUNG. Einleitung: Fahrzeugflotten und Fuhrparks stellen die grundlegenden Produktionsmittel im Transportwesen dar. Ein angemessenes Flottenmanagement ist für alle Transportunternehmen und -firmen von großem Belang. Der vorliegende Artikel ist der dritte von dreien, die der Autor dem strategischen Fahrzeugflottenmanagement widmet.

Methoden: Dieser Artikel beschreibt Möglichkeiten für Unternehmen, die Erneuerung ihres Fuhrparks zu planen. Dies beinhaltet die Entscheidung darüber, für welche Nutzungsdauer unterschiedliche Fahrzeuge einer Flotte aufrechterhalten werden sollen (the fleet replacement problem - FR).

Der Kern dieses Problems liegt in der Minimierung der Flottenkosten, indem die Fahrzeugbeschaffung und -nutzungskosten unter bestimmten Budgetlimitierungen ausbalanciert werden. Im vorliegenden Artikel wird dabei ein ursprünglich mathematisches Modell (Optimierungsmethode) zur FR-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 eine optimale Nutzungsdauer für bestimmte Fahrzeugtypen innerhalb eines Fuhrparks existiert. Allerdings führt eine Kombination der einzelnen Nutzungsdauer zu einer Überschreitung des Zielbudgets. Es ist allerdings möglich dieses durch Anpassung des Ersatzzeitpunkts einzelner Fahrzeuge aufrechtzuerhalten und gleichzeitig einen ökonomisch optimalen Plan zum Flottenersatz zu ermitteln.

Fazit: Dieser Artikel ist der letzte von der dreiteiligen Serie des Autors über verschiedene Belange der strategischen Flottenplanung wie: Eigenfertigung oder Fremdbezug von Fahrzeugflotten, Größe und Zusammensetzung eines Fuhrparks sowie die Nutzungsdauer und der Ersatz von Fahrzeugen.

Codewörter: Management, Optimierung, Fahrzeugflotten, Fahrzeuge, Transport, Flottenersatz.

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ASSESSMENT OF SAFETY AND HEALTH OF STORAGE WORKERS - A PSYCHOSOCIAL APPROACH

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ABSTRACT. **Background:** Although there is still a lot to do as far as prevention and elimination of traditional health and work safety hazards is concerned, the problem of psychosocial risk prevention is extremely important nowadays. It is crucial to take into consideration the health of workers and promotion of health in the workplace, as the occupational stress epidemics is getting more and more widespread.

Methods: The article is based on the statistic analysis of accidents at work as well as the analysis of health problems resulting from the job itself. The latest work safety reports have been reviewed and special attention has been paid to psychosocial risk analysis. The author has tried to explicate the terms of new and emerging risks as regards storage work.

Results: Various threat aspects of storage work have been evaluated. Deficits in psychosocial hazard identification have been indicated. What is more, no correlation between occupational tasks of storage workers and their knowledge about psychosocial risks has been emphasized. An exemplified approach to warehouse psychosocial threat identification has been presented. The approach is based on the diagnosis of the current situation.

Conclusions: The psychosocial risk of storage work may lead to health deterioration, greater accident risk and worse performance at work. Such consequences mean that the psychosocial risks affect both an individual and the organization. Therefore, we should expect more intense efforts to increase psychosocial risk awareness of both employers and employees.

Key words: OSH, safety at work, psychosocial risk, stress, human factor.

INTRODUCTION

Fewer and fewer workers are hired in sectors such as heavy industry or agriculture, where the job is mostly performed in difficult environment conditions and exposed to many physical and chemistry hazards (noise, pollination, high temperature and so on). On the other hand, employment in services, often in big, sometimes foreign companies, demands interpersonal contact closer than ever. It does matter that in the process of globalization competition increases. This forces employers to take a more elastic approach to forms of employment. It also causes an increase in job intensity and a continuous willingness for change.

The feeling of overwork, too many responsibilities, falling behind on novelty, resistance to everlasting change, uncertainty of employment - all this is a more frequent with a worker today. As a result the physical and chemical aspects of work is not the greatest source of occupational risk, but its psychosocial aspect is. Problems such as work-related stress or violence at a workplace that are related with psychosocial hazards are generally considered the main challenges for work safety [EU-OSHA 2007].

The aim of the article is to provide information on new and emerging risks in the work processes, with particular emphasis on warehouse processes. Although working in the warehouse is widely considered to be non-complicated and require few advanced social competences, the research results do not confirm it.

Whereas there is still a lot to do as far as prevention and elimination of traditional health and work safety threats is concerned, the problem of psychosocial risk prevention is extremely important nowadays. It is crucial to take into consideration the health of workers and promotion of health in the workplace, as the occupational stress epidemics is getting more and more widespread. Occupational stress generates 240 billion Euro worth of losses which result from the decrease of work efficiency, numerous medical leaves and all costs connected to it.

PSYCHOSOCIAL RISK AND PSYCHOSOCIAL HAZARDS - AN ATTEMPT TO DEFINE BOTH TERMS

Although the forecasts of warehouse section specialists are careful due to various changes in world economy, there is no denying that in the last couple of years there has been enormous progress in the optimization of logistic processes, especially as far as transport and warehousing are concerned. Warehouse processes are complex and labour-intensive which necessitates using modern installations and advanced methods of work organization. The automation will continue and more attention will be paid to not to the area, but to room. Warehouse which "go up" will require appropriate means of transport with management systems. One of change trends in the forthcoming years will be the replacement paper documents with digital data, using uniform standards (including strengthening the role of GS1) and full integration of supply chains (Niemczyk 2014). As the European logistics is constantly changing, we should not also forget about atmosphere of intense competition - this phenomenon is driven by market requirements, such as: growing importance of customer service, shortening order lead times, price reductions. To live up to those requirements companies must dynamically change - not only in terms of how they are organized, but how they function - by opting for dynamic management rather than static (structural) management [Adamczak, Domański, Cyplik and Pruska 2013].

Over the years not only the types of risk occurring in the human environment have changed but also attitude towards safety. Work-related accidents as well as occupational diseases and pathological symptoms of behavior in a work place are the greatest factors suppressing market growth. In the last years huge changes have occurred in organization and management of the work process. As a result, both new risk factors and new challenges in the field of work safety regulations have appeared. Psychosocial risks are labeled as new and emerging risks [EU-OSHA 2007; NIOSH 2002]. Changes in structure of the job market and the character of human activity have an impact on the mental condition of the society.

International Labor Office defines psychosocial risk factors as the interaction between job content, management and organization of work process and other organizational or environmental factors on one hand and workers' needs and expertise on the other. In this aspect they correlate to the types of interaction which from the point of view of the employee a threat to health [ILO 1986]. Psychosocial risks may also be defined in a simpler matter as such aspects of designing and managing work process along with the social-organizational which have the potential to cause mental or physical harm [Cox and Griffiths 2005].

The term hazard refers to every factor that may cause harm. A general division to physical risks (biological, biochemical, chemical and radiological) and psychosocial risk is accepted. When we consider the psychosocial factors as hazards we greatly widen the definition of work environment. When we look at the dynamic change in work conditions and the examined scale of exposure to psychosocial factors, it becomes more often acknowledged that work environment consists of all material

environment conditions (physical, chemical and biological factors) as well as non-material factors (psychosocial factors) within which work process takes place. In contrast to classic hazards that are present in a work environment, ex. chemical or physical hazards, one may not establish sanitary standards for psychosocial risks such as a TLV indicator (Threshold Limit Value) because the effects depend on both worker's traits (also hereditary) and specified configuration of the work environment (Merecz, Potocka, Wężyk and Waszkowska 2012). Due to this one may not create a universal list of psychosocial hazards or in other words indicate the ones which cause stress to everybody and in every circumstances. In subject literature one can find a list of potential psychosocial

occupational risks and many attempts to categorize them.

According to literature on the subject and research in the field, a rough set of psychosocial work environment factors, which workers consider to be stressful or potentially harmful, was put together. This way 10 separate categories concerning job characteristics, organization and management of work as well as other environmental and potentially health-hazardous organizational factors were established. In specific conditions every one of the 10 aspects of work causes stress and/or is directly hazardous towards health [WHO 2008].
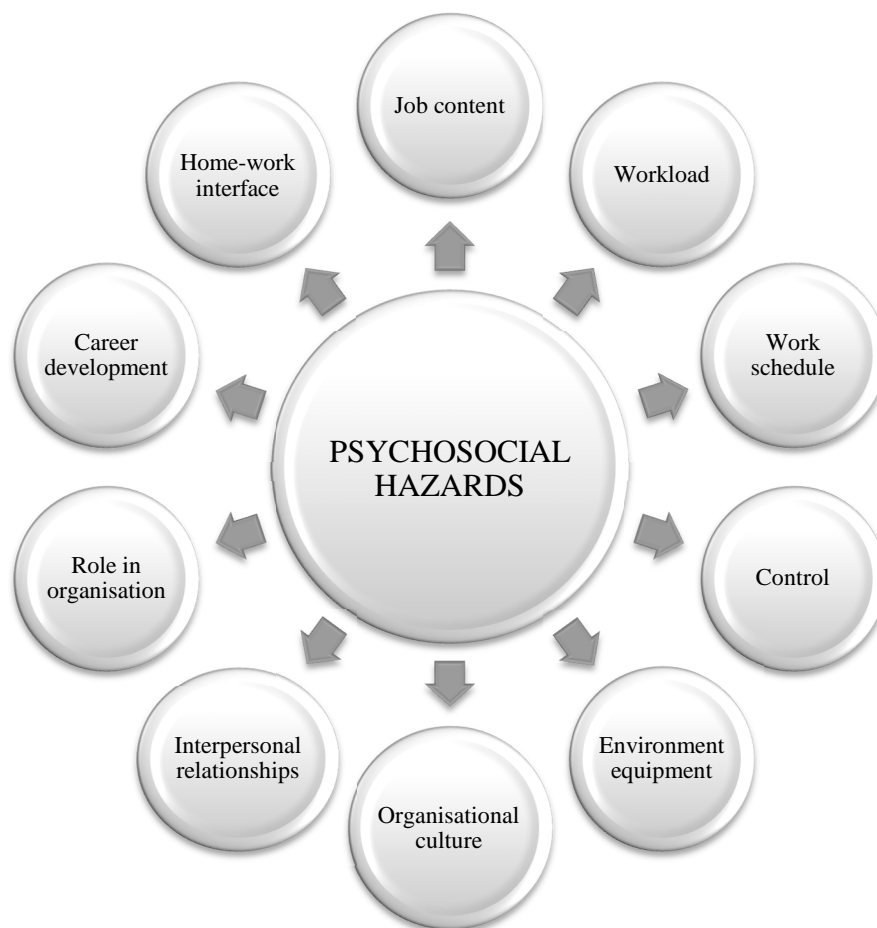
Source: Sadłowska-Wrzesińska 2014

Fig. 1. Psychosocial hazards related to work
Rys. 1. Zagrożenia psychospołeczne związane z pracą

Work-related stress is a common effect that in a bigger or smaller way affects every

employee. For most people a moderate stress level is beneficial - it energizes and motivates

to action and increases effectiveness. However, when stress becomes too big and/or long-lasting and one fails to deal with it, new problems occur, observed not only on the individual level, but also on the organizational level. Stress-resultant burden of mind in some jobs has consequence not only for the results, health and safety of the employee, but may also be a critical factor for safety and health of others.

The above-mentioned results show diverse consequences of stress, starting from changes in the emotional area and mental functioning to behavior and various somatic reactions. In the past it was also proven that stress may be a risk factor for the development of infective processes. However, it must be emphasized that a pathological stress influence arises when it is severe and/or long-lasting. Somatic health disorders as well as mental health disorders (depression, anxiety disorder) are classified as chronic long term work-related stress products. It was shown among others that stress is a risk factor for disease development in the circulatory system and ailment of muscular-skeletal system (ex. lower back pain). It also may cause allergies and decreases body immunity [Merecz, Potocka, Wężyk and Waszkowska 2012]. What's more, work-related stress absence at work usually takes longer than absence due to other reasons, and this also has a negative impact on a worker's productivity index. Occupational stress due to its specificity is related to greater accident risk in during work; it is a deciding argument supporting the statement that attention to safety in work should also involve the elimination of psychosocial risks [Sadłowska-Wrzesińska 2014].

Those problems have been described in European Agency of Occupational Safety and Health [EU-OSHA]. ESENER has pointed out that although 79% of managers in Europe are aware of stress at workplace, and 40% know about violence and harassment in the workplace. In 74% of European companies no problem-solving procedures have been implemented. Besides, only 3% of the companies takes a holistic approach to psychosocial problems. These are frightening data, because it is assumed that about 50-60% of all the missing days are caused by psychosocial risks, and the general cost of treating resultant mental health disorders in the UE is 240 billion EUR a year [ESENER].

Unfortunately, that business in Poland so rarely considers health to be the main area of interest. Systematized psychosocial risk management programs is one of the main elements of running companies in most EU countries. Scientific research and cost analysis point out that it is essential to take preventative measures as to excessive work-related stress. Special attention must be paid to the latest threats such as job insecurity, violence, mobbing, sexual harassment and discrimination [Sadłowska-Wrzesińska and Mościcka-Teske 2014].

SAFETY AT WORK IN WAREHOUSE LOGISTICS

No matter how big the warehouse is and what its character is, there are many threats resulting from inside transport and from storage methods, manual transport and high altitude work. The threats are connected not only to the place, but also to the size and type of goods. Fragile or chemical goods have their specific needs. Statistics prove that the accidents happen mostly while transporting the goods and high altitude storing. An employee may be hit by falling object or fall himself. All the falling, moveable, sharp and protruding elements as well as the mechanical means of transport, cramped spaces and high altitudes may lead to injuries [Sadłowska-Wrzesińska, Gabryelewicz 2014].

There are statistical elaborations of accidents at work published yearly by Central Statistical Office [CSO 2014a]. In 2013, 88 267 persons injured in accidents at work were registered, out of whom 87 462 are lighter accidents at work, 529 are serious accident at work is an accident which results in serious bodily harm (i.e. loss of sight, hearing, speech, fertility or other physical damage. It may also result in other health-related problems, disrupting primary bodily functions, as well as in incurable, life-threatening or mental diseases) and 276 are fatal accident at work is an accident in which the person injured dies at the site or within 6 months from the accident.

A fall in the number of people, who were hurt at work in 2013 as compared to 2012, is caused by a decline in the number of people injured in most kinds of activities. Transportation and storage is one of such activities. Although the number of fatal accidents has decreased, it is to be emphasised that groups of drivers and mobile plant operators characterized the highest percentage of people injured in accidents with fatal outcome, i.e. - 23.0% of all fatal accidents in Poland. The most disturbing fact, though, is the increasing number of women in total accidents. It is worth indicating that the number of work inability days has increased.

Table 1. Persons injured in accidents at work by consequences of the accidents and sex and the number of days inability to work caused by accidents - the section: Transportation and storage

Tabela 1. Poszkodowani w wypadkach przy pracy według skutków wypadków i płci oraz liczba dni niezdolności do pracy spowodowana tymi wypadkami - sekcja: Transport i magazynowanie

section	Year	Total		In accidents			Of total		The number of days inability to work	
		absolute numbers	in %	fatal	Serious	lighter	women	adolescents	absolute numbers	per one person injured
Transportation and storage	2012	6402	7,0	61	45	6296	1249	4	284125	44,8
	2013	6125	6,9	38	36	6051	1272	2	291362	47,9

Source: Sadłowska-Wrzesińska, Rejmer and Drożyner 2014

While analysing accidents at work, the issue of causes of accidents is the most important thing (in the context of prevention). Causes of accident are all short-comings and irregularities related to material (technical) factors and organization of work as well as incorrect behavior of the employee. The age and seniority of the injured are the next important indicators of accidents at work analysis. Compared to the previous year, in 2013, similar proportions of the number of injured persons by age groups were observed. Still the largest group of victims was persons aged 40-49 years (25.8%).The second largest was the group of people aged 30-39 years (25.3%). Regarding work seniority of the injured persons at particular work positions, it turned out that in 2013, similarly to the previous years, accidents in "Transportation and storage" occurred most frequently among persons with short work seniority not exceeding 3 years (43.4%), in which 25.7% comprised persons whose work seniority was 1 year or shorter. The share of fatal accidents at work of persons whose work seniority did not exceed 3 years comprised 60.5%, in which 50.0% constituted persons who worked for a year or shorter [Sadłowska-Wrzesińska, Rejmer and Drożyner 2014].

Unfortunately, the statistical analysis does not fully reveal the situation of security and health at work in the country. A decreasing number of employees is hired in sectors like heavy industry or agriculture, where the job in general is performed in difficult environment conditions and present many physical and chemistry hazards (noise, pollination, high temperature and so on) while employment in sector of services, performed often in big companies; in foreign too, demanding closer than ever interpersonal contact It does matter that in the process globalization and related with it increase in competition. This forces employers to a more elastic approach to forms of employment. It also causes an increase in job intensity and a continuous willingness for change. On the basis of the generalized results of the sample Labour Force Survey and the ad-hoc LFS module survey Accidents at work and work related health problems conducted by the CSO in the second quarter of 2013, there are visible changes in the kinds of threats and the impact on the health of the employees. The module survey was conducted as a part of the Programme of modules for the Labour Force Survey, which are to be carried out in the European Union Member States in the years 2013 - 2015 (introduced by the European Commission Regulation (EC) No. 220/2010 of

March 16, 2010). In the module survey Accidents at work and work-related health problems [CSO 2014b] the objective was providing information concerning the occurrence of work-related health problems not caused by accidents at work and the factors at workplace that adversely affect mental well-being or physical health. In particular this concerned determination of the scope of occurrence of factors at work that adversely affect mental wellbeing or physical health, and determination of the number and types of work-related health complaints.

Should be emphasized that changes in structure of the job market and the character of human activity have an impact on society's mental condition. Psychological factors as the source of threats in the place of work indicated 37.1% of all respondents. The total number of psychological threats (the so-called threats per capita) in the workplace amounted to 6 693 thousand (3 704 thousand among men and 2 989 thousand among women). In the section Transportation and storage alarmingly high indicators of the threat were obtained; severe time pressure or overload of work are the main psychological factors perceived as a major serious work-related threat. Similarly stress associated with the possibility of losing a job in the near future - in the section Transportation and storage every fourth woman is exposed to that factor. Men, on the other hand, are exposed to violence or threat of violence, harassment and bullying (Table 2).

Table 2. The employed persons exposed to psychological factors by sex - the section: Transportation and storage
Tabela 2. Liczba pracujących narażonych na psychologiczne czynniki zagrożeń

Section m - males f - females		Employed	Of which persons threatened with:		
			severe time pressure or overload of work	violence or threat of violence, harassment and bullying	stress associated with the possibility of losing a job in the near future
		in thous.	in %		
Total	M	8624	19,4	2,0	13,9
	F	6874	19,6	1,7	15,4
Transportation and storage	M	721	24,0	4,6	15,0
	F	181	25,4	0,6	24,9

Source: Sadłowska-Wrzesińska, Rejmer and Drożyner 2014

The module survey objective was providing the information on types, frequency, effects, and the scope of occurrence of any work-related health problems, not only confirmed with the sickly leave or formally acclaimed occupational diseases. The survey results indicate that the most often declared health complaint suffered during the last 12 months, was a problem with musculoskeletal system (bones, joints or muscles). This problem had 67.7% of the surveyed population - 2882 thousand persons Health complaints regarding bones, joints or muscles affected mainly back (50.5%), less often hips, legs and feet, and later neck, shoulders, arms or hands. The heart diseases or attack or other problems in the circulatory system - 442 thousand indicated this type of health complaints as the most serious; 224 thousand persons suffered from headache or/and eyestrain. The another group of the most often occurring problems were stress, depression, anxiety - 186 thousand persons, i.e. 23 at twenty-third person in the surveyed population indicated this type of health complaints as the most serious [CSO 2014b].

Occurrence of the most serious health problems in section Transportation and storage is presented below:
1. stress, depression, anxiety - 10,4%
2. heart diseases or attack or other problems in the circulatory - 9,6%
3. bone, joints and muscles problem - 7,5%
4. headache and/or eye strain - 7,1%.

Unfortunately, data concerning frequency of health problems occurrence among the employed in a particular NACE section confirm that the logistics sector has a high level of psychosocial hazards [Sadłowska-Wrzesińska, Rejmer and Drożyner 2014].

THE RESULTS OF ANALYSIS

The risks that accompany warehouse staff, are serious and can lead to hazardous events, endangering the health and lives of workers. Unfortunately, the most common causes of accidents at work in the warehouse are: recklessness, lack of concentration, and disregard for basic safety rules. In order to ensure safety in storage and thus reduce the number of accidents at work, it is necessary to the implement not only requirements relating to the general principles of safe storage of goods, but also a holistic, proactive approach to safety issues. It should concern not only the area of technical issues, but also psychosocial risks - the proper organization of work including human factor weaknesses.

The key to ensure safe and health working conditions is the proper and regular assessment of occupational risk, paying special attention to workers. It should help the employer to plan and implement all the appropriate technical and organizational solutions to prevent and limit occupational hazard. It is clear that risk assessment is NOT a single action required only by the law. A systematic approach to the issue of safety which participation of both workers and managerial staff is a part of is a trusted way of creating a culture of safety and including the matter of safe work in everyday practice [Jasiulewicz-Kaczmarek and Drożyner 2011].

However, the analysis of occupational risk assessment documents show that for the last couple of years nothing in logistics has changed. A typical mistake is the fact that the employees are not involved in the assessment. What's more, such assessments are often done by an outside expert who knows little about the particular workplace. Besides, such experts often fail to do the comprehensive assessment, tend to ignore some threat consequences (especially long-term ones) and have no plan how to correct the mistakes. They also rarely supervise the efficiency of the corrections. Occupational risk assessment is also wrongly documented and employees are not informed. But what worries the most is incomplete identification of workplace threats.

It is essential to collect the information about stressful factors. There are many methods, but each of them matters. One may use ready forms or check letters or even prepare own ones. A very valuable way to learn about possible psychosocial hazards are observations and interviews with employees. Workplace observation may help notice communication problems. Conversations with employees, open discussions or trainings also are very important As far as stress-generating factors are concerned, a subjective assessment of working conditions is necessary, as individual opinions of working condition influences their own assessment of the psychosocial atmosphere of work.

The psychosocial risks in working environment can and must be coped with just like it would if they were physical, chemical or biological hazards. Yet the employer awareness in this field seems relatively small. One should recognize this as a fault because a working environment free of stress overload favors not only the workers' health but also may generate reasonable profit as enhanced productivity and increased quality of work may be noticed [Merecz, Potocka, Wężyk and Waszkowska 2012]. It becomes necessary to better one's understanding of the concept of psychosocial hazard and risk connected with it to be able to evaluate and lessen the risks. In subject literature one can find many titles that suggest usage of risk managing paradigm to successfully manage psychosocial risk. According to this paradigm the correct identification of danger is most important.
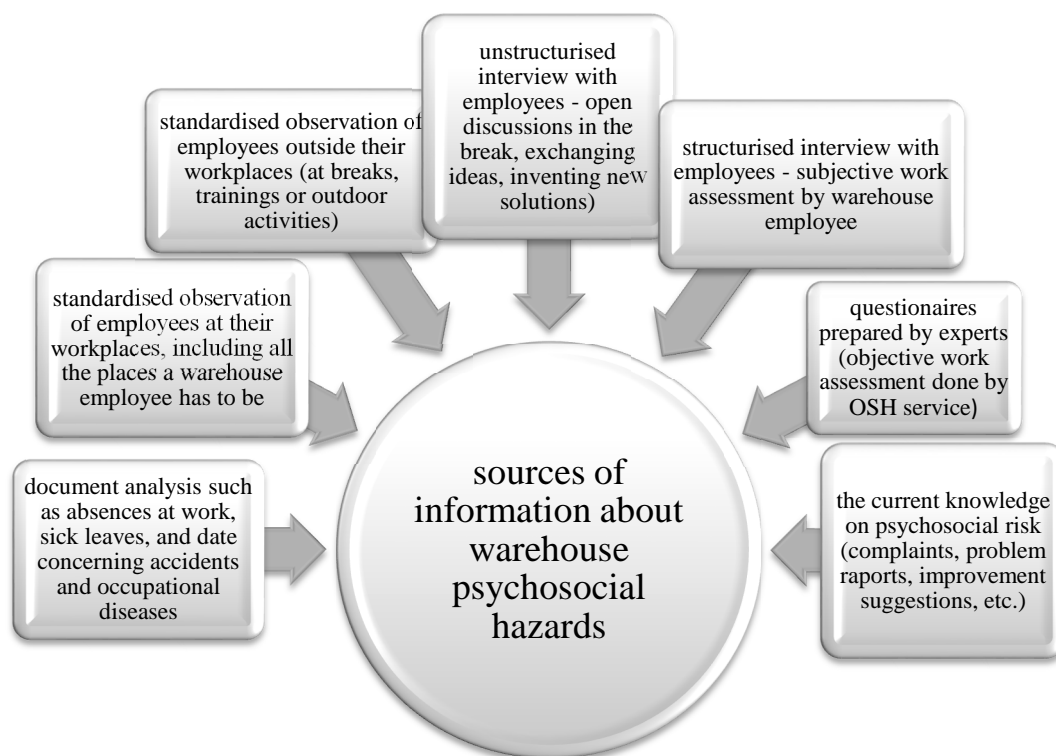
Source: Sadłowska-Wrzesińska, Gabryelewicz and Drożyner 2014

Fig. 2. Sources of information about warehouse psychosocial hazards
Rys. 2. Źródła informacji na temat zagrożeń psychospołecznych w magazynie

CONCLUSIONS

An important element in safety at work from the physical elements, is the human factor. This factor significantly affects performance, cost and quality. The improvement of work systems should not only cover the technical sphere, but also the realm associated with the environment and ergonomics [Lasota 2014]. Human factor presence in all the decisive, at tactic and operational level proves importance of relations of corporate management system and ergonomic factors a macro aspect [Mazur and Stachowiak 2014].

Logistics play a bigger and bigger role in the functioning of the economics. The reason for it is the globalisation of supply and distribution markets and the expansion of the Internet in terms of selling goods [Fechner and Szyszka 2014]. However, the advancement and modern solutions are always followed by certain limitations. It is emphasized in European documents, that taking care of safety and health is common business for both employees and employers. The most important challenge is to make everybody aware that low level of OSH implicates high costs. Not all the costs are obvious or easily assessable such as longer absence or damages. Both economic and social consequences of accidents at work and work-related traumas may be hidden, such as lower morale or loss of orders and customers. New types of risks may create additional difficulties. Although the problem is well researched [WHO 2004; WHO 2010; EU-OSHA 2012a; EU-OSHA 2012b], there are still many mental and organizational barriers in the process of psychosocial risk factors diagnosis and management. The psychosocial

risk of storage work may lead to health deterioration, greater accident risk and worse performance at work. Such consequences mean that the psychosocial risks affect both an individual and the organization. Therefore, we should expect more intense efforts to increase psychosocial risk awareness of both employers and employees. Such an approach will allow to shape the work environment in a truly safe way, where not only the OSH legal requirements are met.

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OCENA STANU BEZPIECZEŃSTWA I HIGIENY PRACY PRACOWNIKÓW MAGAZYNOWYCH - PODEJŚCIE PSYCHOSPOŁECZNE

STRESZCZENIE. **Wstęp**: Mimo że w europejskich zakładach pracy nadal pozostaje wiele do zrobienia w zakresie profilaktyki i zwalczania tradycyjnych zagrożeń zdrowotnych oraz bezpieczeństwa pracy, problem zapobiegania ryzyku psychospołecznemu należy do wyjątkowo aktualnych. Uwzględnienie ochrony zdrowia pracujących i promocji zdrowia w miejscu pracy wydają się być niezwykle istotne w odniesieniu do szerzącej się współcześnie epidemii stresu zawodowego.

Metody: artykuł oparto o analizę statystyczną wypadków przy pracy oraz analizę problemów zdrowotnych występujących w związku z wykonywaną pracą. Dokonano przeglądu najnowszych raportów dotyczących bezpieczeństwa pracy, ze szczególnym uwzględnieniem analizy ryzyka psychospołecznego. Podjęto próbę eksplikacji pojęć z zakresu nowopowstających rodzajów ryzyka w odniesieniu do warunków pracy w magazynie.

Wyniki: ocenie poddano różnorodne aspekty zagrożeń występujących na stanowisku pracy magazyniera. Wskazano na deficyty w zakresie identyfikacji zagrożeń o charakterze psychospołecznym oraz zaakcentowano brak korelacji pomiędzy zadaniami zawodowymi magazyniera a jego wiedzą na temat ryzyka psychospołecznego. Na podstawie diagnozy stanu obecnego zaprezentowano egzemplifikacyjne podejście do identyfikacji zagrożeń psychospołecznych występujących w magazynie.

Wnioski: ryzyko psychospołeczne związane z pracą w magazynie może prowadzić do pogorszenia stanu zdrowia, zwiększenia ryzyka wypadków, gorszego wykonywanie zadań. Konsekwencje te oznaczają istotne oddziaływanie ryzyka psychospołecznego zarówno na poziomie jednostki, jak i na poziomie organizacji - oczekiwać więc należy wzmożonych wysiłków na rzecz uświadamiania w tym obszarze zarówno pracodawców, jak i pracobiorców.

Słowa kluczowe: BHP, bezpieczeństwo pracy, ryzyko psychospołeczne, stres, czynnik ludzki

BEWERTUNG VON DATEN IM BEREICH DES ARBEITSSCHUTZES UND -SICHERHEIT VON LAGERARBEITERN - EIN PSYCHOSOZIALER ANSATZ

ZUSAMMENFASSUNG. Einleitung: Da es in europäischen Unternehmen immer noch eine Menge im Bereich des Arbeitsschutzes, der Unfallverhütung und Bekämpfung von traditionellen Gesundheitsgefährdungen zu tun ist, bleibt heutzutage das Problem der psychosozialen Risikoprävention extrem wichtig. Es ist dabei besonders hervorzuheben, dass der Arbeitsschutz von Arbeitnehmern und die Förderung der Gesundheitsprävention am Arbeitsplatz eine besondere Achtung verdienen, zumal gegenwärtig die "Epidemie" von Arbeitsbelastung sich immer mehr verbreitet.

Methoden: Der Artikel basiert auf der statistischen Auswertung von Arbeitsunfällen sowie auf der Analyse von Gesundheitsproblemen, die im Zusammenhang mit der ausgeübten Arbeit auftreten. Die neuesten Arbeitssicherheitsberichte wurden überprüft, wobei man besondere Aufmerksamkeit auf die psychosoziale Risikoanalyse leitete. Der Autor hat versucht, neue Begriffe hinsichtlich der neuen, in Lagern aufkommenden Risikos und Gefährdungen einzuführen und zu erläutern.

Ergebnisse: Verschiedene Aspekte der Gefährdungen der Lagerarbeiter wurden evaluiert. Ferner wurden Defizite in der psychosozialen Bedrohungsidentifikation angezeigt und der Korrelationsmangel zwischen den beruflichen Aufgaben eines Lagerarbeiters und dessen Kenntnis über das psychosoziale Risiko betont. Auf Grund des gegenwärtigen Zustandes stellte man ein exemplifikationsmä?iges Herangehen an die Fragen der psychosozialen, in Lagern auftretenden Gefährdungen dar.

Fazit: Das psychosoziale, mit der Arbeit im Lager verbundene Risiko kann zur Verschlechterung des Gesundheitszustandes der Lagerarbeiter, zur Erhöhung von Unfallrisikos und zur mangelhaften Ausführung von Lagerarbeiten führen. Die Konsequenzen bedeuten eine wesentliche Einwirkung des psychosozialen Risikos, sowohl auf der Ebene des Einzelnen, als auch auf der Ebene der ganzen Organisation - es ist daher zu empfehlen und zu erwarten, dass die entsprechenden Bemühungen unternommen werden zwecks der Erhöhung des dies bezüglichen Bewusstseins sowohl bei den Arbeitgebern, als auch bei den Arbeitnehmern.

Codewörter: Arbeitsschutz, Arbeitssicherheit, psychosoziales Risiko, Stress, menschlicher Faktor

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THE IMPACT OF TRANSPORT PROCESSES STANDARDIZATION ON SUPPLY CHAIN EFFICIENCY

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ABSTRACT. **Background:** During continuous market competition, focusing on the customer service level, lead times and supply flexibility is very important to analyze the efficiency of logistics processes. Analysis of supply chain efficiency is one of the fundamental elements of controlling analysis. Transport processes are a key process that provides physical material flow through the supply chain. Therefore, in this article Authors focus attention on the transport processes efficiency.

Methods: The research carried out in the second half of 2014 year, in 210 enterprises of the Wielkopolska Region. Observations and business practice studies conducted by the authors, demonstrate a significant impact of standardization processes on supply chain efficiency. Based on the research results, have been developed standard processes that have been assessed as being necessary to standardize in business practice.

Results: Based on these research results and observations, authors have developed standards for transport processes by BPMN notation. BPMN allows authors to conduct multivariate simulation of these processes in further stages of research.

Conclusions: Developed standards are the initial stage of research conducted by Authors in the assessment of transport processes efficiency. Further research direction is to analyze the use efficiency of transport processes standards in business practice and their impact on the effectiveness of the entire supply chain.

Key words: supply chain efficiency, transport efficiency, operational controlling.

INTRODUCTION

In the era of ongoing market competition, focusing on the level of customer service, order completion time and flexibility of deliveries, analysis of efficiency of logistic processes is gaining on significance. Transport processes are a key factor that ensures physical provision of materials to the entire supply chain. The article discusses issues concerning the analysis and evaluation of the efficiency of transport processes.

The analysis of efficiency in a supply chain is one of the fundamental elements of controlling analysis. Despite obligatory performance of extensive analyses in economic practice, the scope of their use is unsatisfactory. It results both from imprecise definition of problems related to the efficiency of logistic processes in reference books, and from the absence of comprehensive solutions supporting analyses in practice. Observations and studies on economic practice, carried out by the Authors, prove considerable impact of the standardisation of processes on supply chain efficiency.

The standardisation of transport processes is a continuous process directed towards constant improvement of activities related to logistic processes. All standards developed at a company should be balanced, i.e. strict and

flexible at the same time. The term "strictness" refers to the procedures an employee who performs specified tasks must follow. Flexibility, on the other hand, allows employees to be creative and not to be limited by imposed standards [Liker 2004]. Liker defines the following types of standards [Kolinska and Cyplik 2010]:

- management standards - concerning internal purpose of employee management. They are essential in managing the workers. The standards describe guidelines for employees, job descriptions, cost settlement rules etc.
- operating standards - providing for technical and organisational aspects of logistic processes in a supply chain.

In the article, the Authors present studies on the application of the standards of transport processes and their impact on supply chain efficiency, and give suggestions regarding the standardisation of selected transport processes.

THE ROLE OF PROCESS STANDARDS IN TRANSPORT MANAGEMENT

Frequent modifications to processes in use may lead to various disruptions, but, considering frequent changes in economic reality, they are unavoidable, although intervals between modifications depend on a number of factors of external and internal nature. Abandoning any changes or introducing them not frequently enough may cause a company to take a step back [Kherbash and Mocan 2015]. Such treatment of changes to processes is defined as evolutionary or revolutionary. The first one assumes continuous improvement of the existing process, while the second one provides for the construction of a new process and is not of continuous nature. Both methods may complement each other, which allows their expansion due to constant improvement of processes. Another method consists in repetitive improvement of existing processes, which leads to their optimisation. Both methods have been presented in Table 1.

Table 1. Methods of transport process management
Tabela 1. Metody zarządzania procesem transportowym

Approach	Subject	Basic methods	Auxiliary methods
Revolutionary (renewal, re-engineering, restructuring of processes)	economic processes	*business process re-engineering* (BPR)	benchmarking outsourcing, insourcing
Evolutionary (incremental, continuous improvement of processes, optimisation of processes)	economic processes	*total cycle time* (TCT)	benchmarking
	subprocesses, actions	*kaizen* KVP *six sigma*	benchmarking

Source: Nowosielski 2008

Analysing the structure of transport processes, the following factors should be taken into account:

- operations which comprise the process,
- order in which individual operations are carried out,
- which operation cannot start until other operations are finished,
- duration of each operation,
- occurrence of idle moments between operations.

The analysis of these factors gives an image of a process, which makes it possible to modify and improve it [Nikfarjam, et al. 2015], with a purpose of developing a repetitive standard. A diagram depicting approaches to the analysis of transport processes directed towards developing standards has been presented in Figure 1.
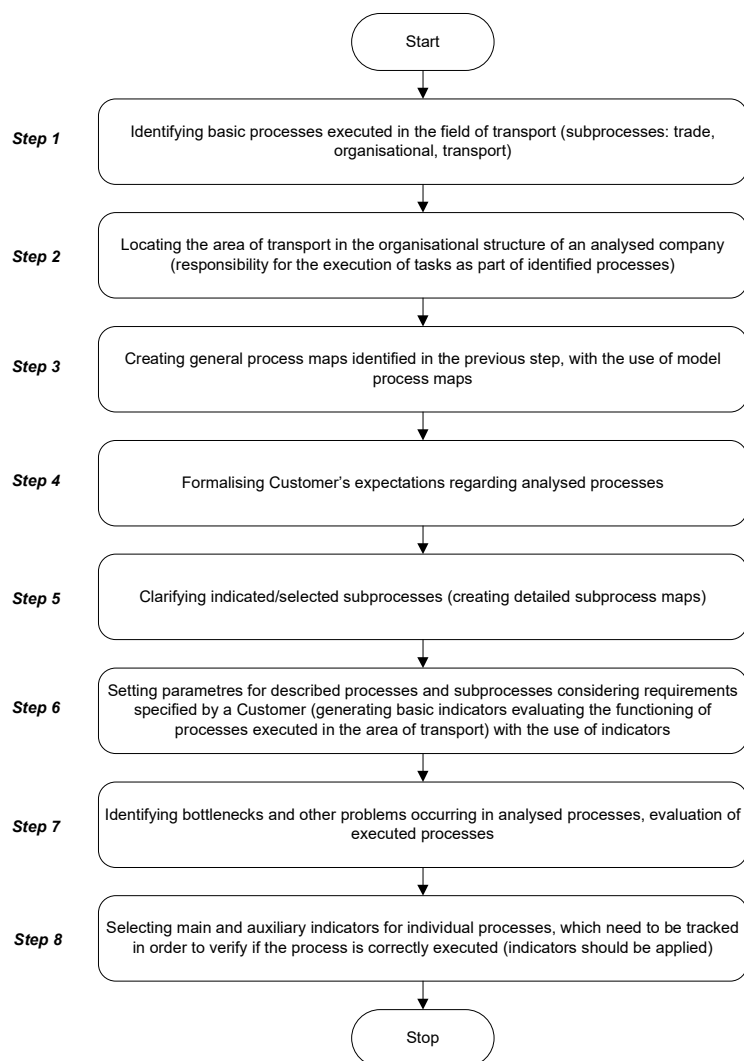
Fig. 1. Diagram depicting the standard of methodological approach to the analysis of transport processes in a company

Rys. 1. Standardowe podejscie metodyczne analizy rpocesów transportowych w przedsiębiorstwie

To manage transport processes efficiently, one needs to determine logical and temporal relations between individual elements of each process, and relations between different process within a company, starting from transactions, through accompanying events and ending with process management, which, in turn, allows reducing time, costs and consumption of human resources [Whipple and Russell 2007]. The way transport processes are organised in a company has direct impact on partnerships with other parties. The awareness of interactions between company departments allows comprehending interactions between links in a supply chain. The better companies cooperate with each other as part of business partnership, the more efficient a supply chain is [Demir et al. 2001; Forza, Salvador and Rungtusanatham 2005].

THE PROBLEM OF TRANSPORT PROCESS STANDARDISATION - STUDY RESULTS

The chief purpose of the standardisation of processes, developed in the form of process maps, is describing business processes

with a view to simplify, eliminate and improve them so that products and services are cheaper, better and more available [Hunt 1996]. For this reason, the Authors decided to run a study of economic practice, whose aim was to identify processes which required standardisation. Figure 2 presents the methodology applied to perform a study of the scope in which transport process standardisation is used.
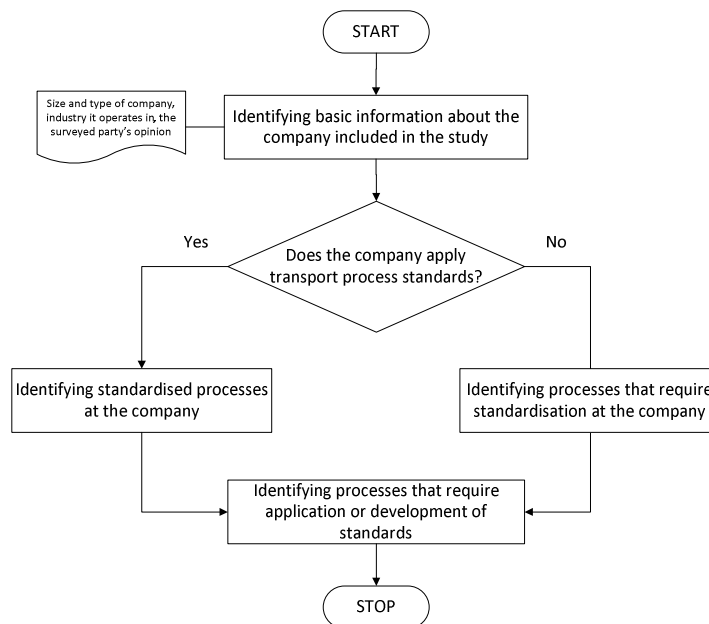
Source: Own study

Fig. 2. Methodology applied to perform a study of the scope in which transport process standardisation is used
Rys. 2. Metodologia zastosowania do analizy przypadku, w których użyto standaryzacji procesu transportowego

The study carried out by the Authors had the form of questionnaires (part of companies allowed the Authors to run observations and direct interviews on their premises). The study was carried out in the second half of 2014 at 210 production, trade, service, service and production, production and trade, trade and service, and production, trade and service companies seated in the Wielkopolska region. The questionnaire included seven open or multiple choice questions. The purpose of the study was to identify the degree of standardisation of transport processes in economic practice. Table 2 presents basic information concerning the companies included in the study.

The first part of the questionnaire included questions classifying companies in terms of employment rate and company type. The central part of the survey focused on issues concerning the analysis of the use of transport process standards and the necessity to develop additional transport processes.

Table 2. Basic information concerning the companies included in the study
Tabela 2. Podstawowe dane dotyczące przedsiębiorstw poddanych badaniom

Characteristics	Answers (%)
1. Number of employees:	
· less than 10 employees	18%
· from 10 to 49 employees	24%
· from 50 to 250 employees	27%
· more than 250 employees	31%
2. Company type:	
- production company	27%
- trade company	12%
- service company	21%
- production and trade company	6%
- production and service company	12%
- trade and service company	14%
- production, trade and service company	8%

Source: own study

The results of the study have shown that 25% of companies covered by the study does not follow transport process standards or is not aware of it. Such a result should come as no surprise, considering the strategy of unifying transport-related orders in the entire logistic chain of supplies. However, the results also prove increased awareness of the need to apply process standardisation in order to improve the efficiency of actions and competitive position in the market.

Further research concerned the identification of transport process standards used in practice and processes which required standardisation. Table 3 includes collective results showing the scope of transport process standardisation, whereas Table 4 presents results regarding processes that need to be standardised.

Table 3. Scope of transport process standardisation in economic practice
Tabela 3. Zakres standaryzacji procesów transportowych w praktyce ekonomicznej

The element of transport process	Per cent of indications*
Transport order acceptance	22%
Consignment collection	16%
Consignment execution (transport)	20%
Load delivery	26%
Execution of transport orders (transport services)	16%

* The companies had the possibility to select more than one answer.

Source: own study

Table 4. The need to standardise transport processes in economic practice
Tabela 4. Potrzeba standaryzacji procesów tranportowych w praktyce ekonomicznej

The element of transport process	Per cent of indications*
Transport order acceptance	20%
Consignment collection	21%
Consignment execution (transport)	18%
Load delivery	28%
Execution of transport orders (transport services)	13%

* The companies had the possibility to select more than one answer.

Source: own study

Analysing the above results, the highest degree of applying standards for the following transport processes must be determined:
- load delivery
- transport order acceptance
- consignment execution.

The results may also denote that identified transport processes have the greatest impact on supply chain efficiency in terms of customer service level.

During the analysis of the need to standardise process, the following processes have been identified:
- load delivery
- consignment collection
- transport order acceptance.

Considering both results obtained from companies applying transport process standards and results from companies planning the standardisation of processes, low need to standardise the process of transport order (transport service) execution has been identified. It may be the consequence of the fact that the process depends on the size of a transport company and specific nature of the industry which it operates in.

STANDARDISATION OF TRANSPORT PROCESSES WITH THE USE OF REFERENTIAL MODELS

A company functioning in a highly competitive environment must make sure that it operates under conditions favouring fast generation of data and its efficient collection. That is why it needs to continuously improve and streamline its operations. An effective solution which positively influences a company's image and the quality of goods and services without generating extra costs is a reconstruction of its process management strategy, It consists in conducting regular analyses, streamlining and controlling actions in order to improve the efficiency of company operations. A prerequisite of process-based approach is seeing a company as a whole and improving actions from different functional areas. These requirements can be met, among

others, by applying process standardisation by means of referential modelling.

When developing a referential model, one must specify proper tools for defining, analysing and designing processes, and, consequently, develop suitable models of procedures, which will indicate what type of data is required to build a referential model [Long and Zhang 2014]. They need to be developed in the same language as process models are suggested to be formulated.

A referential model for procedures may be documented by means of description of processes, functions and organisations suitable for such concepts as BPMN, and adjusted to specific requirements of a project. The role of referential models becomes visible during process construction. The models not only provide process maps, but also allow experimenting on processes before their implementation. As systems are subject to evolution, their models do not have to faithfully reflect reality. In the case of referential models of business processes, the models should include suggestions concerning process improvement. To achieve this goal,

changes and evolutions are most frequently introduced based on best practices. Referential models form a methodological framework for modelled, complex reality of a company. They represent its organisational knowledge, set certain modelling standards and define information structures.

General category of processes in supply chains should be considered to include specific, busi-ness sequence of actions in time and space, with clear-cut beginning and ending of actions, and clearly defined outlays and results [Lambert 2004]. Flexibility of processes facilitates modelling and application of referential models [Sanchez and Perez 2005].

The theoretical premises and studies presented above accompanied the development of referential models used for load handling. Figures 3-6 present diagrams of referential models of processes, which were the object of studies at companies (developed as part of a research project titled "Information tools supporting the optimisation of transport processes in supply chains", Project of the Poznań School of Logistics: KPL1/2013).

Source: Own study

Fig. 3. Process standard - transport order acceptance
Rys. 3. Standard procesu – przyjęcie zlecenia transportowego

Source: Own study

Fig. 4. Process standard - consignment collection

Rys. 4. Standard procesu – konsygnacja wysyłek

Source: Own study

Fig. 5. Process standard - consignment execution on the example of domestic full track load transport

Rys. 5. Standard procesu – realizacja wysyłki na przykładdzie transport krajowego pełnosamochodowego

Source: Own study

Fig. 6. Process standard - load delivery
Rys. 6. Standard procesu – dostawa ładunku

Two fundamental issues are important in practical implementation of referential models: one focuses on construction i.e. searching the methodology, building a model and aiming at defining referential requirements of description methods, while the second one treats models as material to be used in practice.

Advantages of referential models described above include:
- standardisation of process structures,
- possibility to develop process maps,
- easier reading of process maps by creating appropriate diagrams,
- possibility to run process analyses,
- allowing verification of process completeness,
- assistance in selecting key processes,
- recording data and generating information about processes,
- possibility to use verified models with ready process maps.

Presented referential models are the result of the co-Author's long-standing studies in terms of process analysis. They were developed as part of consulting works and transport audits for companies.

One of such tools is undoubtedly BPMN (Business Process Modelling Notation), which, on the one hand, facilitates the development of models and makes them more understandable to users, which makes it suitable for use even in cooperation with people with very low awareness of process modelling (communicating the functioning of a process to users), and, from the other hand, whose simulation functionalities (e.g. iGrafx) add an extra value to graphs developed in BPMN, as they allow evaluating the efficiency of suggested workflow methods and/or assess resources necessary to achieve previously set goals.

CONCLUSIONS

The analysis of effects of referential process applications in logistics has shown that the best

results are achieved following the determination of weaknesses, study of deviations and improvement of current status of transport processes by way of models. Satisfactory effects on parametres of models referring to delivery time and costs of processes have been observed. Furthermore, referential models may be created to support the selection of software, management of chosen processes, certification and knowledge management.

Even if a company does not apply referential models in transport management, acceptance of process-based orientation forces the standardisation of processes which is analogical to the one offered by referential models.

The article presents preliminary studies carried out as part of standardisation of processes occurring in logistic supply chains. Further research will be aimed at analysing the use of transport process standards in economic practice and the impact of transport processes on the effectiveness of the entire supply chain.

All stages of the flow of materials (procurement, production and distribution) and accompanying warehouse processes require similar analyses.

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WPŁYW STANDARYZACJI PROCESÓW TRANSPORTOWYCH NA EFEKTYWNOŚĆ ŁAŃCUCHA DOSTAW

STRESZCZENIE. **Wstęp:** W dobie ciągłej konkurencji rynkowej, koncentrującej się na poziomie obsługi klienta, czasu realizacji zamówień oraz elastyczności dostaw coraz większą rolę odgrywa analiza efektywności procesów logistycznych. Analiza efektywności w łańcuchu dostaw jest jednym z podstawowych elementów analizy controllingowej. Procesy transportowe są kluczowym procesem zapewniającym fizyczne zasilanie przepływu materiałowego w całym łańcuchu dostaw. Z tego względu w niniejszym artykule Autorzy skupili uwagę na efektywności procesów transportowych.

Metody: Prace badawcze prowadzono w drugim półroczu 2014 roku w 210 przedsiębiorstwach z terenów województwa wielkopolskiego. Obserwacje i badania praktyki gospodarczej przeprowadzone przez Autorów świadczą o znacznym wpływie standaryzacji procesów na efektywność łańcucha dostaw. Opierając się na wynikach badań zostały opracowane standardy tych procesów, które zostały ocenione jako konieczne do ustandaryzowania w praktyce gospodarczej.

Wyniki: Na podstawie uzyskanych wyników i obserwacji, Autorzy opracowali standardy procesów transportowych wg notacji BPMN, która umożliwi Autorom przeprowadzenie wielowariantowych symulacji tych procesów w dalszych etapach prowadzonych badań naukowych.

Wnioski: Opracowane standardy stanowią wstępny etap badań naukowych realizowanych przez Autorów w ramach oceny efektywności procesów transportowych. Kierunkiem dalszych badań jest analiza efektywności zastosowania standardów procesów transportowych w praktyce gospodarczej oraz ich wpływ na skuteczność całego łańcucha dostaw.

Słowa kluczowe: efektywność łańcucha dostaw, efektywność transportu, controlling operacyjny

EINFLUSS DER STANDARDISIERUNG VON TRANSPORTPROZESSEN AUF DIE EFFEKTIVITÄT EINER LIEFERKETTE

ZUSAMMENFASSUNG. Einleitung: In der Zeit des andauernden Markt-Wettbewerbs, der sich auf den Kundenservice, auf die Zeit der Ausführung von Kundenaufträgen und auf die Flexibilität von Lieferungen konzentriert, spielt die Analyse der Effektivität von logistischen Prozessen eine immer grö?ere Rolle. Die Analyse der Effektivität in der Lieferkette ist einer der grundlegenden Bestandteile der Controlling-Analyse. Die Transportprozesse stellen einen schlüsselhaften Prozess, der den Materialfluss in der ganzen Lieferkette effektiv gewährleistet, dar. Aus diesem Grunde haben die Autoren der Effektivität von Transportprozessen ihre besondere Achtung geschenkt.

Methoden: Die Forschungsarbeiten führte man im zweiten Halbjahr 2014 in 210 in Gro?polen lokalisierten Unternehmen durch. Die gezielte Wahrnehmung und die von den Autoren durchgeführte Erforschung der Wirtschaftspraxis zeugen von einem bedeutenden Einfluss der Prozess-Standardisierung auf die Effektivität der Lieferkette. Gestützt auf die Forschungsergebnisse wurden die Standards für diejenigen Prozesse, die einer Standardisierung in der Wirtschaftspraxis unbedingt bedürfen, augearbeitet.

Ergebnisse: Aufgrund der erzielten Ergebnisse und Beobachtungen haben die Autoren die Standards für die Transportprozesse nach der BPMN-Notation erarbeitet, die ihnen es erlaubt, in den weiteren Etappen der fortgesetzten wissenschaftlichen Forschungen Mehrvarianten-Simulationen solcher Prozesse durchzuführen.

Fazit: Die ausgearbeiteten Standards gelten als eine einleitende Etappe für die Forschungen, die von den Autoren im Rahmen der Bewertung der Effektivität der Transportprozesse weiterhin in Angriff genommen werden. Die Ausrichtung der weiteren Erforschung zielt auf die Analyse der Effektivität der Anwendung der betreffenden Standards in der Wirtschaftspraxis und auf die Bewertung des auf die Effizienz der ganzen Lieferkette ausgeübten Einflusses hin.

Codewörter: Effektivität der Lieferkette, Effektivität des Transportes, operatives Controlling.

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MODELING THE IMPACT OF AIR TRANSPORT ON THE ECONOMY - PRACTICES, PROBLEMS AND PROSPECTS

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ABSTRACT. **Background:** The issue of measuring the contribution of air transport to the regional economy is very important nowadays since many airport infrastructure projects are being implemented, using available European Union funds. As a result of growing transport needs and increasing incomes among the population, the air transport market is strongly developing. This development results to many direct and indirect socio-economic benefits to locations in close proximity of an airport but also in the whole economy. The measurement of these benefits is important because the decisions made with respect to air transport influence local and regional economic performance. The most commonly used tool for measuring the positive effects associated with the operation of an airport is the input-output analysis. The aim of the article is to present the characteristics of the input-output method, to indicate its applications in Poland - the country with the most dynamic growth of air transport, to present the possible limitations of this method and propose improvements.

Methods: The method used in this research is one that measures the effects of changes in the economy as a result of air transport activity. Particular input-output analysis is used.

Results: On the background of the results of modeling the impact of polish airport on regional economy in 2009 the updated analysis in 2012 is provided. The economic impacts of Krakow, Katowice, Wroclaw and Szczecin airports are estimated. Then the limitations of input-output method are presented and suggestions of possible improvements are made.

Comments: Proper measurement of the impact of airport's operation and investment on the economy, leads to more effective air transport policy development. For future research, the advanced input-output method to assess the positive impact of airports on regional development is recommended. However, a comprehensive assessment of the operation and expansion of airport infrastructure requires comparing the economic benefits with economic costs.

Key words: airport, regional development, input-output analysis.

INTRODUCTION

In Central and Eastern Europe, where the aviation market has been deregulated and new companies entered the market, the air transport market is developing very dynamically. The growing air traffic caused capacity problems and lead to new investments in airports' infrastructure. The expansion of airports was enhanced by the UEFA Championships requirements in terms of airports infrastructure endowment in Poland - the largest of CEE countries. Moreover the local governments intend to benefit from air transport market development and start to build new airports from scratch or rebuild existing military airfields in order to transform them into civil airports, often with financial aid from EU funds. As a result, airport infrastructure in Poland has been changing dynamically and almost all airports in Poland are benefiting from infrastructural investments.

In 2012 new airports entered the polish market namely Lublin and Modlin and two

additional airports (Gdynia and Szczytno) are being prepared to be operational in the nearest future. However one can observe that not all investment projects are economically viable or contribute to increase the social welfare in the long run. Airlines are less interested in providing scheduled flights from the newest airport that was opened in 2014 in Radom. Other regional airports (Lodz, Rzeszow, Lublin) are at risk of returning the EU financial aid, due to failure to achieve the planned number of passengers. Based on these observations, a need to develop a proper tool in order to measure the economic and social effects of airport investment project is clearly highlighted.

This paper is organized as follow: in the next section the state of knowledge concerning the impact of air transport on economy is presented; then the characteristics of the most popular method: input-output model are provided; in the following section the results of the research in the polish market are revealed. The next section includes the critical review of input-output method. In the before last section the improvements in modeling the impact of air transport on economy are suggested. The conclusion and directions for further research are highlighted in the last section.

THE PROBLEM OF THE RELATIONSHIP BETWEEN AIR TRANSPORT AND REGIONAL ECONOMY – STATE OF THE ART

The research on the contribution of air transport infrastructure to the regional economy has the longest history in the United States of America. The reason for this is that the U.S. has the highest number of traffic volume hence a well developed airport network. The U.S. was first to deregulated the air transport market and as a result experienced air traffic growth.

The guidelines for the modeling of the economic significance of an airport was established in the U.S. in the late eighties of the twentieth century by the Federal Aviation Administration. Butler and Kiernan [1986] in

their documents: "Measuring the Regional Economic Significance of Airports" and it's updated version "Estimating the regional economic significance of airports" set the framework for measuring the socio-economic impact of an airport in terms of income and employment that can be directly or indirectly attributed to the operation of an airport [Butler and Kiernan 1986].

The methodology had been widespread in Europe. In 1992 the European branch of Airports Association Council International gave the recommendation for conducting airport impact studies with the use of input-output methodology. The study called "Airports partners in vital economies" stated that airports are major economic assets offering major economic returns and benefits. Decisions made in respect of airports are those that affect local and regional economic performance [ACI 2004].

Based on the ACI (Airport Council International) Europe and U.S. experiences many airport impact studies at different spatial level were conducted. Until now, almost all hub airports and numerous of regional airports had conducted airport impact studies. A large number of studies have been carried out in US and Europe but also in Asia, Africa, the Middle East and South America. Airport impact studies have spread among the world mainly due to their relative simplicity of application and relative low cost of conducting analysis.

A positive correlation is observed between the need of justification of airport expansion and number of airport impact studies. Particularly, the number of airport impact studies coincides with the time of market liberalization - this is because the growing traffic requires infrastructure improvement which leads to airport expansion and may cause disagreement of local community or environmentalists.

INPUT-OUTPUT MODEL AS A TOOL IN THE MEASUREMENT PROCESS OF ECONOMIC AND SOCIAL EFFECTS OF AIR TRANSPORT

Input-output model is a quantitative economic technique that presents the interdependencies between different branches (particular production sectors) of a regional or national economy. It was developed in the thirties- forties and it is used to measure the amount of factors inputs required to produce a given set of outputs [Leontief 1986]. With the use of this tool one can calculates the response of the economy to the changes caused by the implementation of particular project or the modification of policy.

Fundamentals of input-output method have been created by W. Leontief and they were simplified versions of the classical theory of general equilibrium. The economy is presented as a system of interconnected branches and the flow of goods between them connects all sectors of the economy. On the one hand, this flow presents the successive stages of production, on the other, generated values. Therefore the relationships between the various sectors of the economy can be represented by the matrix:

$$X_{11} + ... + X_{1n} + Y_1 = X_1$$
$$X_{i1} + ... + X_{in} + Y_i = X_i$$
$$X_{n1} + ... + X_{nn} + Y_n = X_n \qquad (1)$$

where the output (or value added) of the branch (i) marked as X_i is the sum of the intermediate production X_{ij} made in the branch (i) and consumed in the industry (j), otherwise known as flow of the final demand Y_i of the branch (i) to the branch (j).

Input-output model, which describes the relationship between global product and the end product can be written as a matrix equation:

$$\underline{Y} = (\underline{I} - \underline{A}) \, \underline{X} \qquad (2)$$

The equation 2 is called the Leontief model. Assuming (I-A)10 equation 2 can be written as:

$$\underline{X} = (\underline{I} - \underline{A})^{-1} \, \underline{Y} \qquad (3)$$

where the element $(I-A)^{-1}$ is called the Leontief-inverse and informs about how many units the value of production of industry (i) must increase to achieve an increase of one unit of the final product of the branch (j) with the unchanged final products of others branch. This element is called the coefficients of full material consumption. The extra income generated in the production process is partly used to purchase additional goods and services. The increase in the final demand will be higher than the initial increase in income. This effect is sometimes called the induced impact [Hujer and Kokot 2001].

Extended input-output model, in which the changes of the output ΔX caused by the changes in final demand ΔY can be written as follow:

$$\Delta \underline{X} = (\underline{I} - \underline{A})^{-1} \, \Delta \underline{Y} \qquad (4)$$

The changes in final demand ΔY have an impact on changes in revenue across all sectors of the economy. Vector b includes input coefficient for income generated in every sector of the economy, the element $b_j = W_j/X_j$, where W_j is the income split between households (income from work and profits) X_j is the output of branch (j). ΔW_o is the sum of changes in income across all sectors as a result of changes in final demand ΔY.

$$\Delta \underline{W_o} = \underline{b} \, (\underline{I} - \underline{A})^{-1} \, \Delta \underline{Y} \qquad (5)$$

Indirect income effects of an infrastructure project can be calculated according to the equation 6.

$$\Delta \underline{X}_{indir} = \underline{b} \, (\underline{I} - \underline{A})^{-1} \, \Delta \underline{Y} \qquad (6)$$

While the employment effects are calculated using a sectoral coefficient of labour $(AK_i) = E_i/X_i$ which is the ratio of the number of employees to the gross value.

$$\Delta E_{indir} = \underline{AK} \, (\underline{I} - \underline{A})^{-1} \, \Delta \underline{Y} \qquad (7)$$

Induced effects include the revenue created by the spending of employees in entities directly and indirectly related to the airport. The induced impact is a multiplier effect of the sum of direct and indirect impacts. In order to

calculate the induce effect of an airport one should determine the consumption function and incorporate it into the model inputs and outputs. The matrix multiplier consumption is expressed by a reverse matrix $(I-V)^{-1}$. The relationships between direct effects and induced, as well as intermediate and induced are represented in the equation 8 and 9 [Hujer and Kokot 2001]:

$$\Delta \underline{X}^{dir}{}_{ind} = (\underline{I} - \underline{A})^{-1} (\underline{I} - \underline{V})^{-1} \; \Delta \underline{Y}_{dir} \qquad (8)$$

$$\Delta \underline{X}^{indir}{}_{ind} = (\underline{I} - \underline{A})^{-1} [(\underline{I} - \underline{V})^{-1} - I] \; \Delta \underline{Y}_{indir} \quad (9)$$

Induced effects are calculated using the same interdependencies that occur in indirect effects. The data on the flow of intermediate goods, which are a direct incentive to the creation of an intermediate effect and then induced are used. In order to avoid double counting, in the equation 9, indirect effects were excluded from the induced effects.

The overall effect induced is the sum of the partial results:

$$\Delta \underline{X}_{ind} = \Delta \underline{X}^{dir}{}_{ind} + \Delta \underline{X}^{indir}{}_{ind} \qquad (10)$$

According to the input-output method, the total economic impact of air transport is the sum of direct, indirect and induced effects. In some studies input-output effects are calculated differently however their definitions are fairly homogenous.

The input-output model mainly measures income and employment generated by the operation of an airport. Earnings and fiscal effects are expressed in monetary terms and flow in economy being stimulated by the changes in the size and structure of the production. Employment effects result from changes in the physical resources. Technical and technological changes are supposed to be included in the calculation of the effect of employment. The standard input-output analysis does not include the effect of price changes. The results of input-output analysis are expressed in nominal terms and refer to a certain period of time, most often: one basic year.

THE EXAMPLES OF APPLICATION OF INPUT-OUTPUT MODEL – POLAND CASE STUDY

The first airport impact analysis in Poland was conducted in 2005 by the research team from Poznan University of Economics. The study focused on the impact of Poznan Airport on the economy of the city and region. The method was constructed to capture the direct, indirect and induced effects generated by the operation of an airport. Due to differences in market characteristic there was a need to adapt the ACI methodology to polish conditions. The study was repeated at main regional polish airports in Wroclaw, Gdansk, Katowice and then in central airport in Warsaw. Then the analysis was continued and the methodology has been enriched by the experience gained during the previous studies in 2005-2008. The research subjects of the analysis conducted in 2010 were three regional airports located in Poznan, Katowice and Gdansk (Table 1). The criterion for selection of the airport was socio-economic profile of regional economy and the volume of air traffic. The inability to quantify all variables and identify correlation between them obligated to make cautious conclusions. Data has been collected between April and September 2010. Due to the fact that financial data relate to 2009 fiscal year, this period was adopted as a base for estimating the economic effects. Is should be noted that due to the financial crisis in 2009 air transport market experienced a decrease in air traffic. Therefore, the actual size of the economic impact was probably greater than the estimated effects.

After the economic crisis, which peak was in 2009 and in which the largest downfall of air transport movements was recorded, air transport in Poland began to grow and airports infrastructure continued to develop in order to meet the growing air traffic needs, as well as through investments related to the preparation of the country for the organization of UEFA Championship in 2012. Undertaking the airports infrastructure investments meant that employment was raised and the regional income was increased by the companies implementing the infrastructure projects. However, these are demand-side effects, short-term, which will end with the completion of the construction phase [Rietveld and Bruinsma

1998]. The long-term impact is the employment growth in the companies directly associated with the operation of an airport, including the airport operator, ground handling or trade and services companies. At the airport in Wroclaw after the expansion of passenger terminal the direct employment has increased almost by half from 1,044 in 2010 to 1,476 in 2012. [Pancer-Cybulska et al. 2014]. Therefore

transport investments are important factor for creating the economic impact [Allroggen and Malina 2014]. Additional factor generating employment is active operation of carriers. Wizzair has established its base in Wroclaw in 2010 and Ryanair in 2012. It is estimated that basing one aircraft LCC airlines at the airport contributes to the creation of approx. 35 work places [Pancer-Cybulska et al. 2014].

Table 1. Direct, indirect and induced economic impact of polish airports in 2009
Tabela 1. Bezpośredni i wspomagany wpływ ekonomiczny polskich lotnisk w 2009

	Direct impact		Indirect impact		Induced impact	
	Employment ΔE_{dir}	Income (M EUR) ΔX_{dir}	Employment ΔE_{indir}	Income (M EUR) ΔX_{indir}	Employment ΔE_{ind}	Income (M EUR) ΔX_{ind}
Poznan	1076	21.1	1070	22.5	59	1.27
Gdansk	1214	25.2	886	18.6	49	1.05
Katowice	1954	37.9	832	17.5	46	0.98

Source: Huderek-Glapska 2012

Table 2. Total economic impact and multiplier of polish airports in 2009
Tabela 2. Całkowity wpływ ekonomiczny polskich lotnisk w 2009

	Direct impact			Total impact			Multiplier	
	Employment	Income (M EUR)	Income per passenger (EUR)	Employment	Income (M EUR)	Income per passenger (EUR)	Employment	Income
Poznan	1076	21.1	17	2205	44.9	35.9	1.05	1.13
Gdansk	1214	25.2	13	2149	44.9	23.8	0.77	0.78
Katowice	1954	37.9	16	2832	56.4	24.5	0.45	0.49

Source: Huderek-Glapska 2012

Generally, a positive correlation between the level of development of air transport and the amount of economic impact generated to the environment is observed. The following chart (Figure 1) illustrates the changes in the number of passengers and the development of direct employment at the Krakow Airport between 2002 and 2012. It is a particular period that includes the time of the biggest changes in the air transport market: 2004 moment of accession to the EU and aviation market liberalization, as well as socio-economic changes, including the opening of labor markets in the UK and Ireland, which had a very large impact on increasing the transport needs of Poles; 2009 - the financial crisis and significant drop in air transport movements. During the time period 2007-2014 many airport infrastructure projects were implemented with the use of EU founds [Jankiewicz and Huderek-Glapska 2015]. For instance at Krakow Airport investments related to the expansion of the passenger terminal and

airport infrastructure and communications were implemented and are still ongoing. These projects are co-financed by the European Union Cohesion Fund under the Program Infrastructure and Environment and the Malopolska Regional Operational Program for the 2007-2013 years.

Despite such large changes in the air transport market experienced by the Krakow Airport, one can observe a strong correlation (R2=0,99) between the level of development of the aviation market expressed in the number of passengers and the economic impact represented by the volume of direct employment at the airport (Figure 1). During the economic crisis in 2008, the volume of direct employment declined although not as much as the number of passengers, but then both of these variables started to grow.
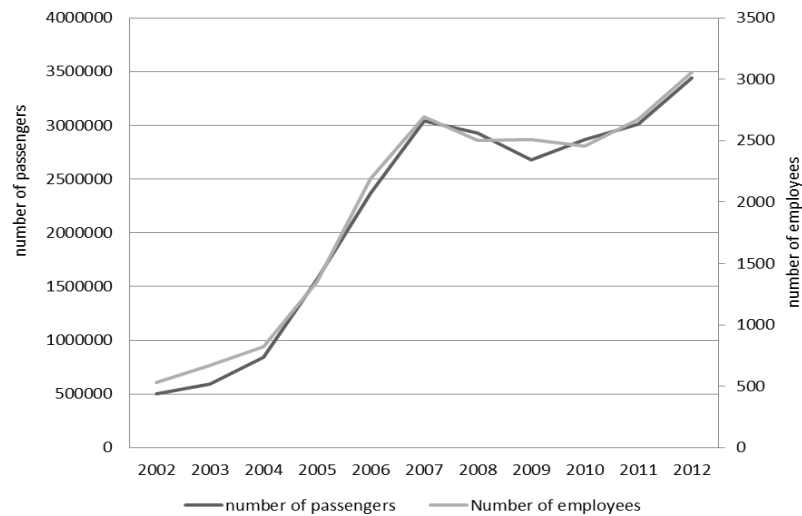
Source: Own calculation based on Krakow Airport statistics and Pancer-Cybulska et al. [2014]

Fig. 1. Number of passengers and number of employees in companies directly related to the operation of Krakow Airport in 2002-2012

Rys. 1. Liczba pasażerów oraz zatrudnionych w przedsiębiorstwach bezpośednio związanych z Lotniskiem Kraków w latach2002-2012
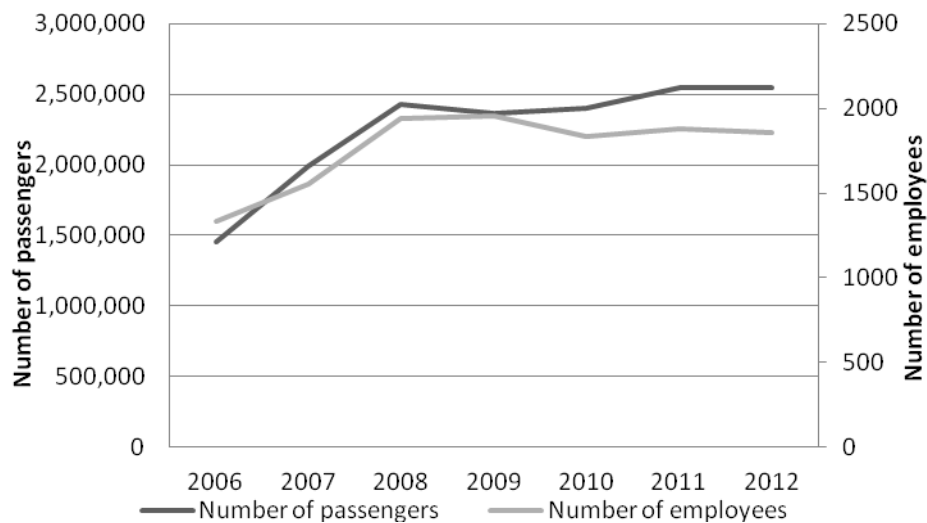
Source: Own calculation based on Katowice Airport statistics and Pancer-Cybulska et al. [2014]

Fig. 2. The number of passengers and the number of employees at Katowice Airport in 2006-2012

Rys. 2. Liczba pasażerów oraz zatrudnionych w Lotnisku Katowice w latac h2006-2012

At Katowice Airport, the number of passengers in 2008 - 2012 was stable despite the economic crisis, which peaked in 2009 (Figure 2), while the employment declined. This was connected among other things to the reorganization of the Border Guard [Pancer-Cybulska et al. 2014]. The biggest increase in the work places occurred in 2004-2007 when the dynamic increase in the number of air traffic movements from Katowice Airport was observed due to an expansion of low cost airlines which resulted in the need for the

expansion of airport infrastructure. The analysis in 2009 and 2012 covered the period after the major changes at the Katowice Airport, which is why the number of companies operating in and around the airport and the structure of airport direct employment, did not change significantly (Table 2).

The development of air transport is likely to create the socio-economic benefits for regional economy. Promoting the development of air transport market contributes to creating positive effects in the environment in terms of creating work places. However there are also negative effects such as noise and air pollution that result from air transport activity and which

should be included in the cost benefit analysis of aviation infrastructure development.

Based on data collected by a research team led by prof. Pancer-Cybulska, an analysis of the impact of air transport on economic development has been conducted and the results of which are presented below. The reference year for the data collected is 2012. Table 2 shows the results of the latest analysis of employment, compared with the results of previous studies. The airport in Katowice is the only one that occurs twice in the study. The latest analysis includes a small regional airport in Szczecin, which in 2012 handled around 350 thousands passengers.

Table 3. Employment structure at polish airports in 2009 and 2012
Tabela 3. Struktura zatrudnionych na polskich lotniskach w 2009 oraz 2012

	Poznan (2009)	Gdansk (2009)	Katowice (2009)	Katowice (2012)	Krakow (2012)	Wrocław (2012)	Szczecin (2012)
Number of passengers (mln)	1.2	1.8	2.3	2.5	3.4	1.9	0.3
Number of companies at airport	82	57	58	57	109	67	17
Employment	1076	1214	1954	1857	3061	1476	390
Employment per million passengers	897	674	850	743	900	777	1300
Employment structure:							
Airport operator and administration	39.1%	31.7%	37.5%	39.8%	50.9%	50.1%	72.1%
Handling	31.6%	29.7%	23.8%	28.2%	27.9%	18.7%	2.3%
Airlines	3.1%	6.3%	7.4%	12.9%	2.3%	6.6%	1.3%
Retail	11.0%	12.4%	12.2%	13.6%	8.7%	11.0%	3.8%
Logistic	12.1%	16.1%	15.7%	5.5%	2.6%	6.8%	5.1%
Others	3.2%	3.9%	3.5%	-	7.5%	6.7%	15.4%

Source: Own calculations based on own research and [Pancer-Cybulska et al. 2014]

The employment structure at Polish airports is not significantly different from the employment structure at other European airports. However the number of direct employment per million passengers handled at polish regional airports (Table 3) is lower than the European average which is 1034 jobs per million passengers at regional airports serving from 1 to 4 million passengers annually [ACI 2004]. The reason for this is low share of commercial activities at airports. Changes began to take place since the liberalization of air transport at the time of Polish entry into the EU, and many years must pass before the Polish aviation market can catch up to the level of development markets in Western Europe.

The structure of direct employment at the airport, to some extent depends on the type and

characteristics of the airport. The one focused on serving the cargo will attract more freight and logistics companies. The airport where airlines have bases will generate employment in the entities providing services to the planes. However, there are some common features in the structure of direct employment at the airports. At the regional airports, the airport operator and administration employ about 30-50% of all employees directly associated with the operation of the airport. It is worth paying attention to their higher share in the small airport in Szczecin (72% - Table 2). This confirms the thesis that there is a minimum level of employment, which is required for the airport to operate. With the development of air traffic and passenger growth, more and more companies are interested in locating their

business at or within the airport. The hub airports such as Amsterdam Schiphol, create the so-called airport cities (Aeropolis, aerotropolis, AIRE, Airport Area) which is the cluster of companies around the airport along with extensive intermodal infrastructure [Schalaack 2009]. Wherein, this area rarely takes the form of a circle, usually entities are concentrated around the airport at irregular distances, and the factors influencing their location are primarily the availability and prices of land and buildings under lease, availability and quality of transport routes or the presence of facilities for investors.

Based on the financial data and the employment figures of the airport operator and the companies operating at the airport and within, the estimates were made of the airport economic impact on the regional development. As a variable number of employees (ΔE) and value-added (ΔX) were adopted. The results of the analysis are interpreted as a direct increase in employment and added value in the region resulting from the operation of the airport.

Direct effect generated by the airport operator and companies located at the airport and in the area within the airport is the most important and rather not debatable impact category. The direct effect of regional airports in Poland was calculated on the basis of work places and added value generated by the companies. Data on the number of employees has been derived from data collected by a research team led by prof. Pancer-Cybulska [Pancer-Cybulska et al. 2014]. The added value generated from the revenue side by the airport operator and entities directly associated with airport operation is calculated based on the number of employees in these companies and an average added value created by a single employee, with respect to the type of company activity and region in which the company is located [GUS 2014]. Results of the analysis are presented in Table 4.

Table 4. Direct economic impact of regional airports in 2012

Tabela 4. Bezpośredni ekonomiczny wpływ lotnisk regionalnych w 2012

Airport	Number of passengers (mln)	Number of companies at the airport	Direct employment ΔE_{dir}	Direct impact-value added (mln EUR) ΔX_{dir}	Direct impact per passenger (EUR)
Kraków	3.4	109	3061	81.1	24
Katowice	2.5	57	1857	51.9	20
Wrocław	1.9	67	1476	40.1	20
Szczecin	0.3	17	390	10.6	30

Source: Own calculations

Among the studied, Kraków Airport creates the largest direct economic impact on the region's economy (3061 direct jobs and 81.1 million EUR of value added in 2012) this is understandable, since it is the largest of the surveyed airports. This is another proof of the thesis that the size of the airport operation has an impact on the size of the positive effects created by an airport on its surroundings.

Beyond the direct impact there are indirect and induced effects - demand impulses that arise as a result of airport activity. The larger the number of entities operating in the airport and within the airport area the greater the number of employees and the greater value of purchases from suppliers, greater value of income from work and greater possibilities of consumption which contributes to the growth of value added level.

Due to the limitation of data availability in the calculation of the indirect and induced impacts the multipliers derived from previous study [Huderek-Glapska 2012] were used. The average value of employment multiplier was assumed at 0.75; and the average income multiplier at 0.79.

The sum of indirect and induced impact is calculated as the multiplication of the direct effect and the multiplier. The total economic impact of air transport on the development of the region's economy is calculated according to the equation (9).

$$\Delta X = \Delta X_{dir} (1+ M) \qquad (9)$$

Table 5. Indirect, induced and total economic impact of regional airports 2012

Tabela 5. Pośredni, wspomagany oraz całkowity ekonomiczny wpływ lotnisk regionalnych w 2012

Airport	Indirect and induced impact		Total impact		
	Employment $\Delta E_{indir} + \Delta E_{ind}$	Income (M EUR) $\Delta X_{indir} + \Delta X_{ind}$	Employment ΔE	Income (M EUR) ΔX	Income per passenger
Kraków	2296	64.1	5357	145.2	42
Katowice	1393	67.9	3250	153.8	62
Wrocław	1107	31.7	2583	71.8	38
Szczecin	293	8.4	683	19.0	63

Source: Own calculations

According to the methodology, airports contributes to the regional economy in terms of employment (ΔE) and income (ΔX). Research results reveals that, on average, polish regional airports contribute directly to the creation of 0.9% of GDP generated in the regional economy. Adding to the indirect and induced impacts the value rises to around 2%. Which is consistent with the results of European airports, by which alone the direct impact of air transport creates on average 1.1% of GDP, and the overall impact is from 0.9% to 2.4% of the regional Gross Domestic Product [Giliingwater et al. 2009]. On average, each passenger contributes directly 24 EUR per year to the region's GDP and nearly the same in an indirect and induced way. In total, one passenger handled from a regional, polish airport contributes on average to the creation of 51 EUR value added in the region per year.

THE PROBLEMS OF AIRPORT IMPACT STUDIES

The airport impact studies based on the simple input-output analysis are widely used all over the world. However there are calls in the literature about misuse of the input-output method and misinterpretation of the analysis results [Montalvo, 1998; Niemeier 2001].

A review of the limitations of input-output method is provided in the paper by Huderek-Glapska [2012]. These are mainly; lack of price effect, difficulties at the data collection stages or differences in defining and calculating each effect. In a large part of U.S. studies indirect effect is calculated on the basis of non-residents expenditure made in the region, in contrast to Europe and Canada

where indirect effect is estimated using input-output multipliers.

Another limitation is the differences in the definition of the impact area of airport, which means that the indirect and induced impact is generated both in the region where the airport is located as well as across the whole country. Moreover the nature of effects varies with the increase in the scope of the study area. When the level of data aggregation is low then the effects can be interpreted as generated by the operation of airport. At the national level the same effects can be interpreted as distributive when there is a change of resource allocation. The fact that the relevant businesses are located in the airport's catchment area does not mean that in the case of the absence of an airport, these companies would stop to operate. The management probably would have chosen a different location characterized by good accessibility, for example road junction.

Since the results of impact analysis are usually based on data collected in the selected base year the outcomes of input-output study are static. Air transport is particularly sensitive to the changes in local and global economic environment. The situation on aviation market can vary significantly between study periods. Analysis conducted during the peak year may overstate test results and conversely conducting economic study during the recession may underestimate the size of the effects. The example of described situation is reflected in this article where data was collected first in 2009 year - during the crisis time and then in 2012 - the peak time when the traffic was increased associated with UEFA Championships. So there is risk that in 2009 the results were underestimated and conversely in 2012 overstated. That is why the static

nature of the results is one the main limitation of input-output analysis.

Apart the factors already stated, the most crucial problem of airport impact studies is that input-output method calculates aviation impact in gross value. All effects are taken into account (called Economic Impact as it is produced - AIIP) [Montalvo, 1998]. In the absence of the airport, the resources would be used, at least partially, in other economy sector. The question about the degree of resource utilization and thus the productivity of labour and capital therefore rises. Does the aviation industry uses resources more effectively than other industries?

The results of airport impact analysis are only part of the total impact of an airport on its surroundings. When assessing the effects generated by airport activity one must consider both the positive and negative effects of air transport operations, including the environmental cost.

IMPROVEMENTS OF AIRPORT IMPACT ANALYSIS

Input-output analysis with price effect

One of the main drawbacks of the airport impact analysis based on the simple input-output model is lack of the price effects [Niemeier 2001]. However the input-output models allow for prices analysis, although, as far as authors know, there is lack of study that would apply this extension in airport impact research.

The prices analysis also rest on the Leontief inverse and its mathematical expression (in matrix form) is as follows:

$$P = (I - A)^{-1} (l + k)$$

P denotes prices, *I* is the identity matrix, *A* is the technical coefficient matrix; *l* and *k* and denotes the labor technical coefficient and capital technical coefficient, respectively. This approach helps in quantifying the changes in prices as a result of exogenous changes in wages or rents of capital.

As it can be seen, both the demand analysis and the prices analysis have to be done separately in the input-output framework. In contrast, computable general equilibrium (CGE) models can tackle both analyses simultaneously.

Dynamic input-output analysis

Input-output models can also cope with time (Duchin and Szyld 1985; Leontief and Duchin 1986). The dynamic approach implies the elicitation of the capital accumulation process because some goods are not used in the current period but in the following ones. The dynamic version (in matrix form) of an input-output model can be written in the following manner:

$$Bx^{t+1} = (I - A + B)^{-1} x^t - D^t$$

where *B* is a coefficient matrix which denotes the amount of the production in one sector held as capital stock so as to produce outputs in other sectors. x^{t+1} is the production in the next period *(t +)*. x^t denotes the production in period *t* and D^t is the final demand in period *t*.

As in the static case, the non-singularity of the coefficient matrix of capital (B) has to be achieved ($|\beta| \neq 0$). However this is not always the case because not all the sectors supply capital goods to other sectors. So, there will be sectors whose rows in the B matrix will contain all zeros and the matrix have no inverse (Miller and Blair 2009). On the other hand, as in the case of dynamic models, dynamic input-output models require both initial conditions/values and terminal conditions/values. Despite this resemblance, both dynamic input-output models and dynamic models differ from each other in their foundations. Nonetheless, some approaches between both kinds of models can be achieved. For instance, a dynamic input-output model can be enriched by including some properties of the endogenous growth model (Los 2001). However, so far, the application of dynamic input-output models has been limited and, in contrast, dynamic models such as dynamic CGE models have been applied more widely.

Finally, input-output models also allow for an alternative approach to dynamics, the so-called "structural decomposition analyses". Briefly, the standard approach decomposes the total amount of change into several components such as changes in technology and changes in final demand over the period analyzed (Rose 1996; Miller and Blair 2009).

Computable General Equilibrium models (CGE)

CGE models can be described as a set of equations solved simultaneously to find prices at which quantity supplied equals quantity demanded (equilibrium) across all (general) markets. CGE models describe the economy using representative agents: consumers, producers, government and other institutions. Consumers allocate time to employment and leisure and income to consumption and savings to maximize utility. Producers combine labour and capital inputs to maximize profits, whereas government collects tax revenue to finance expenditure and make transfers to households and investors. CGE models can broadly be distinguished according to their level of spatial detail (i.e. national, multi-country, regional or multi-regional) or to time dimension (static versus dynamic).

Table 6. Comparison Input-Output and CGE
Tabela 6. Prównanie wejścia-wyjścia oraz CGE

	Input-Output	CGE
Major output	**Range of macro-economic variables**: GDP, employment, income	**Range of macroeconomic variables:** Relative prices, employment, consumption, income, investment, taxes, imports, exports, Industry output, GDP, welfare
Advantages	Provides measure of macro-economic impacts of interest to policy makers	Provides measure of macro-economic impacts of interest to policy makers, Non-linear behavior, Flexible structure, Resource constraints
Limits	Linear structure Tend to exaggerate economic impact (does not allow constraints on various factors) No allowance for environmental externalities Does not provide clear and direct measure of net benefits (costs)	High data requirements, determination of parameters and elasticity values, highly complex, not good for monetary policies.
IO vs CGE	Complexity: medium. May be more practical than CGE for analyzing the path through which changes in sector travel to affect other sector as well as linkages between sectors.	Complexity: large IO can be used as a base for CGE Allowance for constraints provide more realistic modeling of output than IO and more comprehensive approach to the estimation of regional economic impacts Unlike IO specific assumptions about the behavior of consumers, producers and investors

Source: (adapted from MOTOS, 2007 and Wallis, 2009)

CGE models are good for analyzing policies that affect different sectors in different ways. They can help capture the impacts of a policy on factor (capital, labor and land); on commodity markets; on households' types and on different regions. CGE models are also good for understanding the welfare and distributional impact of alternative policies.

CGE models have been extensively used since the 1970s for the evaluation of trade and fiscal policies and for the quantification of the impacts of various shocks on the economy at both national and regional levels. The application of CGE models on airport investments is much more recent (Madden, 2003; Deloitte Access Economics, 2013; PwC, 2014).

Table 4 highlights the main differences between IO and CGE. CGE models have a solid microeconomic foundation and are capable of capturing the indirect and feedback effects of a wide range of possible policy change without excessive simplification and aggregation. CGE models which takes into account and allows for the negative as well as the positive impacts of policy changes or

shocks. Criticisms of CGE models include the reliance on the elasticity parameter values and the lack of financial or monetary aspects.

CONCLUSIONS

Operation of an airport undoubtedly creates economic benefits for the economy. This is confirmed by the analysis of international airports all over the world, and also by national studies presented in this article. An airport together with companies operating within its surroundings create demand effects that results in creating work places and income. This significant impact represent around 2% of GDP of regional economy. On average, one passenger handled from a regional airport contributes to the creation of around 51 EUR of regional income per year. This means that if one airline carries an average of 20 thousand passengers from the regional airport on one route per year, it will contribute to the creation of around 1 million EUR income per year.

Significant economic effect created by the operation of an airport in a region is an important argument in decisions concerning the expansion of existing airport infrastructure and creating a new one. However, the input output analysis in addition to other drawbacks does not include information on the financing of an infrastructure project. Airports in Poland, are in majority public ownership and conducting public investment is associated with increasing public debt. The profitability of investment in infrastructure will reveal in a long term analysis or study. However building the airport to become the main driving force of the regional economy development if there are no other influential factors such as positive economic and political conditions can cause that the potential of the region not to be fully exploited (sentence is too long, needs to be rewritten). Therefore, the objective of undertaking investments in infrastructure will not be achieved and the allocation of public money will be inefficient. Transport infrastructure is only one of many factors affecting the development of a region and it is not the sole and sufficient condition for generating development.

Therefore, it is important to properly and accurately recognize the impact of air transport on the environment. If the significance of the airport for the region is an important argument in the infrastructure development decision process the one should strive to ensure thi impact is precisely reflected. To this end, improvements of the input-output method including consideration of the effect of prices and the dynamics have bee proposed. The comprehensive assessment of airport operation and expanding its infrastructure requires comparing the economic benefits with economic costs.

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MODELOWANIE WPŁYWU TRANSPORTU LOTNICZEGO NA GOSPDOARKĘ - PRAKTYKA, PROBLEMY I PERSPEKTYWY

STRESZCZENIE. **Wstęp:** Tematyka roli transportu lotniczego w rozwoju gospodarki regionalnej jest bardzo aktualna w dzisiejszych czasach, kiedy realizowanych jest wiele projektów inwestycyjnych w infrastrukturę lotniskową, z wykorzystaniem środków finansowych z funduszy Unii Europejskiej. Rosnące potrzeby transportowe i wzrost dochodów ludności, oznaczają, że rynek transportu lotniczego rozwija się i będzie rozwijać się w przyszłości. Temu wzrostowi towarzyszą korzyści bezpośrednie i pośrednie, które pojawiają się w otoczeniu społeczno-ekonomicznym portu lotniczego oraz w całej gospodarce. Pomiar tych korzyści jest istotny, ponieważ decyzje podejmowane w odniesieniu do transportu lotniczego mają wpływ na lokalną i regionalna gospodarkę. Najpowszechniej stosowanym narzędziem do pomiaru efektów związanych z funkcjonowaniem lotniska jest analiza nakładów i wyników. Celem artykułu jest przedstawienie charakterystyki metody nakładów i wyników, ukazanie jej zastosowania w pomiarze społeczno-ekonomicznych efektów transportu lotniczego w Polsce - kraju o największej dynamice rozwoju rynku lotniczego oraz przedstawienie możliwych ograniczeń metody wraz z propozycją jej ulepszeń.

Metody: Narzędziem zastosowanym w badaniu jest metoda nakładów i wyników za pomocą której dokonuje się pomiaru zmian w gospodarce wywołanych aktywnością transportu lotniczego.

Wyniki: Na tle wyników analizy wpływu polskich portów lotniczych na gospodarkę kraju, przeprowadzonej w 2009 roku, ukazano rezultaty najnowszych badań opartych na danych odnoszących się do 2012 roku. Przedmiotem badań są porty lotnicze w Krakowie, Katowicach, Wrocławiu i Szczecinie. Następnie ukazano ograniczenia metody nakładów i wyników i zaproponowano ulepszenia tego modelu.

Wnioski: Właściwy pomiar wpływu funkcjonowania portu lotniczego i efektów wynikających z podejmowania inwestycji lotniskowych na gospodarkę regionalną, prowadzi do bardziej skutecznej polityki rozwoju sektora transportu lotniczego i polityki rozwoju regionalnego. W kolejnych badaniach społeczno-ekonomicznych efektów transportu lotniczego zalecane jest zastosowanie zaawansowanej metody nakładów i wyników.

Słowa kluczowe: port lotniczy, rozwój regionalny, analiza nakładów i wyników.

MODELLIERUNG DES EINFLUSSES DES FLUGTRANSPORTS AUF DIE WIRTSCHAFT - PRAXIS, PROBLEMSTELLUNGEN UND PERSPEKTIVEN

ZUSAMMENFASSUNG. Einleitung: Die Thematik der Bedeutung des Lufttransports für die Entwicklung der Regionalwirtschaft ist gegenwärtig sehr aktuell, zumal viele Investitionsprojekte innerhalb der Luftfahrt- und Flughafen-Infrastruktur mit Inanspruchnahme von Finanzmitteln aus der Europäischen Union realisiert werden. Der wachsende Transportbedarf und die Erhöhung von Einkommen bei der Bevölkerung haben nämlich es zur Folge, dass der Lufttransport-Markt einer ständigen Entwicklung unterliegt und auch in Zukunft ihr unterliegen wird. Der Entwicklungs- und Wachstumstrend wird von mittel- und unmittelbaren Vorteilen begleitet, die im sozial-wirtschaftlichen Umfeld eines Flughafens und in der Gesamtwirtschaft in Erscheinung treten. Da die den Lufttransport anbetreffenden Entscheidungen die Lokal- und Regionalwirtschaft beeinflussen, scheint die Bewertung dieser Vorteile sehr relevant zu sein. Als das meist angewendete Tool für die Bewertung der mit Funktionsausübung eines Flughafens zusammenhängenden Effekte gilt die Aufwands- und Ergebnisanalyse. Das Ziel des Artikels ist es, die Charakteristik der Aufwands- und Ergebnismethode darzustellen, ferner deren Anwendung für die Auswertung der sozial-ökonomischen Effekte des Lufttransports in Polen, dh. im Lande von der höchsten Entwicklungsdynamik innerhalb des Flugtransport-Marktes zu projizieren und die potenziellen Einschränkungen bei der Anwendung der betreffenden Methode, sowie die Vorschläge für ihre Verbesserung aufzuzeigen.

Methoden: Das in der Erforschung des Problems angewendete Tool ist die Aufwands- und Ergebnisanalyse, mit Hilfe deren die Bewertung der infolge der Betätigung des Lufttransports erfolgten Veränderungen innerhalb der Wirtschaft zustande kommt.

Ergebnisse: Gestützt auf die Ergebnisse der 2009 durchgeführten Analyse des Einflusses polnischer Flughäfen auf die Volkswirtschaft projizierte man die Resultate der neuesten Forschungen, die auf die Daten vom Jahre 2012 zurückzuführen sind. Der Untersuchungsgegenstand sind die Flughäfen in Kraków, Katowice, Wrocław und in Szczecin. Demzufolge stellte man auch die Einschränkungen bei der Anwendung der Aufwands- und Ergebnismethode dar und schlug man brauchbare Verbesserungen des betreffenden Modells vor.

Fazit: Die richtige Bewertung des Einflusses der Funktionsausübung eines Flughafens und der Effekte, die aus der Inangriffnahme von Flughafen-Investitionen der Regionalwirtschaft zugunsten resultieren, führt zur Handhabung einer mehr effektiven Politik bei der Entwicklung des Lufttransport-Sektors und der Politik der erfolgreichen Regionalentwicklung. In den weiteren, die sozial-wirtschaftlichen Effekte des Lufttransports anbetreffenden Forschungen wird die Anwendung einer fortgeschrittenen Aufwands- und Ergebnismethode empfohlen.

Codewörter: Flughafen, Regionalentwicklung, Aufwands- und Ergebnisanalyse

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CONCEPTION OF INTEGRATOR IN CROSS-BORDER E-COMMERCE

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ABSTRACT. **Background:** E-commerce is one of the most dynamic and important sectors of the economy. The latest trend in this market is cross-border trade. It is based on selling products to customers who are located in other countries. However, it is connected to several problems, such as a high cost and long time of delivery, language barriers, different legal and tax conditionings, etc.

Methods: The studies were conducted on the basis of the authors' experience in the field of e-commerce. The issue of cross-border commerce was mainly analysed with the use of reports of the European Commission. The aim of the article is to propose a conception of an integrator of cross-border e-commerce, which will make it possible, among other things, to solve logistic problems.

Results: The article presents an authorial conception of an integrator in cross-border e-commerce. Its main task is to integrate the whole supply chain. Thanks to the economies of scale, obtained as a result of consolidation of parcels from many e-shops, the integrator is able to achieve lower delivery costs in international transport, make returns of goods more effective and serve customers from different countries better.

Conclusions: The conception of an integrator in cross-border commerce proposed in the article may increase competitiveness of micro and small e-enterprises, especially in the international arena. Moreover, applying this conception may contribute to a rise in the attractiveness of cross-border commerce, which, as result of a greater sale level, would contribute to an increase in the total e-commerce.

Key words: e-commerce, cross border e-commerce, integration of supply chain.

E-COMMERCE

E-commerce is a set of transactions made by computer networks. These transactions most frequently concern the purchase or sale of goods and services ordered electronically, but the payment for and delivery of the goods or services may be performed in any form (also outside the network) [Central Statistical Office of Poland 2013]. The most popular method of carrying out these transactions is through the Internet, hence the name electronic commerce.

Initially, i.e. in the 1980s, e-commerce took place with the help of Electronic Data Interchange (EDI). It was, however, a solution for the largest enterprises. Later, thanks to dynamic development of the Internet, e-commerce became available for almost everyone.

Although trade conducted via the Internet has had short history and, initially, its importance was marginal, it currently constitutes one of the most dynamic and significant areas of the economy of many countries, including Poland. For the already existing enterprises it has created new possibilities to compete and expand on a larger scale, and for the newly-emerging ones - prospects for fast development. This is possible thanks to low barriers to entry, which

encourage more and more companies to sell their products via the Internet [e-Commerce 2015].

According to the European Commission, e-commerce is the main factor of economic growth and increasing employment levels in the whole European Union. E-commerce gives jobs, directly and indirectly, to 2m people. It is estimated that, altogether, there are approximately 550 thousand e-enterprises in Europe, which send 3.6bn shipments a year [Ecommerce Europe 2013]. The turnover of e-commerce in Europe was €423.8bn in 2014, which was a rise of 14% in relation to the previous year [Gemius 2015].

The level of advancement and popularity of e-commerce varies greatly in individual member states of the European Union (EU). The British market is the largest one in Europe - the total turnover in 2013 amounted to €96.2bn. Next come Germany (€63.4bn) [Fundacja im. Lesława A. Pagi 2015] and France (€51bn) [Ecommerce Europe 2013].

E-commerce in Poland is one of the fastest growing in Europe. The development rate is around 15-20% a year. In 2014 its value was approx. PLN26bn (€6.3bn) [Fundacja im. Lesława A. Pagi 2015]. This year the turnover is expected to exceed PLN31bn. According to different sources, the number of Internet shops is 15-20 thousand. It is estimated that after 2015 there may even be 22 thousand of them [http://proseedmag.pl 2015].

Currently, more than a half of Polish people (54%) are buying products or services on Polish Internet sites. This is 9 percentage points more than last year [Gemius 2015]. According to studies by Gemius (2015), the main reasons why Poles do shopping via the Internet are convenience in the form of round-the-clock access to shops, lower prices, more choice than in traditional shops and easy comparison of the different offers available on the market. Additional arguments for Internet shopping are convenient forms of delivery and return of the purchased goods - direct home/work delivery with the use of CEP operators (courier, express, post companies).

E-COMMERCE LOGISTICS

One of the key areas of e-commerce is logistics, which comes down to such processes as: supplying e-shops, storing and managing goods, shipping them to customers and returning goods. Efficient logistics enables not only to attract new customers (through availability of goods, different forms of delivery and a low cost of shipment), but also to keep those who have already placed an order (through timeliness, accordance to the order, lack of damages) [Kawa 2014b].

E-commerce is becoming more and more demanding in terms of both innovative business models and consumers' expectations. The logistic needs of this market are varied due to growing diversity of products (e.g. books, clothes, consumer electronics, domestic appliances, building materials), due to the value, importance and size [European Commission 2012]. Customers increasingly care about receiving information about the shipment in real time, simplified and free returns of goods and flexible delivery options.

Currently, a few logistic trends that will determine further development of this line of business may be distinguished in e-commerce. These are, among others, logistics of returns, same-day delivery services, development of new logistic co-operation models (dropshipping, fulfilment, one stop e-commerce), broking services and cross-border transport [Kawa 2014b]. The first four trends will be briefly described in the further part of this chapter, while cross-border transport will be discussed in a separate one.

Logistics of returns in e-commerce is mainly dealt with by CEP operators. Returns may concern damaged products and those to be repaired. Their number is, however, relatively small, and the goods usually get to a service centre, often avoiding the shop where they were bought. Most frequently, goods purchased via the Internet are returned because they do not meet the buyer's expectations, have technical faults, are delayed or ordered by mistake. Such shipments get back to the e-sellers. A customer who entered into a contract of purchase via the Internet is entitled to back out of the contract without giving the reason

within 14 days, on the basis of the Act on consumer rights of 30 May 2014.

Recently, shopping with the help of mobile devices has been developing dynamically. This is connected with greater and greater availability thereof, cheap access to the Internet, mobility of people (especially young ones) and their constant lack of time. It affects the logistics of online shops to a large extent. Firstly, the goods are delivered to different places, and the buyer wants to be able to dynamically change the delivery destination. Secondly, the customer - user of a mobile device - does not like to wait too long. The delivery should, therefore, be as fast as possible - preferably within the next working day or even the same day. To date, same-day deliveries are dedicated and very expensive services, because they are connected with direct delivery from the sender to the receiver, omitting intermediate points [Kawa 2014a].

In e-commerce, besides outsourcing deliveries of goods, services of warehousing and order processing are commissioned to external companies more and more often. Three basic models of co-operation may be distinguished: dropshipping, fulfilment and one stop e-commerce. Dropshipping is connected with sending the goods directly from the subject's (producer's, distributor's) external warehouse to the customer, omitting the seller's warehouse. This service consists in storing products, taking orders and collecting them, issuing sales documents and sending parcels to Internet users. Fulfilment, in turn, is a service that consists in taking over all of the logistic processes, e.g., of an Internet shop, by an external operator. On behalf of the customer, operators receive deliveries at the warehouse, manage the stocks, do the stocktaking, process orders from customers, pack shipments, prepare sales documents (e.g. invoices, receipts) and shipping documents (e.g. a shipping list), deal with returned goods, co-operate with transport companies. Such a solution is very flexible, because a specialist fulfilment operator is able to adjust to the customer's changing demand depending on their needs, e.g. by increasing or decreasing the warehouse surface or number of employees. One stop e-commerce, in turn, is fulfilment extended to additional services. This idea

assumes support in the field of logistics (just as fulfilment does) as well as in the area of customer service, marketing, IT solutions and finance and accounting by one company. For example, a call centre may be run in many languages on behalf of a customer, where enquiries, complaints, etc. are handled.

Just a few years ago e-customers could choose from cheaper, but slower and less convenient, postal services or much more expensive, faster and direct courier deliveries. Prices of courier shipments were even 4-5 times higher than postal ones for individual customers and small enterprises, whose number is the greatest in e-commerce. In the case of a low-value purchase, there was no alternative for these two types of deliveries - courier services simply did not pay. A niche appeared, then, and independent subjects decided to fill it. These subjects were CEP intermediaries (called brokers), who represented courier companies in contact with senders of shipments. The model of co-operation is very simple. Namely, an intermediary enters into a very favourable contract with a courier, declaring a large number of shipments. Then, they offer CEP services to natural persons and companies that cannot or do not want to sign contracts with carriers. What is usually necessary to enter into such a contract is running a company and a declaration of the minimal number of parcels to be sent [Kawa 2015].

CROSS-BORDER E-COMMERCE IN EUROPE AND IN THE WHOLE WORLD

E-commerce, just like the Internet, is characterised by a lack of borders, thanks to which customers can do shopping via the Internet from the furthest corners of the world. Although most customers who do shopping online still choose national Internet shops, purchases from shops located outside the country enjoy more and more popularity. This is the so-called cross-border e-commerce.

Cross-border e-commerce has a huge potential because 37.5% of the EU population lives in border areas [European Commission, 2015d]. It accounts for 10 to 15% of the

e-commerce market [Leeuwis, Lukic and Van Heel 2014]. In 2014 in the European Union (EU) 15% of inhabitants did shopping from sellers from a different country. This translates into a rise in the share of this kind of trade by 25% in relation to the previous year [Ecommerce Europe 2015].

The share of cross-border e-commerce in Poland in the total e-commerce market is still small. Even though 13% of all the surveyed subjects admitted that they used foreign Internet shops [Gemius 2015], in 2014 only 4% bought goods online from a seller located in a different country, which placed Poland in the last but one place in the European Union. Luxembourgers (65%) and Austrians (40%) came first and second, respectively; Romanians (1%) came last. The EU average is 15% [Ecommerce Europe 2015].

According to the Ecommerce Europe organisation (2015), the fact that last year almost all member states of the European Union noted an increase in the share of cross-border e-commerce proves that it will be one of the main factors driving the e-commerce market in Europe and the whole world. The Boston Consulting Group estimates [Leeuwis, Lukic and Van Heel 2014] that by 2025 the annual value of the global income from cross-border e-commerce may amount to 250 to 350 billion dollars (this income is now valued at 80 billion). According the data of the Nielsen company, in turn, the cross-border commerce is to be worth as many as 308 billion dollars in 2018 (http://proseedmag.pl, 2015). It is estimated that Asia (40%) will have the greatest share in cross-border e-commerce, Europe (25%) and North America (20%) will come next [Leeuwis, Lukic and Van Heel 2014].

PROBLEMS CONNECTED WITH CROSS-BORDER E-COMMERCE

The main difference between cross-border e-commerce and national trade is that in the case of the former, shopping is done from sellers located in a foreign country. As a result, apart from standard problems which e-shops struggle with in cross-border e-commerce, the following should also be taken into account:

- delivery cost,
- time and quality of delivery,
- communication in a foreign language,
- payment currency,
- payment terms,
- legal and tax conditionings,
- dealing with returns.

One of the greatest barriers in cross-border e-commerce is the delivery cost. When ordering goods in a foreign shop, the customer may even pay several times more than if s/he ordered the same product in a shop located in Poland [Kawa 2015a]. This may seriously discourage customers from a decision to purchase in shops located abroad. A low shipment cost is critical from consumers' point of view. Research suggests that 90% of consumers are more willing to re-purchase from the same seller if they find the delivery cost satisfying [Copenhagen Economics 2013].

Right after the delivery cost, one of the most important factors affecting customer satisfaction is the order fulfilment time. In the case of cross-border e-commerce, satisfying the customer is more difficult due to the distance between the seller and the customer. Mostly (mainly outside border areas), it is much greater than in the case of national shipments. In international trade, shipments often have to be subjected to additional operations, such as clearing through customs, which prolongs the delivery fulfilment time. What matters to customers besides time is the certainty of having the product delivered. When placing orders in foreign shops, customers are concerned about when, but also if at all and in what condition they will receive the parcel. According to the studies conducted by The European Consumer Centres' Network [2011], 49% of consumers do not decide to buy in foreign e-shops for fear of possible delivery problems.

The website, enquiries about the offer, or dealing with the return of goods are only a few aspects that require communication in a language understood by both sides. Studies suggest that only 61% of e-shops located within the European Union offer information in more than one language [The European Consumer Centres' Network 2011]. An offer in

a language that the customer cannot speak discredits the seller at first contact.

Another issue is the currency in which the products offered by the sellers are priced. Customers are more willing to do shopping at shops that offer their national payment currency. Research proves that, on average, 1/3 of consumers leave the website of an e-shop which presents prices in a foreign currency only, and almost 40% of consumers declare no desire to return to websites of such shops [E4X Cambridge Mercantile Group of Companies 2013].

The form of payment is another issue. The lack of well-known to the customer methods of payment may also lead to the abandoning of a purchase. Even though the substantial improvements in international banking services have been made in recent years (payment procedures simplification, fees reduction, credit and debit cards payments popularisation), still not all of the e-shops offer the generally accepted forms of payments. The surveys show that in the European Union (EU) credit card is accepted method of payment in 95% of e-shops, payment via debit card is possible in 65% e-shops, 51% of them supports online payments, 43% accept transfers via banks and payment by the cash on delivery is possible in 20% [The European Consumer Centres' Network 2011].

As in the case of international trade, in cross-border e-commerce the law and taxes play an important role. These two elements still are not clear and unambiguous in cross-border e-commerce. The uncertainty of the end price (including all taxes, duties and banking fees) discourages the customers to purchase from the foreign e-shops effectively. The survey of FTI Consulting [2011] conducted on the request of the European Commission shows that the 57% of Europeans do not shop online cross-borders because of the concerns about returning goods and resolving issues with faulty products and uncertainty about consumer.

In case of products ordered from abroad, the return services are particularly important. The return of goods purchased online cross-border is strictly related to the all above mentioned issues: language - returning goods requires a contact with the seller to specify terms of the return and reimbursement (or to find, read and understand the policy of returning goods if the seller has published it on his web page); currency and form of payment - the customer may not be sure how the refund will be processed (changes in currency exchange rates may cause that the customer will not receive exactly the same amount of money that he paid for the product); delivery costs - the customer has to return the products on his own expense, which in case of more expensive international shipment has a significant impact on the attractiveness of the online shopping cross-border; time and delivery quality - the customer receives the reimbursement only after the seller receives the returned product, in case of international shipment this may affect the timing of the refund. The studies show that in online purchases cross-border in 57% of cases customers do not receive the compensation they are entitled to. According to the EU regulation the consumer is entitled to receive the amount of money which is equal to the product price and the delivery costs however still not all of the sellers comply with it [The European Consumer Centres' Network 2011].

To keep the dynamic growth of cross-border e-commerce sector, the elimination of the above mentioned issues is required. Public institutions and non-governmental organizations undertake a number of activities to increase the competitiveness of online shopping cross-border. In Europe cross-border e-commerce has been developed for many years by the European Union. The European Commission (EC) is the author of numerous policies and regulations aimed at developing public trust in the e-commerce sector. According to the EC [2015b] one of key elements which have the greatest impact on the growth of the e-commerce sector is the right delivery service. One of the EC's top priorities is elimination of these constraints to implement the Digital Single Market in the EU. The Digital Single Market Strategy is built on three pillars: (1) better access for consumers and businesses to digital goods and services cross Europe; (2) creating the right conditions and a level playing field for digital networks and innovative services to flourish; (3) maximising

the growth potential of the digital economy. This strategy is aimed at the development of small and medium enterprises (SME) in particular. The EC's activities are intended to regulate consumer rights, increase shipment efficiency and lower delivery costs [Ecommerce Europe 2015].

Other world regions undertake similar actions. Asia is particularly active in this matter. International trade has been developed in Asia through Free Trade Agreements like ASEAN Free Trade Agreement (AFTA). AFTA is a collaboration between countries of southeast Asia and enables the members to trade internationally on concessional term. AFTA, like the UE, supports cross-border e-commerce development through actions aimed at the reduction of regulations [The Economist 2014].

E-INTEGRATOR MODEL

According to the EC's Green Paper the attractiveness of online shopping is determined by three main factors [European Commission 2012]:
− product price (including the delivery price)
− place and time of delivery,
− information transparency (return options, track and trace possibilities, etc.)

Taking into account all of the issues that e-shops are facing, a proper quality of services in those above mentioned areas is not easy to provide. For small and medium enterprises this task may be especially difficult. SME do not have bargaining power as high as the large companies do. In consequence SME are less competitive. Thanks to the higher efficiency through economies of scale and more financial resources, big companies may offer multilingual customer service and negotiate prices with logistics operators. In effect, shopping in these companies is more attractive for customers.
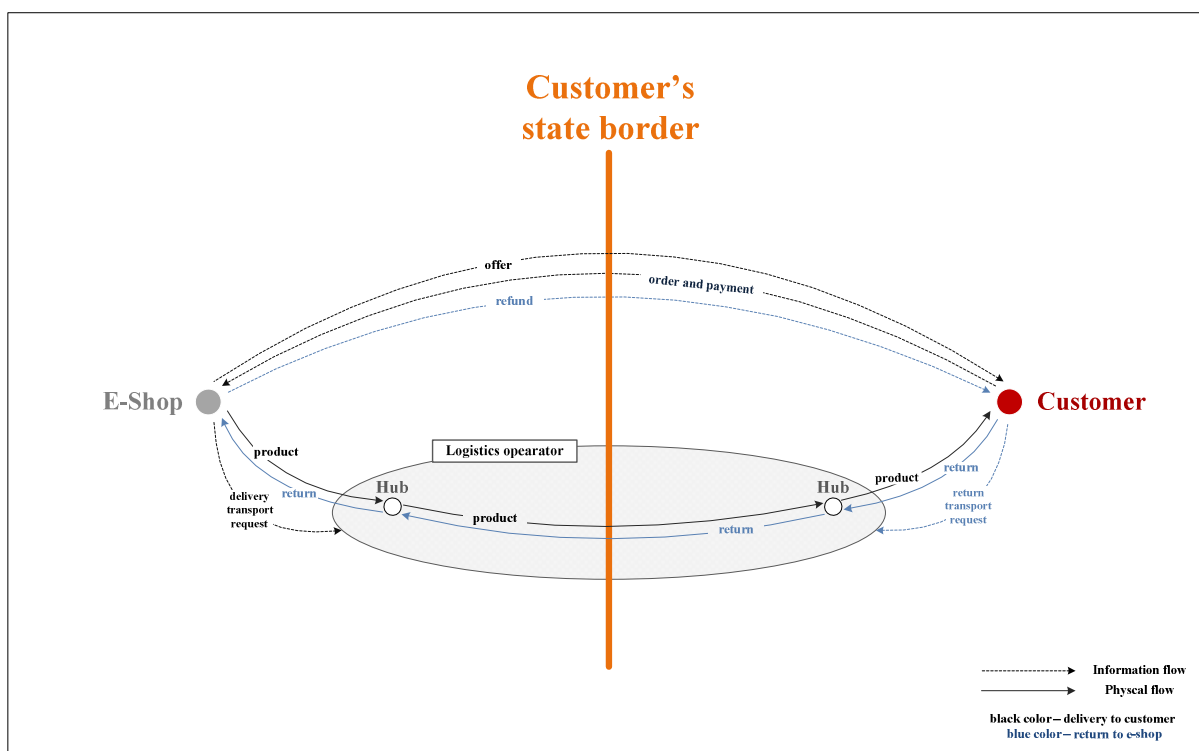

Fig. 1. Traditional e-commerce model
Rys. 1. Tradycyjny model e-handlu transgranicznego

Considering the fact that SME operating online represent a major part of the e-commerce sector - SME make up 85% of Polish e-commerce sector [Kawa 2014a], establishing proper conditions for cross-border e-commerce development of SME seems to be especially necessary.

The cross-border e-commerce model is very similar to the domestic one (hereafter referred to as "traditional e-commerce model"). The model is shown in the figure 1.

The traditional e-commerce model has numerous SME development constraints. The reason of it are the issues described in previous paragraph. Operating in international markets requires from the entrepreneurs additional work like a preparation of offers in foreign languages (in languages native to the customers or generally recognized as international ones like English). Entrepreneurs are obligated to comply not only with the international trade law but also with local customer's state law. One of the biggest constraints for SME is product delivery. Because of the smaller volume of parcels sent abroad small and medium companies are not able to negotiate with logistics operators like the big enterprises do. Due to the lack of scale SME are facing higher delivery costs.

Taking into account all the issues that SME are facing, achieving the competitive advantage in cross-border e-commerce might not be easy for those companies. Therefore finding a solution which will raise the competitive advantage of SME in such a rapidly growing sector of economy seems to be especially important. The European Commission and other research institutions indicate that the broadly defined supply chain integration is one of the main factors which may enhance the competitiveness of the cross-border e-commerce [Grzybowska 2013]. The Copenhagen Economics' survey [2013] shows that the e-shops that are able to send shipments in bulk compared to small e-shops that order delivery as a single piece shipments save at least 18% per parcel on average. Therefore there is a need for the international shipment services integration dedicated to the small and medium enterprises.
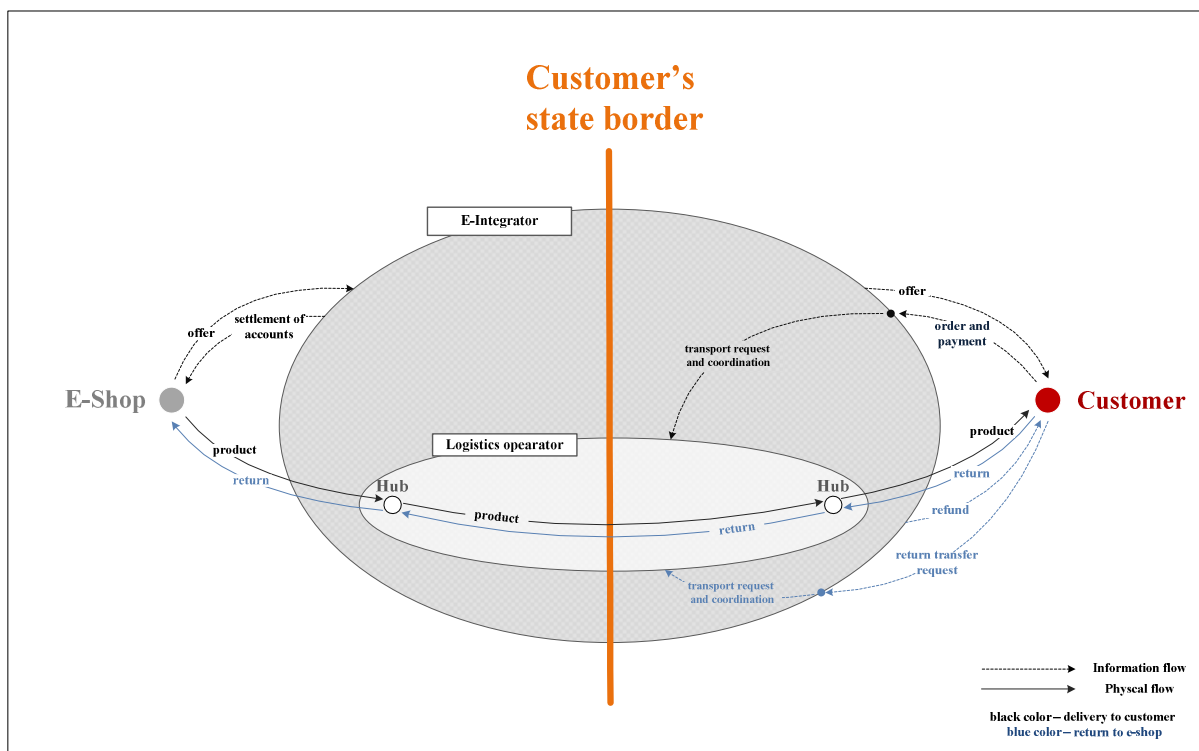

Fig. 2. Integrated cross-border e-commerce model
Rys. 2. Integracyjny model e-handlu transgranicznego

A solution for the identified and described in this article constraints may be creation of a cross-border e-commerce integrator (hereafter referred to as the e-integrator). The e-integrator would operate on local markets, where local market is understood as a one state or a group of states operating under similar legal, economic and cultural conditions. The e-integrator's role would be representing the foreign e-shops on its local market. The e-integrator model is shown in figure 2.

The e-operator would be obligated to:
− offer foreign e-shops products on its local market
− organize the delivery to the customer
− handle returns
− provide customer service

Using a dedicated online platform the e-integrator could offer products of the foreign e-shops on its local market. On the market where the e-integrator operates products would be offered in the language and in the currency native to the customers' state. Similar to the well-known web portals like E-Bay.com, Allegro.pl or Alibaba.com the products could be offered by the different entrepreneurs using predefined templates provided by the portal. The e-integrator could support e-shops in translation of the offers published on its portal or even provide a translation services. Unlike the above mentioned web portals, the e-integrator role would not end with the sales transaction. The integrated cross-border e-commerce model assumes the integration along the whole supply chain. The e-integrator, like the courier brokers, could offer lower international delivery costs. Thanks to the economy of scale, gained through consolidation of parcels from different e-shops, the e-integrator would be able to negotiate rates and service terms with logistics operators. Having all of the necessary information like purchase orders, terms and place of delivery, payment confirmation, the e-integrator would be able to choose the most suitable transport provider and commission the transport. To lower the shipment costs the e-integrator could consolidate parcels sent from (or addressed to) the same state or region. Knowing the local market, the e-integrator could offer a delivery of products from far corners of the world on

terms meeting customers' local preferences. The entrepreneurs whose products would be purchased via dedicated e-integrator's web portal could mark their parcels with defined labels. Those labels would allow entrepreneurs and customers to track and trace parcels independently from the logistics operator and present this information in one place (e.g. via e-integrator's dedicated web portal). This service would of course require the prior integration of processes and IT systems between the e-integrator and logistics operator.

Returns, which in cross-border e-commerce are especially problematic, could also be fully supported by the e-integrator. The consolidation of returned products would make dealing with the returns not only easier but also cheaper. Customers would return the products to the local e-integrator's service center, and the e-integrator would send the product back to the foreign e-shop. If customers would bear only the costs of domestic shipment, it could improve the attractiveness of online shopping cross-border from shops using e-integrator's services.

Having regard to the fact that the confidence in seller is one of the main factors determining customer's purchase decision in online shopping, it seems to be justified to include a contact center role in the e-integrator model. The e-integrator could be allowed to respond to customers inquiries and inform about consumer rights, delivery terms, costs of the purchases including all fees and taxes.

BUSINESS RISK AND BENEFITS OF THE E-INTEGRATOR MODEL

The role of the e-integrator presented in this article offers benefits and risks as well. The main benefits that customers could experience:
− possibility to buy from foreign retailers on local terms (language, currency, delivery type)
− lower delivery costs
− current information about the delivery irrespective of the logistics operator

For the entrepreneurs the benefits could be:

- lower costs of international shipments - thanks to the consolidation of parcels and integration of the supply chain the e-integrator could offer more attractive rates to its customers
- possibility to cooperate with more than one logistics operator - usually e-shops use services of one logistics operator, in case of cross-border e-commerce this may result in limited forms of delivery to the end customer. The e-integrator could offer services of many different providers at the same time.
- possibility to offer products abroad easily - the entrepreneur would be able to offer his products abroad in customers' native languages, currencies, forms of payment, etc. without knowing the local market characteristics
- competitiveness improvement through internationalization
- access to the new markets
- increase of consumers' confidence in e-shops - products offered via the local e-integrator could build trust of customers

The model may give rise to concerns among entrepreneurs. Some of them could be:
- limitations of entrepreneurs' decision making capacity
- limitations of offer customization
- dependency on delivery terms negotiated by the e-integrator
- perception of the entrepreneur through the prism of the e-integrator.

SUMMARY

As many researches show, cross-border trade will be one of the key factors boosting e-commerce world-wide. Model of integrated cross-border e-commerce presented in this article may be the answer for needs of small and medium enterprises, which are willing to operate abroad and offer their products on foreign markets, but do not have enough financial and personal resources to compete with the big companies. Thanks to the e-integrator SME could benefit from the economy of scale. This could lead to the improvement of this form of trade. The

increase of sales could result in increase of the whole e-commerce market.

The model should bring benefits not only to entrepreneurs but also to the customers. The role of the e-integrator might increase confidence of those customers who do not buy products from foreign e-shops because of the concerns about the hidden fees and taxes, sellers' integrity or delivery costs.

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KONCEPCJA INTEGRATORA W ELEKTRONICZNYM HANDLU TRANSGRANICZNYM

STRESZCZENIE. **Wstęp:** Handel elektroniczny jest jedną z najbardziej dynamicznych i istotnych dziedzin gospodarki. Najnowszym trendem tego rynku jest handel transgraniczny. Polega on na sprzedaży produktów klientom, którzy zlokalizowani są w innym państwie. Wiążę się to jednak z kilkoma problemami, takimi jak: wysoki koszt i długi czas dostawy, bariery językowe, różne uwarunkowania prawne i podatkowe itp.
Metody: Badania przeprowadzono na podstawie doświadczeń autorów w zakresie handlu elektronicznego. Do analizy zagadnienia handlu transgranicznego posłużyły głównie raporty Komisji Europejskiej. Celem artykułu jest propozycja koncepcji integratora e-handlu transgranicznego, który umożliwi m.in. rozwiązanie problemów logistycznych.
Wyniki: W artykule przedstawiono autorską koncepcję integratora w elektronicznym handlu transgranicznym. Jego podstawowym zadaniem jest integracja całego łańcucha dostaw. Dzięki efektowi skali, uzyskanej w wyniku konsolidacji przesyłek wielu e-sklepów, integrator jest w stanie uzyskać niższe koszty dostawy w transporcie międzynarodowym, przeprowadzać bardziej efektywnie zwroty towarów czy lepiej obsługiwać klientów z różnych krajów.
Wnioski: Zaproponowana w artykule koncepcja integratora w elektronicznym handlu może zwiększyć konkurencyjność mikro i małych e-przedsiębiorstw, w szczególności na arenie międzynarodowej. Ponadto zastosowanie tej koncepcji może przyczynić się do wzrostu atrakcyjności handlu transgranicznego, co w wyniku zwiększenia poziomu sprzedaży, przyczyniłoby się do zwiększenia całkowitego handlu elektronicznego.

Słowa kluczowe: e-handel, e-handel transgraniczny, integracja łańcucha dostaw

DAS KONZEPT EINES INTEGRATORS IM GRENZÜBER-SCHREITENDEN E-HANDEL

ZUSAMMENFASSUNG. Einleitung: Der E-Handel stellt einen der sich meist dynamisch entwickelnden und wesentlichen Bereiche der Wirtschaft dar. Der neueste Trend dieser Marktentwicklung ist der grenzüberschreitende E-Handel. Er beruht auf der Vermarktung von Produkten unter den Kunden, die in einem anderen Staate lokalisiert sind. Dies ist allerdings mit einigen Problemen wie: hohe Kosten und und lange Lieferzeiten, Sprachbarrieren, unterschiedliche Rechts- und Steuer-Sachverhalte u.ä., verbunden.

Methoden: Die Untersuchungen wurden anhand der Erfahrung der Autoren im Bereich des E-Handels durchgeführt. Der Analyse der Frage des E-Handels lagen hauptsächlich die Berichterstattungen der Europäischen Kommission zugrunde. Das Ziel des Artikel ist es, ein Konzept für die Anwendung eines Integrators, der u.a. die Lösung von logistischen Problemen ermöglicht, vorzuschlagen.

Ergebnisse: Im vorliegenden Artikel stellte man das Autorenkonzept eines im E-Handel brauchbaren Integrators dar. Dessen Hauptaufgabe ist es, die ganze Lieferkette zu integrieren. Dank des infolge der Konsolidierung von Lieferungen aus vielen E-Läden erzielten Skala-Effektes ist der Integrator imstande, niedrigere Lieferkosten im internationalen Transport zu gewährleisten, mehr effektive Waren-Rücklieferungen durchzuführen und die Kunden aus unterschiedlichen Ländern besser zu bedienen.

Fazit: Das in dem Artikel vorgeschlagene Konzept eines geeigneten Integrators für den E-Handel kann die Wettbewerbsfähigkeit von mikro- und kleinen E-Handelsunternehmen erhöhen, insbesondere beim internationalen, grenzüberschreitenden Warenaustausch. Darüber hinaus kann die Anwendung dieses Konzeptes zur Erhöhung der Attraktivität des grenzüberschreitenden Handels beitragen, was dank der Vergrö?erung des Verkaufsniveaus eine Verbreitung des totalen E-Handels zur Folge haben könnte..

Codewörter: E-Handel, grenzüberschreitender E-Handel, Integration der Lieferkette

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GRIEVANCE REDRESSAL INSTRUMENT AND INCLINATION OF DIVERSE MODES USED TO ENLIST COMPLAINTS IN INDIAN BANKS

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ABSTRACT. **Background**: Customer grievances are a bit of the business life of any corporate component. This is more so for banks in light of the way that they are organization affiliations .Indeed the organization business is planned to pass on what its customers conclusively need .Banking industry in India was considered as standard section 10 years back yet the sharp tries of RBI in the later past has changed and changed the substance of Indian dealing with a record industry. It has in like manner understood the challenges which the business has not defied until then and making an unrivaled purchaser reliability and experience is one of them. The engaged differentiator of banks depends on upon the ability to give a better issue than the customers other than offering a wide blend of things.

Methods: The path in which banks talk and oversee customer grumblings is a key variable in picking the way of customer organization .Having an inside and out plot redressal instrument for addressal of all the customer grievances is of prime hugeness. The destinations of the paper are to get a comprehension into the grievance redressal instrument followed in banks, care about it among general populace and its sufficiency. Data has been accumulated with the help of a sorted out survey by 200 bank customer's .With the aid of Statistical Package for Social Sciences (SPSS), both realistic experiences including frequencies, rates, mean, and standard deviations and moreover inferential tests, for instance, Pearson chi-square and ANOVA were joined.

Results and conclusions: Results exhibited a low level of care about grievance redressal approach and demonstrated that private part banks have a more practical grievance redressal framework when appeared differently in relation to open range banks The study has recommendations for the bank customers to show himself seeing protesting determination handle the and furthermore the banks in suitably arranging a reasonable model of grievance redressal.

Key words: purchaser dedication, customer protest, redressal segment, grievance.

INTRODUCTION

As per a late report by RBI Most of the individuals have encounters of bank officials, who have not gave great administrations sooner or later of time. We face issues in initiating our torpid record, issue of check book, including chosen one name, discounting overdraft charges, delay in settlement from abroad, shutting ledger, and so forth. On occasion, we don't get a fitting determination from the bank. In such case need to know not would we be able to document a dissention to determine our issue. Banks are similar to some other business and in this manner you can record a protest against them-if you are not fulfilled by their administrations. Recording a grievance additionally helps you, to set aside a few minutes you won't have any awful involvement with them. On the other hand, for a documenting a dissention against a bank you initially need to know the privilege process. The fundamental object of the grumbling is to get determined your issue as most punctual. So it is most critical to make dissention to fitting individual who will resolve your issue adequately. There is a framework in Indian

managing an account to get your issue determined by reaching compelling voices in strategy. To start with way to deal with concerned bank, then Director of Public Grievances, Govt of India, then Ombudsman (RBI) lastly customer gathering.

In a matter of seconds RBI (Reserve Bank of India) has urged banks to hear client on need premise. On course of RBI each bank needs to name nodal office for redressal of client grievances. Each bank has assigned more elevated amount officer at head workplaces and other senior level officer at controlling workplaces and everywhere branches.

To make the bank's instrument more meaningful and compelling, an organized framework should be fabricated. Such system would guarantee that the review is just and reasonable. The guidelines ought to be made accessible at all branches for the data of all workers, to guarantee better customer administration and general mindfulness in the bank.

OBLIGATORY NECESSITIES

It is required for the bank to give:
− Proper game plan for accepting dissentions and suggestions.
− The name, address and contact number of nodal officer.
− Contact points of interest of 'managing an account Ombudsman' of the zone.
− Code of the bank's dedication to clients/fair practice code.

DETERMINATION OF GRIEVANCES

The branch administrator is in charge of the determination of complaints/grievances. He is in charge of guaranteeing the conclusion of all protestations got at the branches. It is his preeminent obligation to see that the protestations are determined totally to the consumer loyalty's and if the client is not fulfilled, then he ought to be furnished with substitute roads to heighten the issues. In the event that the branch director feels that it is

unrealistic at his level to take care of the issue, he can allude the case to the 'divisional office' for direction. Also, if the 'divisional office' thinks that it is hard to take care of the issue, such cases may be alluded to the nodal officer.

ELEMENTS IMPACTING THE CUSTOMER SERVICE IN BANKS

HR

Any association's prosperity or disappointment is the consequence of progress or disappointment of its representatives aggregately. Here the representative doesn't mean just the staff working down the stepping stool, additionally incorporates individuals up to the top. People may be helped by the innovation for touching base at the choices.

Items/Services

The items which a bank offers are generally money related items like stores, advances and alongside these items additionally give different administrations which are not budgetary in nature, similar to safe store vaults, locker offices and so forth. The adaptability of banks to receive changing needs and desire of clients and convey out items/administrations to suit clients is an imperative territory in saving money administrations.

Forms

The procedures conceived for getting the administrations ought to be exceptionally client amicable, straightforward and complete.

Conveyance channels

Consumer loyalty is additionally subordinate upon the conveyance diverts utilized by banks as a part of giving the administrations. Today's client needs smooth, proficient, secure, straightforward and tried and true channels of conveyance.

LITERATURE REVIEW

It is insufficient to have a scope of items and administrations, productive innovation, all around settled in operational methodology and vast number of touch focuses, it is more critical to rouse individuals in the banks to make clients feel imperative in the saving money space. Well disposed treatment of clients, grinning methodology and preparation to serve them with an individual touch will have all the effect in the nature of administration. Henceforth, keeping in mind the end goal to contend we have to add to a managed client driven authoritative society and operationally productive conveyance models. (Strategies to enhance : Customer Service in Banks M. D. Mallya The Journal of Indian Institute of Banking & Finance October - December 2011).

Incredible client administration won't just produce a first rate client experience, however it can absolutely influence a bank's business and its primary concern. At the point when done right, execution of a sound client administration method satisfies clients, bringing about higher steadfastness. Moreover, it conveys important business insight that can coordinate business system crosswise over numerous offices. As rivalry to hold demographic increments because of the changing structure of customer managing an account charges (ordinary for most banks after administrative changes in the most recent couple of years,) banks ought to investigate their administration method as an approach to balance purchaser apprehension and perplexity (The Golden Rules of Retail Banking Customer Service Paul Logan SEP 26, 2012).

60% of customers who are content with their bank say they have low-or no money related anxiety, and more than half are idealistic about their budgetary future. Besides, shoppers who characterize themselves as content with their bank burn through 72 minutes less (7.3 hours versus 8.5 hours) every week agonizing over their money related circumstance contrasted with the individuals who say they are not content with their bank. "All banks are not the same regarding the matter of the administration they give. Examination demonstrates the individuals who feel esteemed by their bank are more prone to be content with their money related state" said Ryan Bailey, EVP/Head of Deposit Products at TD Bank. TD Bank studied more than 1,500 shoppers up and down the east drift - from Maine to Florida - to better comprehend purchasers' keeping money encounters, their budgetary anxiety, and in addition their monetary standpoint (March 11, 2013 good client administration makes bank clients feel fiscally secure.

PRIMARY OBJECTIVES

1. To understand the level of awareness about grievance redressal mechanism.
2. To understand the impact of demographics on the level of awareness about redressal mechanism.
3. To study the awareness and preference of different modes used to register complaint.

RESEARCH METHODOLOGY

Primary Data has been collected through a structured questionnaire suitably divided to check the awareness level about grievance redressal, preferred mode used for grievance redressal and effectiveness of grievance redressal procedure Sample size includes 200 bank customers from Mumbai. With the aid of Statistical Package for Social Sciences (SPSS), both descriptive statistics including frequencies, percentages, mean, and standard deviation as well as inferential tests such as Pearson chi-square and ANOVA were performed to check the impact of demographics on awareness level and the preferred mode of redressal. Effectiveness of the redressal procedure has been checked on a five point scale with respect to various parameters mentioned in objectives.

Secondary data has been collected through websites of different private and public banks and RBI bulletins besides related articles on internet, books, magazines and newspaper.

DATA ANALYSIS

Level of awareness

Even though 55% of people are not satisfied with their bank, Data analysis showed a low level of awareness about grievance redressal procedure with majority of people addressing their grievance only when loss of money is involved and nearly 15 % of the sample does not complain at all even if loss of money is involved. Nearly 60% of the people do not carry forward their grievance, if their problem is not resolved by preliminary procedures like calling the helpline or mailing the customer care .More than 65% of people are unaware of advanced methods of grievance redressal like approaching the nodal officer or the ombudsmen scheme and only 10% of people who are aware of it are willing to take their grievance to the nodal officer and only 3% are willing to approach banking ombudsmen offices.

Fig. 1. The level of awareness
Rys. 1. Poziom świadomości

Impact of demographics on the level of awareness about grievance redressal mechanism.

Income

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	37.666[a]	8	.000

a. 3 cells (20.0%) have expected count less than 5. The minimum expected count is 2.60.

Since the Sig value is .000, we can say that there is a significant relationship between income and customer awareness about redressal mechanism which consequences in their conduct.

Gender

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	35.942[a]	2	.000

a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 12.87.

Since the Sig value is .000, we can say that there is a significant relationship between gender and customer awareness about redressal mechanism.

Occupation

Chi-Square Tests			
	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1.066E2[a]	6	.000

a. 3 cells (25.0%) have expected count less than 5. The minimum expected count is 1.04.

Since the Sig value is .000, we can say that there is a significant relationship between occupation and customer awareness about redressal mechanism.

Awareness and preference of different modes used to register a complaint

It can be observed from the table 1 that is significant difference with regards to awareness leading to preference towards various modes to register and we can conclude Max people prefer helpline since the response is quick where as e-mails are the last preferences.

Table 1. Which mode is used to register a complaint
Tabela 1. Sposoby składania reklamacji

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Helpline	97	48.5	48.5	48.5
	Email to the customer care	19	9.5	9.5	58.0
	Use the official website	40	20.0	20.0	78.0
	Complaint/suggestion box at the branches	23	11.5	11.5	89.5
	Contact Personally at the concerned branch	21	10.5	10.5	100.0
	Total	200	100.0	100.0	

Impact of demographics on awareness and preference of different modes which are to register a complaint w.r.t gender, income and occupation based decision

Gender

Since the Sig value is .144 (see Table 2), we can say that gender has no impact of preference towards different modes used to register.

Income

From table 3 we can conclude that income has a significant impact of preference towards different modes to register. For further understanding we have applied Multiple Comparisons to understand the difference between the different groups taken for the study.

Table 2. ANOVA modes used to register a complaint
Tabela 2 ANOVA rejestracja skarg a płeć

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.346	1	4.346	2.150	**.144**
Within Groups	400.134	198	2.021		
Total	404.480	199			

Table 3. ANOVA modes used to register a complaint
Tabela 3 ANOVA rejestracja skarg a dochód

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	59.866	4	14.966	8.469	**.000**
Within Groups	344.614	195	1.767		
Total	404.480	199			

(I) income	(J) income	Sig.	Result & Interpretation
below 15,000	15,000-30,000	.426	No significant difference
	30,000-60,000	.325	No significant difference
	60,000-90,000	1.000	No significant difference
	Above 90,000	**.009**	**significant difference**
15,000-30,000	below 15,000	.426	No significant difference
	30,000-60,000	**.000**	**significant difference**
	60,000-90,000	.207	No significant difference
	Above 90,000	.000	No significant difference
30,000-60,000	below 15,000	.325	No significant difference
	15,000-30,000	**.000**	**significant difference**
	60,000-90,000	1.000	No significant difference
	Above 90,000	.703	No significant difference
60,000-90,000	below 15,000	1.000	No significant difference
	15,000-30,000	.207	No significant difference
	30,000-60,000	1.000	No significant difference
	Above 90,000	**.048**	**significant difference**
Above 90,000	below 15,000	**.009**	**significant difference**
	15,000-30,000	**.000**	**significant difference**
	30,000-60,000	.703	No significant difference
	60,000-90,000	**.048**	**significant difference**

Occupation

From table 4 we can conclude that occupation has a significant impact of preference towards different modes to register.

For further understanding we have applied Multiple Comparisons to understand the difference between the different groups taken for the study.

Table 4. ANOVA modes used to register a complaint
Tabela 4. ANOVA rejestracja skarg a zawód

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	43.643	3	14.548	7.902	.000
Within Groups	360.837	196	1.841		
Total	404.480	199			

(I) occupation	(J) occupation	Sig.	Result & Interpretation
Student	Professional	1.000	No significant difference
	Self employed	**.003**	**significant difference**
	Housewife	**.007**	**significant difference**
Professional	Student	1.000	**significant difference**
	Self employed	**.004**	**significant difference**
	Housewife	.017	No significant difference
Self employed	Student	**.003**	**significant difference**
	Professional	**.004**	**significant difference**
	Housewife	.933	No significant difference
Housewife	Student	**.007**	**significant difference**
	Professional	**.017**	**significant difference**
	Self employed	.933	No significant difference

CONCLUSIONS

Managing a complaint is not simple. Indeed, More than half the sample size is not satisfied with their bank in one or more ways and this suggests that banks should have a more effective procedure of managing complaints. Besides they should also work towards educating the customer to address their grievance in a proper way. Customers' expectation and complaints can be better understood by personal interaction. Planned customer meetings at fixed interval will give a message to the customers that the bank values its customer. Many of the complaints arise on account of lack of awareness among customers about bank services and such interaction will help the customers to understand the banking services better. The bank in turn can get the benefit of valuable suggestion from customers who can be utilized for revising its product and services. Staff should be properly trained on handling complaints. Since we are dealing with people, difference of opinion may arise. A complaint management program will not function unless everyone understands her or his role and is held accountable. The program must define who responds to a complaint, when a complaint should be escalated, who it is escalated to, and what steps should be taken when it is received. A bank should have a standard response time for resolving the complaints and should always take feedback on whether the customer is satisfied with the solution provided to them. Banks should engage in research in identifying their problem areas and understanding customer expectations. Complaints management in an organization should integrate itself with the mission of the bank and aim at continually improving quality of products and services offered to customers.

LIMITATIONS

This study assumes that all information gathered for this research project is accurate. The study also assumes that participants will be truthful and honest in their responses but understands that there is an emotional issue often associated with money discussions that sometimes causes participants to be guarded in their responses. Another limitation of this study is the narrow geographical sample of participants filling out the survey.

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METODA GRIEVANCE REDRESSAL ORAZ NAWYKI SKŁADANIA ZAŻALEŃ W INDYJSKICH BANKACH

STRESZCZENIE. **Wstęp:** Skargi klientów są częścią życia każdego przedsiębiorstwa. Również dotyczy to banków. Każde przedsiębiorstwa próbuje oferować swoje produkty, najbardziej odpowiadające potrzebom klientów. W Indiach banki w ostatnich kilku latach przechodzą dość istotne zmiany i zrozumienie wyzwań, jakie muszą sprostać, jest możliwe tylko po ich dokładnym przeanalizowaniu i zdefiniowaniu. Oferowany przez banki poziom obsługi zależy od jakości oferowanych usług i produktów a nie tylko od ich szerokiej gamy.
Metody: Sposób w jaki banki komunikują się z klientem oraz przyjmują skargi jest jednym ze wskaźników oceny banków. Dlatego tak ważne jest dla banku posiadanie systemu obsługi skarg i zażaleń. Celem pracy jest przedstawienie instrumentu grievance redressal, jego zastosowania i użyteczności. Dane zostały zebrane na podstawie wywiadu z 200 klientami banku. Następnie poddano je analizie statystycznej przy użyciu metody SPSS (Statistical Package for Social Sciences), wyliczając takie miary jak częstotliwość, średnia, odchylenie standardowe, rozkład Pearson chi-square czy ANOVA.
Wyniki i wnioski: Wyniki wykazały niski poziom zainteresowania zarządzaniem skargami. Banki prywatne mają praktyczniejszy sposób obsługi skarg aniżeli banki branżowe. Wykazano konieczność dalszej poprawy systemu obsługi zażaleń i konieczności podnoszenia świadomości istotności tego zagadnienia.

Słowa kluczowe: zorientowanie na klienta, skarga klienta, zażalenia.

DIE GRIEVANCE REDRESSAL-METHODE UND DER HANG ZUR BESCHWERDEEINLEGUNG IN INDISCHEN BANKEN

ZUSAMMENFASSUNG. Einleitung: Kundenbeschwerden machen einen Teil der Betätigung eines jeden Unternehmens aus. Das betrifft auch Banken. Jedes Unternehmen versucht, die den Kundenbedürfnissen am meisten entsprechenden Produkte anzubieten. In Indien werden in den letzten Jahren in indischen Banken ziemlich wesentliche Veränderungen vollzogen und daher ist die Wahrnehmung der Herausforderungen, denen sie genügen müssen, erst nach deren Ermittlung, Definition und Analyse möglich. Das von den Banken angebotene Niveau des Kundenservices hängt von der Qualität der angebotenen Dienstleistungen und Produkte, und nicht nur von deren breiten Auswahl, ab.
Methoden: Die Art und Weise, auf welche die Banken sich mit ihren Kunden kommunizieren und von ihnen die Beschwerden annehmen, ist eine der Kennziffern der Bewertung von Banken. Deshalb ist es für eine Bank so relevant, dass sie ein System für die Abwicklung von Klagen und Bescherden betreibt. Das Ziel der Arbeit ist es, das Grievance Redressal-Tool, sowie dessen Anwendung und Brauchbarkeit zu projizieren. Die Daten wurden anhand einer Umfrage unter 200 Bankkunden ermittelt. Demzufolge wurden sie einer statistischen Analyse mit Anwendung der SPSS(Statistical Package for Social Sciences)-Methode unterzogen, indem man solche Werte wie: die Frequenz, den Durschnittswert, die Standardabweichung, den Chi-Quadrat-Verteilungstest von Pearson, ferner den ANOVA-Test ausgerechnet hatte.
Ergebnisse und Fazit: Die Ergenisse wiesen auf ein niedriges Niveau des Interesses für das Beschwerden-Management hin. Private Banken betreiben dabei eine praktischere Vorgehensweise an die Abwicklung von Beschwerden als das bei den Branchen-Banken der Fall ist. Es wurde auf die Notwendigkeit einer weiteren Verbesserung des Systems für die Bedienung der Beschwerden, sowie auf die Notwendigkeit der Erhöhung des Bewusstseins über die Relevanz dieser Problemstellung hingewiesen.

Codewörter: Orientierung auf den Kunden, Kundenbeschwerde, Klagen

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VALUE ESTIMATION OF END OF LIFE VEHICLES AS A SOURCE OF COMPETITIVE ADVANTAGE FOR DISMANTLING STATION

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ABSTRACT. **Background:** End of Life vehicles become an emerging problem because of the type of waste which they are. Each country is creating own recycling network where ELVs are well secured and recycled. Poland is a country where the system is not working correct because of a high absorption of ELVs by illegal dismantling entities which are more competitive than legal elements of recycling network. The problem is well known but there is still lack of solution. The purpose of this article is to present the concept of tools for the valuation of ELVs in order to improve the competitiveness of disassembly stations.
Methods: The research methodology consists of a literature review as well as observations, surveys, BPMN and UML diagrams. On the basis of literature review and observations the problem was identified. The surveys were elaborated in order to identify requirements for the concept of the tool. BPMN and UML diagrams were used to model the processes in dismantling station and the information flow between the user and the tool.
Results: There was established a concept of the tool - ELV's Calculator which support decisions of ELV's value estimation.
Conclusions: Improving competitiveness of legal dismantling station is extremely important issue in order to provide safe for Environment and People and economically justified ELVs' management. Legal entities have to follow the law what makes their business cost higher. This paper provides a solution of encouraging people to return ELVs to legal dismantlers by offering them price adequate to market demand.

Key words: End of Life Vehicle (ELV), dismantling station, recycling network.

INTRODUCTION

End - of - Life vehicles (ELVs) become a major problem from the perspective of the implementation sustainable policy. ELV is a vehicle which is a waste according to the Directive 2000/53 [2000].

Appropriate ELVs management is not an option but it is necessity related to the sustainability issue. From one point of view ELVs are the source of raw materials (e.g. ferrous, non-ferrous metals, glass, plastics and rubber) which properly processed decrease the demand for unrenewable resources. On the other hand, components used in vehicles are dangerous for human health and natural environment (e.g. fluids such as petrol, oil, hydraulic liquids, batteries; airbags; etc.), which should be secured and utilized according to the law [Kosacka et al. 2015].

Dismantling station is a main object in a recycling network which is responsible for properly processing of ELVs according to Recycling Act of ELVs (polish adaptation of Directive 2000/53 [2000]). If ELV is processed in legal dismantling station, negative consequences for the environment, people and economy are reduced. Although the biggest problem of polish recycling network is a big absorption of the stream of ELVs by illegal

objects - representatives of GA (hereafter: grey area). If the input stream to the legal dismantling station is not sufficient to cover operational cost of the business, those objects are closed and the stream of vehicles is absorbed by illegal entities. In the consequence there are recorded losses for the economy, environment and society.

In this paper it was assumed that the legal dismantling station would be more competitive if there was better estimation of the input stream - value of ELVs which are supplied to the dismantlers. In the result less ELVs would get to GE, what is not a sustainable business.

The concept of the tool for ELV's value determination is presented. At the end of this paper are stated conclusions and is described conception of a tool for more adequate estimation the value of ELV.

During the work there were used the following researches methods as: interviews with employees, observations, brainstorming, BPMN, UML.

CHARACTERISTIC OF END OF LIFE VEHICLES IN POLAND

ELVs become an international problem, particularly in Poland [Golińska 2014], what is a result of the vehicle fleet characteristic (Table 1).

Table 1. Characteristic of the vehicle fleet in Poland and European Union (EU)
Tabela 1. Charakterystyka parku samochodów osobowych w Polsce i UE

Characteristic	Poland	EU
Passenger cars number (2013)	19 389 446	256 531 171
Average growing trend (2005-2013)	5,85%	1,76%
Average age of a vehicle (2011)	15 years	8,6 years
Age structure of vehicles:		
0- 5 years	9,6 %	30,8%
+10 years	78.6 % .(51,2 % are vehicles +15 years)	37,5%

Source: own elaboration based on [OICA 2014, SAMAR 2012, ACEA 2014]

There were 19 389 446 passenger cars in Poland in 2013, what was 7,6% of the vehicle fleet of the whole EU [OICA 2014]. The total number of vehicles each year is growing (average growth of 5,85% between 2005 and 2013), what is affected by high level of imported cars after Poland accessed EU in 2004 (from 1.05.2004 till the end of 2007 there were imported about 3,5 million used cars[Krzyk, 2008]. Imported used cars are old (age structure), what causes the increase of the averaged car age (polish vehicle is almost twice older than in EU).
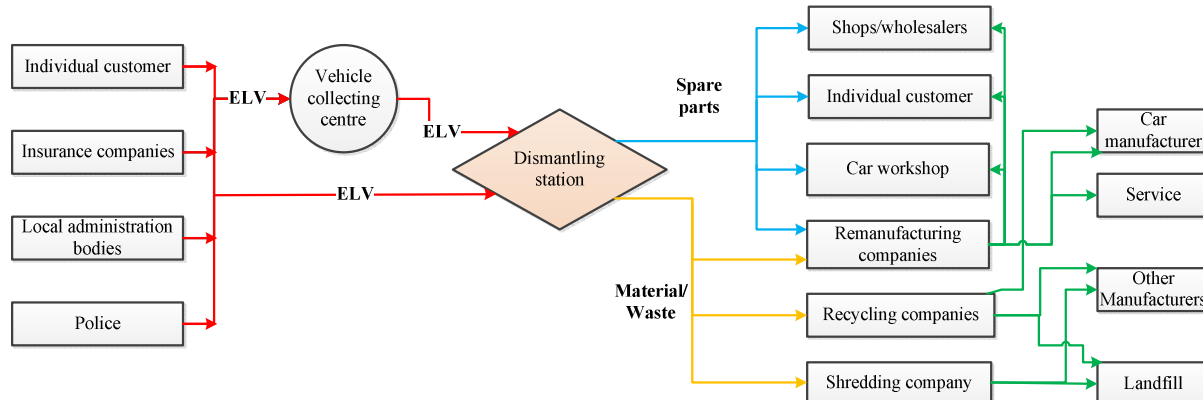
Research of Werner - Lewandowska confirms that the trend of growing number of vehicles and theirs aging structure will persist [2013]. The existing system is not efficient enough to handle such huge amounts of old vehicles [Golińska 2013].

A large number of old cars makes Poland Europe's "automotive heritage park" [Kosacka, Golińska 2014]. It can result in treatment polish market as a main place ELVs disposal in the next decade [Golińska 2013], what can be perceived as a chance if there will be a sustainable management of ELVs (source of materials).

Old, used cars at the end of life stage should be utilized in recycling network. Although in Poland vehicles are used even they have above 30 years. It results in high costs of maintaining old vehicle fleet incurred by car owners (higher fuel consumption) but also all Society (lower level of safety and bigger pollution).

DISMANTLING STATION - REQUIREMENTS AND PROBLEMS

According to ELV Directive each country has to establish recycling network for ELVs collecting and processing. Polish recycling network is consisted of many entities, particularly running illegal business, where there are irregular supplies of ELVs [Kosacka et al. 2015] (Figure 1).

Source: Kosacka et al. 2015

Fig. 1. Polish recycling network
Rys. 1. Sieć recyklingu w Polsce

In the recycling network only dismantling stations are intended for processing ELVs. Vehicles which enter the dismantling company may be obtained from a number of sources including: vehicle collection points (agent), insurance companies, local administration body, police and individual suppliers (car owners). As the result of processes realized in dismantling entity there are generated two output streams: spare parts which can be reused and parts and materials for recovery and recycling.

Dismantling stations are responsible for the following tasks [Nowakowski, 2010]:
− Vehicle collection;
− Storage of ELVs;
− Liquids removal;
− Vehicle disassembly;
− Sorting and transport parts and materials.

Due to the fact that ELVs are potentially dangerous for the natural environment, the dismantling stations are constantly monitored and are required to achieve the goals related to the increasing recycling and recovery rates (from 01/01/2015 there should be achieved the reuse and recovery rate of 95%, recycling rate of 85%).

In 2014 polish recycling network consisted of 970 dismantling stations and 139 vehicle collection points [FORS] The number of those objects is still growing but is still not enough.

Polish dismantling stations are facing many specific problems described in [Golińska 2014]. The most relevant problem refers to the absorption of ELVs by GA. Taking into consideration information about polish vehicle fleet (age structure, number of vehicles, technical condition) experts affirm that about 1 000 000 of vehicles should be deregistered each year. Although an increasing trend in a number of ELVs deregistration (182 153 in 2007, 383 567 - in 2014) [CEPiK] only almost 40 % of all ELVs are directed to recycling network created by legal entities., while rest of them are processed in illegal objects (GA).

Illegal entities are more competitive instead legal dismantlers because they can offer higher price for ELVs. It is a result of lower cost of the dismantling business which is not ran according to the law requirements (appropriate dismantling eco-friendly infrastructure is expensive). There was prepared the comparison of legal and illegal dismantling station from the sustainability perspective (Table 2).

Table 2. Legal and illegal dismantling station comparison in the context of sustainability
Tabela 2. Porównanie legalnej i nielegalnej stacji demontażu w kontekście zrównoważonego rozwoju

Assessment criteria	Legal dismantling station	Illegal dismantling station
Employment	+2	0
Working conditions (harmfulness for workers)	+1	-2
Influence on local community	0	-2
Government cost	+2	-2
Country development (GDP)	+2	-2
Environment pollution	+1	-2
Energy consumption	+1	-2
Recovery and recycling rate	+2	-2
Total	+11	-14

Source: own elaboration

In the presented comparison there was used the following scale of the influence:-2 is very negative, -1 is negative , 0- neutral, +1 - positive, +2 very positive .

There were considered different assessment criteria characterized sustainability. In each case legal dismantling station had better result, because it has got appropriate infrastructure, protective measures for workers, it creates workplaces for new Employees and generated the GDP, it has impact on the local community (noise, vibration) but there is no necessity of fighting by the government with legal objects. Moreover legal entities are taking care of recovery and recycling rate what is equivalent to lower Environment pollution (particularly hazardous substances).

In order to ensure sustainability in dismantling process legal entities should have sufficient stream of ELVs, consequently they should be more competitive than illegal dismantlers. Authors of the papers perceived a chance of better competitiveness achieved by more adequate estimation of the value (price) of the ELV which is supplied to the legal dismantling station. The price will encourage people to return ELV to legal dismantler.

VALUE ESTIMATION OF ELV ASSUMPTIONS

There were conducted surveys in polish legal dismantling stations.

Pilot studies were carried out in one of the biggest dismantling station. After review with the owner of the business and observations there was identified the problem with the price estimation of the supplied ELVs as the main reason of inadequate input stream of ELVs.

At the second stage of the studies researches made the interviews about that problem with other 10 dismantling stations. There was identified that some of dismantling stations establish price for the ELV according to the price list, others calculate the price according to the real weight of the car and assumed value of 1 kilo. To support that there was made an Internet research while there was verified on websites of legal dismantling station how they determine the price of the ELV. In was proved that most of them (about 90%) use only the information about the weight of the car, what will result in price inadequate to market requirements.

After reviews with dismantlers there was prepared list of ELV's features which should be considered during ELV's price estimation (Table 3).

In order to increase the competitiveness of legal dismantlers there was prepared the concept of the tool for ELV's value estimation -ELV's Calculator (Hereafter: EC). In the EC preparation there were took into consideration ELVs features (Table 3) and requirements for the EC which were the effect of the analysis of dismantling station special features arising from the specification of the business and size of the company (Table 4) (most of dismantling stations are Small and Medium Sized Companies).

Table 3. ELV's features influenced price for the ELV
Tabela 3. Cechy Pojazdu wycofanego z eksploatacji wpływającego na jego cenę

ELV's feature	Description	Influence of the value	Verification method
Completeness of the vehicle	Complete vehicle has got all parts which can be later be sold as spare parts (but they have to be not damaged also at the same time)	Increase	visual inspection
Damages	In the damaged vehicle additional profit from the spare parts selling is impossible.	Decrease	visual inspection
Vehicle popularity	If the vehicle is popular, the demand for spare parts is higher, what in the consequence may result in higher profit for dismantler.	Increase	Database according to the market research and experience of Employees
Additional equipment (gas-fittings, Unique components)	If the vehicle has got gas-fittings, it will be heavier so the price should be higher. If the vehicle has got unique components because it was the special version of the car, the value will be higher.	Increase	visual inspection
Weight of the car	If there is a difference between weight from the registration certificate and real weight more than 10%, the value should be reduced.	Decrease (difference more than 10%)	comparison of the weight

Source: own elaboration

Table 4. EC's requirements resulting from dismantling station characteristic
Tabela 4. Wymagania wobec EC wynikłe z cech stacji demontażu

Requirement	Description
Simplicity	EC is easy in operate. There is no need for additional training for Employees.
Service speed	EC allows to fast service of the customer (under 5 minutes) e.g. during short phone call.
Edit ability	The tool should provide the possibility of introducing changes without help of the IT specialist. All required data (e.g. update of the popular cars database) should be possible for every worker.

Source: own elaboration

The EC should be simple, provide fast service of the customer and have a possibility of introducing some changes. The basic assumption for the EC was that estimation the value of the ELV will be made according to the weight taking into consideration only Composition of raw materials. With the technology of the production changes, material composition of passenger cars was changed. For the research, there was assumed raw materials composition from [Nowakowski. 2010].

ELV'S CALCULATOR STRUCTURE

Before step in designing the tool was performed analysis of the processes that occur during the adoption of the vehicle to the dismantling station. For the analysis, were established the BPMN diagrams that graphically showed the essence and the relationships between the various actions (Figure 2).
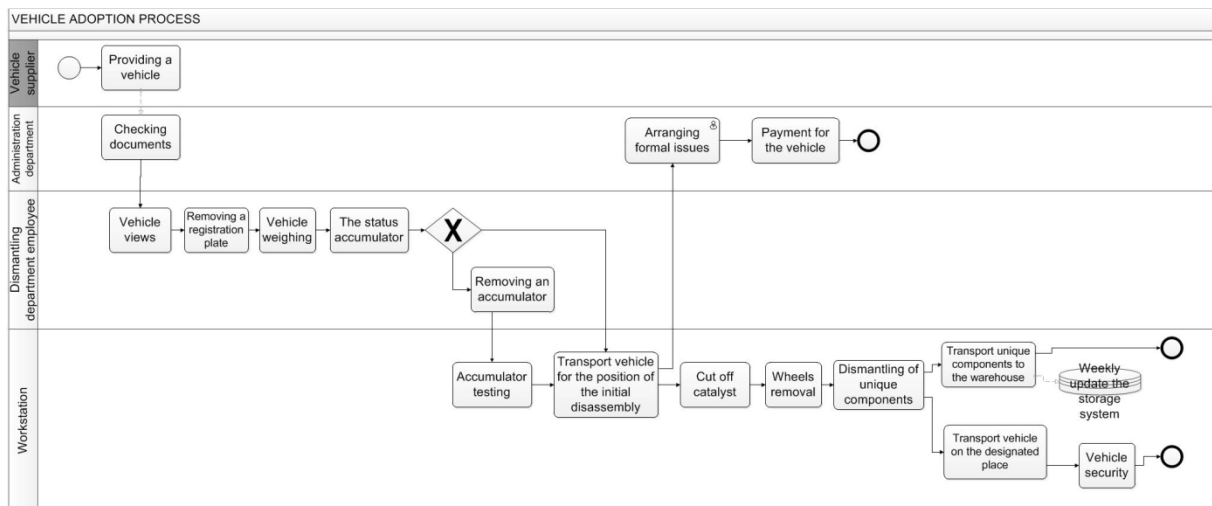
Source: Kosacka et al. 2015

Fig. 2. The process of adoption of ELVs
Rys. 2. Proces przyjęcia PWE
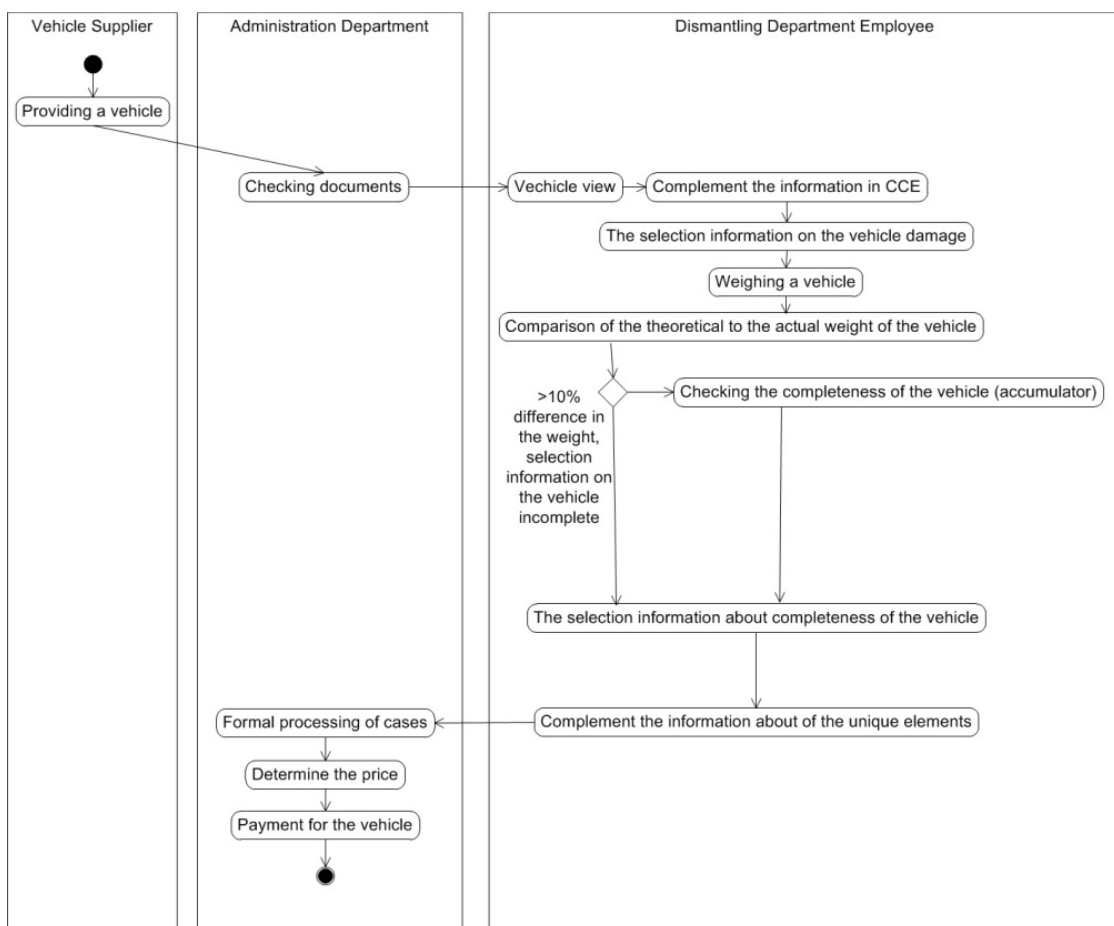
Source: Own elaboration

Fig. 3. The activity diagram
Rys. 3. Diagram czynności

Figure 2 was presented the adoption process. The adoption process is consisted of many steps including: checking the documents, removing parts (e.g. battery, catalyst, wheels), viewing the technical condition of the vehicle, etc. Passing though the complex steps, the value of vehicle can be estimated. According to that information the vehicle's owner will decidee on the destiny of the item - it may be provided to the legal entity or illegal one. From the perspective of the dismantling station, the adoption process is crucial. The number of received vehicles affects the dismantling process profitability. At that stage the value of the vehicle depends on the perception and the experience of the worker. Moreover the adoption might be done by different employes which presents various mental states. That may be a cause of mistakes during assessing the vehicle value. In addition, during the adoption of the ELV it is a huge variety of information that is affected to the value of the vehicle including the weight of the ELV, content of basic parts (e.g. battery) or additional parts or technical condition of the vahicle. Taking into account, all required information supports in carrying out the adotion process. On the other hand, no standard procedure of ELV's value estimation leads to high level of the subjectivism of employees resulted in incorrect value estimation and decreasing the competitiveness of legal dismantling station.

Taking into account, all required information needed in adoption process can be presented as an activity diagram with the use of Unified Modeling Language (UML) (see Figure 3). With the activity diagram, interdependencies among all operations in the adoption process can be clearly presented.
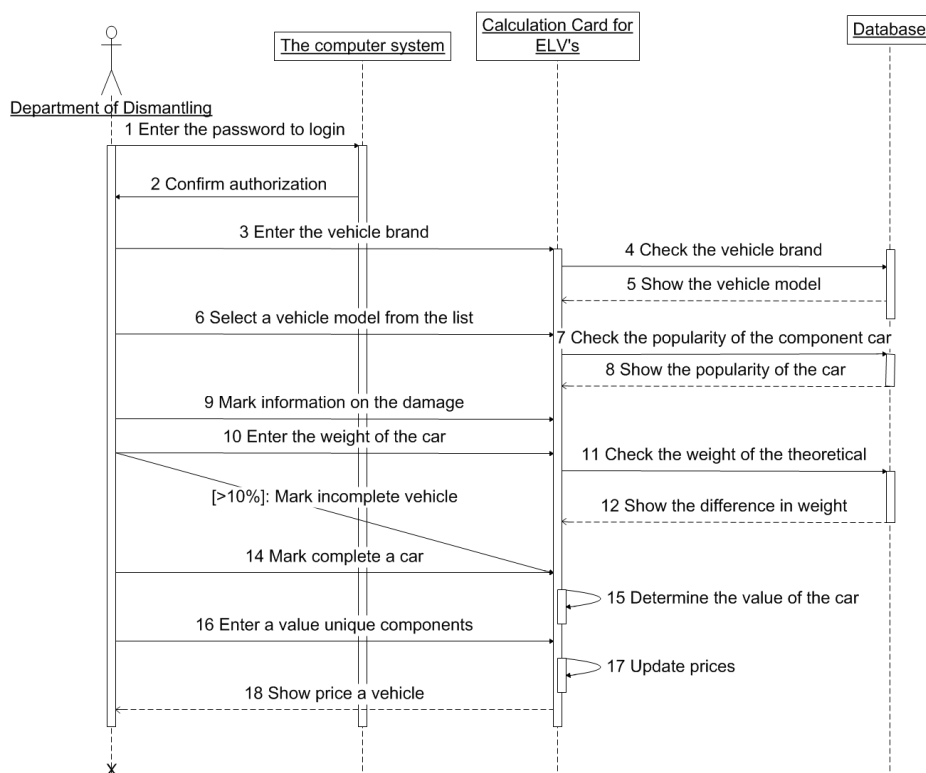
Source: Kosacka et al. 2015

Fig. 4. The sequence diagram
Rys. 4. Diagram sekwencji

Employee of the dismantling department is responsible for verifying the technical condition of the vehicle. After visual assessment, the ELV should be weighted.

According to the polish law there is applicable 10% difference between the real weight of the perceived ELV and its theoretical weight. If the difference is more than 10 % the vehicle is treated as incomplete one. The more

incomplete vehicle is, the payment for it is lower. In the next step, the battery is removed and tested if it is existed in the ELV. If there is no battery, the price is deduced. Any damage on vehicles will affect on the price as 25% reduction compared to the nominal price for undamaged vehicles. In contrast, the price may increase when vehicle contain some unique elements such us ornamental slats (e.g. car after tuning).

After elaboration of the activity diagram, the sequence diagram can be developed as shown in Figure 4 to describe interactions between parts of the system as a sequence of messages exchanged between them. There are interactions between: employees (representing the department of dismantling) and the computer system where available EC tool is installed for the prepared database.

The prepared tool is available for the user after authorization (there should be enter the password) to make the whole process of ELVs' to be secured. The user should complete the information of ELV's brand, model and technical condition (to verify damages). Then, the weight of vehicle should be input. After that, the difference between theoretical and actual weight of the vehicle can be calculated by the tool and displayed at the screen. If the difference is less than 10% the car is treated as complete (the status complete is marked) what will increase the value of the vehicle.

Based on the input data, the initial price can be estimated which can be increased if the unique items exist. Then, the final price will be sent to the following task.

The sample user interface of the proposed system is presented as Figure 5. Designed interface allows employees of the disassembly stations to enter some data manually. However, there are still data that need to be downloaded from the database (e.g. model). The types of used data are described in Table 5.
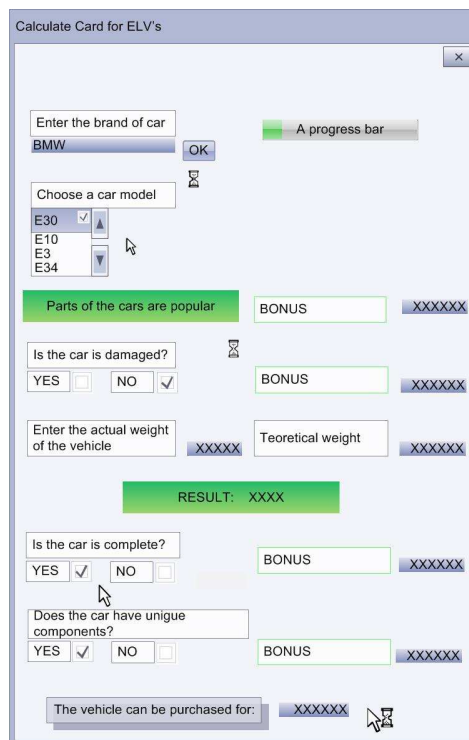
Source: Kosacka et al. 2015

Fig. 5. Interface CCE
Rys. 5. Interfejs CCE

Table 5. A description of the types of fields in a form designed
Tabela 5. Opis typów formantów w zaprojektowanym formularzu

Types of formants	Example of use in the form	Description
Text field	1. Formant entering vehicle brand 2. Formant entering the actual weight of the vehicle	These fields are used to supplement the information
List box	1. The list box which applies the model selection	In the list appears on the model of the vehicle brand
Check box	1. Fields: whether the vehicle is damaged, whether the vehicle has an LPG	The field is a combination of labels: YES and NO
Calculated field	1. Fields 'result'	The fields show the proposed price per vehicle
Field of Progress	1. A progress bar	The box indicating percent of complete the information on the form

Source: own elaboration

Designed interface created specific application scenario, which organizes the needed information for the evaluation of ELV and dismantling operation. It contains dot fields associated that charge the value of the associated database item and unrelated fields, which typically display additional information.

The proposed tool help in facilitate the work of employees and shorten the operation time of the adoption to the dismantling station that will affected to increasing competitiveness of disassembly stations.

CONCLUSIONS

The paper presents the problem of polish recycling network related to the ELVs management. ELVs are waste which appropriate processed in legal dismantling stations is neutralized and well managed from the perspective of recycling. That business is sustained in opposite to illegal entities running business only from the perspective of achieved profits what makes business unsustainable.

The problem of absorbing the stream of ELVs by illegal entities is related to bigger competitiveness of illegal companies offering better price for vehicle. The authors presented the conception of a tool which helps in the price estimation of ELVs and increases competivenesses of the legal dismantlers in term of reasonable price and short operation time.

According to requirements for the dismantlers, there were established ELV's features as well as dismantlers characteristic that is affected on the decision making of the dismantlers.

Proposed tool is developed based on material composition of vehicle that is difficult to be measured accurately. The main disadvantage of the tool is that the basis for the estimation is shared for raw materials in the vehicle structure according to the assumptions of the dimsantlig station owner. This is the weak point of the tool which requires additional researches for the further improvement.

The main advantage of the tool is the simplicity and possibility of editing. The tool is prepared in the spreadsheet available in each dismantling station. Moreover, there is easy access to the data in term of the price of each raw material as well as percentage share that can be easily updated. Created tool allows users to easily set the price ELV. This fuction supports the dismantling station to be more competitive suppliers ELVs than the "green zone", which is the key point for improving the functioning of the network of recovery in Poland.

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SZACOWANIE WARTOŚCI POJAZDU WYCOFANEGO Z EKSPLOATACJI JAKO ŹRÓDŁO BUDOWANIA PRZEWAGI KONKURENCYJNEJ STACJI DEMONTAŻU

STRESZCZENIE. **Wstęp:** Pojazdy wycofane z eksploatacji (PWE) to coraz większy problem ze względu na charakter odpadu jakim są. Każdy kraj buduje sieć recyklingu, w której PWE są odpowiednio zabezpieczone i poddawane recyklingowi. W Polsce system nie działa dobrze ze względu na to, że występuje duża absorpcja PWE przez nielegalnie działające przedsiębiorstwa zajmujące się demontażem, które są bardziej konkurencyjne niż legalne jednostki. Problem jest dobrze znany, lecz nie ma jego rozwiązania. Celem artykułu jest zaprezentowanie koncepcji narzędzia przeznaczonego do wyceny wartości PWE celem poprawy konkurencyjności legalnej stacji demontażu.

Metody: Przeprowadzono badania literaturowe jak również obserwacje, wywiady oraz wykorzystano diagramy BPMN i UML. Na podstawie przeglądu literatury oraz obserwacji został zidentyfikowany problem. Celem przeprowadzonych wywiadów było opracowanie narzędzia. Diagramy BPMN i UML zostały wykorzystane do zamodelowania procesów realizowanych w stacji demontażu oraz przepływów informacyjnych między użytkownikiem narzędzia a narzędziem. Wykorzystane zostały następujące metody badawcze: analiza źródeł literatury, obserwacje, wywiady, diagramy UML i BPMN. Na podstawie analizy literatury oraz obserwacji zidentyfikowany został problem. Ankiety były przeprowadzone celem identyfikacji wymagań dotyczących narzędzia. Diagramy natomiast zostały wykorzystane do modelowania procesów w stacji demontażu oraz przepływów informacji między użytkownikiem a narzędziem.

Wyniki: Opracowano koncepcję narzędzia - Kalkulator PWE celem wsparcia podejmowania decyzji w zakresie szacowania wartości PWE.

Wnioski: Zwiększanie konkurencyjności legalnie działających stacji demontażu jest bardzo ważnym zagadnieniem w kontekście zapewnienia bezpiecznego dla ludzi i środowiska oraz ekonomicznie uzasadnionego zarządzania PWE. Legalne stacje demontażu muszą działać zgodnie z prawem, co podwyższa ich koszty funkcjonowania. Przedstawiony artykuł dostarcza rozwiązania, które ma zachęcić właścicieli PWE do dostarczania PWE do legalnych obiektów przez zaoferowanie im ceny odpowiedniej do wymagań rynku.

Słowa kluczowe: Pojazd Wycofany z Eksploatacji (PWE), stacja demontażu, sieć recyklingu.

BEWERTUNG EINES AUßER BETRIEB GESETZTEN FAHRZEUGS ALS FAKTOR ZUM AUFBAU DER WETTBEWERBSFÄHIGKEIT EINER DEMONTAGE-STATION

ZUSAMMENFASSUNG. Einleitung: Die außer Betrieb gesetzten Fahrzeuge stellen wegen Charakter des dabei entstandenen Abfalls ein immer größer werdendes Problem dar. Jedes Land baut ein Recycling-Netz, in dem die betreffenden Fahrzeuge entsprechend sichergestellt und recycelt werden, auf. In Polen funktioniert ein solches System nicht richtig, denn es besteht die Erscheinung einer unerwünschten Übernahme solcher Fahrzeuge seitens der illegal betätigten Demontage-Unternehmen, die wettbewerbsfähiger als die legalen Demontage-Einrichtungen sind. Das Problem ist allgemein bekannt, es gibt jedoch keine gute Lösung dafür. Das Ziel des Artikels ist es, das Konzept eines Tools für die Bewertung eines außer Betrieb gesetzten Fahrzeugs zwecks Verbesserung der Wettbewerbsfähigkeit einer legal betriebenen Demontage-Station darzustellen.

Methoden: Es wurden Literaturforschungen, Wahrnehmungen vor Ort und Interviews durchgeführt, sowie die BPMN- und UML-Diagramme in Anspruch genommen. Anhand der Gegenstandsliteratur und der Wahrnehmungen vor Ort wurde die Problemstellung ermittelt. Das Ziel der durchgeführten Interviews war es, ein brauchbares Tool für die Lösung dieser Probleme auszuarbeiten. Die BPMN- und UML-Diagramme wurden für die Modellierung der in der Demontage-Station verlaufenden Prozesse und der zwischen dem Tool-Anwender und dem Tool selbst bestehenden Informationsflüsse angewendet. Es wurden dabei folgende Forschungsmethoden wie: Analyse der Literaturquellen, Wahrnehmungen vor Ort, Interviews und die BPMN- und UML-Diagramme in Anspruch genommen. Auf Grund einer entsprechenden Literaturrecherche und der Wahrnehmung der Problemstellung wurde das Problem identifiziert. Die Interviews wurden zwecks der Bestimmung der das Tool selbst anbetreffenden Herausforderungen durchgeführt. Die Diagramme dagegen wurden für die Modellierung der in der Demontage-Station verlaufenden Prozesse und der zwischen dem Tool-Anwender und dem Tool selbst bestehenden Informationsflüsse angewendet.

Ergebnisse: Es wurde ein Konzept für das Tool in Form eines Kalkulators für das au?er Betrieb gesetzte Fahrzeug zwecks der Unterstützung von Entscheidungen bezüglich der sachgemäßen Bewertung der betreffenden Fahrzeuge ausgearbeitet.

Fazit: Die Erhöhung der Wettbewerbsfähigkeit von den legal betätigten Demontage-Stationen gilt als eine sehr wichtige Frage im Kontext der Gewährleistung eines für die Menschen und die Umwelt sicheren und wirtschaftlich begründeten Management-Systems für die au?er Betrieb gesetzten Fahrzeuge. Die legal betriebenen Demontage-Stationen müssen jedoch gesetzmäßig betätigt werden, was die Betriebskosten erheblich erhöht. Der dargestellte Artikel bietet eine Lösung, die die Besitzer von au?er Betrieb gesetzten Fahrzeugen dazu bewegen soll, die betreffenden Fahrzeuge an die legalen Demontage-Einrichtungen, die ihren Kunden einen den Marktanforderungen entsprechenden Preis anbieten müssen, abzuliefern..

Codewörter: außer Betrieb gesetztes Fahrzeug, Demontage-Station, Recycling-Netz.

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THE IMPACT OF E-COMMERCE ON WAREHOUSE OPERATIONS

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ABSTRACT. **Background:** We often encounter opinions concerning the unusual nature of warehouses used for the purposes of e-commerce, most often spread by providers of modern technological equipment and designers of such solutions. Of course, in the case of newly built facilities, it is advisable to consider innovative technologies, especially in terms of order picking. However, in many cases, the differences between "standard" warehouses, serving, for example, the vehicle spare parts market, and warehouses that are ready to handle retail orders placed electronically (defined as e-commerce) are negligible. The scale of the differences between the existing "standard" warehouses and those adapted to handle e-commerce is dependent on the industry and supported of customers' structure.
Methods: On the basis of experiences and on examples of enterprises two cases of the impact of a hypothetical e-commerce implementation for the warehouse organization and technology have been analysed.
Results: The introduction of e-commerce into warehouses entails respective changes to previously handled orders. Warehouses serving the retail market are in principle prepared to process electronic orders. In this case, the introduction of (direct) electronic sales is justified and feasible with relatively little effort.
Conclusions: It cannot be said with certainty that the introduction of e-commerce in the warehouse is a revolution for its employees and managers. It depends on the markets in which the company operates, and on customers served by the warehouse prior to the introduction of e-commerce.

Key words: e-commerce, e-trade, electronic trade, warehouse, store.

We often encounter opinions concerning the unusual nature of warehouses used for the purposes of e-commerce [Graves 2012], most often spread by providers of modern technological equipment and designers of such solutions. Of course, in the case of newly built facilities, it is advisable to consider innovative technologies, especially in terms of order picking. However, in many cases, the differences between "standard" warehouses, serving, for example, the vehicle spare parts market, and warehouses that are ready to handle retail orders placed electronically (defined as e-commerce) are negligible. The scale of the differences between the existing "standard" warehouses and those adapted to handle e-commerce is dependent on the industry and supported of customers' structure.

DEFINITION OF E-COMMERCE

First, you must determine what e-commerce is. E-commerce, electronic or online trade is defined in different ways - "Although the concept of e-commerce has functioned for many years, its single general and widely recognised definition has not been formulated," [Szymanski 2013]. Literature definitions cited in the publication are summarised in a concise definition reflecting the specific nature of the term: "handling, use and generation of commercial activities based on Internet technologies" [Szymanski 2013]. It is true that this definition excludes the use of other media for the exchange of

correspondence - a bit outdated fax or ordering via electronic mail are no longer treated as a tool for e-commerce - however, no importance is attached to dedicated ordering tools. The World Trade Organization [2013] defines e-commerce in a more comprehensive way: the sale or purchase of goods or services, carried out via a computer network using tools specially designed to place and receive orders [WTO 2013]. Payments do not have to be made electronically. Only the communication channels are the Internet, extranet and electronic information exchange (EDI). Thus, according to this definition, e-commerce differs from traditional mail-ordering only by the method of placing orders - mail-order catalogues, which used to be commonly used for decades, have been replaced by another medium. The global availability of the Internet, regulations favourable to buyers and dissemination of courier parcel service have determined the extremely wide availability of electronic "mail-order catalogues."
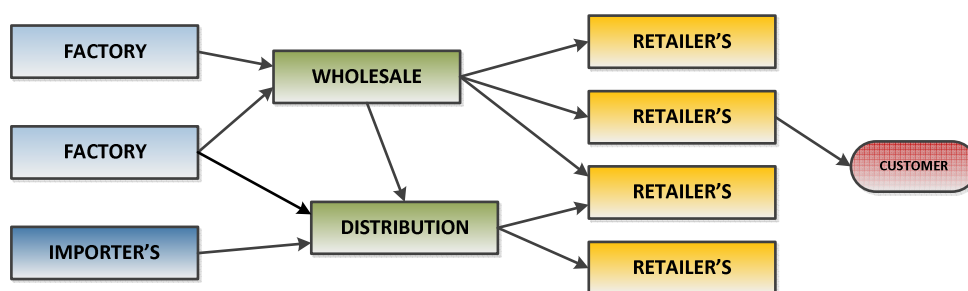

Fig. 1. Basic warehouses and their relationships in the distribution network of commercial products/goods
Rys. 1. Podstawowe magazyny i ich relacje w sieci dystrybucji wyrobów / towarów handlowych

THE IMPACT OF ELECTRONIC COMMERCE ON WAREHOUSE OPERATIONS

From the point of view of warehousing, e-commerce is not a homogeneous concept. Cooperation with existing customers in the B2B market on unchanged terms and conditions, only through the use of electronic forms of communication, in principle, does not change much. In fact, placing an order is less labour intensive, and the order arrives immediately to the supplier. This may reduce the size of orders and increase the frequency of their placement. However, it is the tendency not connected with electronic commerce that had also occurred before its emergence. It can be assumed that in principle in B2B relations, which are governed by the economic size of the order or limited by the economics of the cost of single shipment/transport, electronic media have not revolutionised warehousing.

There is no denying, however, that e-commerce is a tool (or perhaps an excuse) to take stock "higher" in the supply chain - this leads to a reduction in stock, bringing it "closer" to the end customer at the expense of stock held by the manufacturer or importer, while keeping the level of customer service (at least) unchanged. From the retailer's point of view, there are concepts assuming elimination of the warehouse, which is mistakenly interpreted as a (physically impossible) elimination of warehousing from the supply chain. Accumulation of stock in the higher levels of the supply chain can lead to their correct management and ultimately reduce the required total storage capacity throughout the supply chain.

If you try to skip one (or more) levels of distribution, the issue of e-commerce becomes more complicated, and a revolution occurs most often in B2C relations (Figure 2) - the so-called e-tailing ("electronic retailing"), as opposed to e-merchandising [Glinkowska,

2011]. Electronisation of retail trade leads to an increase in the quantity and fragmentation of orders handled by warehouses, and the need to deal with returns that the buyer is entitled to make in the case of distance sales. Returns

mean plenty of additional work for the warehouse staff. This applies particularly to the clothing industry, where the purchase of goods in the wrong size ends without consequences for the customer.
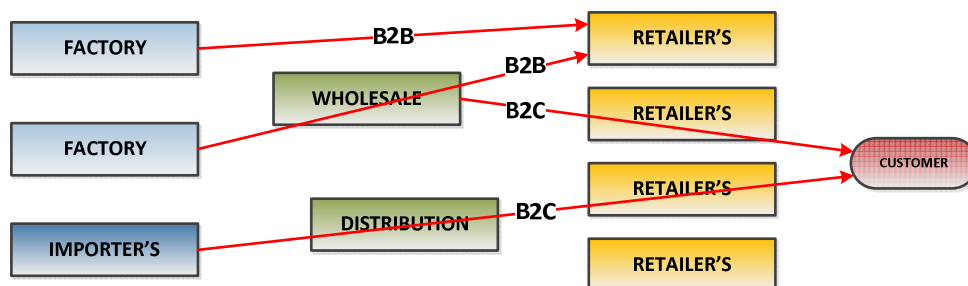

Fig. 2. Example directions for skipping warehouses in the commercial goods/products distribution network
Rys. 2. Przykładowe kierunki pominięcia magazynów w sieci dystrybucji towarów handlowych / wyrobów

Another characteristic feature of the e-commerce market is also the significant irregularity of sales - seasonality [Graves 2012], particularly at the end of the year. This is illustrated by the data made public by amazon.com and presenting the sales of one of the largest online stores - see Figure 3. Significant differences between Q3 and Q1 of the following year compared to Q4 (Christmas) are a challenge for each warehouse, even the one that correctly forecasts its goods flows. In the case of poor forecasting, both performance of infrastructure and out-of-stocks may quickly spoil the store's opinion in the electronic market and lead to a collapse in sales - in the era of the Internet not only shopping but also negative feedback is extremely quick. "In terms of e-commerce, unpredictability is a constant factor" [Graves 2012]. Even correct forecasting with such a high proportion between seasonal and out-of-season sales requires the use of dedicated solutions - it is necessary to adjust technology and organisation to sale in the peak season, as out of season there is usually job reduction and technological equipment works at partial capacity.

Another requirement of customers is full transparency [Graves 2012] - information about availability of goods in the warehouse [Fechner 2010], and upon placing an order - information on its status at each stage of

processing must be available to the customer. It basically does not affect the operation of the warehouse, but requires the use of management information systems, transmission of online information about ongoing orders at each stage of processing.

In the case of the clothing industry, differences between e-commerce and sales via the (once) popular mail-order catalogues, are small from the point of view of organisation of the warehouse. It can therefore be concluded that there are sectors in which well-developed mail ordering somewhat prepared warehousing technologies for e-commerce. What has probably changed are expectations concerning order processing time in the warehouse (and the whole logistic chain). But not in all industries were (are) warehouses adapted to electronic commerce.

How, then, fragmentation of orders and a significant increase in the number of minor complaints influence the warehouse? The answer is in this case a "standard" one: it depends. Seemingly e-commerce does not bring anything new to warehouse management, as the total trading volume remains at the same level (of course, not taking into account seasonality and sales growth). What is important is that customers have access to goods/products directly at the distribution level, which depends on the decision of

the participants of the supply chain. The results of this access are: increased volumes and fragmentation of orders. Translating this into warehouse terminology, there is a need to handle more documents with fewer lines in each of them. Also, the number of units of measure in the lines is less - the lines are "thinner".

Source: http://www.statista.com/chart/1299/amazons-revenue-and-profit-growth/

Fig. 3. Irregularity of revenues at amazon.com stores
Rys. 3. Nierównomierność przychodów sklepów amazon.com

EXAMPLES OF POTENTIAL IMPLEMENTATION OF E-COMMERCE IN WAREHOUSES

Differences compared to traditional methods of ordering are the greater, the "higher" an enterprise is located in the supply chain. In fact, the biggest change in the case of the introduction of e-commerce concern factory warehouses, and the smallest - retailers' warehouses. Hence the answer to the question of how electronic ordering will affect the warehousing operations depends (among other things) on the structure of existing customers. It is advisable to consider two extreme cases, for instance, a "mega" automotive wholesaler and a factory warehouse of a book publisher.

Characteristic features of the automotive market are significant amounts of returns and quick processing of orders. Small garages basically do not store spare parts. Cars left by customers in the morning are diagnosed, then spare / ware parts and consumables are ordered. The ordered goods are delivered to garages within several hours or they are collected by their representatives. The idea behind such a system is to complete the repair/inspection, if possible, within one day, in order to minimise unproductive vehicle stoppage. It is worth noting that due to the considerable differentiation of spare / ware parts and consumables, mechanics often make mistakes that can be verified only during the installation of parts. Hence, many automotive wholesalers offer free return of unused parts, which in turn is used by their customers - they can buy without consequences several versions of a spare part and return those that are not appropriate. Currently, the level of retail returns in the automotive parts market reaches several percent.

In the automotive parts distribution system, central and wholesale warehouses usually function as retail stores in the region in which they are located, disregarding the economic justification and efficiency of this type of solution. So the distribution network includes

warehouses, where customers are wholesalers, retailers and garages, which generate a full range of order sizes.

Storage technologies and organisation of work in such warehouses are designed to handle orders of any size - if there are framework pallet racks, they are used primarily to store stocks. The picking operation is performed mostly from shelf slots. There are often (partially) automated solutions (for example, pick-by-light, automatic transport or sorting of picked goods), supporting employees in the performance of their tasks. Warehouse processes are carried out with the use of automatic identification, based on barcodes and terminals connected online to the warehouse management system, which is fully justified by the scale and structure of orders. This is done because there are dozens or even hundreds of issue documents a day. And each document usually covers from a few cartons (wholesale customers) to one piece (small garages).

For this type of warehouse, opening an online store does not involve a revolution. In the case of an increase in electronic sales, emphasis will be placed on orders whose size and frequency corresponds to those previously placed by garages. The storage technology (especially order picking) is suitable for this purpose or can be adapted with a relatively small degree of technological or organisational changes, allowing to appropriately adjust its performance. The warehouse is prepared to handle a significant amount of returns, their larger scale is associated only with increased effort in the use of the existing technology, as in the case of order picking. Thus a central or even regional warehouse distributing spare parts in the automotive market is basically technologically prepared to handle electronic commerce. With organisational changes, like the introduction of parallel picking of several small orders or limiting one line issues control (low error rate), it is possible handle increased flow, provided that performance is not exceeded.

A somewhat similar example is the pharmaceutical distribution market, where a pharmacy receives small-size deliveries even several times a day. However, there scale of returns is not as big as in the case of garages. Thus, in this market barriers to possible introduction of retail electronic commerce (currently limited by law regulations) are relatively easy to cross.

The second example, a book publisher, is a completely different situation. Assuming that the publisher distributed finished products through two levels of intermediaries between it and the retail customer (through wholesale warehouses and retail stores), books were sold at least in bulk packaging, and a large portion of issues included mainly uniform loading units. The storage technology is adapted to this type of operations - only pallet racks are available in the warehouse. The picking operation is performed from the lowest pallet rack level, directly from the pallet. There are several issue documents per day, and each of them usually includes several pallet units. The picking operation is performed using paper documents. Barcodes are not used. If the warehouse management system has been implemented, it is usually limited in terms of functionality.

The decision to omit intermediaries and introduce sales via electronic channels directly to retail customers is in this case associated with a revolution. Firstly, in terms of the number of orders from customers, as their number will grow by several hundred percent. Secondly, in terms of employment, as the first step without technological changes, the storage process can be executed correctly only by increasing workload. Thirdly, in terms of the storage technology, as handling a few hundred orders per day using the described technology is reckless in the long-term. Fourthly, a revolution in terms of returns, which so far have generally been non-existent in the warehouse or existed in the "wholesale scale". Of course, changes aimed at adapting the technology to customer requirements can also be made in an evolutionary manner (which is preferred), through a gradual or only partial withdrawal from the current method of distribution. A revolutionary change can considerably interfere with the operation of the warehouse.

SUMMARY

Hence, the introduction of e-commerce into warehouses entails respective changes to previously handled orders. Warehouses serving the retail market (for example, warehouses functioning as supporting facilities for sales through mail-order catalogues, automotive wholesalers, pharmaceutical wholesalers) are in principle prepared to process electronic orders. In this case, the introduction of (direct) electronic sales is justified and feasible with relatively little effort.

Another thing is justification for the use of electronic commerce addressed to end retail customers by manufacturers or importers – a factory warehouse is usually not adapted to process orders (and returns) from retailers, and in this case the introduction of direct retail sales will require substantial outlays (and in the first stage - much effort). One of the requirements for an online store is a wide range of product items [Graves 2012], which the manufacturer/importer - in addition to its own finished products or commercial goods - cannot deliver. Hence the application of B2C solutions in the case of manufacturers or importers is also limited. A computer user usually requires access to more than one product to minimise the cost of delivery.

Therefore, you cannot say with certainty that the introduction of e-commerce in the warehouse is a revolution for its employees and managers. It depends on the markets in which the company operates, and on customers served by the warehouse prior to the introduction of e-commerce.

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WPŁYW E-COMMERCE NA FUNKCJONOWANIE MAGAZYNU

STRESZCZENIE. **Wstęp:** Często spotykane są opinie, dotyczące nietypowości magazynów przeznaczonych do obsługi handlu elektronicznego, najczęściej rozpowszechniane przez dostawców nowoczesnego wyposażenia technologicznego czy projektantów takich rozwiązań. Oczywiście w przypadku nowopowstających obiektów wskazane jest rozważenie innowacyjnych technologii, zwłaszcza w zakresie kompletacji. Jednak w wielu przypadkach różnice pomiędzy "standardowymi" magazynami, obsługującymi przykładowo rynek samochodowych części zamiennych, a magazynami, które są przygotowane do obsługi detalicznych zamówień składanych elektronicznie są pomijalne. Skala różnic pomiędzy istniejącymi "standardowymi" magazynami a magazynami przystosowanymi do obsługi e-commerce jest zależna od branży i obsługiwanego przekroju klientów.
Metody: Na podstawie doświadczeń oraz przykładowych przedsiębiorstw przeanalizowane zostały dwa przypadki wpływu hipotetycznego wdrożenia e-commerce na organizację i technologię magazynową.
Wyniki: Wprowadzenie e-commerce do magazynu będzie skutkowało zmianami odpowiednimi do poprzednio obsługiwanych zleceń. Uogólniając magazyny obsługujące rynek detaliczny są w zasadzie przygotowane do obsługi zamówień elektronicznych przeciwieństwie do magazynów przyprodukcyjnych. Wprowadzenie w tym przypadku bezpośredniej sprzedaży detalicznej będzie wiązało się ze znacznym nakładem środków.
Wnioski: Nie można jednoznacznie określić, że wprowadzenie e-commerce w magazynie to rewolucja dla jego pracowników i kierownictwa. Jest to zależne od rynków, na których operuje przedsiębiorstwo, oraz od klientów, których przed wprowadzeniem e-commerce magazyn obsługiwał.

Słowa kluczowe: e-commerce, e-handel, handel elektroniczny, magazyn

DER EINFLUSS VON E-COMMERCE AUF DAS FUNKTIONIEREN DES LAGERS

ZUSAMMENFASSUNG. Einleitung: Häufig sind Meinungen über die Ungewöhnlichkeit der Lager anzutreffen, die zur Handhabung des elektronischen Handels vorgesehen sind [Graves 2012], meistens werden sie von Lieferanten moderner technologischer Ausrüstungen oder von Entwicklern solcher Lösungen verbreitet. Natürlich ist es im Falle von neu zu errichtenden Objekten richtig, über innovative Technologien, insbesondere im Bereich der Komplettierung nachzudenken. In vielen Fällen können aber die Unterschiede zwischen den "Standardlagern", die Dienstleistungen z.B. für den Markt für Autoersatzteile erbringen, und den Lagern, die auf die Bearbeitung von Bestellungen im Einzelhandel, die elektronisch aufgegeben werden, ausgerichtet sind, außer Acht gelassen werden. Die Skala der Unterschiede zwischen den existierenden "Standardlagern" und den Lagern, die an die Handhabung des E-Commerce angepasst sind, hängt von der Branche und von der Art der zu betreuenden Kunden ab.

Methoden: Anhand von Erfahrungen und Beispielsunternehmen wurden zwei Fälle des Einflusses einer hypothetischen Einführung des E-Commerce auf die Lagerorganisation und -technologie analysiert.

Ergebnisse: Die Umsetzung des E-Commerce in einem Lager hat Änderungen zur Folge, die den Bestellungen entsprechen, die vorher bearbeitet wurden. Um es allgemein zu fassen, sind die Lager, die Dienstleistungen für den Einzelhandel-Markt erbringen, im Gegensatz zu den im Produktionsbereich tätigen Lagern, grundsätzlich auf die Bearbeitung von elektronischen Bestellungen vorbereitet. Die Einführung von direktem Einzelhandelsverkauf ist in diesem Fall mit einem erheblichen Mittelaufwand verbunden.

Fazit: Es lässt sich nicht eindeutig feststellen, ob die Einführung des E-Commerce in einem Lager eine Revolution für dessen Mitarbeiter und Führungskräfte bedeutet. Es hängt von den Märkten, auf denen das Unternehmen tätig ist, und von den Kunden, die das Lager vor der Einführung des E-Commerce betreut hat, ab.

Codewörter: E-Commerce, elektronischer Handel, Online-Handel, Lager

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THE ROLE OF INFORMATION IN PRODUCT INNOVATION PROCESS AND ASSORTMENT MANAGEMENT

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ABSTRACT. **Background**: Entities participating in the product innovation process and assortment management create an organization that processes information, so spending invested in the information processing determines the final form of the new product and assortment management. An important condition for effective communication processes, integration and cooperation between these entities is the right combination of company centers. Cooperation in this system is the basis of combining knowledge, information, experience and the skills of individual team members within the scope of the individual's role and responsibilities. The combined intellectual values determine the efficiency of new product development and assortment management. The level of cooperation in the team results in a particular level of assertiveness and cooperative spirit. Moreover, this cooperation provides the base for the concept of concurrent engineering, which is an integrated process for the development and introduction of a new product onto the market.

Methods and results: Studies carried out so far reveal a positive relationship between the use of information derived from market research (marketing information obtained from MDSS / MES) and the success of a product. On the basis of this study, it was found that inappropriate, irrelevant and outdated data and technical documentation, and inadequate distribution of such information causes communication problems between the members of the project team, which is a major barrier to integration and cooperation teams, and has a negative impact on the level of success of new product designs.

The information technologies discussed above should generate eight key types of information required in supporting decision-making processes in new product development: the strategic, financial and program management, new product design (internal sources), technical, the customer and their needs (internal and external sources), and competition and regulations (external source) . This arrangement presents sets of information corresponding to information necessary for the formulation of a strategic marketing plan proposed by Ph. Kotler and G. Armstrong.

Conclusions: The use of the above types of information differs in the different phases of the integrated product life cycle. In the pre-project phase (FFE - fuzzy front - end activities), the company may need all kinds of information. However, in the commercialization and marketing phases what is primarily required is information about the recipient (the formulation of marketing programs) and program-project management (introduction of a new product onto the market). Technical information is required in the design and development phases of prototypes. Legal and regulatory information regarding the competition, and financial and strategic considerations are especially important in the testing and the economic evaluation phases of new product development.

Key words: information streams, product innovation, process innovation, new product assortment management.

INTRODUCTION

Currently, information describing the status of the product innovation process must be collected in large databases, taking into account the high expenditure on technical measures. This requires the use of effective methods of collecting and processing data and information on-line. It should also be noted that the traditional models, analytical or empirical, cannot solve all the problems identified in the process of product innovation and assortment management. There are few models with which to predict whether

a potential new product is selected in the ranges of tolerance, accepted by the parties surrounding the company, but sometimes the information supporting these technologies are applicable elements of artificial intelligence, for example, such as neural networks. The purpose of this article is to present the information flow in the process of product innovation and management of new assortment and controlling technology of these streams in companies introducing new products into the market. Authors also propose the strategic tools that provides access to high quality information CIDMM and EIA as the result of analysis of information systems used in marketing channel.

INFORMATION STREAMS OF PRODUCT INNOVATION PROCESS

The current business management information systems contain data sets and information necessary to make a decision. However, in most companies these collections are scattered across the many different systems and platforms and places of occurrence. Thus, lack of integrity of the collection of data and information needed for decision-making extends access to them and, consequently, the process of decision-making.

Product innovation process and assortment management requires a very large number of information links synchronized in time. In conventional systems, the information flow of information is not an integrated and synchronized, which results from the nature of media and information. Also, the process of distributing data and information causes many delays, incompleteness, distortion and higher costs to obtain them. These companies can solve problems by using advanced information technology to capture and data collection, transmission, processing, decision-making processes, sharing in all phases of new product development process and assortment management [compare Dąbrowski 2009].

Today, every business is a system of data and information processing, and the level of expenditures for the processing of information also determines the final concept, form and structure of the new products in marketing offer [Kahn 2006].Thus, there are two important, mutually interpenetrating, range of activities related to the processing of information: focus on the development of the product and the process of technical and logistics flow of information and focused on the process, organizational and marketing information flow. The strength and width of the two streams of information flow increases, along with the progress of the product innovation process, see figure 1.

Technical information flow in the different phases of the innovation process and assortment management is characterized by repeated determination of the required data and corresponding to this redundancy. Systems, incorporating more elements than is necessary for functional reasons for increased reliability, are developed techniques and software tools for the products design and their visualization, quality control, process planning, engineering support and logistics (Computer-Aided Design , Quality, Planning, Engineering, Logistics). In these systems contain information necessary for the geometric description of the new product. CAD systems, in particular, are a starting point for the flow of technical efficiency, and electronic data interchange systems - EDI (Electronic Data Interchange) to optimize the logistics flow (exchange of technical data, documentation and exchange of information, collaboration with customers, suppliers) [Atuahene-Gima 2005, Moorman and Miner 2007].

Appropriate data structures and information, including a common data model and information allow to integrate partial solutions. The flow of information must also be possible in the opposite direction to the acquired knowledge can be tested and verified for immediate correction and updating of the major phases of the product innovation process, microstructure, and to compare the size of the received and selected to ensure the quality of the new product.

To achieve the best quality of the new product under the circumstances it is therefore possible economically, because spending on information processing and investment in the process, you can rationalize simultaneously. At the same time only in the production and

marketing phases of the investment can fall at the same time, so as soon as possible from the start of production of the new product must achieve a stable level of production without reservation in terms of quality. Thus, already

in the design and development phases of the new product must take action to minimize the time lag between onset and diagnosis of errors and defects in construction of the new product [Warnecke 1999].
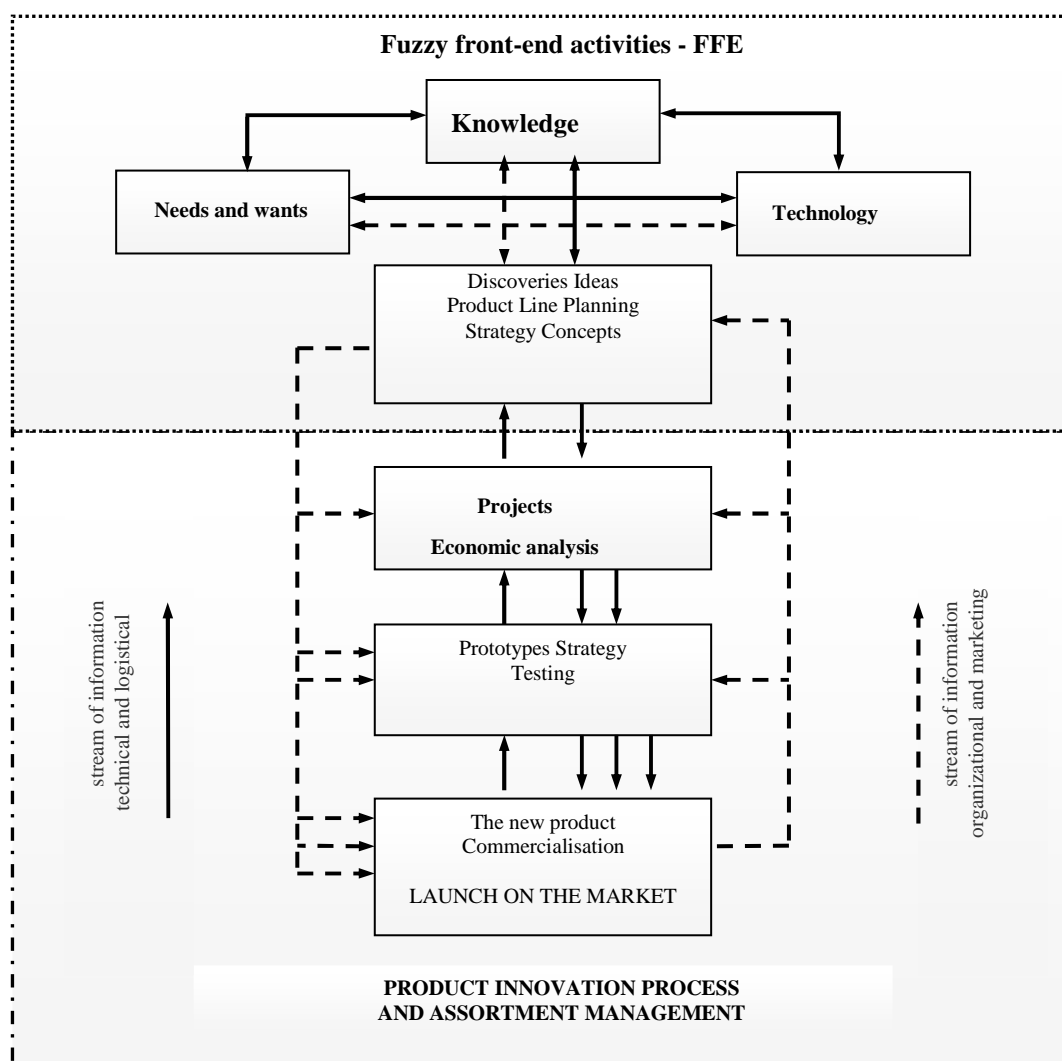
Source: own study and elaboration

Fig. 1. Information streams in the product innovation process and assortment management
Rys. 1. Strumienie informacyjne w procesie innowacji produktu i zarządzania asortymentem

Stream of information organizational and marketing content is to assist the rationalization of the product innovation process and match the dimensions of a new product to meet the needs, expectations and preferences of customers, and suppliers, intermediaries and other entities surrounding the company.

THE CONCEPT OF CIDMM MODEL

On the basis of current network structures, the structure of the software can be formed, supporting the product innovation process and assortment management, coordinated with the processes of production and marketing (sales). You can try to rebuild an inclusive D. Schacher model CIM - Computer Integrated

Manufacturing, and as a result can be implemented computer-integrated concept CIDMM - Computer Integrated Development, Manufacturing and Marketing. In this system, the information generated at any point in the process flow as soon as possible, to those customers whose decisions and actions are dependent on this information. CIDMM concept introduces the principle of grouping and its synthetic information sharing, especially for analytical purposes. Integration is possible provided that the introduction of standards for the exchange of data between programs. It should be noted that the implementation of modern methods of product innovation process and assortment management, such as concurrent engineering, it may be feasible only with the use of the concept of CIM or CIDMM, enabling a significant increase in the efficiency of the new product development process, also due to the high efficiency of the flow of streams Information.

Comprehensive use of techniques and tools in CIDMM system requires a comprehensive analysis of conventional information links between information entities and recreate them in the communication between the software modules. These links can be easily seen in all phases of product development, from fuzzy front-end phase (FFE) to the phases of design, product development, manufacturing, commercialization and assortment management. The design and prototyping phase, the project team should be made to the CAD recording features of the new product, relevant to the recipient, which should be identified by the method of quality function deployment (QFD - Quality Function Deployment) and the techniques of analysis functions (FAST - Function Analysis System Technique) [compare Rutkowski 2007]. In this way they are developed by the public perceived value, build the "house of quality". It is also important to identify and take account of market trends, product innovation, and taking into account the ideas of independent innovators. This record can then be used in the control phase and qualitative analysis of the product, implemented using a CAQ software. Conclusions of the examination and analysis of the quality of the new product should then hit the CAD system. You can also see the impact

on the construction of new issues raised in the design process of technological processes and assembly using the CAP. Programs control devices and machines of CAM technology is receiving information from the CAP, but they can also be a source of information for other systems. These information technologies can improve and optimize control programs, and ultimately improve the quality of the new product at a given level of the cost of its development and production. Thus, the development of systems CIDMM should move towards the fulfillment of assumptions without errors and product defects [Organizacja i Sterowanie Produkcją 2002].

New techniques such as artificial intelligence (AI - Artificial Intelligence), based on neural networks, are used as tools to help design and prototyping stages. Artificial intelligence systems enable the development of complex projects, new products, characterized by variable parameters during the technical and structural characteristics. Also allow solving disclosed in the development of quality problems. Expert systems based on models using AI and neural networks at the same time, generate process management procedures based on information obtained in the previously completed operations. Thus, existing solutions can be adapted to current conditions by enabling opportunities for learning neural network system controlled by AI. The accuracy of designs and prototypes of new products and their compatibility with the needs of customers, is significantly dependent on the quality, quantity and reliability of data (sequences of training data) collected during the monitoring of the actual process of new product development and assortment management.

In the process of new product development and assortment management effective knowledge management and its creation is largely dependent on the implementation of the concept of the product data management system (Product Data Management System - PDMS). Product data management system provides the infrastructure for data and information generated in the process of product development and assortment management. This is a fundamental argument in favor of its implementation in the company. However, this

implementation requires significant investments in software and hardware, and maintenance, consulting services, systems integration and training. It also requires a commitment of time and management of the enterprise and can potentially cause interference within the organization.

THE BENEFITS OF INTEGRATION OF DECISION SUPPORT SYSTEMS IN THE PRODUCT INNOVATION PROCESS AND ASSORTMENT MANAGEMENT

The benefits resulting from the implementation of this system may include [Armstrong 2001]:
- costs reduction through better access to consistent data and information, and faster communication and the ability to fully assess the various options for new projects, the introduction of the concept of concurrent engineering as a method of developing a new product,
- improve the productivity of the design and prototyping (the development team efficiently and productively use their time),
- better engineering changes manage,
- can be the basis for the implementation of ISO 9000 quality system, to maintain a balance between staff, processes, and technology (the company's organizational culture change),
- realistic costs of system implementation.

The basis for product data management, decision support, is oriented to specific thematic data warehouse applications. Data Access Tools provide team members a graphical interface with a data warehouse. Therefore, people involved in the development of a new product can directly affect the structure contained in the databases with naming libraries, with records, tables, and columns. These tools allow for extensive formatting, so that reports on the action taken in the development of a new product may have a specific figure. In the latest IT solutions are integrated MRPII / ERP class systems (manufacturing resource planning / enterprise resource planning) systems on a new data management product (PDMS), a database

application is the integration of material requirements planning. These systems are characterized by a variety of different sources of origin and to achieve the objectives which have been constructed.

The following are recommended best practices for integrating class systems MRPII / ERP (material resource planning / enterprise resource planning) systems on a new data management product (PDMS / CIDMM) [MRP/ERP and PDM: Understanding the fit…]:
- use the product structure management interface and its amendments, including the exchange of data;
- PDM considered as a server in an address, and if possible, to control all access to the data obtained by the product data management system;
- ensure automatic compliance process, in order to preserve the integrity of the structure of the product in its life cycle;
- provide access to data without undue registration;
- break down the traditional barriers between existing designers and engineers, and marketing and finance employees through the use of project teams, training, co-operation and full exchange of data;
- create data in the PDM system and transfer to MRP / ERP (transferred data includes both data on the product, as well as the structure of the product, and because data on the unit of measure, source code, product code, type-status identification document supplier, supplier part number);
- use parallel processing of data in both systems in a situation to make a formal engineering change (control number, description, classification codes, etc.);
- electronically on-line (in real time) permanently monitored and updated product data;
- avoid duplication of data errors, obsolete and unauthorized access to data.

Manufacturing, which will have significant control over the configuration of the product down through the integration of systems, MRPII / ERP and PDM / CIDMM can expect the following benefits:

- reduced storage costs / materials, lower stocks of overdue materials, smaller differences in the states of materials, better use of existing stocks, the reduction of costs of the new product;
- reduction of production costs and sales, lower labor costs, waste, more efficient and faster made changes, better use of lines, higher production efficiency.

Information systems development and implementation, especially Web-based, facilitates data management and information and increases the efficiency of the new product development process. It should be noted, however, that the usefulness and functionality of the application available to a greater degree focuses on the information supporting the production, marketing and sales of existing products, rather than the information supporting the decisions taken in the process of product innovation. So this is a potential area to be completed by the software vendors.

It should be noted that the availability, timeliness, value determines the possibilities of using the information in a rational manner the various methods in the process of product innovation and assortment management, its marketing during the product life cycle.

STRATEGIC MANAGEMENT PRODUCT OFFERING TOOL - EFFICIENT ITEM ASSORTMENT

Satisfactory financial performance depends on properly selected range of appropriate strategies and new products. New products appear and disappear from the market more quickly, which is why it is extremely difficult to build a product mix of appropriate width and depth of assortment, which contains the optimal number of best-moving brands. Finding the right answers to the challenges faced by managers brands of products, product category, and space is not an easy task. Recommendations for determining the optimal balance between product breadth and depth of assortment, there are still difficult for many companies to implement. On the market there are many solutions to support the process of effective management range, but most of them

are in the planning phase of the main letter assortment approach is pushing the "one model fits all". Meanwhile, taking into account the criteria required by various attributes, such as size, location, income, consumers, etc. This requires the development of appropriate assortment ranges (i.e. assortment ranges) tailored to the needs of the local market, it is also a prerequisite for the success of a new product commercialization phase [Rutkowski 2011].

Efficient Item Assortment is a strategic tool that provides access to high quality information, using effective and recognized by the market EIA procedures and analyzes to help decision making in the management of product offerings. To quickly create a complex assortment lists EIA also offers retailers, manufacturers and distributors the opportunity to combine forces and use of competitive advantage and achieve additional growth of the product line or category.

Processing and analyzing the available data product manager is able to check whether a range of products includes appropriately shaped product mix to ensure the diversity sought by customers while increasing sales across the category. Using a friendly-to-use data import wizard, Efficient Item Assortment allows you to import relevant data and market sales, which greatly facilitates selection of appropriate information needed to make effective decisions assortment. Another improvement is the ability to maintain employment data import settings as a profile for multiple use. In addition, fast and simple implementation allows you to enjoy better results after implementation of the program. With the right strategy and tactics define the product and corrections applied on the product mix, you can quickly record an impressive improvement in labor productivity and a significant shortening of the implementation of category plans.

Regardless of whether or not the strategy for the product line is to increase the speed and defense market segment, the system gives the possibility of partnerships between retailers, manufacturers and distributors who share their knowledge of the market and the producers of common strategies. Putting basic questions

such as who, what, how, where, why, how often, how the customer buys the system supports an objective analysis to create the optimal product mix. This allows you to achieve the main goals for the product line or category. To confirm that the share of the product in the category meets the requirements of the market and sales allocation, the system helps to filter the list of products with detailed methodology and procedures.

The removal of unprofitable units of the product offer, add or maintain efficient range of products from each market segment will allow its effective implementation of product and market strategy, and thus achieve measurable benefits - higher sales and profits and lower losses and operating costs [Nakata Cheryl, Di Benedetto C. Antony 2012; Merle, Di Benedetto 2011].

The system provides flexible and simple-to-use reports that allow you to focus on the analysis and spend less time on data processing. Powerful graphical user interface presents the analytical elements in tabular and graphical form, so greatly simplifies the process of decision-making. As a result, it is easier to monitor changes in sales value and quantity. Using the module system (Combined Performance Index - CPI) of the product or segment groups, using one or more sets of data can be compared to the products category or another. The user has access to critical information to determine whether the objectives of the category in the right way to optimize the cost of distribution and exhibition space, the stock and the flow of customers.

The main benefits of the system supporting the management of product offerings:
- flexible data structure - no predefined fields,
- import market data, POS and processed panel data available in different formats,
- connection to the source data range using the data import wizard,
- flexible structure design options based on user-defined key data for the use of user-defined multi-criteria weighted according to the applicable business rules,
- load the consumer decision tree structure (CDT) and its use in the analysis of range,

- generation of key assortment lists with one click,
- assortment management decisions with exceptions,
- review recommendations to facilitate decision-making by removing, adding, or behavior of the product range,
- use notes to track the logic of the proposed changes in assortment,
- use a fully reversible mesh allowing for analysis and finalization of range,
- monitoring the performance category with powerful reporting module,
- analysis and extensive tabular charts with advanced graphical user interface,
- integration with most systems management space through the use of Excel and CSV format (Comma Separated Values - comma separated values for data transfer).

For example Strategix is a supplier of market-leading range of management tools and a sales space. JDA Portfolio Company Intactix Software Inc.. is a fully integrated solution that provides support in the process of category management, assortment planning and optimization, data analysis, reporting, sales, demand planning and maintenance category. It consists of: Space Planning by IntactixTM, Floor Planning by IntactixTM, Shelf Assortment by IntactixTM, Efficient Item Assortment by IntactixTM, Intactix Knowledge BaseTM [Strategix, Assortment Management]. The system allows for instant access to information to assist in managing the company's products. So you can get information about the number and value on offer goods, the amount established and realized margins, the size of the profit markdown control, the amount of loss, the size of loss, the results of the promotion is the sales, turnover of goods. All these details are known, both for individual goods, and groups of the whole range. Thanks to determine their role in shaping the overall turnover of the company. This information and the resulting consequences are used to make strategic decisions about the directions of further development of the company.

CONCLUSIONS

Complex financial and marketing analysis requires vast amounts of data processing. To analyze these do not jeopardize the operation manager, has been developed data replication technology. This means copying data from other databases (Oracle, PostgreSQL). These databases are characterized by an open architecture that enables the creation of arbitrarily complex queries in SQL, and therefore obtaining even the most complex reports. For managers, managing a highly extensive range of products, information showing the impact of individual marketing activities on the overall financial performance and the ability to plan the cyclical nature of such actions are necessary for the continued, effective operation of the company. Thus obtained, using the marketing, statistics (daily, monthly, etc.) and their analysis, form the basis for delineation of the direction of the company.

Quick access to information, via remote transmission of data to the control panel, allows the preparation of any studies which are aimed at facilitating decision-making for management, R&D, purchasing and marketing department. With the information provided by the system, you can quickly make decisions, which in the modern market is very important.

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ROLA INFORMACJI W PROCESIE INNOWACJI PRODUKTU I ZARZĄDZANIA ASORTYMENTEM

STRESZCZENIE. **Wstęp**: Podmioty uczestniczące w procesie innowacji produktu i zarządzania nowym asortymentem tworzą sieć organizacji (ta sieć powinna być zintegrowana) przetwarzających informacje, zatem nakłady poniesione na realizację procesów informacyjnych determinują ostateczną formę nowego produktu oraz jego sukces rynkowy [Crow 2002]. Istotnym warunkiem sprawnego przebiegu procesów komunikacji, integracji, współpracy tych podmiotów jest właściwa kolokacja centrów wartości w przedsiębiorstwach. Współpraca w tym układzie jest podstawą łączenia wiedzy, informacji, doświadczenia oraz umiejętności poszczególnych członków zespołów projektowych w ramach indywidualnego zakresu roli oraz odpowiedzialności. Poziom współpracy w zespole jest natomiast wypadkową poziomu asertywności oraz poziomu kooperatywności. Poza tym współpraca jest fundamentalną bazą koncepcji inżynierii współbieżnej, czyli zintegrowanego procesu rozwoju i wprowadzania nowego produktu na rynek.
Metody i rezultaty: Dotychczasowe badania ujawniają pozytywny związek pomiędzy stopniem wykorzystania informacji pochodzącej z badań marketingowych, a różnymi miernikami powodzenia produktu. Poza jednak informacjami rynkowymi zespoły projektowe potrzebują także innych rodzajów danych i informacji, które istotnie determinują powodzenie nowego produktu. Przedstawione technologie informacyjne powinny generować osiem kluczowych rodzajów informacji niezbędnych we wspomaganiu decyzyjnym procesu rozwoju nowego produktu: strategiczne, finansowe, zarządzania projektem, techniczne, dotyczące odbiorcy i jego potrzeb oraz konkurencji i regulacji prawnych. Taki zbiór informacji odpowiada grupom informacji, niezbędnych w procesie formułowania strategicznego planu marketingowego.
Wnioski: Zakres wykorzystania wymienionych wyżej rodzajów informacji jest różny w poszczególnych fazach zintegrowanego cyklu życia produktu. W fazach przedprojektowych (FFE - fuzzy front - end activities) firma może potrzebować wszystkie rodzaje informacji. Natomiast w fazie komercjalizacji i wprowadzania na rynek wymagane będą przede wszystkim informacje dotyczące odbiorcy (formułowanie programów marketingowych) oraz zarządzania programem-projektem (wprowadzanie nowego produktu na rynek). Informacja techniczna wymagana jest w fazach projektowania i rozwoju prototypu nowego produktu. Informacje prawno-regulacyjne, dotyczące konkurencji oraz uwarunkowań finansowych i strategicznych ważne są przede wszystkim w fazie testowania i oceny ekonomicznej nowego produktu.

Słowa kluczowe: strumienie informacji, produkt, innowacja, proces innowacji, nowy produkt, zarządzanie asortymentem.

DIE ROLLE VON INFORMATIONEN IM PROZESS DER PRODUKTINNOVATION UND DES SORTIMENTSMANAGEMENTS

ZUSAMMENFASSUNG. Einleitung: Die Unternehmen, die am Prozess der Produktinnovation und des Managements eines neuen Sortiments teilnehmen, bilden ein Netz von Organisationen (dieses sollte nach Möglichkeit integriert sein), die Informationen verarbeiten. Die Aufwendungen für den Informationsaustausch zwischen ihnen bestimmen also die endgültige Form des neuen Produkts und beeinflussen seinen Markterfolg [Crow 2002]. Wesentliche Bedingung für einen effizienten Verlauf der Kommunikations-, Integrations- und Kooperationsprozesse zwischen diesen Unternehmen ist die richtige Kollokation der Wertschöpfungszentren in den Unternehmen. Die Zusammenarbeit auf diesem Gebiet bildet die Grundlage für die Verknüpfung von Wissen, Informationen, Erfahrung und individuellen Fähigkeiten der Mitglieder der Projektteams im Rahmen ihrer je individuellen Rollenzuweisung und Verantwortlichkeit. Das Niveau der Zusammenarbeit im Team ist dagegen die Resultante aus den Niveaus von Durchsetzungswillen und Kooperativität. Außerdem ist Zusammenarbeit die grundlegende Basis für die Konzeption der verteilten, gleichzeitigen Entwicklung (Concurrent Engineering), also des integrierten Entwicklungs- und Markteinführungsprozesses für neue Produkte.

Methoden und Resultate: Bisherige Untersuchungen haben eine positive Korrelation zwischen der Nutzung der Informationen aus der Marktforschung und verschiedenen Messgrößen für den Erfolg des Produkts gezeigt. Neben Informationen aus dem Markt brauchen Projektteams jedoch auch noch andere Arten von Daten und Informationen, die den Erfolg eines neuen Produkts wesentlich determinieren. Die vorgestellten Informationstechnologien sollen acht grundlegende Informationskategorien hervorbringen, die zur Entscheidungsunterstützung bei der Entwicklung neuer Produkte erforderlich sind: strategische, finanzierungsbezogene und Informationen aus dem Bereich des Projektmanagements, technische Informationen und solche über den Abnehmer und seine Bedürfnisse, schließlich Informationen über die Konkurrenz und die rechtlichen Rahmenbedingungen. Eine solche Informationssammlung entspricht den Gruppen von Informationen, wie sie im Prozess der Formulierung eines strategischen Marketingplans benötigt werden.

Fazit: Welche der vorstehend genannten Informationsarten in den einzelnen Phasen des integrierten Produktlebenszyklus vorwiegend abgerufen werden, unterscheidet sich je nach diesen Abschnitten. In der Phase vor Beginn des eigentlichen Projekts (FFE - fuzzy front-end activities) kann das Unternehmen alle Arten von Informationen gebrauchen. In der Phase der Kommerzialisierung und Markteinführung dagegen sind vor allem Informationen über den potentiellen Abnehmer (Formulierung von Marketingprogrammen) und solche zum Management des Projektprogramms (Markteinführung des neuen Produkts) gefragt. Technische Informationen sind während der Projektentwicklung und der Erstellung des Prototyps des neuen Produkts erforderlich, Informationen zu den rechtlichen Rahmenbedingungen, zu den Wettbewerbern und den finanziellen und strategischen Bedingungen sind vor allem während der Testphase und während der wirtschaftlichen Bewertung des neuen Produkts wichtig.

Codewörter: Informationsströme, Produkt, Innovation, Innovationsprozess, neue Produkte, Sortimentsmanagement.

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ACCOUNTING THE SCALE AND SYNERGIES IN THE DEA-ANALYSIS

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ABSTRACT. **Background:** The proposal is to non-linear performance into account in terms of synergy when conducting DEA (Data Envelopment Analysis). The solution to the problem is produced for interacting schools, which can be regarded as business clusters. The inputs and outputs are selected by importance on the basis of the author's opinion. However, the technique does not change when taking into account other factors that are expressed numerically.
Methods: The proposal is to reduce the number of the inputs and outputs to one input and one output using weighting factors. Thus a solution can be found by linear programming. The DEA algorithm is easily coded in Mathcad.
Results: As a result, we obtain a vector of the effectiveness of each element in the business cluster, including stand-effective and super-efficient elements.
Conclusions: A model of DEA is proposed which takes into account the scale and synergies of the business cluster. This allows a performance rating against the collective interaction to be obtained.

Key words: DEA, business cluster, linear programming, inputs, outputs, synergies, efficiency, super-efficiency.

INTRODUCTION

A mathematical method of DEA (Data Envelopment Analysis) [Charnes, Cooper, Rhodes, 1978] allows us to make an adequate model assessment of business clusters, which are identical in the economic activity. The activity of the informationally interacting enterprises can be fully considered as the business activity of the business cluster, so the method of DEA with an appropriate choice of comparable inputs and outputs can be extended to these companies [Akbarian et al., 2015].

In the simplest case, the result of the business cluster's activity is defined by its single output (e.g. profit) depending on a single input (e.g. investment). To quantify the relative effectiveness on the plane (X, Y) it

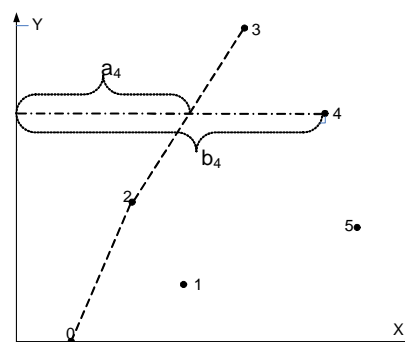is constructed a scatter chart (input, output), as shown for the 5-members business cluster in Fig. 1.

Fig. 1. Scatter plot of the input-output
Rys. 1. Schemat wejść-wyjść

RESULTS AND DISCUSSION

Obviously, the participants of a business cluster which are the extreme left points will be the most effective, because their output values are maximum when the input values are minimum. In accordance with this principle, these points are the points 1, 2, 3. However, as we can see in Fig. 1, the point 1 is not the most efficient. Because despite having larger input than the point 2 has, its output is much less than of point 2. To avoid the possibility of including these points in the category of effective work [Novikov, Falko, Petrunya, 2009] it is proposed to introduce a fictitious point 0 on the axis X. The meaning of the 0 point is reduced to the minimum *allowable* input, for example according to the safety standard (floor space). In extreme cases, this point may be at the beginning of the coordinate system (X, Y). With the introduction of a fictitious point 0, as shown in Fig. 1, point 1 is automatically excluded from the category of the most effective. Leftmost points on the scatter chart are considered big-effective with the efficiency θ = 1 (points 0, 2, 3 in Fig. 1). These points form a convex polygon 0-2-3. In order to calculate the efficiency of the other points from the point *i,* we draw the line parallel to the axis X (see Fig. 1 point 4). Efficiency point *i* is given by:

$$\theta_i = \frac{a_i}{b_i} \ ,$$

where a_i, b_i correspond to the segments shown in Fig. 1 for point 4. Obviously, the efficiency ratio is in the range $0 \le \theta_i \le 1$. Than smaller θ_i we have, than lower the efficiency of the party business cluster we get. For example, if $\theta_i = 0{,}1$ the efficiency is 10 times lower than that of big-effective business cluster. That is, the coefficient of inefficiency can be defined as:

$$L_i = \frac{1}{\theta_i} \ .$$

The task of evaluating the effectiveness becomes much more complicated when there are multiple inputs X and multiple outputs Y. Taking all the information about the inputs and outputs into consideration it is necessary to evaluate relative measurement of the specific input and output in the form of weight ratio α_i β_j for inputs and outputs. Values α_i and β_j may be not-normalized from 0 to 1, and may take any positive value. Value $\alpha_i = 0$ means that the i-th input is not accounted in the evaluation of effectiveness. α_i = max value specifies the maximal evaluation degree to i-th input. After setting the weight ratio α_i, β_j inputs and outputs can be reduced by mixing weighting to one input and one output, as proposed in contrast to the known methods in [Novikov, Falko, Petrunya, 2009]. To provide adequacy of mixed inputs and outputs they are to be normalized to a maximum of 1, in other words should be deprived of dimensionality.

$$XM_i = \max_n X_{in}, \quad \overline{X}_{in} = X_{in}/XM_i \ ,$$

where: i - i-th input, n - n-th value of the i-th input

$$YM_j = \max_k Y_{jk}, \quad \overline{Y}_{jk} = Y_{jk}/YM_j \ ,$$

where: j - j-th input, k - k-th value of j-th input.

This method of calculation in DEA is attractive due to the fact that the higher accuracy allows to eliminate direct programming and to use Mathcad calculations only [Peiwu, Kai, Mei, 2015].

Main drawbacks of the above method are the following two problems.

Firstly, this method does not take into account the influence of the size of the members of the business cluster on efficiency. So almost always, the business cluster with bigger staff will be big-effective, since it is obvious that the sum of its output will be incommensurable with the business cluster with smaller staff. On the other hand the total input, in condition when the staff is not taken into account, leads towards the under-performance.

Thus, it is necessary to define two categories among the inputs and outputs. The first category includes the inputs and outputs that are independent of the number of team members. The second category includes the inputs i and outputs j, which values are necessary to be counted by one staff unit S_k for *k-th* member of the business cluster:

$$x_{ik} = x_{ik} / S_k, \quad y_{jk} = y_{jk} / S_k.$$

Secondly, method does not take into account the degree of contribution of an input and output to the synergy of the totality of the business cluster which contradicts to the law of Robert Metcalfe. It is obvious, for example, that the party of the business cluster with a large amount of investment is making a significant contribution to the development of new technologies for the whole system of the business cluster. The accounting of such an input in the method above is linear. The linear model in this case would significantly mark down the synergistically important inputs and outputs and generally underestimate the effectiveness of the participant of the business cluster. According to the law of Robert Metcalf it is necessary to take a non-linear relationship for these inputs i and outputs j:

$$x_{ik} = x_{ik}^2, \; y_{jk} = y_{jk}^2.$$

On the other hand in the system of business clusters there are inputs and outputs that negatively affect the synergy of the system and they need to be taken into account with the degree of ½:

$$x_{ik} = x_{ik}^{0.5}, \qquad y_{ik} = y_{ik}^{0.5}$$

In general, all inputs and outputs must be overridden by the formulas:

$$x_{ik} = x_{ik}^{\gamma_i}, \quad y_{jk} = y_{jk}^{\sigma_j},$$

where: $(\gamma_i, \delta_j) = [0.5; 2]$.

The meaning of $(\gamma_i, \delta_j) = 2$ and $(\gamma_i, \delta_j) = 0.5$ is described above. The meaning of $(\gamma_i, \delta_j) = 1$ comes to the inputs and outputs, the effect on synergy system of which is independent of the

value. For example, this input can be a bill of goods in the store, the number of cash registers in the store, etc.

In this problem, as in [Koster, Kosterin, 2006], we calculate the efficiency and super-efficiency for big-effective schools with Mathcad.

The calculations were performed for the 10 hypothetical schools with data, where the first school of [Novikov, Falko, Petrunya, 2009] is a dummy in accordance with the method and defines minimum permissible parameters on standards for the school:

ORIGIN := 1

The input: The number of graduates

x1:= (5 52 23 82 23 18 12 45 32 53)^T

The input: The number of visitors of the creative sections in the school

x2:= (0 71 33 17 33 28 18 35 72 83)^T

The input: The number of visitors of the sport sections

x3:= (0 21 13 27 24 21 11 25 32 33)^T

The input: The number of members of the youth organizations

x4:= (0 41 23 42 54 51 35 31 20 45)^T

The input: The number of excellent pupils among the graduates

x5:=(0 12 3 6 9 11 5 13 18 16)^T

The input: The number pupils with scores above 3.5

x6:= (0 22 13 4 15 9 7 17 28 22)^T

The output: The number of entrants to universities

y1:= (0 15 1 46 5 4 5 22 1 16)^T

The output: The number of entrants to colleges

y2:= (0 25 11 16 15 11 5 24 21 20)^T

In our opinion the most important parameters of the school are taken as the inputs and outputs, although there may be added other parameters that have numeric expressions. The only condition for the input selection is the condition of its positive efficiency with an increase in the numerical value of the condition, so, for example, the number of pupils with scores above 3.5 is taken as input, and not vice versa. Also the positive parameter of business cluster must be taken as output.

After making the initial data it is necessary to define the normalization ratios, which determine the importance of each input and output.

The normalization ratio

For inputs   a:= (1 1.6 1.8 1.3 3 2.5)^T

For outputs   b:= (1 0.4)^T

In this example, the significance of the fifth input (the number of excellent pupils among the graduates) is defined with a ratio 3 relatively to the first input (the number of graduates). And for outputs, the significance of the second output (the number of entrants to colleges) is defined with a ratio 0.4 relatively to the first output (number of entrants to universities).

The accounting of the collective impact leads the elements of the collective system to the same of conditions relative to the number of students in the school, which excludes the effect of the dependence of the efficiency on the size of the school in the analysis:

$$i := 2..6$$

The accounting of the collective impact $\vec{y_1} := \dfrac{\vec{y_1}}{x_1} \quad \vec{y_2} := \dfrac{\vec{y_2}}{x_1} \quad \vec{x_i} := \dfrac{\vec{x_i}}{x_1}$

Where the vector x_1 determines the number of students in schools.

One of the novelties of the proposed method of calculation is the accounting of synergies associated with the nonlinear impact

of some outputs on the collective self-organization of the whole system. In case of our analysis of schools it can be considered that the greatest synergy is provided by visiting creative sections by pupils (factor 2) and the number of excellent pupils at the school (factor 1.8). On the other hand, the number of graduates with a score below 3.5 obviously affects the whole synergy of the collective system, so for this input the synergy ratio is taken minimal:

The accounting of synergy $x_2 := \left(x_2\right)^2 \qquad x_6 := \left(x_6\right)^{0.5} \qquad x_5 := \left(x_5\right)^{1.8}$

As suggested in [2], all the inputs and outputs need to be led to one input and one output using the normalization factors:

$$j := 1..6 \qquad m := 1..2$$

calculation of the maximum values $\quad x\_m_j := \max(x_j) \quad y\_m_m := \max(y_m)$

normalization $\quad x_j := \dfrac{\vec{x_j}}{x\_m_j} \qquad y_m := \dfrac{\vec{y_m}}{y\_m_m}$

reduction to one input $\quad X := \sum_j \left[\overrightarrow{(x_j \cdot a_j)}\right] \quad X\_m := \max(X) \quad X := \dfrac{X}{X\_m}$

reduction to one output $\quad y := y_1 \cdot b_1 + y_2 \cdot b_2 \quad y\_m := \max(y) \quad y := \dfrac{y}{y\_m}$

Note that when calculating the vectors x and y and the sum for X in Mathcad it is necessary to use the operation of vectorization.

The direct implementation of the method is implemented by solving the problem of linear programming, as shown for the 4th input (S = 4):

calculation of the efficiency ratio for S input

$$S := 4 \quad m := rows(y) \quad m = 10 \quad i := 1..m \quad \lambda_i := 0$$

$$F(\lambda) := \dfrac{1}{X_S} \cdot \sum_{ii=1}^{m} \left(X_{ii} \cdot \lambda_{ii}\right)$$

Given

$$\sum \lambda = 1 \quad y_S = \sum_{ii=1}^{m} \left(y_{ii} \cdot \lambda_{ii}\right) \quad \lambda \geq 0 \quad \lambda_S = 0$$

$$\lambda := Minimize(F, \lambda)$$

$$\theta := F(\lambda) \qquad \theta = 1.683$$

For clarity, Figure 2 shows the distribution of all the points of generalized normalized input and output in the plane, where the point at the origin corresponds to a fictitious school. For the calculation of big- effective schools S it is necessary to put $\lambda_S S = 0$ into the block Given.
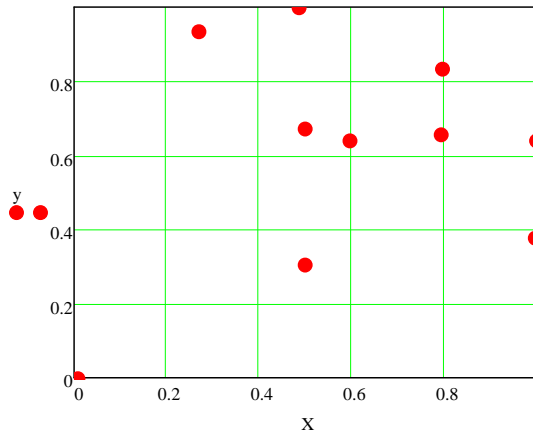

Fig. 2. Diagram of an input-output
Rys. 2. Wykres wejść-wyjść

This resulted in the following effectiveness parameters:

$$\Theta\Theta := (0 \quad 0.39 \quad 0.19 \quad 1 \quad 0.24 \quad 0.19 \quad 0.3 \quad 1 \quad 0.12 \quad 0.32)$$

$$\Theta\Theta\_super := (0 \quad 0.39 \quad 0.19 \quad 1.6 \quad 0.24 \quad 0.19 \quad 0.3 \quad 1 \quad 0.12 \quad 0.32)$$

According to these results, the least effective is the 8th school with efficiency ratio of 0.12, but the most effective is the third school with the super-efficiency ratio 1.6.

If you place the assessment of super-efficiency in descending order, it is natural to get school's ranking score of rating from the leader to the outsider.

SUMMARY

The proposed methodology of DEA-analysis, in contrast to [Charnes, Cooper, Rhodes, 1978, Novikov, Falko, Petrunya, 2009] allows to take into account the synergy of the system in two directions. First, it allows eliminating the effect of the scale of school, which puts all the schools in the same conditions. Secondly, it allows to take into account the non-linear nature of the inputs and outputs that are either extremely needed for synergy, or make no effect on the synergy, or negatively affect the synergy.

The described method is interesting because it allows you to specify the rating not only of schools, as it is done in this work, but to make a full DEA in the form of rating for any group of objects that can be represented in the form of a business cluster. Note that the proposed method of DEA-analysis does not require a high-level programming tools and can be elegantly realized in MathCad.

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OBLICZANIE SKALI I SYNERGII W ANALYZIE DEA

STRESZCZENIE. **Wstęp:** Poddano analizie metodę nieliniową dla synergii przy zastosowaniu metody DEA (Data Envelopment Analysis). Rozwiązanie zostało zrealizowane dla współpracujących szkół, które mogą być traktowane, jako klastery biznesowe. Dane wejściowe i wyjściowe zostały wyselekcjonowane według ważności (w opinii autora). Aczkolwiek należy zaznaczyć, że metoda postępowania nie zmienia się przy analizie innych czynników, mogących być przedstawione w formie liczbowej.
Metody: Zaproponowano redukcję liczby danych wejściowych i wyjściowych przy zastosowaniu współczynnika wagi. Następnie poszukano rozwiązania przy użyciu programowaniu liniowego. Algorytm DEA może być z łatwością zaimplementowany przy użyciu MATCAD.
Wyniki: Otrzymano wektor efektywności każdego elementu klastra biznesowego, łącznie z elementami o stałej i bardo dużej efektywności.
Wnioski: zaproponowano model DAE, uwzględniający skalę oraz synergię klastra biznesowego. Umożliwia to uszeregowanie zachowań wobec zbiorowych interakcji..

Słowa kluczowe: DEA, klastera biznesowy, programowanie liniowe, wejście, wyjście, synergia, efektywność, superefektywność.

DIE BERECHNUNG DER SKALA UND DER SYNERGIE ANGESICHTS DER DEA-ANALYSE

ZUSAMMENFASSUNG. Einführung: Die nichtlineare Methode für die Synergie wurde unter Anwendung der DEA-Methode (Data Envelopment Analysis) einer Analyse unterzogen. Die Lösung wurde für eng zusammen arbeitende Schulen, die dabei als Business-Cluster behandelt werden können, ausgearbeitet. Die In- und Output-Daten wurden nach deren Relevanz (nach der Ansicht des Autors) ausgesondert. Es muss dabei allerdings beachtet werden, dass die Vorgehensweise bei der Analyse von anderen Faktoren, die in zahlenmäßiger Form projiziert werden können, sich jedoch nicht verändert.
Methoden: Es wurde die Einschränkung der Anzahl von den betreffenden In- und Output-Daten unter Anwendung des Relevanz-Koeffizienten vorgeschlagen. Demzufolge suchte man nach einer Lösung mit der Inanspruchnahme von linearer Programmierung. Der DEA- Algorithmus kann durch die Anwendung vom MATCAD leicht implementiert werden.
Ergebnisse: Es wurde ein Effizienz-Vektor für jeden Bestandteil des Business-Clusters, einschließlich der Elemente von konstanter und sehr hoher Effizienz, erzielt.
Fazit: Es wurde ein DAE-Modell, das die Skala und die Synergie des Business-Clusters, mit berücksichtigen kann, vorgeschlagen. Dies ermöglicht eine angemessene Anordnung der einzelnen Verhaltensweisen den Sammel-Interaktionen gegenüber.

Codewörter: DEA, Business-Cluster, lineare Programmierung, Input, Output, Synergie, Effizienz, Supereffizienz

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EVALUATION MODEL FOR PRODUCTION PROCESS ECONOMIC EFFICIENCY

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ABSTRACT. **Background:** Economic activity focused on manufacturing and supplying products for sale is one of the basic processes in the logistics supply chain. The specificity of production processes requires concentration on the factors, which are crucial for the continuity of the material flowin terms of both business practice and in relation to the relevant literature. The significant impact of production processes on the financial result of the company affects the costs, revenues, turnover of assets and working capital cycle, so this is the main reason to focus production management on ways to improve process efficiency for both internal and external supply chain, and also on the continuous supervision and evaluation of the results obtained. This article presents an original model for the analysis and evaluation of production process efficiency in economic terms.

Material and methods: The results of research carried out in Polish companies in 2011-2013 and the results of a literature review indicate the unsatisfactory use of efficiency analyses in managing production processes, related supply chains and the production environment. These formed the basis for the selection and compilation of factors to evaluate the production process' economic efficiency. Complementary research concerning the importance of each factor in business practice was carried out in the first half of 2015 in 138 manufacturing companies in Wielkopolska Voivodship.

Results: Based on the results and observations, the authors developed a model for evaluating the economic efficiency of the production process, which will make it possible to conduct multivariate simulations using parametric models of production processes and the environment at later stages of their research.

Conclusions: Despite numerous considerations in the literature, the issue of production process efficiency has not yet been comprehensively presented nor developed. The concept for evaluation of production process efficiency presented here applies to its economic aspects. The authors are aware of the need to combine the analytical scope with analysis and evaluation of operational efficiency, thus further research will aim to provide a comprehensive analysis and evaluation of production process efficiency and value engineering in its operational development.

Key words: production process efficiency, operational controlling, balanced scorecard.

INTRODUCTION

It is difficult to clearly define the concept of efficiency. In the economic aspect, efficiency is the result of company's business activity, which is the ratio of the effect achieved to the spending incurred:

$$E = \frac{e}{s} \quad (1)$$

where:
E - efficiency; e - effects; s - spending

Therefore, efficiency is a measure of expected results to the actual production volume, usually shown as a percentage [APICS 2004]. The presented efficiency measurement formula (1) became the basis for considerations in literature and study of business practice in respect of comprehensive evaluation of the production process efficiency.

The resulting efficiency improvement can be achieved through a deliberate development

of value-oriented processes, thus establishing the proper (standard) allocation of resources. The method for evaluating the resource allocation efficiency presented in this paper is consistent with the concept of Kaldor-Hicks efficiency, according to which the solution leads to increased efficiency when the proper allocation of resources enables improvement of efficiency ratio described by formula (1). In a situation where any change of a specific allocation of resources causes a decrease of efficiency ratio - the current allocation is the most effective [Kaldor, 1939; Hicks, 1939]. According to P. Blaik, efficiency also contains the effect evaluation from the point of view of

the purpose of operation and the adoption of the following two basic aspects in analyses [Blaik 2010]:
- the market aspect, leading to development of the optimal value added structure for the customer,
- the process structure aspect examines operations and costs while taking into account rational economic relations.

The production process efficiency in the market and structural aspect is shown in Table 1.

Table 1. Production process efficiency
Tabela 1. Efektywność procesu produkcji

Market aspect	Structural aspect
Comparison of results requested and results achieved through the production process	Rationality of projects - a proper effects-spending ratio in the production process
Customer orientation (customer value)	Orientation on production costs and the costs of entire company
Criterion of purpose and usefulness of the production process effect	Criterion of the right selection of means in the production process
Highest efficiency - full compliance with customer preferences	Highest performance - optimal application and utilisation of production resources
Analysis of the market as a source of creation of conditions for the production process efficiency	Analysis of the production potential as a source of creation of conditions for efficient production projects
Benefits for the customer, taking into account long-term production process effects	Rational involvement of the production process components in order to create value

Source: Own work based on [Blaik 2010]

The economic aspect of the production process efficiency makes it necessary to take into account the analysis and evaluation of the production cost. Direct production costs are determined by material consumption, labour, energy consumption and the ratio of inventory being treated. Their importance for the production efficiency lies in the fact that they are a reference point for the design and evaluation of the entire system. The ratio between the direct and total production cost should be an economic criterion for evaluating the production process [Fertsch 2010]. However, the analysis of efficiency of production processes carried out in companies and supply chains requires a broad perspective to balance all the elements of the logistics process and customer service. A multivariate analysis of efficiency makes it possible to balance all production process resources in

order to improve their cooperation and achieve the synergy effect. It should be noted however that efforts to maximize the production process efficiency can entail a number of risks. The most important traps while maximising the production process efficiency are as follows:
- lack of coordination between operational objectives of individual departments with strategic objectives of the company or supply chain,
- conflict of strategic objectives developed by individual companies, which are elements of the supply chain,
- conflict of operational objectives of various departments within the company,
- risk of negative impact on the environment.

ANALYSIS OF PRODUCTION PROCESS ECONOMIC EFFICIENCY

The production process efficiency analysis should be based not only on operational indicators directly related to the production process, but also on financial indicators. The objectives and measures of the production process efficiency analysis should be a result of the company's vision and strategy. The production process efficiency analysis should be considered complete when it relates not only to the measures concerning the past results, but also to the measures that allow anticipating the impact on the results in the future. The issue of the production process efficiency evaluation may be based on assumptions of Balanced Scorecard [Michalska, 2005] developed by R. Kaplan and D. Norton. The authors proposed a balanced performance evaluation according to the relation between the objectives and the value of their measures in the following perspectives: financial, customer, internal business processes, and learning and growth [Kaplan and Norton, 1996]. Economic efficiency should therefore be understood as analysis and evaluation using financial and non-financial indicators that have a direct impact on the production process economics.

A set of measures was developed according to the production process efficiency analysis in these four perspectives [Corbett 1998; Śliwczyński 2011; Twaróg 2005] while taking into account the basic efficiency feature described by formula [1]. The first proposal of a set of indicators was included in the publication [Koliński 2013]. Table 2 shows the selected measures of economic evaluation of the production process efficiency in the financial perspective. Pre-selection of measures representative for each perspective (for which the importance analysis is presented in the article) was based on the sensitivity analysis for the main objective in each perspective with respect to multiple measures applied in companies.

Table 2. Measures of the production process economic efficiency in the financial perspective
Tabela 2. Mierniki efektywności ekonomicznej procesu produkcyjnego w perspektywie finansowej

No.	Measure name	Data relation	Data	UoM
1.	Share of defective production		a - value of defective products	%
			b - total value of products	
2.	Return on labour		a – net profit	%
			b - salary costs	
3.	Return on sales (ROS)	$\dfrac{a}{b}$	a – net profit	%
			b – net sales	
4.	Labour productivity rate		a – net sales	PLN/employee
			b - size of employment	
5.	Inventory turnover ratio		a - costs of material consumption	number of cycles
			b - average inventory value	
6.	Employee productivity rate		a – net sales	%
			b - salary costs	

Source: Own work

The presented table includes only selected financial indicators; according to the Author, they are most frequently used to evaluate the production process efficiency also in the environmental aspect [Golińska 2013]. There may be much more indicators useful in business practice, but keep it should be borne in mind that the greater the number of indicators applied in the analysis, the greater the risk of blurring its main objective. Table 3 shows the selected measures of economic evaluation of the production process efficiency in the customer perspective.

Table 3. Measures of the production process economic efficiency in the customer perspective
Tabela 3. Mierniki efektywności ekonomicznej procesu produkcyjnego z perspektywy klienta

No.	Measure name	Data relation	Data	UoM
1.	Order delivery effectiveness		a - number of orders delivered	%
			b - total number of orders	
2.	Quantity and value share in the market	$\dfrac{a}{b}$	a - size of the target customer group	%
			b - total market size	
3.	Average lead time		a - total lead time	h/order
			b - number of orders	
4.	Share of defective product deliveries to the customer		a - number of defective deliveries	%
			b - total number of deliveries	

Source: Own work

Some of the measures above are often reduced to one indicator - OTIF (On Time and In Full delivery). This indicator should be treated as customer service level seen from the perspective of the customer (e.g. retail chain) - "on-time, in-full" - the order is delivered on time and in full according to the customer requirements. In practice, sometimes OTIF is expanded to include "error-free" - taking into account picking errors (e.g. the quantity is right, but the delivered product variant is other than ordered). OTIF has become a key factor for process improvement initiatives. The planning of orientation and organizational integration by optimizing the processes throughout the supply chain leads to higher service level associated with the reduction in inventory [Sehgal et al. 2006]. Table 4 shows the selected measures of economic evaluation of the production process efficiency in the internal process perspective.

Table 4. Measures of the production process economic efficiency in the internal business process perspective
Tabela 4. Mierniki efektywności ekonomicznej procesu produkcyjnego z perspektywy procesów wewnętrznych przedsiębiorstwa

No.	Measure name	Data relation	Data	UoM
1.	Production flow		a - production process uptime	%
			b - total production time	
2.	Use of production capacity		a - used production capacity	%
			b - total production capacity	
3.	Share of defects and waste in the production process	$\dfrac{a}{b}$	a - value of raw materials classified as defects in the production process and employee labour	%
			b - value of total raw materials released for production	
4.	Electricity use efficiency at production post		a - productive time using electricity	%
			b - total labour time at post	
5.	Lead time for production orders for assortment group		a - total lead time for production orders	h/order
			b - number of production orders	

Source: Own work

The aspect of production process economic efficiency is most evident in the compilation of indicators in the company's internal business process perspective. This should not be surprising, as the operational processes that enable manufacturing of products have the greatest impact on the evaluation of the production process efficiency. Table 5 shows the selected indicators of economic evaluation of the production process efficiency in the learning and growth perspective.

Table 5. Indicators of the production process economic efficiency in the learning and growth perspective
Tabela 5. Wskaźniki efektywności ekonomicznej procesu produkcyjnego z perspektywy uczenia się i wzrostu

No.	Indicator name	Data relation	Data	UoM
1.	Share of replacement parts in the product	$\dfrac{a}{b}$	a - number of replaceable components	%
			b - total number of components in the product	
2.	Production process flexibility		a - number of special orders delivered	%
			b - total number of special orders	
3.	Effectiveness of design of new products		a - number of delivered designs of new products	%
			a - total number of designs of new products	
4.	Share of defective deliveries of raw materials		a - number of defective deliveries of raw materials	%
			b - total number of deliveries of raw materials	

Source: Own work

The indicators of production process efficiency evaluation in the learning and growth perspective are the most desirable form of evaluation, but are also the most difficult indicators to develop. The risks posed by learning and growth indicators may not only be contrary to the production process management objective, but also to the basic strategic objectives of the company or supply chain [Lichocik and Sadowski 2013]. While preparing the compilation of indicators of production process efficiency evaluation it should be taken into account that there are close links between the various perspectives according to the balancing of perspectives in the BSC. Analysis and development of measures for efficiency evaluation separately for each perspective can lead to effect opposite to the one expected - a set of indicators that are mutually exclusive or show divergence of objectives can be obtained.

IMPORTANCE ANALYSIS OF INDICATORS - RESULTS OF BUSINESS PRACTICE RESEARCH

The set of indicators developed above was confronted by the Authors with the business practice expectations. The research involved the importance analysis of the developed indicators in individual perspectives. The research was conducted in the first two quarters of 2015. 138 production companies in the Wielkopolska Province participated in the research. Basic information on the surveyed companies is presented in Table 6.

Table 6. Basic information on the surveyed companies
Tabela 6. Podstawowe informacje dotyczącego badanych przedsiębiorstw

Survey sample characteristics	Responses (%)
1. Number of staff employed by the company:	
fewer than 10 employees	2.9%
10 to 49 employees	5.8%
50 to 250 employees	55.8%
more than 250 employees	35.5%
2. Type of company:	
production	60.87%
production and trade	2.17%
production and services	18.12%
production, trade and services	18.84%

Most of the analysed companies are large and medium-sized enterprises, which increases the reliability of statistical sample, as such companies use IT systems that support management support for data and indicator analysis.

The analysis of importance of various indicators of production process economic efficiency is shown in Figure 1.
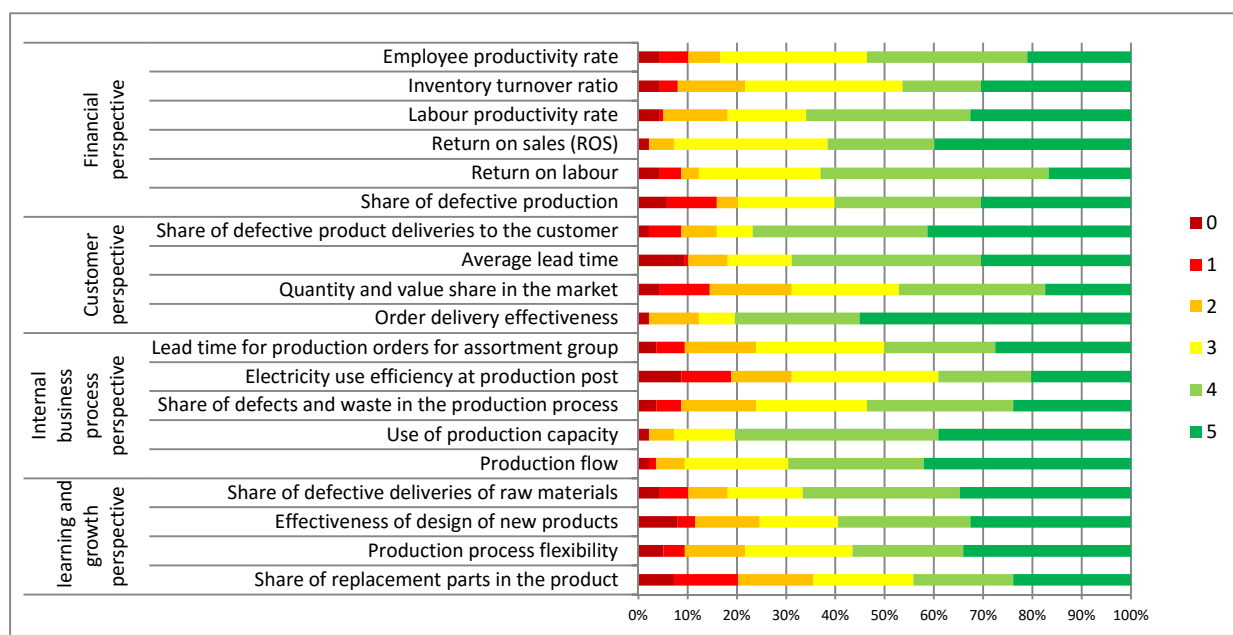
Legend: The importance of evaluation indicators: 0 - no significance, 1 - very low significance, 2 - low significance, 3 - medium significance, 4 - high significance, 5 - very high significance

Source: Own research

Fig. 1. Importance analysis of the production process economic efficiency
Rys. 1. Analiza istotności ekonomicznej efektywnosci procesu produkcyjnego

Table 7. Detailed importance analysis of individual efficiency evaluation indicators
Tabela 7. Szczegółowa analiza istotności poszczególnych współczynników indywidualnej oceny efektywności

Perspective	Name of indicator	Indicator importance [number of responses]						Average value
		0	1	2	3	4	5	
Learning and growth perspective	Share of replacement parts in the product	10	18	21	28	28	33	*3.051*
	Production process flexibility	7	6	17	30	31	47	*3.543*
	Effectiveness of design of new products	11	5	18	22	37	45	*3.478*
	Share of defective deliveries of raw materials	6	8	11	21	44	48	*3.688*
Internal business process perspective	Production flow	3	2	8	29	38	58	*3.964*
	Use of production capacity	3	0	7	17	57	54	*4.080*
	Share of defects and waste in the production process	5	7	21	31	41	33	*3.413*
	Electricity use efficiency at production post	12	14	17	41	26	28	*3.007*
	Lead time for production orders for assortment group	5	8	20	36	31	38	*3.406*
Customer perspective	Order delivery effectiveness	3	0	14	10	35	76	*4.188*
	Quantity and value share in the market	6	14	23	30	41	24	*3.145*
	Average lead time	13	1	11	18	53	42	*3.616*
	Share of defective product deliveries to the customer	3	9	10	10	49	57	*3.913*
Financial perspective	Share of defective production	8	14	6	27	41	42	*3.486*
	Return on labour	6	6	5	34	64	23	*3.543*
	Return on sales (ROS)	3	0	7	43	30	55	*3.899*
	Labour productivity rate	6	1	18	22	46	45	*3.710*
	Inventory turnover ratio	6	5	19	44	22	42	*3.428*
	Employee productivity rate	6	8	9	41	45	29	*3.435*

Source: Own research

The Authors assumed that the concept of significance (importance) expresses the respondent's strength of belief/confidence as to the validity, effectiveness and the ability to use the indicator in various perspectives. The same mechanism was established for evaluation of each criterion - based on a five-level Likert scale [Likert 1932], plus a zero level. The indicator importance measurement scale was developed to determine the strength of impact according to an average of the results obtained. The position of many research teams presented in the literature indicates that the analyses based on the assumptions of Likert scale are quantitative [Elliott and Woodward 2007; Gamst, Meyers and Guarino 2008; Gatignon 2013]. The scores mean the following:
− 0 - no significance,
− 5 - very high significance.

When analysing the importance of each indicator, it should be noted that all the evaluated indicators were considered important. The decision threshold was an average of the results obtained above 3.0 (medium significance). Table 7 presents detailed results for individual indicators used for evaluating the production process economic efficiency.

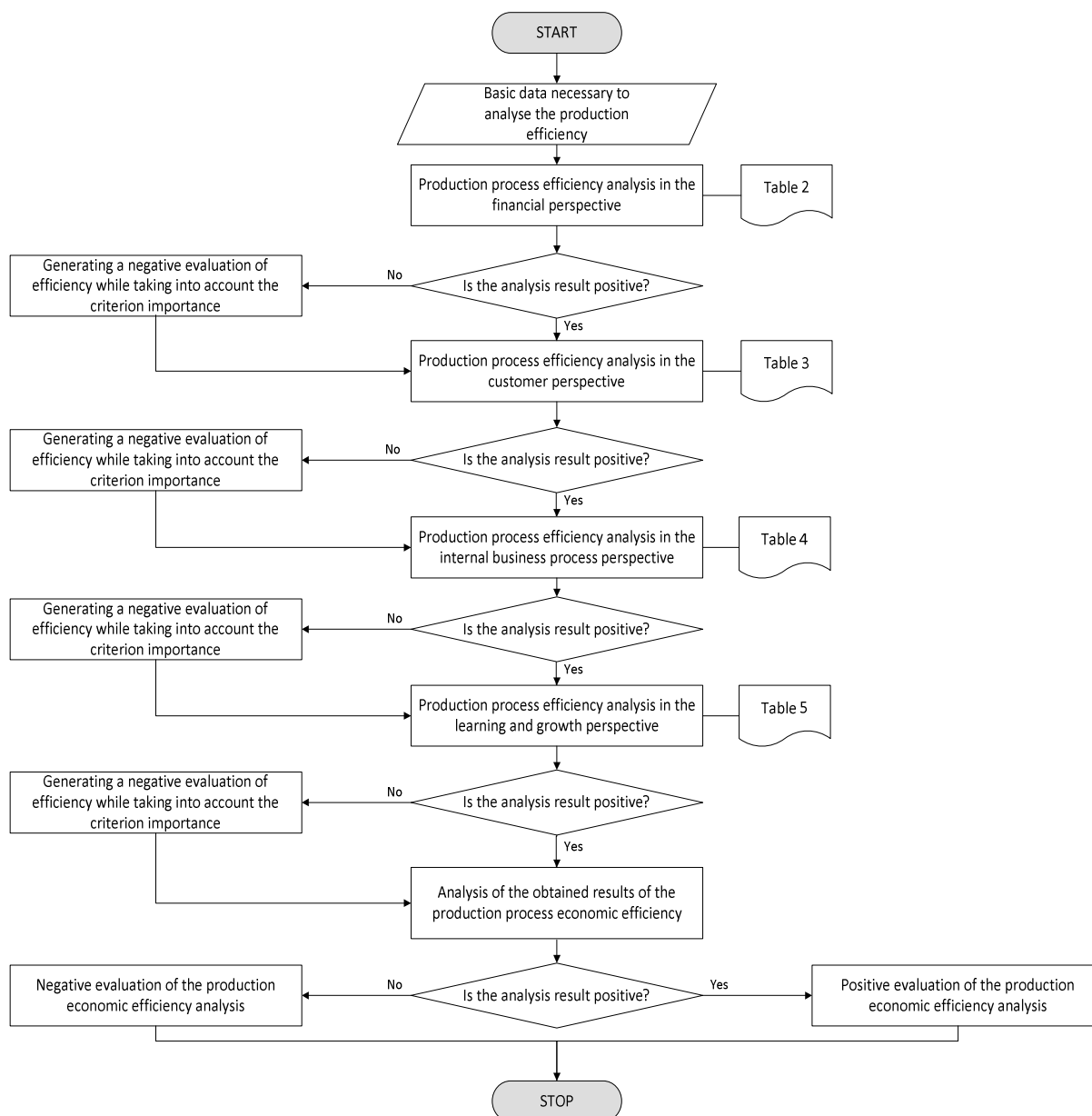## CONCEPT OF EVALUATION MODEL FOR PRODUCTION PROCESS ECONOMIC EFFICIENCY

Based on the analysis of literature analysis and taking into account the importance of each indicator in economic practice, an evaluation model was developed for the production process economic efficiency. The figures below show the concept of evaluation model for the production process economic efficiency, detailed algorithms for efficiency analysis in individual perspectives of the Balanced Scorecard, and also present the logic of analysis of economic benefits of the results obtained.

Figure 2 shows an overall evaluation model for the production process economic efficiency.

The algorithm for evaluation of the production process economic efficiency shown in Figure 2 is based on the assumption that individual perspectives of the analysis are equivalents in terms of decision-making. Therefore, in the absence of a positive result of any of the perspectives, the analysed production process state is deemed economically inefficient. It should be noted, however, that the efficiency analysis in individual perspectives does not have to generate all the results within the normative values. It is possible to use the analysis of economic benefits to establish that despite the presence of deviations the process situation can be considered effective or economically acceptable. Figures 3-6 show the concept of the production process economic efficiency evaluation in individual perspectives.

The algorithm in the figure 3 shows the procedure for determining the indicators of production process economic efficiency evaluation in the financial perspective according to the set of indicators set out in Table 2. After obtaining the data needed for analysis and after determining all indicators a comparative analysis should be conducted for the results obtained and normative values. The analysis of economic benefits (shown in Figure 7) is used to evaluate the set of indicators in this perspective. A positive or negative evaluation of the perspective is used for further analysis of the overall evaluation of the production process economic efficiency.

Figure 4 shows the evaluation model for the production process economic efficiency in the customer perspective. After determining the values of all the indicators in this perspective, an analysis of economic benefits should be conducted again.

Source: Own work based on [Koliński, Śliwczyński and Golińska 2014]

Fig. 2. Overall evaluation model for the production process economic efficiency
Rys. 2. Ogólny model oceny efektywności ekonomicznej procesu produkcyjnego
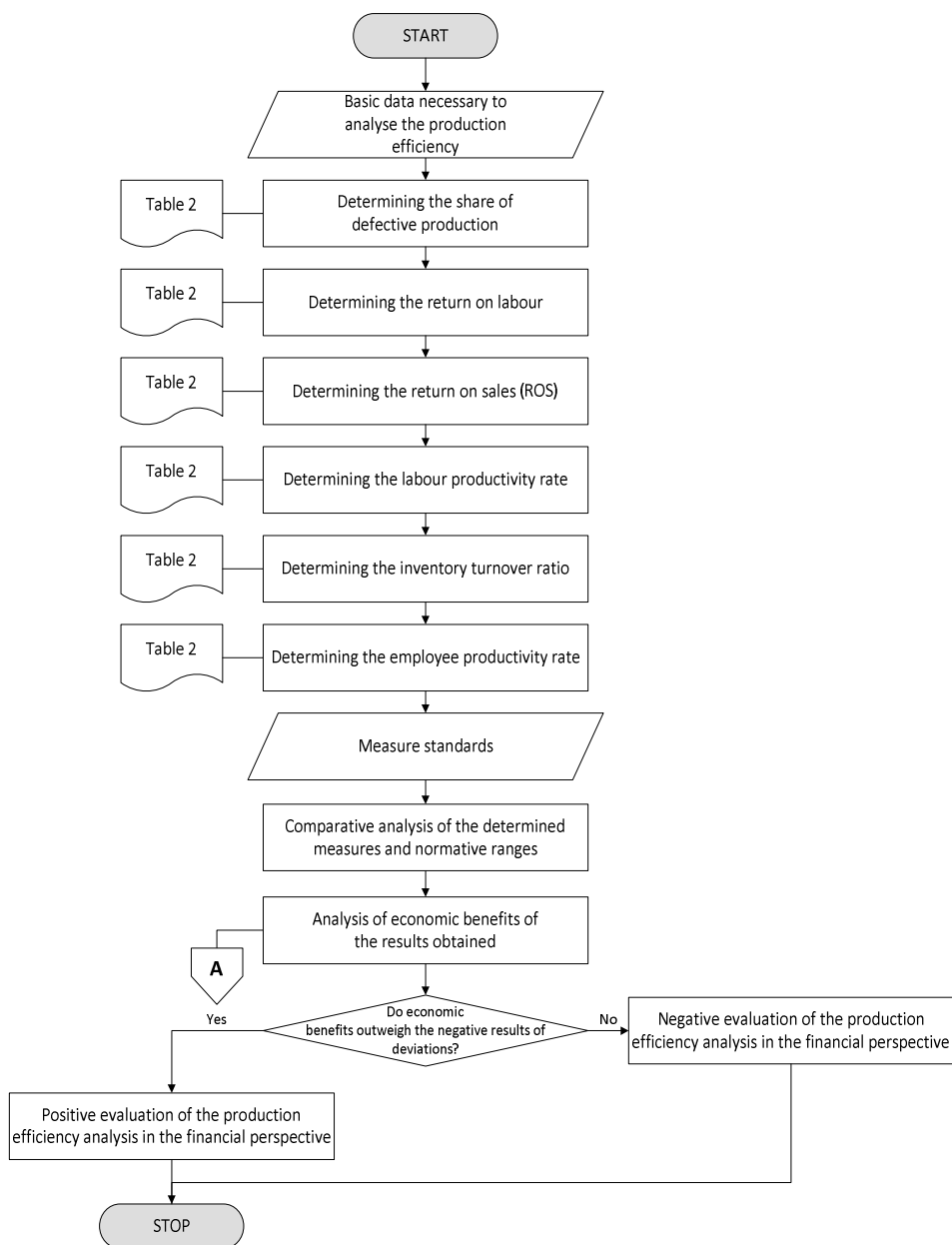
Source: Own work

Fig. 3. Evaluation model for the production process economic efficiency in the financial perspective
Rys. 3. Model oceny efektywności ekonomicznej procesu produkcyjnego w perspektywie finansowej
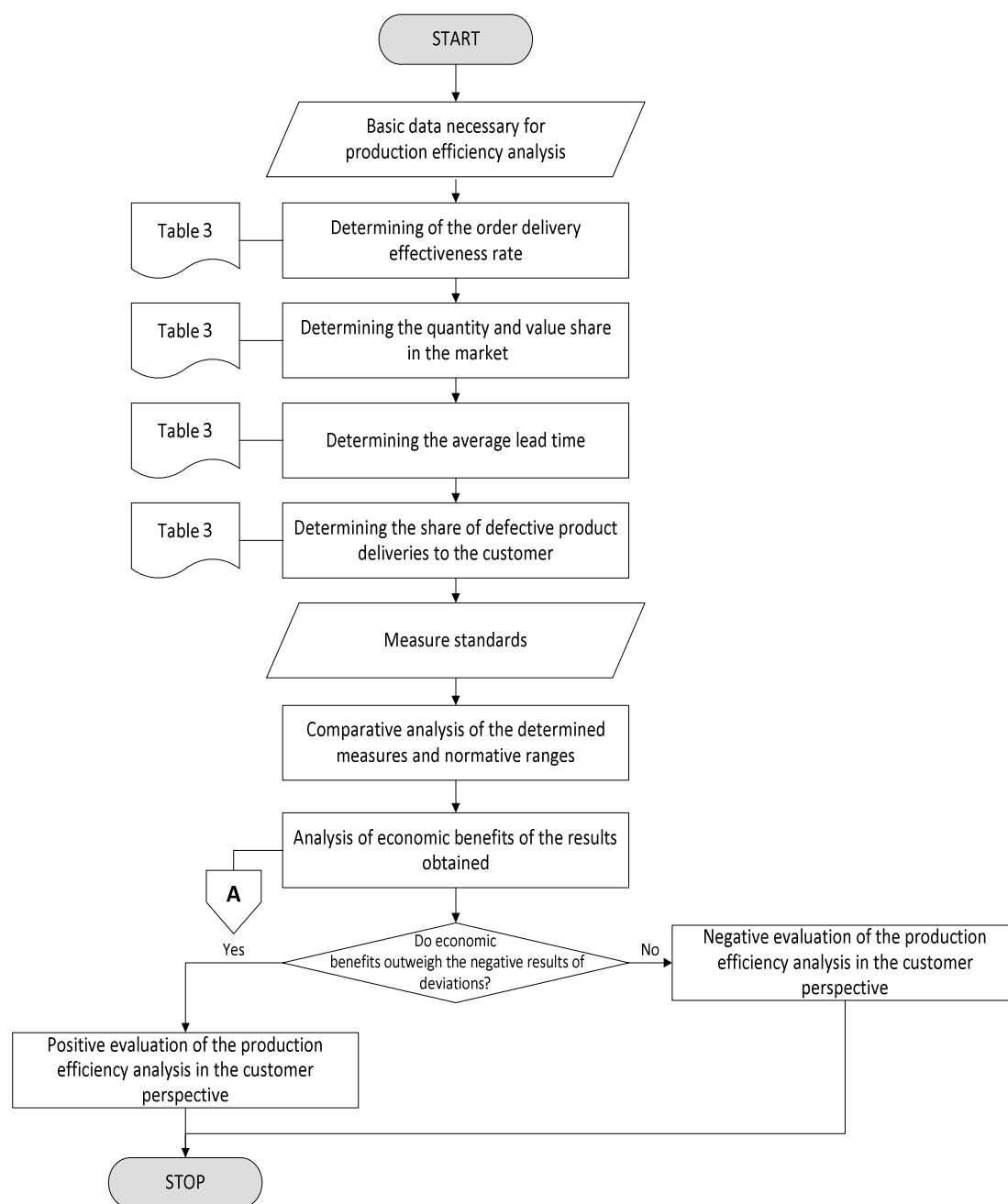
Source: Own work

Fig. 4. Evaluation model for the production process economic efficiency in the customer perspective
Rys. 4. Model oceny efektywności ekonomicznej procesu produkcyjnego z perspektywy klienta

Source: Own work

Fig. 5. Evaluation model for the production process economic efficiency in the internal business process perspective
Rys. 5. Model oceny efektywności ekonomicznej procesu produkcyjnego w perspektywie procesów wewnętrznych
    przedsiębiorstwa
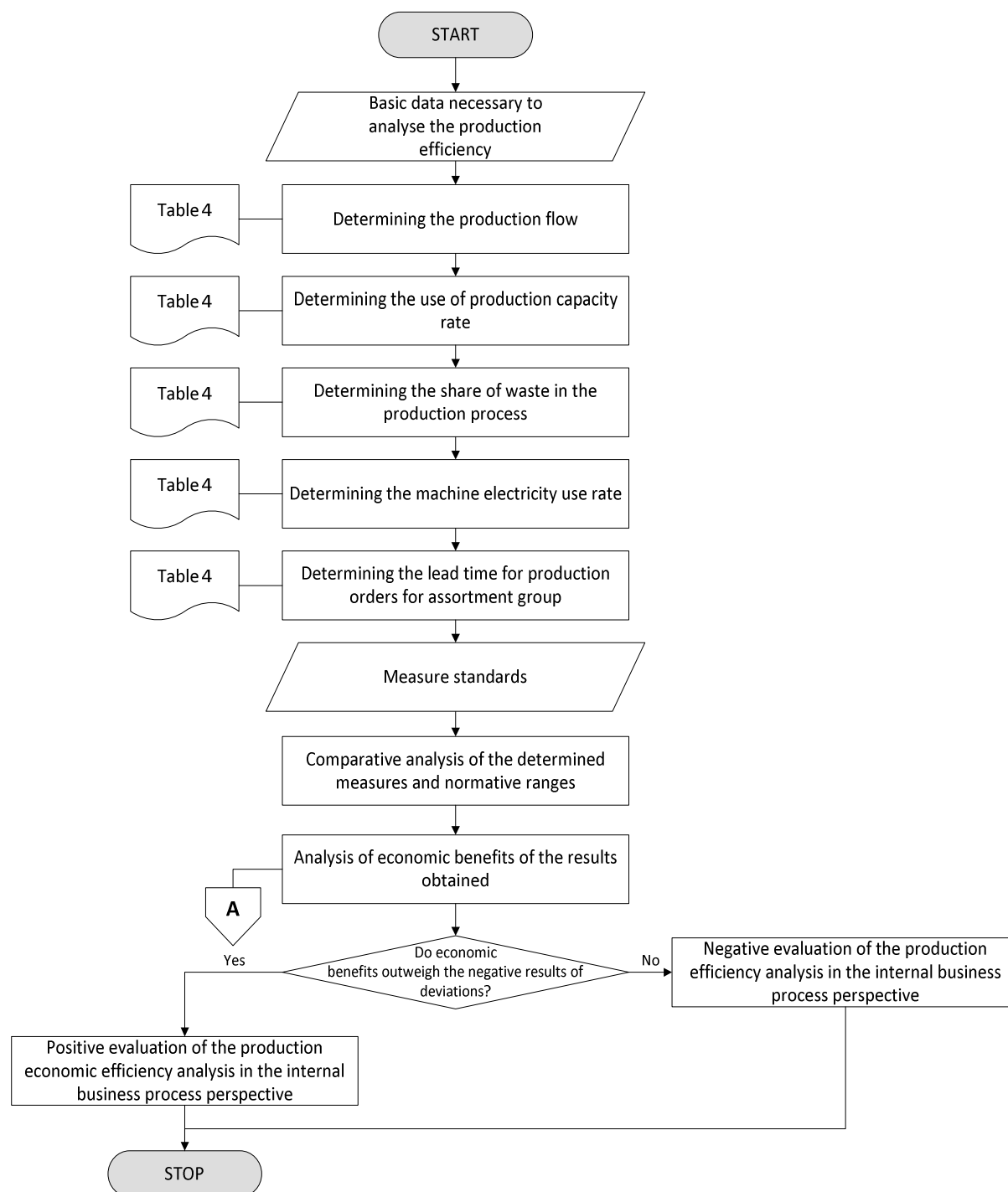
Source: Own work

Fig. 6. Evaluation model for the production process economic efficiency in the learning and growth perspective
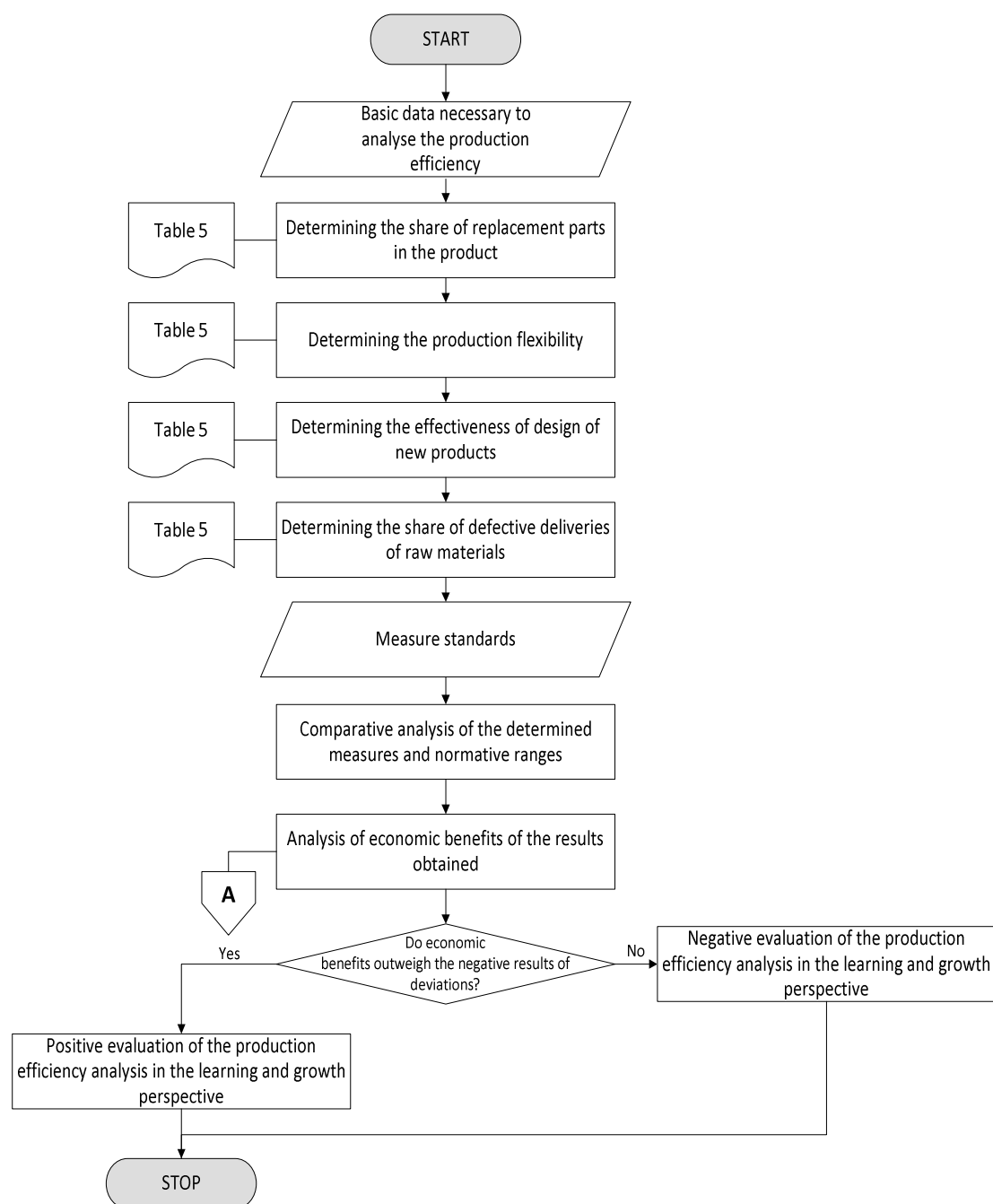Rys. 6. Model oceny efektywności ekonomicznej procesu produkcyjnego w perspektywie nauki i możliwości
rozwoju

It should be noted that the algorithms of the production process economic efficiency in all perspectives are equivalent and independent of each other. A deliberate intent during the development of the evaluation model for the production process economic efficiency was to develop similar algorithms in each of the analysed perspectives. The results of comparison of values calculated according to the input data with normative values are used in summarising the overall evaluation of the production process economic efficiency.

Another research problem for individual algorithms of the production process economic efficiency model is the generating of normative values for indicators in individual perspectives. Preliminary considerations for determining the normative values can be found in publication [Koliński 2014]. It should also be noted that a negative evaluation of one of the analysed perspectives makes the entire production process economically inefficient.

The diagram (Figure 7) of the analysis of economic benefits of the results obtained concerns scoring according to the following assumptions:

− maximum score - 10 points,
− after identifying the hierarchy of indicators, the amount of advantages or balance of the analysed measure compared to others was determined,
− scores were rounded up.
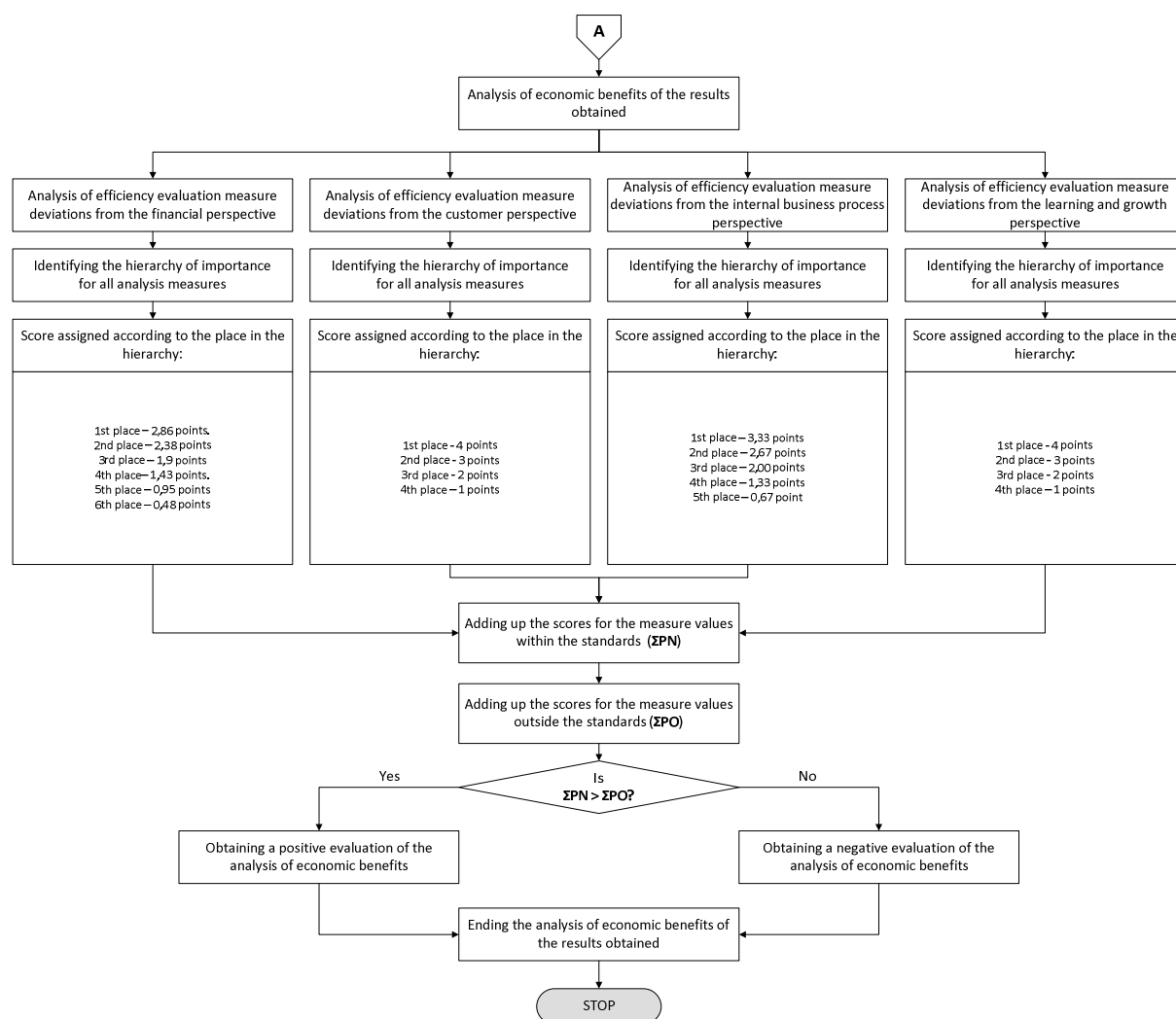
Source: Own work

Fig. 7. Analysis of economic benefits of the results obtained
Rys. 7. Analiza korzyści biznesowych otrzymanych wyników

The logic of score for each place in the hierarchy for the relevant elements of the production process economic efficiency evaluation in individual perspectives is identical. As an example, Table 8 shows the logic of scoring only for the internal business process perspective.

Production process efficiency analysis in the internal business process perspective:

− number of developed indicators - 5,
− description of indicators according to the hierarchy: (W1, W2,..., W5).

The logic of analysis of economic benefits was developed based on the Author's own research results within the research project Simulation of managing the flow of company's material as an instrument of multivariant analysis of transport processes efficiency No. N N509 549940 presented in publication [Doliński and Koliński 2011; Śliwczyński and Koliński 2012].

Table 8. Score assigned in the hierarchy of indicators - W5
Tabela 8. Punkty przypisane w hierarchii wskaźników – W5

	W1	W2	W3	W4	W5	Advantage	Weight	**Score**
W1	X	X	X	X	X	5	0.333	**3.33**
W2		X	X	X	X	4	0.267	**2.67**
W3			X	X	X	3	0.2	**2.00**
W4				X	X	2	0.133	**1.33**
W5					X	1	0.067	**0.67**
						15	1	**10**

Source: Own work

The algorithm of the analysis of economic benefits was developed due to the fact that it is unlikely to obtain all the analysis results in normative ranges. It is caused by the interaction between indicators, i.e. by taking intended actions to improve one indicator it is at the same time possible to negatively affect the value of other indicators. The analysis of respective variants should be based on the principles of process optimization and comprehensive evaluation according to the network thinking logic. The essence of the principle is the creation and subsequent value-based arrangement of the hierarchy of sets of solutions based on the objective function, which as a result leads to the selection of the best solutions. Therefore, the foregoing considerations also allow optimization variants defined as economically accepted for further analysis. The developed logic enables a universal defining of the hierarchy of indicators. The hierarchy of indicators presented in the article was developed in consultation with the management of a production company in the household appliances industry.

CONCLUSIONS

Despite numerous considerations in literature, the issue of production process efficiency has not yet been comprehensively presented and developed. Decisions made in companies operating in a dynamically changing environment are rarely verified for their impact on the efficiency of individual processes. This is due to the lack of or unclear efficiency evaluation procedures. According to the Authors, the issue of evaluation of the production process efficiency is an important element of effective business management, and requires a thorough analysis. The current academic works do not provide a clear solution for the scope and method of analysis and evaluation of the production process efficiency. The absence of precise theoretical indications makes it impossible to provide comprehensive development and application of the production process efficiency analyses in practice. In this article the Authors present an original concept of analysis and evaluation of the production process efficiency in the economic aspect. The developed concept should also include causal relations with the production process operational efficiency.

The direction of future research and continuation of this work should be an analysis of conditions and system connections as part of evaluation of the logistics process efficiency in companies and supply chains. The efficiency analysis should compare the key indicators in companies within specific industries. Observations on benchmarking of analysis and evaluation of logistics process efficiency prove

the need for managerial evaluation models and algorithms in business practice [Kolińska and Cudziło 2014]. Joint development of a set of indicators within the supply chain would enable a mutual comparison of the results obtained, which could have a direct impact on improving the efficiency of decisions - not only those affecting individual processes carried out within the company, but also throughout the supply chain.

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MODEL OCENY EFEKTYWNOŚCI EKONOMICZNEJ PROCESU PRODUKCJI

STRESZCZENIE. **Wstęp:** Działalność gospodarcza skoncentrowana na wytwarzaniu i dostarczaniu produktów przeznaczonych na sprzedaż, jest jednym z podstawowych procesów zachodzących w logistycznym łańcuchu dostaw. Specyfika procesów produkcji powoduje konieczność koncentracji na czynnikach, które mają kluczowy wpływ na ciągłość przepływu materiałowego, zarówno w odniesieniu do praktyki gospodarczej, jak również w odniesieniu do literatury przedmiotu. Znaczący wpływ procesów produkcji na wynik finansowy przedsiębiorstwa, oddziałując na koszty, przychody, rotację aktywów oraz cykl kapitału obrotowego, jest główną przesłanką ukierunkowania zarządzania produkcją na sposoby poprawy efektywności procesów, zarówno wewnętrznego, jak i zewnętrznego łańcucha dostaw oraz ciągłego nadzorowania i oceniania uzyskanych rezultatów. Celem artykułu jest przedstawienie autorskiego modelu analizy i oceny efektywności procesu produkcji w aspekcie ekonomicznym.
Metody: Wyniki badań w polskich przedsiębiorstwach przeprowadzonych w latach 2011-2013 oraz badań literaturowych, świadczą o niezadowalającym stopniu wykorzystania analiz efektywności w zarządzaniu procesami produkcji, powiązanymi łańcuchami dostaw oraz środowiskiem produkcyjnym. Na ich podstawie dokonano wyboru i zestawienia wskaźników oceny efektywności ekonomicznej procesu produkcji. Badania uzupełniające dotyczące stopnia ważności poszczególnych wskaźników w praktyce gospodarczej przeprowadzono w pierwszej połowie 2015 roku w 138 przedsiębiorstwach produkcyjnych z województwa wielkopolskiego.
Wyniki: Na podstawie uzyskanych wyników i obserwacji, Autorzy opracowali model oceny efektywności ekonomicznej procesu produkcji, który umożliwi Autorom przeprowadzenie wielowariantowych symulacji parametrycznych modeli procesów i środowiska produkcji w dalszych etapach prowadzonych badań naukowych.
Wnioski: Problematyka efektywności procesu produkcji, pomimo wielokrotnego podejmowania rozważań literaturowych, nie została do tej pory kompleksowo przedstawiona i opracowana. Zaprezentowana koncepcja oceny efektywności procesu produkcji dotyczy aspektu ekonomicznego. Autorzy mają świadomość konieczności sprzężenia tego zakresu analitycznego z analizą i oceną efektywności operacyjnej, kierunkując dalsze badania na kompleksową analizę i ocenę efektywności procesu produkcji oraz inżynierię wartości w jego operacyjnym kształtowaniu.

Słowa kluczowe: efektywność procesu produkcji, controlling operacyjny, strategiczna karta wyników

EIN MODELL FÜR DIE BEWERTUNG WIRTSCHAFTLICHER EFFIZIENZ EINES PRODUKTIONSPROZESSES

ZUSAMMENFASSUNG. Einführung: Einer der grundlegenden, innerhalb der logistischen Lieferkette vorkommenden Prozesse ist die wirtschaftliche Betätigung, die auf Erzeugung und Bereitstellung der für den Verkauf vorgesehenen Produkte konzentriert ist. Die Eigenart der Produktionsprozesse verursacht die Notwendigkeit einer Fokussierung auf die Faktoren der Produkt-Erzeugung sowohl hinsichtlich der Wirtschaftspraxis, als auch in Bezug auf die Gegenstandsliteratur, die einen schlüsselhaften Einfluss auf die Kontinuität des Materialflusses ausüben. Die ausschlaggebende Beeinflussung des Finanzergebnisses eines Unternehmens durch die Produktionsprozesse, die die Kosten, Einnahmen, den Kapitalumschlag und den Betriebskapital mit einprägen, macht die Hauptprämisse für das auf die Vervollkommnung der Prozesse ausgerichtete Produktionsmanagement, für die Verbesserung der inner- und außerbetrieblichen Lieferkette sowie für die Notwendigkeit der ständigen Überwachung und Bewertung der erzielten

Resultate aus. Das Ziel der vorliegenden Arbeit ist es, ein Autoren-Modell für die Analyse und Bewertung der Effizienz eines Produktionsprozesses unter dem wirtschaftlichen Aspekt darzustellen.

Methoden: Die Ergebnisse der in polnischen Unternehmen in den Jahren 2011-2013 durchgeführten Erforschung und der betreffenden Literaturforschungen zeugen von einem nicht zufriedenstellenden Niveau der Inanspruchnahme von Effektivitätsanalysen im Management von Produktionsprozessen, die mit Lieferketten und dem produktiven Bereich verbunden sind. Aufgrund dieser Ergebnisse wurden die Auswahl und die Zusammenstellung von Koeffizienten für die Bewertung der wirtschaftlichen Effizienz des Produktionsprozesses projiziert. Die ergänzenden, die Relevanz der einzelnen Koeffizienten in der Wirtschaftspraxis anbetreffenden Forschungen wurden in der ersten Jahreshälfte 2015 in 138 in Großpolen lokalisierten Produktionsunternehmen durchgeführt.

Ergebnisse: Aufgrund der erzielten Resultate und Wahrnehmungen haben die Autoren ein Modell für die Bewertung der wirtschaftlichen Effizienz des Produktionsprozesses ausgearbeitet, das den Autoren in ihren weiteren Forschungsarbeiten die Durchführung einer Mehrvarianten-Simulation von parametrischen Modellen für die Bewertung von Prozessen innerhalb des produktiven Bereiches ermöglichen wird.

Fazit: Die Problematik der Effizienz von Produktionsprozessen wurde, trotz der zahlreichen Inangriffnahmen von Fachliteratur-Erwägungen, bisher in ihrer Komplexität weder ausgearbeitet noch dargestellt. Das hiermit projizierte Konzept für die Bewertung der wirtschaftlichen Effizienz des Produktionsprozesses bezieht sich auf den wirtschaftlichen Aspekt. Die Autoren sind sich dessen völlig bewusst, dass es notwendig ist, den analytischen Bereich mit der betreffenden Analyse und der Bewertung von operativer Effizienz in einen Zusammenhang zu bringen, indem die weiteren Forschungen auf eine komplexe Analyse und die Bewertung der Effizienz des Produktionsprozesses sowie auf das Wert-Ingenieurwesen bei dessen Ausgestaltung ausgerichtet werden müssen.

Codewörter: Effizienz des Produktionsprozesses, operatives Controlling, strategische Ergebniskarte

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OPTIMAL INVENTORY CONTROL FOR PERISHABLE ITEMS UNDER ADDITIONAL COST FOR DETERIORATION REDUCTION

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ABSTRACT. **Background:** This paper analyses the problems of carrying out inventory control of perishable goods subject to deterioration during warehousing. It aims to propose a generalization of the classical models used in optimal inventory control theory for perishable goods adapted for the case of additional expenses incurred by supply companies to goods' deterioration reduction.

Methods: A generalized Wilson model for optimal lot sizing has been developed. It is assumed that the rate of deterioration depends non-linearly on the volume of investment intended for a reduction in goods deterioration. The case of inverse power dependence is analyzed in details. Firstly, the generalized Wilson model for a single item is examined, and then this model is considered for multi-item case.

Results and conclusions: For the joint optimization of lot sizes and volumes of investments, corresponding non-linear optimization problems are formulated. Numerical results are presented to illustrate the model. It is indicated that the proposed optimization model can be used as the methodical basis for supply companies in their investment activities aimed at improving storage technology of perishable products.

Key words: inventory management; perishable product; control of deterioration; the generalized Wilson model; lot sizing optimization.

INTRODUCTION

Recently, in logistics theory and practices the great attention has been paid to problems of transportation and storage of perishable products as an important part of population supply with food products [Kitinoja 2013, Lin et al. 2015, Postan and Filina-Dawidowicz 2013]. It is related, in particular, to the growing demand for food, including exotic fruit, increasing requirements for product quality as well as the need for supplied products variety. It is induced i. a. by the living standards growth and international trade development.

The main feature of perishable cargo is its limited shelf life, which causes the necessity to assure the specific temperature and humidity conditions of these goods transportation and storage [Agreement 2014, Studziński 2005]. Failure to comply with the strict cargo requirements can result in products quality loss, which can lead to significant financial losses [Lin et al. 2015]. All this makes it necessary to improve the logistics systems of perishable goods delivery, including optimization of the inventory control process.

Inventory management, as an integral component of the perishable goods logistics, deals with the analysis of methods and techniques of planning and inventory control [Silver 1981,Venkata Subbaiah et al. 2004]. The main objective of this process is to provide the optimal balance of inventory levels, improvement of the service quality level and

minimizing the costs together with the smooth and continuous operation of enterprise [Bramel and Simchi-Levi 1997, Churchman et al. 1957, Hadley and Whitin 1963].

Inventory control problems are discussed in a number of sources [Almeder et al.2009, Baran et al. 2010, Bed-Daya and Raouf 1994, Thomopoulos 2015,Thomopoulos 2016]. In these works particular attention is paid to the optimization of the ordered lot size, order execution time, the costs of goods storing and orders maintenance, etc. Moreover, these issues are provided in special studies on the problems of inventory control in warehouses in seaports, logistics centers, in storage facilities of distributors and retailers [Postan and Filina-Dawidowicz 2013, Song and Zhang 2011, Thomopoulos 2015].

The specificity of the perishable products imposes additional restrictions on the storage process and inventory control of these goods [Dash et al. 2014, Shah and Shah 2000, Li et al. 2010]. Perishable loads have to be stored in warehouses, providing the necessary cargo storage conditions [Ghare and Scharder 1963, Studziński 2005]. In the case of servicing of multi-item production, it is necessary to assure storage capacity (cold stores with microclimate required) for each type of cargo. Additionally, planning and orders implementation for each single product should be considered separately. Furthermore, the appropriate rotation of products in a warehouse, according to the FEFO (first expired, first out) rule has to be organized. These products should be ordered as close as possible to the moment of sale. The time of servicing of perishable commodity products in a warehouse is also important. This proves that these products are ordered with high frequency to reduce the possibility of products deterioration and their quality loss.

Deterioration deals with specificity of perishable goods and cannot be completely avoided in logistic chains. Ghare and Schrader [1963] proposed to divide inventory deterioration into following types: direct spoilage, physical depletion and deterioration. Direct spoilage determines the unstable state of inventory items caused by some breakage during transaction as well as sudden accidental events. For example, quality of food products might be reduced due to non-functioning of a warehouse refrigerator or a transport vehicle cooling unit caused by absence of power supply or some refrigerated system damages [Filina and Filin 2008]. On the other hand, deterioration deals with slow but gradual loss of qualitative properties of products with the passage of time [Kundu et al. 2013]. Lin et al. [2015] discussed indicators that reflect and factors that influence the quality of perishable goods, such as food.

Rau et al. [2004] in his paper proposed deteriorating item inventory model with a shortage occurring at the supplier considering a supply chain between the producer and buyer. An alternative rate of production was analysed in inventory model for perishable items developed by Venkata Subbaiah et al. [2011]. Ghosh et al. [2011] considering model of a perishable product for the case of price dependent demand, partial backordering which depends on the length of the waiting time for the next replenishment, and lost sale. Moreover, Dalfard and Nosratian [2014] presented a pricing constrained single-product inventory-production model in perishable food for maximizing the total profit. A production inventory model for an item with three parameter Weibull deterioration taking into account price discount for partially deteriorated item has been developed by Pradhan and Tripathy [2012].

Ali et al. [2013] discussed problems of inventory management of perishable products based on logistic approach with regard to shortages and time decay functions. Bhunia et al. [2013] in his study showed two-warehouse partially backlogged deteriorating inventory models under inflation via particle swarm optimization. Kundu et al. [2013] implemented an economic order quantity (EOQ) model to analyse the inventory problem with alternating demand rate using a gradient based non-linear optimization technique (LINGO). Furthermore, the ability to quantify the effect of items lost due to deterioration by optimizing the fuzzy net profit for the retailer applying modified fuzzy EOQ (FEOQ) model was considered by Pattnaik [2014].

The literature review showed that there are also researches focusing on generalization of

well-known problems of inventory control of perishable products. The example of generalization of classical Wilson model used to optimize the lot size of goods deliveries exposed to deterioration during storage is given in [Dash et al. 2014, Lee and Nahmias 1993, Li et al. 2010, Shah and Shah 2000]. However, these studies do not take into account the possibility of reducing deterioration of stored products due to additional costs (investment), aimed at improving the technology of goods transportation and storage. An approach that takes account of these circumstances was proposed in an article [Postan and Filina-Dawidowicz 2013], where an example of generalization of the Wagner-Whitin classical model of inventory control in distribution centre is demonstrated.

The purpose of this article is to spread the approach mentioned in [Postan and Filina-Dawidowicz 2013] to the case of the Wilson model, taking into account the possibility of reducing deterioration of stored production in the warehouse due to additional costs (or investments). Firstly, the calculations results of the generalized Wilson model for perishable single item were presented, then the case of multi-item production was considered.

NOTATIONS AND ASSUMPTIONS

Let's consider a warehouse of supply company or retailer of the same item (homogeneous products), that faces the constant goods demand. The company periodically places orders for replenishment of perishable products with suppliers, which are assumed to deliver unlimited number of goods. Below, the principal notations and assumptions for model creation are listed:

- the order quantities are fixed at Q items per order;
- the planning horizon is T;
- the demand for planning horizon is constant and equal D; it means that products are distributed from warehouse uniformly with the rate $d = D/T$;
- the order execution time is zero;

- the order point is the time when the inventory level of products in warehouse is zero;
- the initial inventory level is zero;
- the set-up cost K is incurred every time the warehouse places an order;
- the per unit order cost is c;
- the per unit time costs of storage per unit's product is equal to h;
- the intensity of product deterioration (as the result of natural processes) at warehouse is proportional to inventory level with proportionality coefficient δ (growth rate of deterioration);
- the per unit's product sale price is s;
- the size of company's investments at the beginning of the planning horizon aimed to reduce the losses of products deterioration, is v;
- coefficient δ is a decreasing function of the parameter v.

As it is applied in different inventory control models, above assumptions let us simplify the real situation. There is an assumption that predetermined volume of demand is fixed for planning horizon, but it is not very realistic. It is assumed that fixed volume of delivered consignment is restrictive, the real execution order time is always positive.

However, during further improvement of relatively simple Wilson model for determining the optimal replenishment policy, all above assumptions may be relaxed. But for a better understanding of the main model's results, we will keep them.

THE GENERALIZED WILSONMODEL FOR SINGLE PERISHABLE ITEM

The main purpose of inventory management is to find an optimal replenishment and investment policy, that minimizes the overall costs per time unit for orders placement, goods purchase and warehousing, taking into consideration the possible market loss (or sale profits loss because of products deterioration) and the cost

of investment to reduce the products quality loss.

In order to find the optimal policy of ordering and investing in products deterioration reduction, we consider the inventory level as a function of time. Let I(t) be the inventory level of acceptable (without deterioration and damage) quality products at time t. We refer to the time between two successive replenishments as a cycle time. Thus, total company's inventory cost in a cycle of length τ is

$$cQ + K + (h+\delta s)\int_0^\tau I(t)dt \quad (1)$$

According to above assumption

$$\frac{d}{dt}I(t) = -d - \delta I(t), t \in [0,\tau] \quad (2)$$

with initial condition

$$I(0) = Q. \quad (3)$$

Note that the second term in the right-hand side of equation (2) determines the intensity of product's damage during period of its storage in a warehouse. The solution of initial-value problem for equation (2) is given by

$$I(t) = e^{-\delta t}(Q + \frac{d}{\delta}) - \frac{d}{\delta}. \quad (4)$$

According to Zero Inventory Ordering Policy (every order is received precisely when the inventory level drops to zero) $I(\tau) = 0$, hence from (4) we find the order cycle length

$$\tau = \frac{1}{\delta}\ln(1 + \frac{Q\delta}{d}). \quad (5)$$

From (4), it follows that changing the inventory level during the time is described by the curve presented on the Figure 1. This is type of so-called saw-toothed inventory pattern..
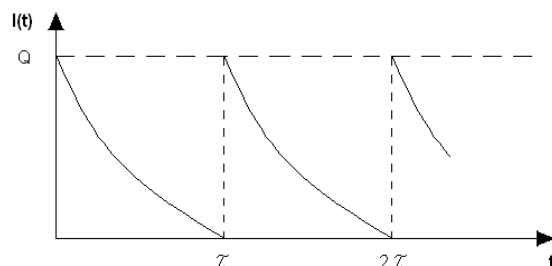
I(t) - inventory level, t - time, Q - the size of the product ordered consignment, τ - order cycle length.

Fig. 1. Inventory level as function of time
Rys. 1. Poziom zapasu jako funkcja czasu

Now we can re-write the expression (1) as follows

$$cQ + K + (h+\delta s)\tau \bar{I},$$

where $\bar{I} = \frac{1}{\tau}\int_0^\tau I(t)dt$ is average inventory level for the cycle, besides

$$\bar{I} = \frac{Q}{\ln(1+\frac{Q\delta}{d})} - \frac{d}{\delta}.$$

After some calculations, taking into account (4) and (5), from (6), we obtain

$$cQ + K + \frac{(h+\delta s)}{\delta}(Q - \tau d).$$

Multiplying the last expression by the number of order cycles, that is equal T/τ, and adding the costs to reduce the product deterioration, we find the full average cost over the planning horizon (see(5))

$$\bar{C}(Q,v) = \frac{T}{\tau}\left[cQ + K + \frac{(h+\delta s)}{\delta}(Q - \tau d)\right] + v =$$

$$= T[\frac{Q(h+\delta c + \delta s) + \delta K}{\ln(1+\frac{Q\delta}{d})} - \frac{(h+\delta s)d}{\delta}] + v, \quad (7)$$

where $\delta \equiv \delta(v)$. The explicit form of the dependence $\delta(v)$ can be found using methods of mathematical statistics. The simplest forms of this dependence can be, for example, as follows

$$\delta(v) = \frac{\delta_0}{(1+\mu v)^\alpha},$$

$$\delta(v) = \delta_0 e^{-\mu v^\alpha}, \quad (8)$$

where δ_0 is the value of the growth rate of deterioration with zero investment, i.e., suitable to standards of products natural loss using a given storage technology; μ is coefficient characterizing the decline rate of products deterioration for non-zero investments, aimed at more advanced products storage technology; α, $0 \le \alpha \le 1$, is given parameter.

For example, according to (8) the function (7) takes the following form:

$$\overline{C}(Q,v) = T\{ \frac{\delta_0[Q(c+s)+K)+hQ(1+\mu v)^\alpha]}{(1+\mu v)^\alpha \ln(1+\frac{\delta_0 Q}{d(1+\mu v)^\alpha})} - [s+\frac{(1+\mu v)^\alpha}{\delta_0}hd]\} + v.$$

(9)

Thus, the optimal size of the products ordered consignment Q^* and the optimal amount of investment v^* are defined by a necessary condition for achieving a minimum of function (9), i.e.

$$\frac{\partial}{\partial Q}\overline{C}(Q,v^*)\bigg|_{Q=Q^*} = 0, \frac{\partial}{\partial v}\overline{C}(Q^*,v)\bigg|_{v=v^*} = 0.$$

(10)

A sufficient requirement for existence of a minimum of this function is given by the condition

$$\begin{vmatrix} \dfrac{\partial^2\overline{C}(Q,v)}{\partial Q^2} & \dfrac{\partial^2\overline{C}(Q,v)}{\partial Q\partial v} \\ \dfrac{\partial^2\overline{C}(Q,v)}{\partial v\partial Q} & \dfrac{\partial^2\overline{C}(Q,v)}{\partial v^2} \end{vmatrix}_{Q=Q^*,v=v^*} > 0.$$

(11)

Using (9), we obtain a system of nonlinear equations to determine the optimal values of the parameters Q^*, v^*. However, its numerical calculation is very time consuming, so it's easier to solve the minimization problem using standard software, for example, Microsoft Excel. It should be taken into account that not all values of the initial parameters of optimization model satisfy the conditions (10) and (11).

NUMERICAL EXAMPLE

We consider a numerical example. Let $T = 365$ d., $c = 1,5$ th. \$/t, $s = 2,0$ th. \$/t, $h=0,01$\$/t·d., $\delta_0 = 0,2$ 1/d., $\mu=0,003$ (th.\$)$^{-1}$, $\alpha=1$, $K = 2th$. \$. The Table 1 shows the results of the calculation using the Microsoft Excel software for different values of the parameter d (daily demand for products). The data in the table shows that with the increase in demand the optimal size of ordered consignment, order cycle and investments in storage technology improvement have the largest value, while the demand is located in the range from 0,35 to 0,4 t/d.

Table 1. Calculation results for the optimization problem
Tabela 1. Wyniki obliczeń problemu optymalizacyjnego

The values of d parameter, t/d.	The optimum value of ordered consignment size Q, t	The optimum value of investments v \$	The optimal value of delivery cycle τ, d.	The minimumvalue of the function (9), \$	The minimum value of the function(9) when v=0, \$
0,10	1,14	239,62	7,25	228536,2	292063,0
0,15	3,52	2674,50	18,91	169821,9	363494,4
0,20	3,76	2290,52	15,36	216353,9	427878,9
0,25	4,18	2290,52	13,94	255414,3	487791,0
0,30	4,27	2070,72	12,00	298635,8	544540,2
0,35	7,95	4749,62	19,87	296800,7	598899,6
0,40	8,14	4427,89	17,91	333983,0	651373,1
0,45	6,04	2587,23	11,71	395472,5	702305,8
0,48	6,47	2748,63	11,76	412678,5	732233,0
0,49	6,49	2748,63	11,65	419632,6	742114,7

The optimum value of the coefficient due to set initial data is changing in the range from 0,02 to 0,12. In the case of lack of investment the minimum costs exceed significantly the costs when the investment takes place (see the last column of the Table 1) and, in addition, increase faster while the demand increases. It is not surprising; since the lot size of the purchased consignment grows in the face of rising demand, respectively, the loss from product deterioration increases. These data illustrate the feasibility of such investments.

MULTI-ITEM INVENTORY CONTROL MODEL

The model examined in previous Section established optimal inventory policy for a single perishable item. It is obvious that without assumption of presence of joint purchase costs, a problem with several items each facing a constant demand can be solved by examination of each item's replenishment problem separately, if a warehouse capacity is large enough. But in reality, management of a single warehouse inventory system involves coordinating inventory orders to minimize costs without exceeding the warehouse capacity. The warehouse capacity limits the total volume held by the warehouse at any point in time. This constraint ties together the different items and necessitates careful scheduling of the orders [Bramel and Simchi-Levi 1997]. That is, not only it is important to know how often an item is ordered, but exactly the point in time at which each order takes place. This problem is called the Economic Warehouse Lot Scheduling Problem (EWLSP). The scheduling part, hereafter called the Staggering Problem, is exactly the problem of time-phasing the placement of the orders to satisfy the warehouse capacity constraint. This problem has no simple solution and it has attracted a considerable attention in the last decades even for nonperishable items.

The earliest known reference to the problem appears in the books of Churchman et al. [1957], Hadley and Whitin [1963]. These authors were concerned for determining lot sizes that made an overall schedule satisfactory for the capacity constraint and not with the possibility of phasing the orders to avoid holding the maximum volume of each item at the same time. Thus, they only considered so called Independent Solutions, where every item is replenished without any regard for coordination with other items.

Below, we generalize these results for the case of several items of perishable products using the results of previous Sections.

Let $N = \{1,2,...,n\}$ be a set of n items of perishable goods and the ith item facing a constant demand rate $d_i, i \in N$. The per unit cost C_i and ordering cost K_i are incurred each time an order for item i is placed. A holding cost h_i is accrued for each unit of item i held in inventory per unit of time. Demand for each item must be met over an infinite horizon without shortages or backlogging. The per unit sale price for item i is S_i.

Denote by $\gamma_i > 0$ the volume usage rate of item i. Then the volume of inventory of item i held at a given point in time is the product of its inventory level at that time I_i and γ_i. Note that the volume usage rate is defined as the volume displaced by one unit of item i.

As above, we denote by $I_i(t)$ the inventory level of item i at time t, and by τ_i the cycle time of item i. By definition, we assume that following differential equation is valid

$$\frac{d}{dt} I_i(t) = -d_i - \delta_i I_i(t), i \in N, \quad (12)$$

where δ_i is parameter which determines the intensity of the ith kind of product's damage during period of its storage in warehouse. Initial condition for equation (12) is

$$I_i(0) = Q_i, i \in N, \quad (13)$$

where Q_i is order quantity of item i. We denote the investments directed on decreasing of deterioration of the nth item by V_n. From (12), (13) it follows (see also (4) – (7)) that average total cost per unit of time for all items (including possible market loss) is

$$\overline{C}(Q_1,Q_2,...,Q_n) = \sum_{i=1}^{n} \left[\frac{Q_i(h_i + \delta_i c_i + \delta_i s_i) + \delta_i K_i}{\ln\left(1 + \frac{Q_i \delta_i}{d_i}\right)} - \frac{(h_i + \delta_i s_i)d_i}{\delta_i} + v_i \right]$$

(14)

The control parameters Q_1, Q_2,…, Q_n are subjected to constraint

$$\sum_{i=1}^{n} \gamma_i \overline{I_i} \le V$$

or in the evident form

$$\sum_{i=1}^{n} \gamma_i \left[\frac{Q_i}{\ln\left(1 + \frac{Q_i \delta_i}{d_i}\right)} - \frac{d_i}{\delta_i} \right] \le V, \quad (15)$$

where V is the given value of warehouse cubic capacity.

The evident form of dependence $\delta_i (v_i)$ on the control parameter v_i may be taken, for example, in the form (see (8))

$$\delta_i(v_i) = \frac{\delta_{0i}}{(1 + \mu_i v_i)^{\alpha_i}}, i \in N. \quad (16)$$

We arrive at the optimization problem: it is needed to find a positive vectors $(Q_1, Q_2,…,Q_n)$ and $(v_1, v_2, ……, v_n)$ minimizing the objective function (14) under conditions (15), (16). This problem can be solved only numerically with the help of standard software (e.g. Microsoft Excel).

CONCLUSIONS AND DISCUSSIONS

Rational and efficient inventory control of perishable products ensures continuity of their supplies at the minimum cost of stocks maintaining.

The proposed generalized Wilson model can be applied to solve the problem of optimal inventory control of both single item and multi-item perishable production. Analysis of the inventory control process of perishable goods showed that the observed cargo deterioration can be reduced or even eliminated by the various types of investments. It could be the investments in storage facilities,

handling equipment, product packaging methods, etc.

The results shown above indicated that the proposed optimization model can form the methodical basis for supply companies in their investment activities and measures to improve storage technology of perishable products. For this purpose, it is necessary to create the relevant databases, collect essential information relating initial parameters of optimization models and implement the above optimization models in interested companies. The development and presentation of this methodology will be a subject of future scientific research and publications.

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OPTYMALNE STEROWANIE ZAPASAMI PRODUKTÓW SZYBKO PSUJĄCYCH SIĘ Z UWZGLĘDNIENIEM DODATKOWYCH KOSZTÓW REDUKCJI PSUCIA SIĘ TOWARU

STRESZCZENIE. **Wstęp:** Artykuł analizuje problemy sterowania zapasami towarów szybko psujących się, których jakość może się pogorszyć podczas magazynowania. Ma on na celu zaproponowanie uogólnienia klasycznych modeli, stosowanych w teorii optymalnego sterowania zapasami produktów szybko psujących się, dostosowanych do sytuacji, w której dostawca ponosi dodatkowe koszty związane z redukcją psucia się towaru.
Metody: Opracowany został uogólniony model Wilsona dla optymalnego sterowania zapasami. Założono, że tempo pogorszenia jakości towaru zależy nieliniowo od wielkości inwestycji przeznaczonych na redukcję tego zjawiska. Najpierw, przedstawiono uogólniony model Wilsona dla jednej pozycji asortymentowej, następnie ukazano ten model dla przypadku wieloasortymentowej produkcji.
Wyniki i wnioski: W celu wspólnej optymalizacji wielkości partii zamówienia i wielkości inwestycji zostały sformułowane odpowiednio zadania nieliniowej optymalizacji. W celu zilustrowania poprawności funkcjonowania modelu przedstawiono wyniki obliczeń. Stwierdzono, że proponowany model optymalizacyjny może być wykorzystany przez dostawców jako metodyczna podstawa w ich działalności inwestycyjnej skierowanej na poprawę technologii przechowywania produktów szybko psujących się.

Słowa kluczowe: sterowanie zapasami; produkt szybko psujący się; kontrola psucia się; uogólniony model Wilsona; optymalizacja wielkości partii.

OPTIMALE BESTANDSKONTROLLE DER VERDERBLICHEN WAREN MIT BERÜCKSICHTIGUNG DER ZUSÄTZLICHEN KOSTEN DER VERDERBREDUKTION

ZUSAMMENFASSUNG. Einleitung: Die vorliegende Arbeit analysiert Probleme der Bestandskontrolle verderblicher Waren, die während der Lagerung verderben können. Der Artikel bezweckt eine Empfehlung von allgemeinen, klassischen Modellen, die in der Theorie der optimalen Bestandsführung von verderblichen Waren angewendet werden und auch an die Situationen angepasst sind, in denen der Lieferant Zusatzkosten für die Reduzierung des Warenverderbs tragen muss.
Methoden: Das verallgemeinerte Wilson-Modell für optimale Losgrößen wurde entwickelt. Es wird angenommen, dass die Rate des Verderbs nichtlinear von dem für die Reduktion des Warenverderbs bestimmten Investitionsvolumen abhängt. Der Fall der inversen Leistungsabhängigkeit wurde im Detail analysiert. Zunächst wurde das verallgemeinerte Wilson-Modell für ein einzelnes Element untersucht, und dann wurde dieses Modell für den Multi-Element-Fall in Anspruch genommen.

Ergebnisse und Fazit: Für die gemeinsame Optimierung der Losgrößen und Volumen der nötigen Investitionen wurden die entsprechenden nichtlinearen Optimierungsprobleme formuliert. Die numerischen Ergebnisse wurden dargestellt, um die Richtigkeit der Modell-Funktion zu veranschaulichen. Es wurde darauf hingewiesen, dass das vorgeschlagene Optimierungsmodell als eine methodische Grundlage für die Lieferanten in ihrer Investitionstätigkeit zur Verbesserung der Lagerungstechnologie bei verderblichen Produkten verwendet werden kann.

Codewörter: Bestandsmanagement, verderbliches Produkt, Kontrolle des Verderbs, das verallgemeinerte Wilson-Modell, Losgrößenoptimierung.

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ACCOUNTING TOOLS VS. LOGISTICS COSTS CONTROL IN A TRADING COMPANY

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ABSTRACT. **Background:** Logistics costs constitute an important part of trading companies' costs. The main problem in logistics costs management is the fact that these costs are not included in financial statements. The profit and loss statement includes control accounts exclusively. This article discusses the accounting tools that may be used in trading companies in order to improve present logistics costs and the management thereof.

Methods: In the article, the author gives examples of how accounting tools are applied in trading companies operating in the same industry. On the basis of the financial statements from selected companies for 2013-2015, the way to use the basic tools of accounting in business management are presented. For this purpose a system of full-cost accounting with the use of analytical accounts of logistics is presented, along with a preliminary analysis of the balance sheet and an indicative analysis of costs for logistics.

Results: The article is based on a review of the literature and the financial statements of the companies surveyed. The model solutions for the cost analysis and cost management presented herein make it possible to create a detailed analysis of logistics costs and assess how effectively they are managed . In this way, the foundations for further analyses related to logistics costs management are laid.

Conclusions: The work presents the accounting tools that assist the decision-making processes in the management of logistics costs. In the article, an example of the plan of sub-accounts for the logistics costs of trading companies is presented. Furthermore, the cost accounting system for the accounts of group 4 and 5 in trading companies is shown, together with the benefits that this accounting system brings for the companies. The author also presents preparatory and index analyses as the basic tools that assess the effectiveness of logistics costs management.

Key words: costs, logistics, control, accounting tools.

INTRODUCTION

Companies in all sectors of the market face fierce competition. The loss of a steady customer is the highest cost a company may pay. The management board, to improve their competitive edge, may group with other companies to form purchase groups or similar organizations. They may also try to optimize their costs. These two solutions, that is running a joint-venture business or cost reduction, have a major impact on the price, which is supposed to generate profit and attract buyers. There is no production in trading companies, so they have fewer departments that would deal with cost reduction policies in manufacturing or providing services. Trading companies purchase goods on which they apply margin and in this way the price is calculated. Margin, in turn, must cover overhead costs that the company pays in relation to the activities of the management and sales departments. However, trading companies have a group of costs related to logistics, which is very often beyond control. It is caused by the fact that these costs are not included in their financial statements. Control accounts used to record costs do not list them as a separate category. Logistics costs are "hidden" within control accounts.

Therefore, it is important to introduce certain methods and tools that would allow these costs to be listed, which would have a beneficial effect on savings. For this reason it is worth employing simple tools used in accounting and finance. Once regularly used, they allow to thoroughly control this cost group, which should improve business and boost the competitive edge of companies. The aim of this article is to present the accounting tools that make it easier to control the logistics costs in trading companies.

LOGISTICS COSTS

The Accounting Act defines costs as "probable decreases of economic benefits of a reliably estimated value, which may arise during a reporting period, in the form of decreases in the value of assets or increases in the value of liabilities and provisions, that will result in a decrease of the equity or an increase of the equity deficit in a manner other than through a withdrawal of funds by shareholders or owners" [The Accounting Act]. Costs provide an excellent source of information about the way in which the company is managed.

Logistics costs are a basic quantitative factor that determines the effectiveness and modernity of logistics processes [Twaróg 2003]. Therefore, it is very important to thoroughly report and control them. Logistics costs are also very often referred to as the costs of logistics. They may be defined as "the use of labour input, operating resources and subjects of labour expressed in money, financial expenses and other negative effects of exceptional occurrences which are caused by the flow of material goods (raw materials, materials, products, goods) within a company and among companies, as well as maintaining stock levels [Skowronek, Sarjusz-Wolski 2003].

There are many criteria that govern the division of logistics costs. One of them is the division into variable and fixed costs. Variable costs change together with the scale of production, or purchase in trading companies. Fixed costs are not affected by the changes in the volume of production or purchase. One of

the most important divisions of logistics costs is the division according to the basic components of logistical process into three groups:
− physical flow costs,
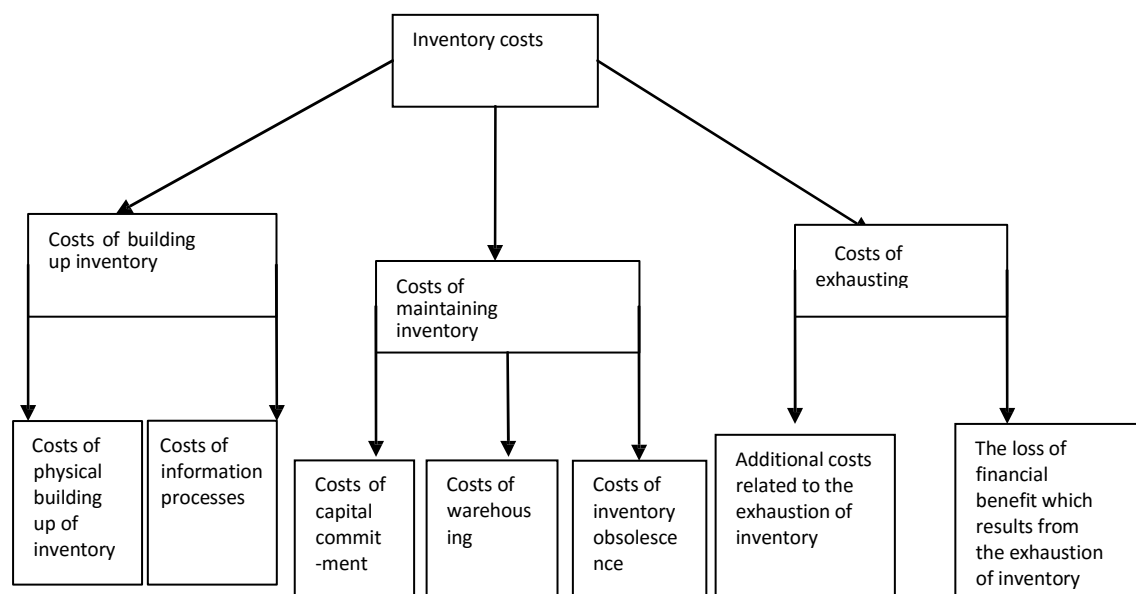− inventory costs,
− information flow costs.

Physical flow costs constitute one of the most important cost categories. They are made of the following components [Twaróg 2003]:
− costs of the depreciation of assets,
− labour costs,
− costs of materials, fuel and energy,
− other flow costs, such as property tax, vehicle tax.

Material flow costs concern all the three stages of the flow: purchase, production and distribution. They primarily include the costs of external (external services) and internal transportation. An important function of these costs (as far as making records goes) is the fact that they are easy to assign to respective departments. For instance, external delivery costs are assigned to the purchasing department, distribution costs to the sales or internal transportation department and internal transportation and manipulation costs are included in operational costs [Skowronek, Sarjusz-Wolski 2003].

In order to reduce the high costs of external transport, providers are seeking an access for information about inventory levels of its customers. Next, they create the distribution plan for their customers and they use the VMI method [Archetti, Speranza 2016].

Inventory management costs constitute the basic component of logistics costs. Inventory costs are described as warehousing management costs, which result from the activities related to the building up, maintaining and exhaustion of the inventory [Karmańska 2000]. A detailed division of inventory management costs is shown in diagram no. 1.

Fig. 1. The division of inventory management costs
Rys. 1. Podział kosztów zarządzania zapasami

The first group of costs is the costs of building up inventory. It includes the costs of physical building up of inventory and the costs of information processes related to the purchase of materials, goods and products. The information process costs of inventory include: the costs of choosing a supplier, the costs of purchase order preparation, negotiation costs and the costs of sales order preparation [Twaróg 2003].

Another cost group is the costs of maintaining inventory. In this group managers may gain most by employing proper methods of inventory management and aiming at the optimization thereof. Sales forecasts have a primary impact on the costs in this group, which affect the inventory level, thus influencing the costs. The most expensive component in this group is the cost of warehousing, also known as the storing cost. To reduce this type of cost the cheapest places for storage of inventory are looked for, and often, for this purpose the sellers are used [Jaber, Zanoni, Zavanella 2014].

The last cost group of inventory management costs is the cost of the exhaustion of inventory. They relate to the loss of financial benefit that the company would have in the event of a lack of inventory when the customer needs it. In other words, these are the costs of lost gains that the company may have if a sufficient level of inventory was there at the proper place and time [Karamańska 2011].

The costs of information processes may be divided according to two different criteria: the place where they appear and the type of cost. This division is a significant facilitation while designing the corporate chart of accounts that includes logistics costs. The division into the place where the costs appear usually includes the following groups [Skowronek, Sarjusz-Wolski 2003]:
– costs of information process of purchase,
– costs of information process of production,
– costs of information process of distribution.

As a part of the distribution logistics costs, the costs of customer service comprise an

important group [Christopher 2011]. Excessive savings in this area may lead to loss of contractors as customers are very sensitive to the level of these services [Jiang, Wang, Liu 2016].

ACCOUNTING TOOLS TO SUPPORT CONTROL OF LOGISTICS COTS

Trading companies in order to improve and increase control over logistics costs should use different types of tools from various areas of accounting:

Full cost accounting system

Costs of operating activities include costs on manufacturing and selling products, providing services, buying and selling materials and goods as well as the management of the company. They may be grouped into two different sections, specified by nature of costs (accounts of group no. 4) and by function of costs (accounts of group no. 5), however, they are simplified cost accounting systems [Nowak 2003]. They provide general information on incurred costs. Cost accounting within group no. 5 is typical for production and service companies. Trading companies usually keep cost accounting records on accounts of group no. 4, i.e. classified by nature. These costs are grouped according to used resources, which are so called prime costs [Biernacki, Kowalak 2010].
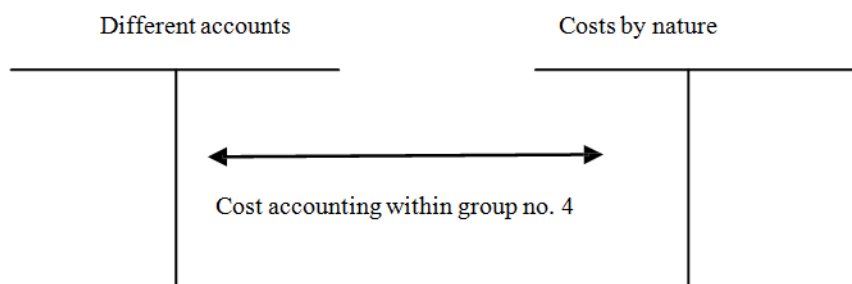

Fig. 2. Diagram of cost accounting within group no. 4
Rys. 2. Schemat ewidencji kosztów na kontach zespołu nr 4

It is worth remembering that costs classified by their nature are treated as costs of both the current and the future reporting periods. In a profit and loss account in a single-step version, the corrections of costs relating to future periods are made by the change in products.

The third method described as a full cost accounting system with the use of groups no. 4 and 5 together is an accounting system which offers the most information. Companies keeping their cost accounting records this way

receive full information on costs. They know about the nature of costs and the departments where they appear. To group no. 4, i.e. costs classified by their nature, belong:
- Depreciation, capital allowances of fixed and intangible assets
- Materials and energy consumption, group of costs on consumed basic and auxiliary materials, fuel, stationery, etc.,
- External services, costs of works and services provided by others for the company, e.g. transport services, rental services, bank services and IT services,

− Taxes and charges, costs of stamp duties, administrative fees, notary fees, court fees, motor vehicle tax and property tax,
− Remunerations, costs of remunerations,
− Insurance and other benefits, costs of social security contributions in part paid by the employer, costs of obligatory contributions on Labour Fund, Guaranteed Employment Benefit Fund, Bridging Pension Fund and costs of worker training, deductions on social benefit fund, costs relating to occupational safety and health,
− Other costs classified by their nature are costs which cannot be put into groups described above, e.g. costs of business travels, costs of representation, costs of advertising, lump sum car allowance, costs on organisations to which it is obligatory to belong,

Within the presentation of costs, the group no. 5 is added which contains costs of production activity, costs of auxiliary production, trade costs, costs of sales and management costs. This option is used by companies which run disperse business activity to a great extent, which are characterised by a complex organisational structure, manufacturing products in several processes or stages, using modern management methods based on rich information service.

This system functions well in companies operating in purchasing groups [Zimon 2015].

This record provides basic information about the costs incurred. Below in figure 3 the records of accounting costs in trading companies operating in the fields of heating technology are presented.
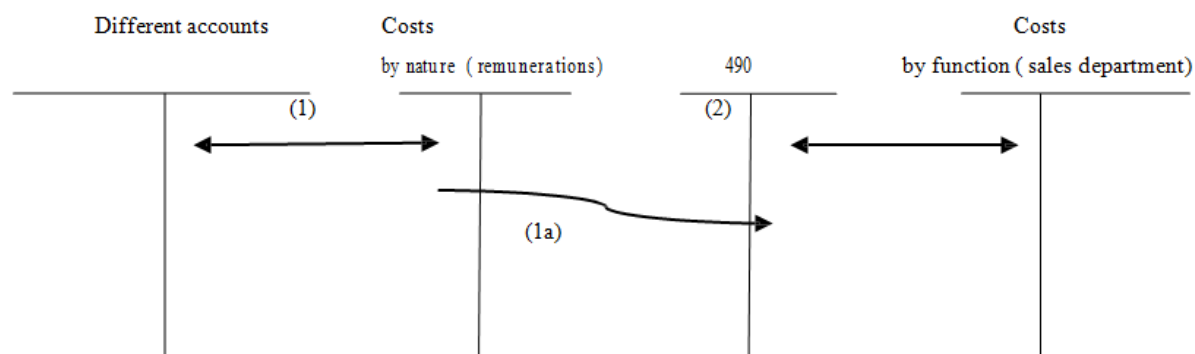
1 - costs accounting according to the nature of costs
1a- transfer of costs classified by nature to account 490 - allocation of costs classified by nature
2 - transfer of costs according to their function

Fig. 3. Diagram of cost accounting within groups no. 4 and 5 together
Rys. 3. Schemat ewidencji kosztów na kontach zespołu nr 4 i 5 łącznie

Auxiliary accounts, i.e. analytical accounts

To keep records on analytical accounts requires only a single record. It is a copy of a record from a control account. Trade companies mainly use only accounts within group 4 while cost accounting. It is a simplified cost accounting form. In the table no. 1 below the typical accounts of group no. 4 are presented, for which sample solutions of

logistics cost accounting in trading companies are given.

Keeping cost accounting records this way would inform about their nature and function. The sample way of fuel consumption costs accounting in a trading company is presented in the figure 4.

Table 1. Typical chart of accounts of group no. 4 in trading companies including logistics costs
Tabela 1. Typowy plan kont zespołu nr 4 w przedsiębiorstwie handlowym z uwzględnieniem kosztów logistyki

Control accounts	Logistics analytical accounts
Depreciation	– Depreciation of motor vehicles – Depreciation of other fixed assets relating to logistics
Materials and energy consumption	– Consumption of logistics materials – Fuel consumption – Consumption of energy for logistics purposes
External services	– Transport – Loading and unloading – Leasing – Telecommunications services – Repair services – Other external services
Remunerations	– Drivers' remunerations – Warehouse workers' remunerations – Other logistics workers' remunerations - sales, procurement
Social securities and other benefits	– Social security and other benefits for drivers, e.g. – ZUS (Social Insurance Institution in Poland) contributions, – training, expenses on health protection, – Expenditure on Occupational Safety and Health – Social security and other benefits for other logistics workers', e.g. – ZUS (Social Insurance Institution in Poland) contributions, – training, expenses on health protection, – Expenditure on Occupational Safety and Health
Taxes and charges	– Motor vehicle taxes – Taxes on logistics property – Environment protection charges – Other charges, e.g. stamp duties, court fees
Other costs classified by their nature	– Insurance – Business travels of logistics workers – Advertising – Other costs

Source: own work
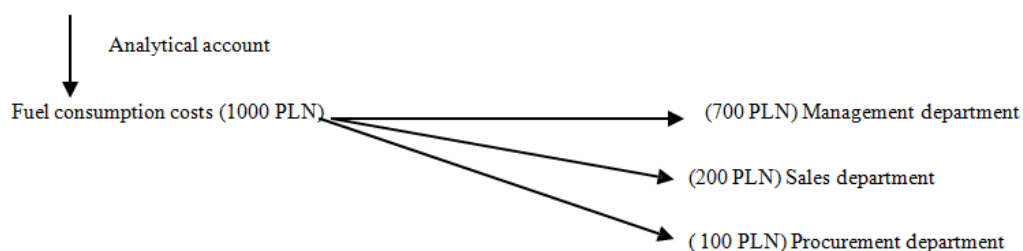
Fig. 4. Diagram of cost accounting within groups no. 4 and 5 together
Rys. 4. Schemat ewidencji kosztów na kontach zespołu 4 i 5 łącznie

While creating analytical accounts arises the problem with separation of costs within group no. 5. Warehouse costs are a classic example of this problem. They refer to both finished goods and materials that are to be used in the future production. In this case, it is worth to split warehouse costs into supply and distribution stages [Filipiak 2013]. It is useful to split costs into two indirect departments: procurement and sales. In order to allocate costs accurately, appropriate allocation keys for indirect costs should be used.

An introductory analysis of financial reports is the first stage of a company's financial analysis and it includes within its scope generally two elements: balance sheet and profit and loss account. In order to analyse costs, an introductory analysis of profit and loss account should be conducted. It is based on listing, as a point of reference, currently received values of individual items with assumed amounts, which is usually the data from the past reporting periods or from financial plans for the future. This analysis is conducted regarding structure (vertical analysis). In reference to the analysis of logistics costs, it will inform of the share of individual costs in total logistics costs. In the table below an example of this type analysis of logistics costs on the example of distribution logistics costs in a trading company is presented.

Table 2. Horizontal analysis of logistics costs
Tabela 2. Analiza pionowa kosztów logistyki

Structure of logistics costs	2015	2014	2013
Fuel consumption	10 %	9 %	10 %
Drivers' remunerations	76 %	75%	80 %
Costs of transport	5 %	15 %	5 %
Other costs	9 %	1 %	5 %

Source: own work

An introductory analysis of costs is conducted regarding dynamics as well (horizontal analysis). It enables close examination of trends in individual items of costs incurred. An exemplary analysis of dynamics of logistics costs distribution is presented in table no. 3.

Table 3. Level of analysis of logistics costs
Tabela 3. Analiza pozioma kosztów logistyki

Cost / Dynamics	2015/2014	2014/2013
Fuel consumption	110 %	105 %
Drivers' remunerations	120 %	101 %
Costs of transport	105 %	98 %

Source: own work

A detailed introductory analysis of costs may be conducted only when the company keeps records of logistics costs on analytical accounts and runs full cost accounting system.

Once an introductory analysis of company costs has been conducted and the initial information about the company has been collected, another part of the financial analysis is started, called the index analysis. It is based on the calculation of a series of indexes that show the dependencies between the individual data included in the financial reports. The results obtained in this way allow for a synthetic characteristics of all the economic aspects of the business activity. A common problem in this kind of analysis is to determine the choice of the grounds on which the comparisons of company results will be made. Most often they are compared against the planned or the previously reached levels. The structure of the indexes that show the financial situation of the company depends on its needs. To conduct the index analysis of costs and to employ the following cost meters.

The operating costs ratio (OCR) is the most important ratio in this group of ratios and it informs how much of operating costs is attributed to sales revenue. It is calculated from the relation:

$$\frac{\text{operating expenses}}{\text{sales revenue}}$$

The level of this ratio informs about the safety of the company. The lower the score, the lower the costs charged for the core business revenues from this activity [Wędzki 2006].

On the basis of this ratio, one can create an overall index for the logistics costs

$$\frac{\text{logistics costs}}{\text{sales revenues}}$$

This indicator will provide information how many logistics costs charge the generated revenue.

For more information, one can use the information on the cost from the analytical accounts e.g. payroll costs of logistics staff

$$\frac{\text{remuneration costs of logistics staff}}{\text{sales revenues}}$$

It tells how many costs of remunerations for the staff were deducted for the work out of the sales revenues.

A very good ratio informing about the management costs would be the rate of the sales department costs (department of distribution) for operating costs. In the companies involved in the provision of logistics services or trading units where the costs of logistics distribution can be separated, this ratio may inform about whether a department does not incur excessive costs

$$\frac{\text{sales costs(distribution logistics)}}{\text{operating costs}}$$

In addition, in trading companies it is possible to analyse the cost of procurement logistics.

$$\frac{\text{purchase costs(procurement logistics)}}{\text{operating costs}}$$

Operating costs in the given formula are the costs of the group no. 4 (these costs do not include - the value of goods sold in the purchase price). The results of the ratios on the example of three selected trading companies operating in the same industry (thermal engineering) are presented in Table 4.

Table 4. Ratio analysis of logistics costs in the selected companies in 2015
Tabela 4. Analiza wskaźnikowa kosztów logistyki w wybranych przedsiębiorstwach w roku 2015

Ratio	Company A	Company B	Company C
Ratio of logistics costs in sales revenues	9%	11%	10%
Ratio of remuneration costs of logistics in sales revenues	5%	6%	6%
Ratio of logistic distribution costs in operating costs	58%	62%	60%
Ratio of logistics procurement costs in operating costs	10%	12%	11%

Source: own research

CONCLUSIONS

The selected accounting tools applied in trading companies presented above allow the managers to easily get the information about the logistics costs and facilitate control over them. The companies that want to employ them need to keep strict costs records and create a database concerning logistics costs. To achieve it companies that collect, assign and record individual economic events need to spend extra time in comparison to simple costs reporting. It is a definite disadvantage, yet the use of new accounts for logistics costs and full costs recording allow for the creation of a comprehensive breakdown of logistics costs in a trading company. Consequently, it creates many opportunities for conducting analyses related to the incurred costs and maintaining control over them. Reliable and detailed information about costs is the foundation for the introduction of changes that should bring economic profit to companies.

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NARZĘDZIA RACHUNKOWOŚCI A KONTROLA KOSZTÓW LOGISTYKI W PRZEDSIĘBIORSTWIE HANDLOWYM

STRESZCZENIE. **Wstęp:** Koszty logistyki w przedsiębiorstwach handlowych stanowią ważną grupę. Głównym problemem w zarządzaniu kosztami logistyki jest fakt, że nie są one prezentowane w sprawozdaniach finansowych. W rachunku zysków i strat umieszczone są tylko konta syntetyczne. W artykule wskazano narzędzia z obszarów rachunkowości, które można zastosować w przedsiębiorstwach handlowych w celu poprawy prezentacji kosztów logistyki i zwiększenia kontroli nad nimi.
Metody: W artykule autor przedstawia przykłady zastosowania narzędzia rachunkowości w przedsiębiorstwach handlowych działających w tej samej branży. Na podstawie sprawozdań finansowych wybranych przedsiębiorstw za lata 2013-2015 przedstawiono, w jaki sposób można wykorzystać podstawowe narzędzia rachunkowości w zarządzaniu przedsiębiorstwem. W tym celu przedstawiono system pełnej ewidencji kosztów z wykorzystaniem kont analitycznych logistyki, następnie wykonano wstępną analizę bilansu oraz wskaźnikową dla kosztów logistyki.
Rezultaty: Artykuł został przygotowany na podstawie literatury z badanego obszaru oraz sprawozdań finansowych badanych firm. Przedstawione modelowe rozwiązania z zakresu analizy i zarządzania kosztami pozwalają na szczegółową ewidencje kosztów logistyki, kontrolę i ocenę ich zarządzania. Stanowi to podstawę do przeprowadzenia dalszych analiz związanych z gospodarowaniem kosztami logistyki.
Wnioski: Wynikiem pracy jest przedstawienie narzędzie rachunkowości, które wspomagają procesy decyzyjne w zarządzaniu kosztami logistyki. W artykule przedstawiono przykładowy dla przedsiębiorstw handlowych plan kont pomocniczych dotyczących kosztów logistyki. W artykule również zaprezentowano system ewidencji kosztów na kontach zespołu 4 i 5 łącznie w firmach handlowych oraz korzyści, jakie ten sposób księgowania przynosi zarządzającym przedsiębiorstwom. Autor przedstawił również analizę wstępną i wskaźnikową, jako podstawowe instrumenty oceniające efektywności zarządzania kosztami logistyki.

Słowa kluczowe: koszty, logistyka, kontrola, narzędzia rachunkowości.

WERKZEUGE DES RECHNUNGSWESENS UND DIE KONTROLLE DER LOGISTIKKOSTEN IM HANDELSUNTERNEHMEN

ZUSAMMENFASSUNG. Einführung: Die Kosten der Logistik im Handelsunternehmen machen eine wichtige Gruppe aus. Das Hauptproblem im Management der Logistikkosten beruht darauf, dass sie nicht in den Finanzberichten aufgeführt werden. In den Gewinn-und Verlustrechnungen werden nur synthetische Konten angeführt. Im Artikel wurden die Werkzeuge im Bereich des Rechnungswesens gezeigt, die in Handelsunternehmen zur Verbesserung und zur Darstellung der Logistikkosten sowie zu deren Kontrolle verwendet werden können.

Methoden: In diesem Artikel stellt der Autor die Beispiele für die Verwendung der Werkzeuge des Rechnungswesens in den Handelsunternehmen, die einer und derselben Branche angehören, dar. Auf der Grundlage der Jahresfinanzberichte der Unternehmen in den Jahren 2013-2015 wurde es projiziert, auf welche Art und Weise die Hauptrechnungswerkzeuge im Bereich der Unternehmensführung verwendet werden können. Zu diesem Zweck wurde das System der vollständigen Kostenverzeichnisse unter der Anwendung von analytischen Konten der Logistik dargestellt, dann wurde auch eine vorläufige Bilanz- und Koeffizienten-Analyse für die Logistikkosten durchgeführt.

Ergebnisse: Der Artikel wurde auf der Grundlage der Literatur aus dem Forschungsgebiet und anhand der Finanzberichte aus den befragten Unternehmen ausgearbeitet. Die dargestellten Modelllösungen im Bereich der Analyse und Kostenverwaltung ermöglichen eine detaillierte Kostenevidenz der Logistik und die Kontrolle der betreffenden Kostenführung. Dies bildet eine Grundlage für weitere Analysen, die mit dem Management der Logistikkosten verbunden sind.

Fazit: Das Ergebnis der Arbeit ist die Präsentation der ausgewählten Werkzeuge innerhalb des Rechnungswesens, die die Entscheidungsprozesse im Management von Logistikkosten unterstützen. Der Artikel enthält einen beispielweisen Kontenplan für die Kostenführung innerhalb der Logistik in Handelsunternehmen. Der Artikel zeigt auch ein System für die Kostenevidenz auf den Konten der Gruppe 4 und 5 in den Handelsunternehmen sowie die Vorteile, die diese Buchhaltungsweise den Geschäftsführern in den einzelnen Unternehmen mit sich bringt. Der Autor projizierte auch eine einleitende- und Koeffizienten-Analyse als grundlegende Tools für die Bewertung der Effizienz des Managements von Logistikkosten.

Codewörter: Kosten, Kontrolle, Logistik, Werkzeuge des Rechnungswesens

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REDESIGNING SUPPLY CHAIN NETWORK OF A LUBRICANT COMPANY: AN INNOVATIVE APPROACH

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ABSTRACT. **Background:** The purpose of this paper is to redesign the supply chain network of a lubricant company by implementing an innovative solution concentrated on the delivery of products and minimizing total loading, unloading and transportation costs.

Methods: In this paper the authors' approach to redesigning the supply chain network (SCN) is presented. It comprises 3 phases: analysis of the current state of the SCN, identification of disadvantages in the SCN and SCN improvement. This step-wise procedure is verified on a real-world supply chain network, which is analyzed, evaluated and redesigned. Based on this analysis, the most important strengths and weaknesses are identified. The main criteria for evaluation are loading, unloading and transportation costs. A redesign of the company is proposed, the stakeholders' opinions are gathered and the innovative solution is implemented.

Results: After successful implementation of the innovative solution, the result shows savings in loading, unloading and transportation costs and an improvement in the level of service.

Research Limitations: The proposed methodology can be implemented in other supply chain networks. However, the way of limiting the loading, unloading and transportation costs presented in this paper cannot be regarded as a general rule applicable to all companies.

Conclusions: This study presents innovative thinking in the logistics network of a company andthe results obtained prove that companies which are innovative in terms of products can also become innovative in their services.

Key words: Innovation, Logistics, Transportation, Supply Chain, Lubricants.

INTRODUCTION

Nowadays, innovation in supply chain management is an integral part of any organization. It does not matter which business is considered, innovation in supply chain might set the company apart from crowd. However, on the one hand, not all that new solutions are successful. In some cases excessive innovations in supply chain can be a disadvantage for organizations. Prof. Vaclav Smil [2015] from University of Manitoba in Canada claims that one of the most remarkable examples of a prolonged and costly innovation failure is the fast breeder reactor. Due to high costs, technical problems, social and environmental issues, the shutdowns of experimental reactors were made in many countries. Therefore, companies should be very careful in changing or selecting new products or services.

On the other hand, in order to remain competitive, innovation can be a key difference between market leaders and their contenders [Kotler and Keller, 2014]. In any kind or nature of business, generation of new ideas is essential for organization's success. If organizations are un-innovative, they have a risk of losing their edge in the market.

With the help of innovation in supply chain process, organizations can also discover opportunities, which already exist or are likely to emerge in the future. Responses to current customers needs are not only the key for successful business, but predicting future needs and developing new ideas and incorporating innovative ways of operations allow organizations to meet future challenges in an effective and efficient way.

It is universally accepted that innovation is the key to ensure the future growth and survival of any firm. Innovation allows organizations to coordinate themselves with the changes of the environment, market and customer demand. It is found that there is a relationship between organizational culture innovations and the adoption of information system. The innovation is described as a critical factor in organization performance and survival of the firm in a competitive environment. The importance of product innovation for good long-term company results is now widely recognized and has been extensively reported in the literature [Tohidi and Jabbari, 2012].

There is a misperception about innovation and many professionals think that it is only about designing a new product or service to sell. Despite the fact that innovation has been studied in different disciplines, the term is often poorly understood and can be sometimes confused with related terms such as change, invention, design, and creativity.

J. Schumpeter [1983], well-recognized as an authority in the area of companies' organization, defines the innovation as follows:
− the introduction of a new product with which consumers have not yet had to deal with;
− the introduction of a new production method, which has not been utilized in the particular field of industry;
− the opening of a new market, i.e. an area in which the type of industry previously did not work, regardless of whether the market has existed before or not;
− getting new source of raw materials or semi-finished products, regardless of

whether the source already existed, or had to be created;
− the introduction of a new organization of industry.

According to The New Oxford Dictionary of English [1998], innovation is the application of practical tools and techniques that make changes, large and small, to products, processes, and services that result in the introduction of something new for the organization that adds value to customers and contributes to the knowledge store of the organization. This shows that even a small incremental change of any process is an innovation. Innovating and improving continuously operations is essential for the better performance of an organization.

Innovation can be also explained as the using of new ideas that lead to the making of any new products, services or processes. Not only the invention of something new is important, but getting it out into the marketplace is just as significant. Thus, implemented innovation includes technologically new products (goods and services) and processes or represents significant technological improvements in products and services [European Commission & Eurostat, 2005]. Based on this definition, innovation is considered as implemented if it is placed on the market or is used in the production process.

In a literature review on innovation, Edison, et al., [2013], found over 40 definitions. They also performed an industrial survey to capture how innovation is defined in industry. Based on the analysis of the existing definitions covering all the dimensions of innovation, they presented the following one to be the most complete:

"Innovation is: production or adoption, assimilation, and exploitation of a value-added novelty in economic and social spheres; renewal and enlargement of products, services, and markets; development of new methods of production; and establishment of new management systems. It is both a process and an outcome."

Undoubtedly, novelty is a common part of all the above-mentioned elements of innovation. The company is innovative when a new or technologically developed products or processes are introduced on the market.

Due to increasing rate of new product launched or new service introduced on the market, innovation management becomes important. The objective of innovation management is to enhance the effectiveness and efficiency of new product development or service.

The models, which explain the development and commercialization of new products, are key elements of innovation management. Researchers and academic professionals define many process models presenting companies' evolution or new products or services. It is essential for organizations to develop process models, because this will help them to standardize their innovative efforts.

In many companies the innovation management is considered to be a set of tools that help managers a general understanding of processes and goals. It also allows organizations to respond to external or internal opportunities, and use its creativity to introduce new ideas, processes or products [Kelly and Kranzburg, 1978].

The importance of innovation measurement is well emphasized in industry. According to The Boston Consulting Group's survey, 74% of the executives believed that their company should track innovation as rigorously as core business operations, but only 43% of the companies actually measured innovation. Although, some companies think that innovation cannot and should not be measured, the real issue is lack of metrics and measurements. This makes companies measure too little, measure the wrong things or not measure innovation at all [Andrew et al., 2008].

Literature and studies confirmed that all organizations are eager to be more innovative. Most of the companies believe that innovation is essential for them. This shows that the importance of innovation is increasing and increasing significantly. Due to globalization

and shorter technology life cycle, innovation has become an integral factor in strategic planning.

According to Chesbrough H., [2006], companies that don't innovate die. Few years ago, "business as usual" was enough for most of the companies but nowadays all stakeholders of any organization are agreeing that "business as usual is soon no business at all".

It is a fact that nowadays we need innovation more than any time before. Due to the impact of globalization, migration, technological and knowledge revolutions, innovation will bring added value to business and helps organizations to remain competitive.

If your company manufactured a product from a purchased raw material and sells it to customers, it means that your organization has supply chain and needs its management. Simchi-Levi et al. [2008] define the supply chain management (SCM) as follows:

"It is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize system-wide costs while satisfying service level requirements".

This definition leads to several observations. First, SCM takes into consideration every facility that has an impact on cost and plays a role in making the product conform to customer requirements; from supplier and manufacturing facilities through warehouses and distribution centers to retailers and stores. Indeed, in some supply chain analyses, it is necessary to account for the suppliers' suppliers and the customers' customers because they have an impact on supply chain performance [Simchi-Levi et al., 2008].

In order to improve competitiveness in the market, organizations should be aware of the importance of incremental innovation and its opportunities in logistics management.

Organizations are forced to maintain competitive in the market and deliver products to the customers according to 7R in logistics, i.e. right products, to right place, at right price, to right customer, in a right condition, at right time and right quantity. The example of highly competitive market is the oil sector. Part of the top importers of oil from all over the world is located in Pakistan. Therefore, their supply chain network should be of the highest quality and cost effective at the same time.

This study proposes an incremental innovation in Pakistan's biggest oil company's supply chain network and the improvement of customers' service, warehousing and transportation costs reduction based on the redesign procedure presented by the authors of this paper.

The paper is composed of 5 sections. The first one presents the introduction to innovation and the problem considered. In the second section the methodological background is described, including an overview of innovation that many companies have adopted in the field of supply chain management and logistics. The third section presents the authors' approach to redesign SCN, which is composed of 3 phases. In the fourth section the application of a proposed procedure is presented. There is described information about the company's background and current logistic management. There is also presented the innovation in company's supply chain network. The results of the innovation process introduced to the company are analyzed. The special attention is put into the costs' reduction and customers' satisfaction improvements, as well. Finally, in the fifth section, the conclusions are drawn and future recommendations are presented.

METHODOLOGICAL BACKGROUND

Management focus and commitment is vital in supply chain innovation. Moreover, supply chain managers should benefit from technological advancement to better management of the supply chain. According to Gravier and Swartz [2009], the interaction of managerial policies and technological factors

presents an important focus of research for innovation management research.

Literature has proven that companies adopting innovative ways to enter the market, and then supporting those plans with successful supply chains, can gain competitive advantage quickly and increase market share in short period of time.

The relation between innovation and supply chain management is not a new trend in the market. Many leading organizations applied radical or incremental innovations over a period of time. In late 1800s, company named "Taylorism" applied innovation in manufacturing shop floor and invented the concept of standard time. Similarly "3M" company applied innovation in its transportation lead control center and adopted the concept of centralization in transportation planning to look for network synergies.

Abbott lab Canada developed and implemented a first computerized distribution requirement planning system. This system is more or less similar to material resource planning and based on its core concepts. It is considered as the start of today's supply chain planning software. Moreover, Fedex Tracking System, the Universal Product Code, Toyota production system and Ocean Shipping Container Technology are the examples of innovations in supply chain.

Some studies provided evidence that better integration of suppliers in managing overall supply chain cycle within the product innovation process can improve a firm's overall performance (e.g. Bonaccorsi and Lipparini [1994]; Ragatz et al. [2002]; Johnsen [2009]; Lau et al. [2010].

Continuous innovation is a vital solution to overcome pressures from customers, competitors, and regulators, and this increases the entire supply chain performance [Porter and Van der Linde, 1995].

According to Rice [2014], most innovations in supply chain management are built on existing achievements and reconfiguration of known methods and technologies, rather than

on inventing new ones. This doesn't mean supply chain innovation is unexciting or largely irrelevant. On the contrary, incremental change represents one of the most powerful weapons companies have to stay ahead of the competition. Table 1 shows some examples of supply chain innovations in real-world companies.

Gattorna, et al. [2003] and Skjott-Larsen [2000] claim that, in order to maintain cooperation between supply chain partners, coordinated supply chain relationships are the best form. Thus, it is very important for key players in supply chain to improve coordination and communication. Moreover, information sharing is vital for effective SCM.

Table 1. Supply chain innovations
Tabela 1. Innowacje w łańcuchu dostaw

Company		Examples of Supply Chain Innovation
Name	Short description	
Caterpillar	manufacturer of construction and mining equipment	Service parts availability via integrated network
Cisco	designer, seller and service provider of information technology	Proactive and upstream supply chain risk management, monitoring, and measurement
Dell	developer, seller of computers, related products and services	Make-to-order, sell direct, product and supply chain tailored to market segments
Fedex	global courier service company	Hub-and-spoke systems and network
Ford	manufacturer and seller of automobiles and vehicles	Vertically Integrated assembly line at River Rouge plant
Intel	semiconductor chip maker, inventor of the processors	Copy Exactly: standard fab design
Li & Fung	consumer goods designer, developer, sourcing and logistics company for retailers and brands	Complete upstream contract manufacturing management
Lucent *(currently Alcatel-Lucent)*	telecommunications equipment company	Platform/component standardization, supplier contract margin management
Procter & Gamble	producer of consumer goods, including cleaning agents and personal care products	Diamond relationship customer reams, Streamlined Logistics, Efficient Customer Response, Continuous Replenishment
Reebok	producer and distributor of fitness and sports items	Responsive supply chain via product redesign postponement and near shoring
Toyota	manufacturer and seller of automobiles and vehicles	Toyota Product System, SMED
UPS	global courier service company	IT integration across system, standardized engineering processes
Walmart	retailer operating a chain of discount department stores and warehouse stores	Everyday Low Prices, upstream supply chain management, store location impact on supply chains
Zara	clothing and accessories retailer	Hi-automation and near-market production aligned for supply chain of fast fashion

Similarly Miles and Snow [2007] mentioned that it is important for organizations to adopt strategic approach for better supply chain relationships. They also stated that this approach is critical for many organizations to survive and maintain adequate market share. Moreover, Lambert and Knemeyer [2007], indicated that different types and nature of supply chain relationships such as coordination, cooperation and collaboration affect these connections. Therefore, a strong effective relationship is the key success factor for efficient entire supply chain management.

The other factors, such as utilization and ability to get information are vital for overall supply chain innovations activities and its performance. Nowadays, organizations depend

on their customers and suppliers. Managing the information between them can help organizations to fulfill customers' expectations and suppliers' requirements effectively and efficiently.

From customers' perspective, new or improved service or product is innovation. According to Benner and Tushman [2002], there can be distinguished two types of innovations, i.e. exploratory and exploitative. The first one is connected with radical changes, which are designed for new markets' needs. It requires new knowledge or a departure from existing knowledge in the organization. In the second type, it is assumed that the innovations are incremental and designed for existing customers' or market's needs. The aim of all these activities is to add the value of products and services. In particular, according to Sakchutchawan et. al, [2011], the channel of the supply chain which adds the value of time and place utility is logistics. It is defined as the management of the flow of goods, information, service and other resources between the point of origin and the point of consumption in order to meet the requirements of consumers. Lin [2006] states that logistics involves the integration of information, transportation, inventory, warehouse, material handling, security, and packaging. It also means the supply of service or product to the demander or demanding unit at the right time, with the right quantity, in the right quality, with the right cost and at right place. Innovation can occur within services, processes, or any business system.

Logistics has evolved with the overall responsibility for the movement, storage and handling of both inbound materials and outbound products. Logistics innovativeness and logistics service differentiation positively influences logistics performance [Ralston et al., 2013]. It means that innovation in logistics is essential for overall supply chain performance.

PROPOSED APPROACH TO REDESIGN SUPPLY CHAIN NETWORK

In order to reduce inventory and to keep total supply chain costs at the minimum level, constant incremental innovations are required in logistics. These innovations include new routes and trade options. Therefore, it is essential for organizations to monitor their logistics activities, reduce disadvantages and introduce innovative solutions in order to maintain competitive edge and fulfill customer needs.

This approach of redesigning the supply chain network can be presented as a procedure, composed of the following phases:

− Phase 1. Analysis of the current state of the supply chain network. The aim of this phase is to precisely define how the SCN operates. Thus, its major components should be identified and the relations between them, as well. The analysis should also lead to the identification of the most important challenges and the level of their fulfillment.
− Phase 2. Identification of disadvantages in SCN. The aim of this phase is to rank drawbacks from the most to the least important. Their identification should be concentrated on overall characteristics of the SCN. The strategic thinking should also be incorporated. Not only disadvantages are important, but their reasons should be recognized, too.
− Phase 3. SCN improvement. The aim of this phase is to improve the supply chain network by adding the value of time and place utility. Thus, the innovative solution is required. This phase should be concentrated on the coordination of product and information flow in the SCN. The holistic approach of the redesign procedure makes that stakeholders' participation is required. Their opinions and preferences should influence the process of changes. Based on them different SCN variants of redesign should be constructed. They should reflect various aspects of SCN, such as technical, organizational, economical,

social, environmental etc., and stakeholders' preferences, as well.

Finally, the variant that has the most important influence on the overall system and at the same time is innovative should be selected. Its implementation in the system should reduce the most important disadvantages and provide competitive advantage.

To verify this procedure a real-world SCN has been considered and presented in the next section.

APPLICATION OF INNOVATION IN XYZ LUBRICANTS

Analysis of the current state of the supply chain network

For over a century XYZ Lubricants has been an innovator in lubrication technology and has manufactured breakthrough lubricants for automotive, commercial and industrial sectors. From energy to manufacturing, from cement plant to metal processing, from textiles to plastics, every industry can utilize and benefit from the extensive range of XYZ Lubricants products.

The XYZ Lubricants brand is known for performance and innovation. It is highly recognized for its advanced technology in lubricants and services, and it is synonymous with Motorsport where performance counts.

To meet such challenges as: competitive prices, constantly improved quality of products, customers' requirements with shorter lead times, on time deliveries and a wide range of variety of available oil grades near the customers, the company has to be redesigned and new ways of operating their businesses should be specified.

Fig. 1. Map of Pakistan with an exemplary supply chain of XYZ Lubricants - current state
Rys. 1. Mapa Pakistanu z przykładowym łańcuchem dostaw firmy XYZ Lubricants - stan obecny

XYZ Lubricants has its customers spread all over the country in various cities of Pakistan. In order to satisfy customer's demand on time, XYZ Lubricants currently has three warehouses, as presented in figure 1. There is a warehouse with imported products in Karachi, and two warehouses with local and imported products in Hub (Lube Oil Blending Plant - LOBP), and in Lahore. Karachi and Hub (LOBP) Warehouses are located in south of Pakistan. They satisfy the demand of the following provinces: upper and lower Sindh (placed in southeast of the country) and selected regions of Balochistan (placed in southwest of the country). Some products delivered to Karachi Port are transported to

Karachi Warehouse, and then to Lahore Warehouse, located in the eastern part of Pakistan. The distance between Karachi Warehouse and Lahore Warehouse is around 1300 km. The products from the Lahore Warehouse, are delivered to upper and lower Punjab (the province placed in east of the country) and selected northern areas.

Current supply chain process of major customers in northern Pakistan is presented in figure 2.

It is composed of the following steps:

– Step 1. Orders placed by customers. Marketing and Sales (M&S) department of XYZ Lubricants receives information about the volume of customers' demand for the next 3 months. The company is the only one distributor of lubricant products to major customers in northern Pakistan. Therefore, it is mandatory for XYZ Lubricants to provide deliveries of products in right quantity and at right time.

– Step 2. Consolidation of products. Once the order quantity has been confirmed, Supply and Distribution (S&D) department consolidate different products to make it one full container load (FCL). If the order quantity is FCL, then S&D department places an order next day. This department also communicates Expected and Actual Arrival Times (ETA) at Karachi Port with M&S department to ensure information flow in the analyzed supply chain network.

– Step 3. Arrivals of products to Karachi Port and customs clearance. All shipping documents, including the list of consolidated products, are received from the supplier one week before the arrival of products to Karachi Port. After detailed screening of all documents, S&D department sends these documents to customs clearance service provider. The products are imported from different countries. However, 60% of them are delivered form Singapore and Thailand. They are transported to the Karachi Port by sea. Once the products arrive to Karachi Port, customs clearance service provider starts clearance process immediately.

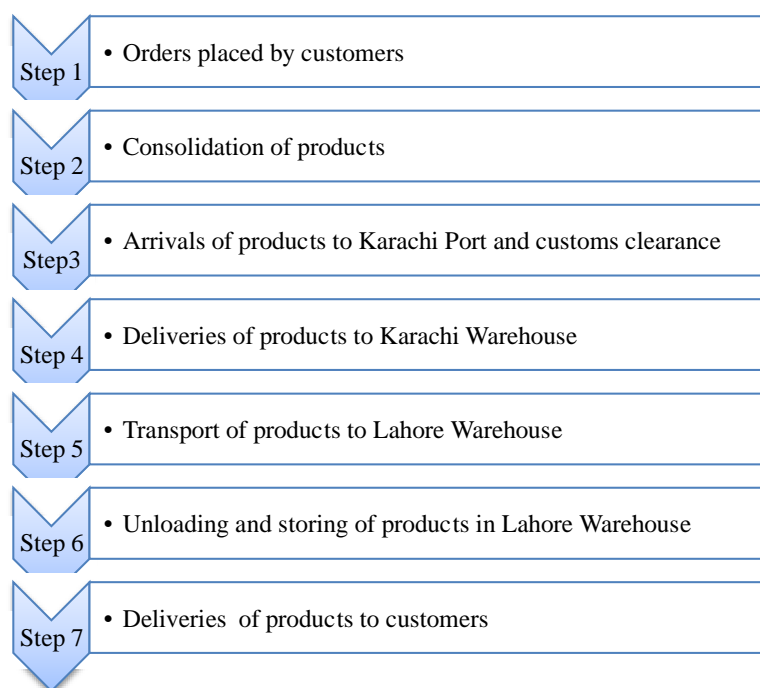| Step 1 | • Orders placed by customers |
Step 2	• Consolidation of products
Step3	• Arrivals of products to Karachi Port and customs clearance
Step 4	• Deliveries of products to Karachi Warehouse
Step 5	• Transport of products to Lahore Warehouse
Step 6	• Unloading and storing of products in Lahore Warehouse
Step 7	• Deliveries of products to customers

Fig. 2. Current supply chain process
Rys. 2. Stan obecny procesu dostaw

− Step 4. Deliveries of products to Karachi Warehouse. After customs clearance process, the products are transported to Karachi Warehouse for temporary storage. All mandatory procedures such as inventory unloading and stock updating in SAP system take place.

− Step 5. Transport of products to Lahore Warehouse. Once the warehouse supervisor in Karachi Warehouse receives information from M&S department to transfer products to Lahore Warehouse, the internal transfer in SAP system is made. At the same time, FCL is transported to Lahore Warehouse by truck.

− Step 6. Unloading and storing of products in Lahore Warehouse. The products delivered to Lahore Warehouse are unloaded and stored. M&S department informs customers located in northern Pakistan about the availability of products in Lahore Warehouse.

− Step 7. Deliveries of products to customers. Based on the demand, the deliveries from Lahore Warehouse to customers are organized. The products are picked and delivered to customers.

Identification of Disadvantages in SCN

Based on the analysis of current supply chain process, there can be observed the unnecessary delays between step 4 and 7 (see figure 2), i.e. after customs clearance until the products are delivered to customers. The way of importing lubricants to the northern part of Pakistan starts in Karachi Port, because it is the only one port in the country. Moreover, there is XYZ Lubricants strategic decision and policy to deliver only FCL from Karachi Warehouse to Lahore Warehouse, which in some cases takes time to raise the load.

After overall analysis one can state that some operations are doubled, such as unloading, storing and loading of the same products in Karachi Warehouse and Lahore Warehouse. They cause the delays, they are labor consumers and they generate additional costs.

One of the measurable criteria evaluating the analyzed supply chain is cost of loading, unloading, storing and transporting of goods. Current inbound and outbound cargo costs are presented in table 2.

Table 2. Costs of inbound and outbound cargo
Tabela 2. Koszty ładunków przychodzących i wychodzących

Cargo unit	Inbound costs		Outbound costs	
	Monetary units		Monetary units	
	PKR	USD	PKR	USD
Carton/ pallet	80.00	0.76	80.00	0.76
Drum/ pallet	85.00	0.81	85.00	0.81

The above presented charges are for destuffing of the incoming cargo and include the utilization costs of labor and equipment, necessary for removal of cargo from the container or vehicle and transporting it to the gate of the warehouse. In addition, the cost involves preparation of the documents of incoming cargo, operations with the cargo from the warehouse gate to the storage area, striping and segregating the cargo (in case of mixed pallet), quality assurance (QA) activities, labeling the cargo and stacking it into respective pallet positions. Moreover, the inbound and outbound cargo cost also includes the following operations:
− preparation of goods in documentation for all the consignment received and prepared for delivery,
− updating the volume in the system to maintain the inventory level,
− communication expenses connected with the coordination and liaison within XYZ Lubricants,

− utilization of human and technical resources (e.g. printers, photocopiers, fax) to do all the above-mentioned activities.

Transportation cost from Karachi Port to Karachi Warehouse is given below (table 3).

Total logistics cost, which includes loading/unloading operations and transportation from Karachi Port to Lahore Warehouse is summarized in the following table 4.

Information presented in table 4 shows that the highest are total transportation costs from Karachi Port to final customers. Their value is 3.288 PKR/ liter, which is 0.030 USD/ liter. The total costs of operations in Karachi and Lahore Warehouses equal 1.219 PKR/ liter, which is 0.012 USD/ liter. It means that transportation costs are more than 2.5 times higher than warehouse operation costs. Thus, it is important to redesign the analyzed supply chain network, concentrating on the deliveries of products.

Table 3. Transportation costs between points of origin and points of destination
Tabela 3. Koszty transportu pomiędzy punktami nadania i punktami odbioru

Point of origin	Point of destination	Transportation cost / FCL	
		Monetary units	
		PKR	USD
Karachi Port	Karachi Warehouse	5400.00	51.22
Karachi Warehouse	Lahore Warehouse	43000.00	407.87

Table 4. Logistics cost of the current supply chain
Tabela 4. Koszty logistyczne w obecnym łańcuchu dostaw

Activity	PKR/load unit		USD/load unit		PKR/ liter	USD/ liter
	FCL	PALLET	FCL	PALLET		
1. Transportation from Karachi Port to Karachi Warehouse	5 400	-	51.19	-	0.324	0.003
2. Unloading at Karachi Warehouse	-	85	-	0.81	0.102	0.001
3. Loading at Karachi Warehouse	-	85	-	0.81	0.102	0.001
4. Transportation from Karachi Warehouse to Lahore Warehouse	43 000	-	40.76	-	2.580	0.024
5. Unloading at Lahore Warehouse	-	85	-	0.81	0.102	0.001
6. Loading at Lahore Warehouse	-	85	-	0.81	0.102	0.001
7. Transportation from Lahore Warehouse to Customers in northern Pakistan	6 400	-	60.67	-	0.384	0.003
8. Average inventory holding cost	-	675	-	6.40	0.811	0.008
				Total Cost	4.507	4.50

Supply Chain Network Improvement

Based on the above-mentioned supply chain analysis the directions of changes have been presented. S&D department of XYZ Lubricants is aware of this situation and the improvements of the current state of the company and innovations are required, as well. After several meetings of the stakeholders such as M&S department, Information Technology department, customs clearance service provider, transportation company, customers in northern Pakistan, they agreed for changes within the transportation. One of the solution is a transformation of fast moving products to Full Container Load (FCL). Thus, the improved supply chain can be presented as follows (figure 3).
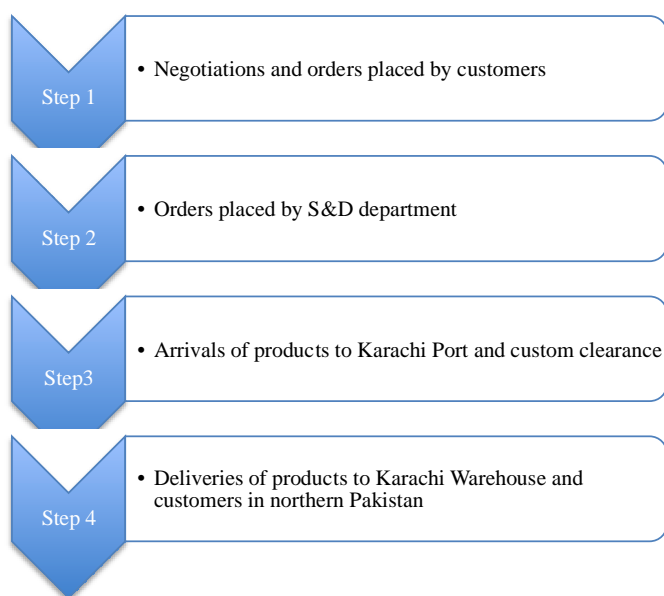
Fig. 3. Innovative supply chain
Rys. 3. Innowacyjny łańcuch dostaw

This innovation is composed of 4 steps, which are as follows:

− Step 1. Negotiations and orders placed by customers. In order to reduce unnecessary costs of loading and unloading operations, S&D department analysis historical data of demand. Then it informs M&S department about selected groups of products that have a potential to be ordered as FCL by particular customers. Once M&S department has information about potential products, which can be ordered by customers in northern Pakistan, the negotiations with these customers start. At the end, there are expected orders placed by the customers.

− Step 2. Orders placed by S&D department. After receiving FCL order, S&D department places order with supplier in Singapore or Thailand. S&D department also communicates ETA in Karachi Port with M&S department to ensure information flow.
Moreover, S&D department gives instructions to an export coordinator about the specification of packing list. This helps customs clearance service provider to identify the container's load. This operation is important because the customer will not accept the container if seal is broken and if there is no possibility to identify the container's load. Therefore, in proposed innovative logistics solution, it is mandatory to include container's number on packing list. Next, S&D department receives the original documents from supplier.

− Step 3. Arrivals of products to Karachi Port and customs clearance. The products are delivered to Karachi Port from suppliers located in Singapore and Thailand, S&D department instructs customs clearance service provider about the allocation of selected containers to be transported to Karachi Warehouse. The other products are left for a few hours in Karachi Port and when they are going to be delivered directly to customers in northern Pakistan. After customs clearance, the packing list and the other shipping documents are sent to S&D department for internal documentation.
Warehouse supervisor enters products virtually in SAP system and generates delivery challan and invoice per each container. Unique container number in packing list helps warehouse supervisor to identify the load for specific customer in northern Pakistan. Once the product is entered in SAP system and delivery challan

is generated, the documents such as invoice, delivery challan and packing list are transferred to clearing agent for onward transportation to customer in northern Pakistan.

− Step 4. Deliveries of products to Karachi Warehouse and customers in northern Pakistan. Once the documents are

generated, the specific containers identified by the S&D department, are transported directly from Karachi Port to customers (see figure 4). The other products are transported from Karachi Port to Karachi Warehouse. Then, they are delivered to customers in Sindh and Balochistan provinces.
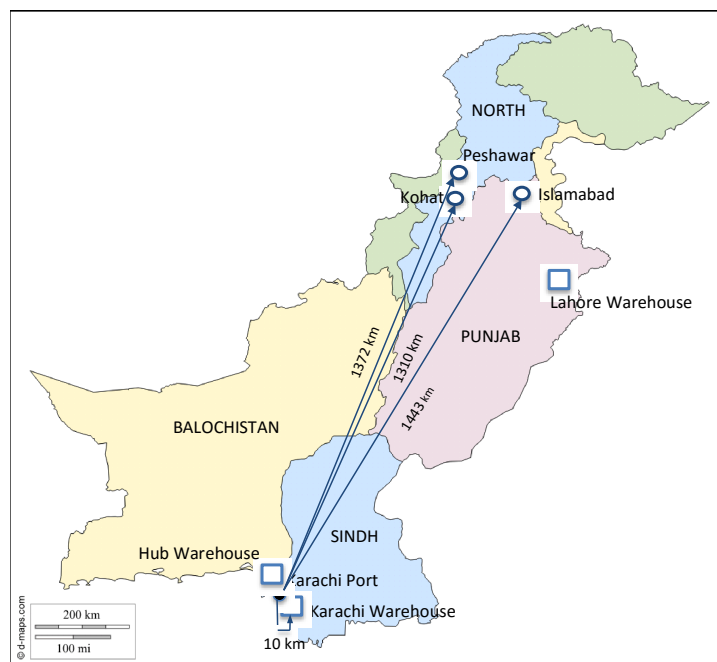

Fig. 4. Map of Pakistan with an exemplary supply chain of XYZ Lubricants - proposed changes
Rys. 4. Mapa Pakistanu z przykładowym łańcuchem dostaw firmy XYZ Lubricants - proponowane zmiany

Table 5. Logistics cost of innovative supply chain
Tabela 5. Koszty logistyczne w innowacyjnym łańcuchu dostaw

	Activity	PKR/ FCL	USD/ FCL	PKR/ liter	USD/ liter
1.	Special Handling Charges in Karachi Port	2 000	18.96	0.120	0.001
2.	Additional Cost incurred in Karachi Warehouse	2 800	26.54	0.168	0.001
3.	Transportation from Karachi Port to customer in northern Pakistan	48 000	455.02	2.880	0.027
	Total Cost			**3.168**	**0.029**

In this procedure, there is no temporary storage, unnecessary loading and unloading operations. Thus, total cost which includes loading/unloading and transportation from Karachi Port to customers in northern Pakistan is summarized in the following table.

The data presented in table 5 shows that the proposed innovation can benefit in logistics

cost savings. The reduction of total transportation cost from Karachi Port to final customers in northern Pakistan equals almost 12.5 %, i.e. the transportation costs in current supply chain equal 3.288 PKR per liter (0.031 USD per liter), while in the innovative solution they are 2.880 PKR per liter (0.027 USD per liter). Moreover, for the analyzed group of customers XYZ Lubricants can reduce the

number of loading and unloading operations in warehouses from 4 to 0, which means savings of 0.408 PKR per liter (0.004 USD per liter).

Concluding, total logistics savings in analyzed supply chain equal 30%, i.e. they are reduced from 4.50 PKR per liter (0.043 USD per liter) to 3.16 PKR per liter (0.030 USD per liter). The proposed innovation has been successfully implemented. The company negotiates with other customers in northern Pakistan convincing them for this new solution.

CONCLUSIONS AND FUTURE DIRECTIONS

This paper presents the methodology to redesign supply chain network. This approach combines different components of supply chain management and is concentrated on relationships between chains, including communication and coordination aspects. The final result of the redesign process should add the value of time and place utility.

This innovative idea of changes is presented on a real-world supply chain. There is described the current state of the XYZ Lubricant company and its analysis. Based on the analysis of the company's supply chain network, the most important disadvantages, which are delays in deliveries, has been recognized. The main reason of this situation are unnecessary loading and unloading operations in Karachi Port and Karachi Warehouse. They generate additional loading and unloading costs and transportation costs, as well. It is worth to mention, that they have an influence on further operations, including loading and unloading of materials in Lahore Warehouse and customers' service, as well. Thus, to improve the supply chain performance changes in deliveries of products to customers have been proposed. This complex solution of the problem combines organizational and technical changes within ordering operations, transportation and storage process. It also takes into account stakeholders' opinions and preferences.

Based on the authors' experience, innovation process requires a lot of time for successful implementation. Sometimes this process is much more difficult than the product innovation. This situation happened in XYZ Lubricants. It took a long time to negotiate and convince all the departments in the company and all cooperating institutions that the innovative idea is the step of company's evolution. Finally, the proposed changes were successfully implemented and now the organization's savings are approximately 263700 PKR per month, which is 2500 USD per month.

Further studies should be based on more complex evaluation of the current supply chain. The set of criteria should be constructed satisfying all stakeholders' points of view, which are usually contradictory, such as: logistics costs, time of deliveries, environmental issues. The company should also find more customers in northern Pakistan and other parts of the country, interested in FCL deliveries. This solution should reduce the logistics costs, including transportation costs, loading and unloading operations' costs and inventory costs in Karachi and Lahore Warehouses. It should also improve the level of customers' satisfaction.

ACKNOWLEDGEMENT

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REORGANIZACJA ŁAŃCUCHA DOSTAW W PRZEDSIĘBIORSTWIE BRANŻY OLEJOWEJ: PODEJŚCIE INNOWACYJNE

STRESZCZENIE. **Wstęp:** Celem niniejszego artykułu jest reorganizacja łańcucha dostaw firmy funkcjonującej w branży olejowej, poprzez wdrożenie innowacyjnego rozwiązania skoncentrowanego na dostawach produktów i poprzez minimalizację całkowitego załadunku, wyładunku towarów i kosztów transportu.

Metody: W niniejszym artykule jest przedstawione podejście do reorganizacji łańcucha dostaw (ŁD). Składa się ono z 3 faz, tj. analizy stanu aktualnego ŁD, identyfikacji słabych stron ŁD oraz poprawy funkcjonowania ŁD. Przedstawiona wielofazowa procedura jest zweryfikowana na przykładzie rzeczywistego łańcucha dostaw, który jest poddany analizie, ocenie i reorganizacji. Na podstawie przeprowadzonej analizy, są definiowane jego najważniejsze mocne i słabe strony. Głównymi kryteriami oceny są koszty załadunku, wyładunku i transportu. Rekomendowana jest reorganizacja przedsiębiorstwa, zbierane są opinie osób zainteresowanych funkcjonowaniem łańcucha i zaimplementowane jest innowacyjne rozwiązanie.

Wyniki: Po udanym wdrożeniu innowacyjnego rozwiązania, uzyskany rezultat pokazuje oszczędności w kosztach załadunku, wyładunku i transportu oraz poprawę poziomu świadczonych usług. Ograniczenia badawcze: Proponowana metodyka może być zastosowana w innych łańcuchach dostaw. Jednak przedstawiony sposób ograniczenia kosztów załadunku, wyładunku i transportu nie może być uznany, jako ogólna zasada dla wszystkich przedsiębiorstw. Ponadto badania nie uwzględniają sytuacji ewentualnych niedoborów magazynowych.

Wnioski: Przedstawione wyniki badań koncentrują się na innowacyjnym podejściu do sieci logistycznej w wybranej firmie, a uzyskane wyniki dowodzą, że przedsiębiorstwo świadczące innowacyjne produkty, może stać się innowacyjne w sferze usług.

Słowa kluczowe: Innowacja, logistyka, transport, łańcuch dostaw, branża olejowa

NEUGESTALTUNG DER LIEFERKETTE IM UNTERNEHMEN DER ERDÖLBRANCHE: EIN INNOVATIVER ANSATZ

ZUSAMMENFASSUNG. Einleitung: Das Ziel dieser Arbeit ist es, das Lieferkettennetzwerk eines Erdölprodukte und Schmierstoffe umsetzenden Unternehmens durch die Einführung von innovativen Lösungen, die sich auf die Lieferungen von Produkten und auf die Minimierung von Gesamt-Be- und Entladungen sowie der betreffenden Transportkosten konzentrieren, neu zu gestalten.

Methoden: In der vorliegenden Arbeit wird der Ansatz der Autoren zur Neugestaltung des Supply-Chain-Netzwerkes (SCN) dargestellt. Er besteht aus drei Phasen, d.h. aus der Analyse eines aktuellen Status des SCN, aus der Identifizierung von Nachteilen im SCN und einer SCN-Verbesserung. Dieses schrittweise Verfahren beruht auf der Verifizierung einer realen Lieferkette, die zu analysieren, zu bewerten und neu zu gestalten ist. Basierend auf der Analyse werden die wichtigsten Stärken und Schwächen identifiziert. Die wichtigsten Bewertungskriterien sind Be-, Entladungs- und Transportkosten. Die Neugestaltung des Unternehmens wird vorgeschlagen, es werden ferner Meinungen der an der richtigen Funktionsausübung der Lieferkette Interessierten gesammelt und dementsprechend die innovativen Lösungen eingeführt.

Ergebnisse: Nach der erfolgreichen Implementierung der innovativen Lösung stellte man weitgehende Einsparungen innerhalb der Be-, Entladungs- und Transportkosten und die Verbesserung des Service-Levels fest. Die forschungsmäßige Einschränkung: die vorgeschlagene Methode kann innerhalb von anderen Liefernetzwerken implementiert werden, allerdings kann die Art und Weise für die Minimierung der Be-, Entladungs- und Transportkosten jedoch nicht als ein für alle Unternehmen geltendes Prinzip angesehen werden. Darüber hinaus werden in dieser Erforschung die Out-of-Stock-Situationen auch nicht berücksichtigt.

Fazit: Diese Studie stellt ein innovatives Denken im Logistiknetzwerk eines Unternehmens dar, und die erzielten Ergebnisse beweisen, dass die Unternehmen, die innovative Produkte anbieten, zu innovativen Dienstleitungsanbietern werden können.

Codewörter: Innovation, Logistik, Transport, Lieferkette, Schmierstoffe, Erdölprodukte

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FUZZY ECONOMIC PRODUCTION QUANTITY MODEL WITH TIME DEPENDENT DEMAND RATE

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ABSTRACT. **Background:** In this paper, an economic production quantity model is considered under a fuzzy environment. Both the demand cost and holding cost are considered using fuzzy pentagonal numbers. The Signed Distance Method is used to defuzzify the total cost function.

Methods: The results obtained by these methods are compared with the help of a numerical example. Sensitivity analysis is also carried out to explore the effect of changes in the values of some of the system parameters.

Results and conclusions: The fuzzy EPQ model with time dependent demand rate was presented together with the possible implementation. The behavior of changes in parameters was analyzed. The possible extension of the implementation of this method was presented.

Key words: Inventory, Pentagonal Fuzzy Number, Signed Distance Method.

INTRODUCTION

In real-life situations, exact data are often inadequate for a mathematical model. Inventory is a physical stock that a business keeps on hand in order to promote the smooth and efficient running of its affairs. But in practice, the effects of deterioration, shortages, holding cost, ordering cost etc. are important for inventory. Various types of uncertainties are involved in any inventory system. Historically, probability theory has been the primary test for representing uncertainty in mathematical models. Because of this, all the uncertainty was assumed to follow the characteristics of random uncertainty. A random process was one where the outcome of any particular realization of the process is strictly a matter of chance, and prediction of a sequence of events is not possible. Fuzzy set theory is an excellent tool for modeling the kind of uncertainty associated with vagueness, imprecision and the lack of information regarding a particular problem at hand.

Initially, L.A. Zadeh [1963] introduced the concept of fuzzy sets. In this area a lot of research papers have been published by several researchers viz. S. K. Goyal [1985], Z.T. Balkhi [1998], K.J. Chung[2000], T. Chang [2003], Huang [2007], G.C. Mahata and A. Goswami [2010], S. K. Indrajitsingha et. al. [2015].

In this paper, we develop the EPQ model with a time-dependent demand rate using a pentagonal fuzzy number. The average total inventory costs in the fuzzy sense are derived. The parameters are fuzzified by pentagonal fuzzy number. The fuzzy model is defuzzified by using the Signed Distance Method.

DEFINITIONS AND PRELIMINARIES

In order to treat a fuzzy inventory model by using the graded mean representation method to defuzzify, we need the following definitions.

Definition 2.1 (Fuzzy Set) Let X be a space of points with a generic element x of X. Let $\mu: X \longrightarrow [0,1]$ be such that for every $x \in X$, $\mu(x)$ is a real number in the interval $[0,1]$, usually called ' grade of membership'. We define a fuzzy set $\tilde{A}$ in X as the set of points $\tilde{A} = \{(x, \mu_{\tilde{A}}(x)) : x \in X\}$.

Definition 2.2 (Convex Fuzzy Set) A fuzzy set $\tilde{A} = \{(x, \mu_{\tilde{A}}(x))\} \subseteq X$ is called convex fuzzy set if all $\tilde{A}_x$ are convex sets for every $x \in X$. That is, for every pair of elements $x_1, x_2 \in A_\alpha$ and $\alpha \in [0,1]$, $\lambda x_1 + (1 - \lambda) x_2 \in A_\alpha$, $\forall \lambda \in [0,1]$. Otherwise the fuzzy set is called a non-convex fuzzy set.

Definition 2.3 A fuzzy set $[a_\alpha, b_\alpha]$ where $0 \le \alpha \le 1$ and $a < b$ defined on R, is called a fuzzy interval if its membership function is

$$\mu_{[a_\alpha, b_\alpha]} = \begin{cases} \alpha, & a \le x \le b \\ 0, & Otherwise \end{cases}$$

Definition 2.4 A fuzzy number $\tilde{A} = (a, b, c, d, e)$ where $a < b < c < d < e$ defined on R, is called pentagonal fuzzy number if its membership function is

$$\mu_{\tilde{A}} = \begin{cases} L_1(x) = \dfrac{x-a}{b-a}, a \le x \le b \\ L_2(x) = \dfrac{x-b}{c-b}, b \le x \le c \\ 1, \qquad\qquad x = c \\ R_1(x) = \dfrac{d-x}{d-c}, c \le x \le d \\ R_2(x) = \dfrac{e-x}{e-d}, d \le x \le e \\ 0, \qquad\qquad Otherwise \end{cases}$$

Then $\alpha - cut$ of $\tilde{A} = (a, b, c, d, e)$, $0 \le \alpha \le 1$ is $A(\alpha) = [A_L(\alpha), A_R(\alpha)]$.

Where $A_{L_1}(\alpha) = a + (b - a)\alpha = L_1^{-1}(\alpha)$
$A_{L_2}(\alpha) = b + (c - b)\alpha = L_2^{-1}(\alpha)$
$A_{R_1}(\alpha) = d - (d - c)\alpha = R_1^{-1}(\alpha)$

$$A_{R_2}(\alpha) = e - (e - d)\alpha = R_2^{-1}(\alpha)$$
$$L^{-1}(\alpha) = \frac{L_1^{-1}(\alpha) + L_2^{-1}(\alpha)}{2}$$
$$= \frac{a + b + (c - a)\alpha}{2}$$
$$R^{-1}(\alpha) = \frac{R_1^{-1}(\alpha) + R_2^{-1}(\alpha)}{2}$$
$$= \frac{d + e - (e - c)\alpha}{2}$$

Definition 2.5 If $\tilde{A} = (a, b, c, d, e)$ is a pentagonal fuzzy number then signed distance method of $\tilde{A}$ is defined as

$$d(\tilde{A}, \tilde{0}) = \int_0^1 d([A_L(\alpha), A_R(\alpha)], \tilde{0})$$
$$= \frac{1}{8}(a + 2b + 2c + 2d + e)$$

ASSUMPTIONS

The following assumptions are made throughout the manuscripts:
1. Items are produced and added to the inventory.
2. The lead time is zero.
3. Two rates of production are considered.
4. No shortage is allowed.
5. The production rate is proportional to the demand rate.
6. The production rate is always greater than the demand rate.

NOTATIONS

$d(t) = a + bt$, $a > 0$, $0 < b < 1$.
$I(t) =$ inventory level at any time $'t'$.
P = production rate in units per unit time.
d = demand rate in units per unit time.
I_0 = on hand inventory level during $[0, T_1]$.
Q = production quantity.
p = production cost per unit.
C_1 = holding cost per unit time.
C_2 = setup cost per setup.
h_c = holding cost per unit time.
T_c = total cost.
T = cycle time.
T_1 = production time.
P_c = production cost.

SC = setup cost.
$\tilde{d}$ = fuzzy demand.
$\tilde{C}_1$= fuzzy holding cost per unit time.
$\tilde{T}_c$ = total fuzzy inventory cost per unit time.
$\tilde{Q}_s$ = production quantity in the Signed Distance Method.
$\tilde{T}_{cs}$ = defuzzifying value of $\tilde{T}_c$ by applying Signed Distance method.

MATHEMATICAL FORMULATION

In this model it is assumed that the production starts with a rate P , at $t = 0$ and is stopped at $t = T_1 > 0$. It is also assumed that from the starting itself the demand is met. As P is assumed as $P = \tau d$, $\tau > 1$, during the interval $[0, T_1]$, the inventory accumulates at a rate $P - d$. During the interval $[T_1, T_2]$, there is no production and only the inventory is consumed as per the demand till it becomes zero at $t = T_2$. Thus the rate of change of inventory is governed by the differential equations.

CRISP MODEL

$$(5.1)\frac{dI(t)}{dt} = P - d \ ; \ 0 \le t \le T_1$$
and
$$(5.2)\frac{dI(t)}{dt} = -d \ ; \qquad T_1 \le t \le T_2$$

where
$d \equiv d(t) = a + bt, a > 0, 0 < b < 1,$
$P = \tau d \ and \ \tau > 1.$

Solution of (5.1) and (5.2) with the condition $I(0) = 0, I(T_1) = I_0, I(T) = 0,$ and $T = T_1 + T_2$ is given by
$$(5.3) \quad I(t) = (\tau - 1)\left(a + \frac{bt}{2}\right)t \ , 0 \le t \le T_1$$
and from (5.2)

$$\frac{dI(t)}{dt} = -(a + bt)$$
$$\int dI(t) = - \int (a + bt)dt$$
$$I(t) = -\left(a + \frac{bt}{2}\right)t + K,$$
where K is a constant of integration.

With condition $I (T) = 0$, we get
$$K = aT + \frac{bT^2}{2}$$
Hence we have
$$(5.4) \quad I(t) = a(T - t) + \frac{b}{2}(T^2 - t^2)$$
At $t = T_1$ (5.3) and (5.4) are same i.e.,

$$(5.5) I_0 = (\tau - 1)\left(a + \frac{bT_1}{2}\right)T_1$$
$$= aT_2 + \frac{b \, T_2}{2}T_2 + 2T_1$$

At $t = 0,$ the order quantity
$$(5.6) \quad Q = aT + \frac{bT^2}{2}$$
$$(5.7) \quad T = \frac{\sqrt{a^2 + 2bQ} - a}{b}$$

The total cost is calculated by considering the setup cost, production cost and inventory holding cost:

1. Setup cost $SC = \frac{C_2}{T} = \frac{bC_2}{\sqrt{a^2 + 2bQ} - a}$

2. Production cost $P_c = \frac{PpT_1}{T} = \frac{P}{2}(a + \sqrt{a^2 + 2bQ})$

3. Inventory holding cost
$$h_c = \frac{C_1}{2T}[(\tau - 1)\left(a + \frac{bT_1}{3}\right)T_1^{\,2}$$
$$+a(T_2^{\,2} - T_1^{\,2}) + \frac{b}{3}(T_2 - T_1)(2T_1^{\,2} + 2T_2^{\,2} + 5T_1 T_2)]$$

The total cost is
$$(5.8) \qquad TC = SC + P_c + h_c$$
$$= \frac{b(C_2 + AC_1)}{\sqrt{a^2 + 2bQ} - a} + \frac{P}{2}(a + \sqrt{a^2 + 2bQ})$$
where
$A = \frac{1}{2}[(\tau - 1)\left(a + \frac{bT_1}{3}\right)T_1^{\,2} + a(T_2^{\,2} - T_1^{\,2}) + \frac{b}{3}(T_2 - T_1)(2T_1^{\,2} + 2T_2^{\,2} + 5T_1 T_2)]$

FUZZY MODEL

Due to uncertainty in the environment, it is not easy to define all the parameter precisely, thus we assume some of these parameters $\tilde{a}$, $\tilde{b}$ and $\tilde{C}_1$ may change within some limits.

Let $\tilde{a} = (a_1, a_2, a_3, a_4, a_5)$, $\tilde{b} = (b_1, b_2, b_3, b_4, b_5)$, $\tilde{C}_1 = (h_1, h_2, h_3, h_4, h_5)$ are pentagonal fuzzy numbers.

The total cost of the system per unit time in the fuzzy environment is given by

$$(5.9)\tilde{T}_c = \frac{\tilde{b}C_2}{\sqrt{\tilde{a}^2 + 2\tilde{b}Q} - \tilde{a}}$$
$$+ \frac{\tilde{C}_1}{\sqrt{\tilde{a}^2 + 2\tilde{b}Q} - \tilde{a}}\left[(\tau - 1)\left(\tilde{a} + \frac{\tilde{b}T_1}{3}\right)T_1^2 + \tilde{a}(T_2^2 - T_1^2)\right.$$
$$\left.+ \frac{\tilde{b}}{3}(T_2 - T_1)(2T_1^2 + 2T_2^2 + 5T_1T_2)\right] + \frac{P}{2}\left(\tilde{a} + \sqrt{\tilde{a}^2 + 2\tilde{b}Q}\right)$$

We defuzzify the fuzzy total cost $\tilde{T}_c$ by the Signed Distance Method.
By the Signed Distance Method, the total cost is given by

$$\tilde{T}_{cs} = \frac{1}{8}[\tilde{T}_{cs1} + 2\tilde{T}_{cs2} + 2\tilde{T}_{cs3} + 2\tilde{T}_{cs4} + \tilde{T}_{cs5}]$$

Where

$$\tilde{T}_{cs1} = \frac{b_1 C_2}{\sqrt{a_1^2 + 2b_1Q} - a_1} + \frac{h_1}{2\sqrt{a_1^2 + 2b_1q} - a_1}[(\tau - 1)\left(a_1 + \frac{b_1 T_1}{3}\right)T_1^2 + a_1(T_2^2 - T_1^2)$$
$$+ \frac{b_1}{3}(T_2 - T_1)(2T_1^2 + 2T_2^2 + 5T_1T_2)]$$

$$\tilde{T}_{cs2} = \frac{b_2 C_2}{\sqrt{a_2^2 + 2b_2Q} - a_2} + \frac{h_2}{2\sqrt{a_2^2 + 2b_2Q} - a_2}[(\tau - 1)\left(a_2 + \frac{b_2 T_1}{3}\right)T_1^2 + a_2(T_2^2 - T_1^2)$$
$$+ \frac{b_2}{3}(T_2 - T_1)(2T_1^2 + 2T_2^2 + 5T_1T_2)]$$

$$\tilde{T}_{cs3} = \frac{b_3 C_2}{\sqrt{a_3^2 + 2b_3Q} - a_3} + \frac{h_3}{2\sqrt{a_3^2 + 2b_3Q} - a_3}[(\tau - 1)\left(a_3 + \frac{b_3 T_1}{3}\right)T_1^2 + a_3(T_2^2 - T_1^2)$$
$$+ \frac{b_3}{3}(T_2 - T_1)(2T_1^2 + 2T_2^2 + 5T_1T_2)]$$

$$\tilde{T}_{cs4} = \frac{b_4 C_2}{\sqrt{a_4^2 + 2b_4Q} - a_4} + \frac{h_4}{2\sqrt{a_4^2 + 2b_4Q} - a_4}[(\tau - 1)\left(a_4 + \frac{b_4 T_1}{3}\right)T_1^2 + a_4(T_2^2 - T_1^2)$$
$$+ \frac{b_4}{3}(T_2 - T_1)(2T_1^2 + 2T_2^2 + 5T_1T_2)]$$

$$\tilde{T}_{cs5} = \frac{b_5 C_2}{\sqrt{a_5^2 + 2b_5Q} - a_5} + \frac{h_5}{2\sqrt{a_5^2 + 2b_5Q} - a_5}[(\tau - 1)\left(a_5 + \frac{b_5 T_1}{3}\right)T_1^2 + a_5(T_2^2 - T_1^2)$$
$$+ \frac{b_5}{3}(T_2 - T_1)(2T_1^2 + 2T_2^2 + 5T_1T_2)]$$

NUMERICAL EXAMPLE

Consider the inventory system with the following parametric values:

CRISP MODEL

$a = 1000$ unit/year, $\tau = 1.3$, $b = 0.2$ unit/year, $C_2 = 20, C_1 = 2$ per unit/year, $P = 20$ units, $T_1 = 0.3$ year, $T_2 = 0.36$ year.

The solution of the crisp model is
$T_c = Rs.\,20033, \quad Q = 660.04$.

FUZZY MODEL

$\tilde{a} = (600,800,1000,1200,1400)$,
$\tilde{b} = (0.16,0.18,0.20,0.22,0.24)$,
$\tilde{C}_1 = (1,1.5,2,2.5,3)$
The solution of the fuzzy model can be determined by the Signed Distance Method.

Total cost is $\tilde{T}_{cs} = Rs. 20033.63,$ and $\tilde{Q}_s = 660.04$.

SENSITIVITY ANALYSIS

A sensitivity analysis is performed to study the effects of changes in parameters P and C_2.

Table 1. Results of the sensitivity analysis
Tabela 1. Wyniki analizy wrażliwości

P	$\tilde{T}_{cs}$	C_2	$\tilde{T}_{cs}$
21	21033.62	21	20035.25
22	22033.87	22	20036.62
23	23034.12	23	20038.25
24	24034.25	24	20039.62
25	25034.25	25	20041.50
26	26034.25	26	20042.62
27	27034.25	27	20044.50
28	28034.50	28	20045.87
29	29034.50	29	20047.50
30	30034.50	30	20048.87

From the above observation we have concluded as follows:
- As the value of C_2 increases, the fuzzy total cost $\tilde{T}_{cs}$ increases.
- As the value of P increases, the fuzzy total cost $\tilde{T}_{cs}$ increases.

In the cases of both production cost and setup cost, the fuzzy total cost increases more in event of an increase in production cost as compared to an increase in the setup cost.

CONCLUSION

This paper presents a fuzzy EPQ model with a time-dependent demand rate. The demand and setup cost is represented by pentagonal fuzzy numbers. To evaluate the total fuzzy cost the Signed Distance Method was used. A sensitivity analysis was also conducted to determine the behavior of changes in parameters. For instance, we may extend this model to use a graded mean representation method and centroid method etc.

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MODEL ROZMYTEJ EKONOMICZNEJ WIELKOŚCI PRODUKCJI FUNKCJI POPYTU ZALEŻNĄ OD ZMIENNEJ CZASU

STRESZCZENIE. **Wstęp:** W pracy przedstawiono model ekonomicznej wielkości produkcji w rozmytym otoczeniu. Zarówno koszy popytu jak i koszt utrzymania zapasu zostały ujęte, jako rozmyte liczby pentagonalne. Metoda Signed Distance została użyta w celu uszczegółowienia funkcji kosztu całkowitego.

Metody: Wyniki otrzymane w obu metodach zostały ze sobą porównane w przykładzie liczbowym. Przeprowadzono analizę wrażliwości w celu określenia wpływu niektórych parametrów na zmiany otrzymywanych wartości.

Wyniki i wnioski: Zaprezentowano model ekonomicznej wielkości produkcji funkcji popytu zależnej od zmiennej czasu wraz z możliwym jej zastosowaniem. Przeanalizowano zależności zmian wielkości parametrów. Zaproponowano możliwe rozszerzenie zastosowania tej metody.

Słowa kluczowe: zapas, rozmyta liczba pentagonalna, metoda Signed Distance.

EIN MODELL FÜR DIE WIRTSCHAFTLICHE FUZZY-PRODUKTIONSGRÖßE IN BEZUG AUF DIE VON DER ZEITVARIABLE ABHÄNGIGEN NACHFRAGEFUNKTION

ZUSAMMENFASSUNG. Einleitung: Im vorliegenden Beitrag wurde ein Modell für die wirtschaftliche Produktionsgröße im Fuzzy-Umfeld dargestellt. Sowohl die Nachfragekosten, als auch die Kosten der Vorratshaltung wurden als Fuzzy-Pentagonalzahlen angeführt. Die Signed Distance-Methode wurde zwecks einer Detaillierung der auf die Gesamtkosten bezogene Funktion angewendet.

Methoden: Die bei der Anwendung der beiden Methoden erzielten Ergebnisse wurden in einem Zahlenbeispiel miteinander verglichen. Es wurde eine Sensitivitätsanalyse zwecks der Ermittlung des Einflusses mancher Parameter auf die Veränderung der erzielten Werte durchgeführt.

Ergebnisse und Fazit: Es wurde ein Modell für die wirtschaftliche Produktionsgröße in Bezug auf die von der Variable der Zeit abhängigen Nachfragefunktion samt deren möglichen Anwendung dargestellt. Es wurden Abhängigkeiten innerhalb von Veränderungen der betreffenden Parameterwerte analysiert sowie eine mögliche Verbreitung der Anwendung dieser Methode vorgeschlagen.

Codewörter: Vorrat, Fuzzy-Pentagonalzahl, Signed Distance-Methode

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FUZZY LOGIC-DECISION-MAKING SYSTEM DEDICATED TO EVALUATION OF LOGISTICS PROJECT EFFECTIVENESS

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ABSTRACT. **Background:** Project effectiveness is synonymous with project success. It is measured or assessed in terms of the degree to which project objectives are achieved. This paper presents an approach to evaluating the effectiveness of logistics projects. The starting point is the analysis of the current state of knowledge in the area of assessing project effectiveness, including logistics projects. The purpose of the study was to identify the critical factors determining the success of logistics projects and develop a model of logistics project effectiveness.
Methods: The paper is based on the available recent scientific-theoretical research and publications and on practical studies in 25 enterprises seated in Poland. The study carried out by the authors had the form of questionnaires. The authors used a case study to validate the model of fuzzy decision-making system dedicated to estimate the level of logistics project effectiveness.
Results: Based on a literature review and research findings, the authors propose the key success factors for logistics project effectiveness. In the paper the authors propose an approach to measure the level of logistics project effectiveness using their model based on fuzzy logic. This model laid the foundations for a fuzzy decision-making system in MATLAB environmental. The paper describes the implementation of the model via a case study.
Conclusions: This approach allows for a more detailed description of logistics project effectiveness. The proposed model may be implemented by logisticians in an enterprise and/or supply chain. The approach can be useful to assess the level to which logistics project objectives are achieved - logistics project effectiveness.

Key words: project, logistics project, performance, effectiveness, efficiency, project success, fuzzy decision-making system, fuzzy logic, MATLAB software system.

INTRODUCTION

In today's highly competitive market for goods and services, the ability of project management and especially of logistics project management to plan, schedule, execute and monitor progress within strict cost, time, and performance guidelines is becoming increasingly important in order to obtain competitive priorities, such as on-time delivery and customization [Chen 2007]. More demanding customers, short product life cycles, globalization, rapid technological changes, and the need to deliver highly quality products at the right time may in fact demand break-through thinking to develop highly effective, efficient, and differentiated sets of logistics activities [Fugate, Stank 2010], including unique sets of logistics activities named logistics projects.

A logistics project can be defined as a planned set of interrelated tasks to be executed over a fixed period, limited by budget and time, which is carried out in order to improve the efficiency and effectiveness of product flows and of the associated information in companies, supply chains or spatial systems [Kisperska-Moroń, Krzyżaniak 2009]. According to another definition, a logistics project is a set of tasks characterized

by a timeframe, costs and organization, the aim of which is to perform a singular and unique action that sets out to optimize a specific logistics process [Kasperek, Szołtysek 2008]. A logistics project is a non-routine set of task apart from other projects by time and cost, the purpose of which is to perform a singular and unique action that effects change to the logistics system of one enterprise or a supply chain within which this enterprise operates [Pisz 2011a, Pisz 2011b, Pisz 2013].

The market for goods and services is characterized by uncertainty and complexity [Anari, Rezei 2013]. These facts affect the performance of logistics projects, creating a greater risk to logistics project management [Pisz, Łapuńka 2015]. Planning and implementing projects, including logistics projects, always involves a certain level of uncertainty. This is due to the fact that these projects are often innovative and unique and it is difficult to predict the direction of implementation in uncertain situations. This uncertainty is the result of not having full access to information regarding a project type, and can be defined as the probability that the objective will not reach its planned target value [Jaffari, 200]. The internal and external conditions of project management are full of uncertainty, which stems from changing customer requirements, resource utilization, personnel mobility, economic turbulence, etc. Under such conditions, enterprises and supply chains have to manage several different logistics projects. A multi-project context is common in contemporary enterprises and supply chains. Enterprises and supply chains increasingly use multiple logistics projects in their daily work to achieve their goals. However, most logistics projects are either over budget, late or are simply not good enough and still different people claim that those projects have been successful. In that context, the effectiveness of logistics project has to be taken into account. Project effectiveness is measured or assessed in terms of the degree to which project objectives are achieved [Baccarini 1999; Belout 1998].

This paper presents an approach to evaluating the effectiveness of logistics projects. The starting point is an analysis of the current state of knowledge in the area. The

authors proposed criteria for assessing the effectiveness of logistics projects based on the literature and studies in the selected 25 enterprises. Logistics project effectiveness was assessed using fuzzy logic and the authors have developed a model of fuzzy decision-making. This model laid the foundations on which to build a fuzzy decision-making system in a MATLAB environment. In this paper, implementation of the model was presented via a case study.

LITERATURE REVIEW

The knowledge of a logistics project can vary in each phase of a logistics project life cycle. In the first phase of the life cycle, knowledge is incomplete, which means that logistics projects are characterized by a high level of uncertainty during the initial stage of implementation. The knowledge of a logistics project in this phase of its life cycle is rather limited, although it grows during implementation of the project. At the end of the logistics project life cycle, knowledge is full (Fig. 1).
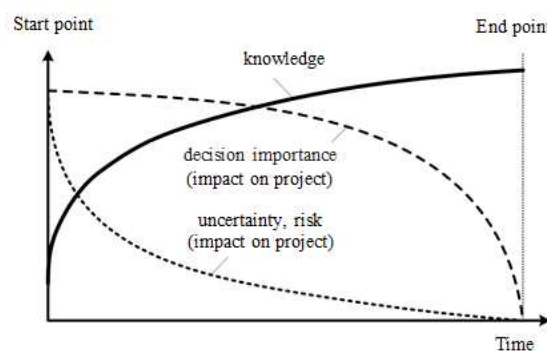
Fig. 1. Decision importance and knowledge in the logistics project life cycle
Rys. 1. Istotność decyzji i wiedzy w cyklu życia projektu logistycznego

Logistics project management consists of the following areas: time management, cost management, scope management, integration management, quality management, human resources management, communications management, risk management, procurement management. All of these areas (knowledge management of project) include procedures, methods and tools that are needed to

management these projects efficiently. The success of a single enterprise and a supply chain results from the skillful use of processes, principles, rules of conduct and resources in response to opportunities and risks that arise, including non-standard processes like logistics projects.

Recently, there has been a significant change in how business is conducted, which has been particularly visible in the SME sector. Enterprises in this sector are sensitive to changes in the market for goods and services. In addition, they are prone to turbulences that arise due to economic crises. Therefore, the transformation of business conduct and the differentiation between routine tasks and tasks that are unique (projects) in a production system become necessary. Both the process approach and the project approach are important for any given enterprise that wants to maintain its market position [Artto, and Kujala, 2008]. From the perspective of logistics management, logistics project management is crucial, as its results have an impact on the effectiveness of the transformation and flow of goods and services, including their attendant information flows, from the sources of materials to the end users. Logistics project management refers to integration of all activities, both internal and external to the single enterprise and to many enterprises in supply chain.

From the research perspective, logistics project management deserves special attention. In practice, this involves carrying out unique orders - logistics projects, which require an individualized approach and a substantial amount of preparation time. Enterprises and supply chains carrying out orders of this kind are particularly vulnerable to the loss of competitiveness, since logistics project management entails the application of substantial knowledge, experience, tools, methods and techniques to planning in order to satisfy or surpass the needs and expectations of clients. This, in turn, necessitates compromises between a number of parameters, such as time, costs, clients' needs, stakeholder's requirements and expectations, and logistics project goals.

The problem of delays and cost overruns in the field of logistics projects are a common phenomenon worldwide. The process of transforming a logistics project initiative into material results is executed in a manner that can be described as chaotic: transformation diverges fundamentally from baseline plans made on commencing a project, no project management methodologies are implemented and more often than not it resembles ad hoc activities rather than a systematic set of methods which would constitute a conceptually coherent approach to project management.

It has been observed that near half of all undertaken logistics project are over cost, near 70 percent of all logistics projects are over schedule. This is confirmed by the results of studies on the state of knowledge about practices employed by Polish managers in the management of logistics projects, titled 'Logistics projects - experiences of Polish enterprises'. These studies were carried out by Logisys Ltd. as part of the Panel of Polish Logistics Managers [PPML 2011] cycle. The aim of the study, in which 142 logistics managers participated, was to answer the following questions: 'How do Polish managers manage logistics projects?' and 'What obstacles to achieving the goals set out in logistics projects do they face?' The report indicates that the enterprises surveyed carried out at least one logistics project (over 70% of enterprises in Poland), apart from their basic business activity. In the period in question (i.e. in the last three years), a significant number of enterprises (40%) carried out at least four projects. The logistics projects undertaken by entrepreneurs involved rearranging warehouse space, changing processes, expanding warehouses, introducing or changing a logistics operator. Other examples of logistics projects included 'integration of processes with other company departments in Europe', 'unification of a material index', or 'carrying out external audit and an attempt to reorganize company departments'. The report exposed weak points in the practices of logistics project management in the enterprises under study, of which those pertaining to the costing of logistics projects were deemed vital. In over 2/3 of the enterprises studied the calculations performed during the costing of a logistics project were not thorough enough, one of the consequences being budget overruns

(only 42% of the projects did not exceed the planned budget). Exceeding the expected deadline of a logistics project, more often than not by 20% compared with the original schedule, was common practice. Only 1/3 of all logistics projects were completed on time [PPML 2011].

Project management's ability in the area of logistics to schedule activities and monitor progress within strict cost, time, scope, quality and performance guidelines is becoming increasingly important to obtain competitive priorities such as on-time delivery of the right product in the correct quantity to the right consumer in good condition at an acceptable cost. Today's managers of logistics projects are working in a fast-moving, ever-changing environment. Their competencies are one of the key critical factors of a logistics project's success. Effective logistics project managers are needed for the successful completion of

logistics projects [Kisperska-Moroń, Krzyżaniak 2009].

Effective management of logistics projects is crucial for the development and survival of any enterprise, especially of any supply chain. Enterprises in a supply chain which plan a new logistics project are forced to look for scientific tools that assist them in evaluating their logistics projects. The logistics project management team is responsible for producing the logistics project output. Together with their team, the logistics project manager must be constantly aware of the project goal, logistics project purpose and efficiency of the logistics project management. Effective logistics project management is the key for successful accomplishment of sophisticated projects in a single enterprise, and in several enterprises (Figure 2).
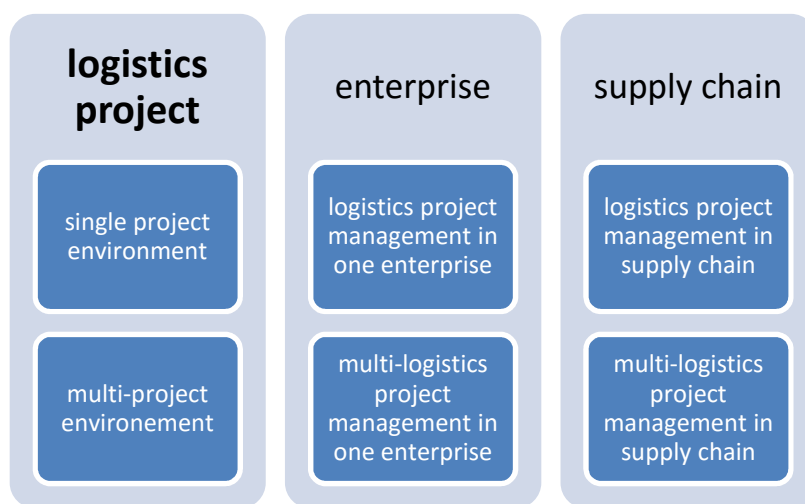
Fig. 2. Framework of logistics project management
Rys. 2. Podejście do zarządzania projektami logistycznymi

Enterprises in a business network are a part of supply chain, which is a chain of interconnected links that facilitates the movement of supplies. The chain can be short with only few links and handoffs, or it can be lengthy, extensive, and complex, with dozens of links and handoffs [Arway 2013]. This depends on the structure of the product being moved along the chain and also the requirements and limitations of the chain. Since the product design dictates multiple requirements for the supply chain, once a product design is completed, it drives the

structure of the supply chain, limiting the flexibility of engineers to generate and evaluate different (and potentially more cost-effective) supply chain alternatives [Gokhan, Neddy 2010]. In practice, this means that management of such unique processes can be characterized by different levels of effectiveness and efficiency. Logistics project management can help to obtain a higher level of effectiveness in such processes.

A low level of logistics project effectiveness must be addressed and, to the

extent possible, resolved. A high level of logistics project effectiveness can be achieved through more effective logistics project management and education of logistics project managers.

Many researchers and practitioners consider performance, effectiveness, and success as synonyms [Belout 1998], which means that effectiveness is a synonym of success. It can be treated as the degree to which objectives are achieved [Belout, 1998; Baccarini 1999]. Success is corresponding to the effectiveness and the efficiency of the project and Brudney and England claim that efficiency is broadly understood as the maximization of output for a given level of input or resources. Effectiveness is aimed at achieving goals or objectives [Belout 1998]. Usually, success and effectiveness were related to three principal criteria: time, cost, quality. Various aspects of success were assessed: project efficiency (measured by the project management triangle), the project's impact on the client (measured by client satisfaction level), organization success (measured by the actual impact of project outcomes on the organization), as well as future-proofing (measuring how well project outcomes were aligned with the strategic goals of a company) [Mir, Pinnington 2014]. Nevertheless, to date success has in principle been measured by business results. Today, we can note an evolution of project success concepts.

So far, social or ecological values have not been deemed to constitute a fundamental aspect of project success [Floricel et. al. 2014]. This changes diametrically with the introduction of the so-called triple bottom line (TBL), an approach that balances economy, environment and society, embodying the idea of sustainable development. The aim of TBL is to support business solutions which are simultaneously socially responsible, environmentally friendly and economically valuable. The environmental and social outcomes are treated on an equal footing with the financial outcomes. The three together make up shared value. In this respect, the concept of creating shared value (CSV), proposed in 2011 by M. Porter and M. Kramer in Harvard Business Review [Porter, Kramer 2011], is of great significance.

AN APPROACH TO MEASURING THE LEVEL OF LOGISTICS PROJECT EFFECTIVENESS

The concept of logistics project effectiveness is a controversial concept and can be treated as a synonym of logistics project success. Evaluation of logistics project effectiveness should produce information on outcomes and should shed light on the influence of the project, enterprise performance and/or supply chain effectiveness. It should be a multi-determined measure [Mustapha, Naoum,1998].

The present authors tried to study logistics project success factors and to measure logistics project success using a practical example. They identified the key success factors - criteria that influence the effectiveness of logistics projects. These success factors were prepared based on a literature review and questionnaires. The study carried out by the authors took the form of questionnaires. It was carried out between July 2014 and October 2014 in production, production and service, service enterprises, transportation-freight forwarding-logistics business enterprises seated in Poland. Over 80 questionnaires were distributed to enterprises and valid responses were received from 25 enterprises. The overall response rate for the study was approximately 31 per cent. Table 1 presents basic information concerning the enterprises included in the study. The respondent enterprises are divided into micro, small, medium and large enterprises, and production, service, production and service, transportation-freight forwarding-logistics industries.

Twenty-five responses were received where all the questions were answered. Data were obtained from logistics project managers using questionnaires comprising multiple-choice questions and one open question. The first part of the questionnaire included questions classifying enterprises in terms of employment rate and enterprise type. The central part of the study focused on issues concerning measurement of logistics project success factors. The master list of success factors of logistics project is shown in Table 1. The respondents were asked to identify the success

factors that are relevant to their enterprises. This list contains the success factors of logistics projects to be considered for logistics project effectiveness. In addition, they were asked to add any other success factors of a logistics project that they believed are relevant but not listed in the questionnaire.

Table 1. Basic information concerning the enterprises included in the study of logistics project success factors
Tabela 1. Podstawowe informacje dotyczące przedsiębiorstw biorących udział w badaniu krytycznych czynników sukcesu projektów logistycznych

Type of enterprise	Production n	Service n	Production and service n	Transportation-freight forwarding-logistics n	Total n
Micro-sized enterprise	0	1	1	1	3
Small-sized enterprise	2	2	2	2	8
Medium-sized enterprise	2	2	2	3	9
Large-sized enterprices	2	1	1	1	5
	6	6	6	7	25

Table 2. The proposed questionnaire on success factors of logistics projects
Tabela 2. Kwestionariusz ankiety dotyczący czynników sukcesu projektów logistycznych

Logistics project success factor	Relevant	
meeting logistics project schedule	yes	no
staying within budget	yes	no
meeting quality standards	yes	no
delay in payment	yes	no
penalties	yes	no
customer satisfaction	yes	no
end-user satisfaction	yes	no
logistics project team satisfaction	yes	no
logistics project manager satisfaction	yes	no
supplier satisfaction	yes	no
meeting technical performance	yes	no
meeting operational performance	yes	no
labor productivity	yes	no
quality of materials	yes	no
late delivery of materials	yes	no
delivery on time	yes	no
materials damage	yes	no
delay in inspection and testing	yes	no
communication and coordination	yes	no
errors and delays	yes	no
solving logistic problems	yes	no
created new market	yes	no
reducing logistics cost	yes	no
reducing supply chain logistics cost	yes	no
increased market share	yes	no
created new product line	yes	no
development new supply chain	yes	no
development new technology	yes	no

Statistical analysis suggested that the effectiveness of a logistics project is mostly associated with the project schedule and cost budget as an objective measurement of the a project's effectiveness. The study findings show that all logistics project managers covered by the study indicated these success criteria. Meeting logistics project schedule and staying within budget are the key criteria of a logistics project. The analysis shows that the

effectiveness of a logistics project is also related to many other criteria such as: reducing logistics cost (88% of respondents), meeting quality standards (95% of respondents), stakeholders' satisfaction (83% of respondents), especially end-user satisfaction (89% of respondents), logistics project manager satisfaction (78% of respondents), logistics project team satisfaction (73% of respondents), and supplier satisfaction (58% of respondents). Meeting operational performance and technical performance is relevant to 76% and 72% of logistics project managers, respectively. These results showed that creating new market (82% of respondents), increasing market share (88% of respondents) and creating new product lines (75% of respondents) are very important for logistics project managers. The logistics project covered by the study indicated that solving logistic problems is relevant for logistics project implementation. Ninety-five logistics project managers identified this factor of logistics project effectiveness. Developing a new supply chain and new technology are key project success factors for 84% and 78% of respondents, respectively. Some of the logistics project managers covered by the study indicated that the number of penalties (78% of respondents), delivery on time (79% of respondents), materials damage (68% of respondents), labor productivity (67% of respondents), delay in payment (65% of respondents), errors and delay (73% of respondents), delay in inspection and testing (62% of respondents) is relevant for logistics project effectiveness. Communication and coordination is a key success factor for nineteen of the logistics project managers.

The success factors of a logistics project may constitute basic indicators for the analysis and assessment of effects resulting from the logistics projects.

EVALUATION OF LOGISTICS PROJECT EFFECTIVENESS

It is necessary to use the appropriate tool to assess the effectiveness of logistics projects.

One tool of this type is a performance measurement system (PMS), which in the literature has been defined as a set of measures used to quantify efficiency and effectiveness. A properly designed and functioning system for measuring and evaluating the effectiveness of logistics projects should indicate what is important in achieving the objectives of the logistics project. Measuring the effectiveness of logistics projects should be based on financial and non-financial indicators.

The approach to evaluating logistics project effectiveness proposed here is based on using Balance Scorecard and fuzzy logic. This proposes using a dedicated system that can measure and evaluate the effectiveness of logistics projects implementation. The system uses this type of fuzzy logic, which enables the modeling of certain and uncertain data. The objective is to combine the criteria into a single measure that can indicate the effectiveness of the logistics project. These criteria can be divided in a few groups. The authors claim that the Balanced Scorecard approach can be used in solving the problem. The idea of the Balanced Scorecard can be adopted to measure the effectiveness of a logistics project. The proposed set of criteria of logistics project effectiveness are listed in Figure 3. All criteria that are considered in the process of evaluating the effectiveness are determined by experts, especially logistics project managers based on the real value and on their knowledge of logistics project data. These data are gathered by logistics project managers and their team and important data are defined using linguistics terms.

The criteria listed in Figure 3 can be used to measure the effectiveness of a logistics project. These criteria may be useful to combine into one measure to get an overall judgment of how well the logistics project was managed and executed. These factors can be clustered into four factors. The effectiveness of logistics project can be measured in terms of financial, stakeholder, process, learning and growth. The authors propose to use the Balanced Scorecard concept.
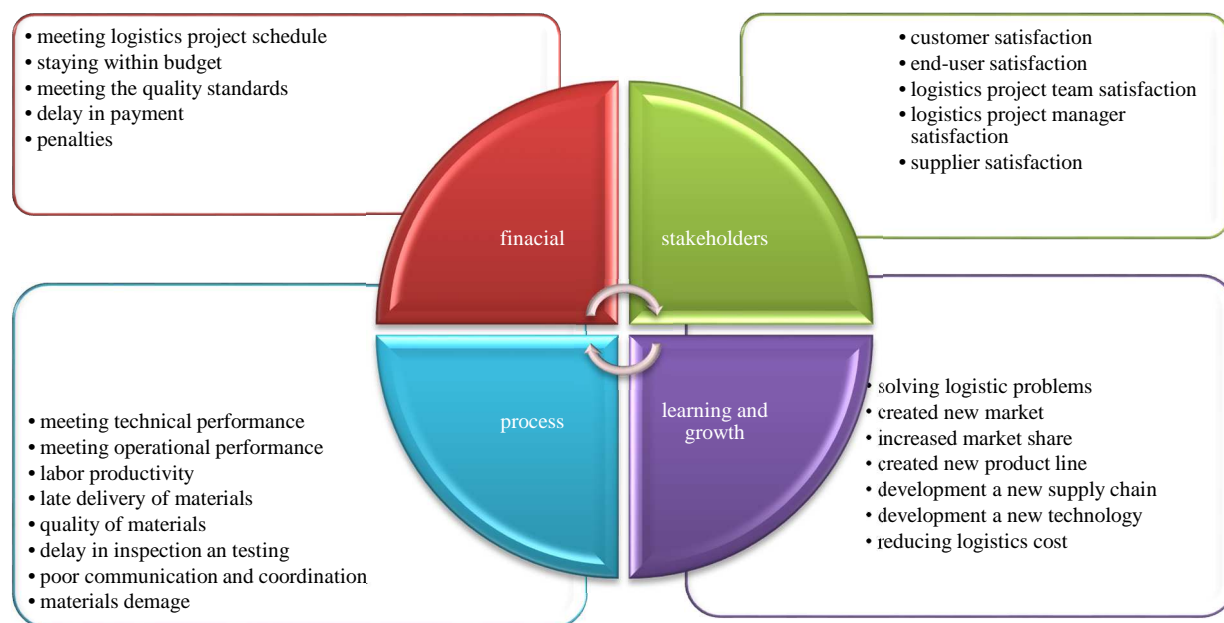
Fig. 3. The key criteria of logistics project effectiveness
Rys. 3. Kryteria pomiaru efektywności projektów logistycznych

The Balanced Scorecard provides a formalized mechanism to achieve a balance between non-financial and financial results across short-term and long-term horizons [Brewer, Speh, 2000]. The Balanced Scorecard distinguishes four main perspectives [Kaplan, Norton, 1992]: customer, internal, financial, innovation and learning. Using the Balanced Scorecard, the effectiveness of a logistics project may be defined as the goal which is achieved in the area of these four perspectives. Logistics project managers need to create their own version of the Balanced Scorecard and concentrate on the most critical measurements of logistics projects [Pisz, 2013; Pisz, Kolasa-Więcek, 2013].

Questions like the following may arise when evaluating logistics project effectiveness: When does a logistics project have low, medium, or high effectiveness? The decision-maker should solve these kinds of problems. This is a vague problem and it can be solved by introducing fuzzy logic. This is a problem-solving technique introduced by Zadeh (1965) and can solve imprecise and vague problems. Using fuzzy logic, fuzzy sets may be defined on vague linguistic terms such as very high effectiveness, low impact, medium delay.

Fuzzy logic copies human decision-making using levels of possibility in a number of uncertain categories.

According to Zadeh's principles, every variable x can be expressed verbally with a value (linguistic term) $L(x)$, which is associated with fuzzy set A. The values of linguistic variables are both qualitatively and quantitatively by a fuzzy set. In fuzzy set theory, the values from the universe of variables are members of fuzzy sets, taking into account the grade of membership expressed as a function $\mu_A(x)$, so that [Rudnik, Pisz, 2014]:

$$\mu_A : x \rightarrow [0, 1]$$ (1)

where:
0 - lack of membership of the value x in fuzzy set A,
1 - full membership of the value x in fuzzy set A,
(0,1) - partial membership of the value x in fuzzy set A.

The representation of fuzzy sets can be done in many ways, for example, triangular, trapezoidal or Gaussian [Santos, Camargo

2010]. The context will determine what is the best among the existing ones. In this paper we use representation by triangular fuzzy sets.

A fuzzy-logic decision-making system is a useful tool that can be used to handle such problem. This kind of system can be implemented using the MATLAB software. Generally, a fuzzy-logic decision-making system consists of four main components: a fuzzifications interface, a knowledge base, decision-making logic, and a defuzzification interface (Figure 4) [Dweiri, Kablan, 2006].
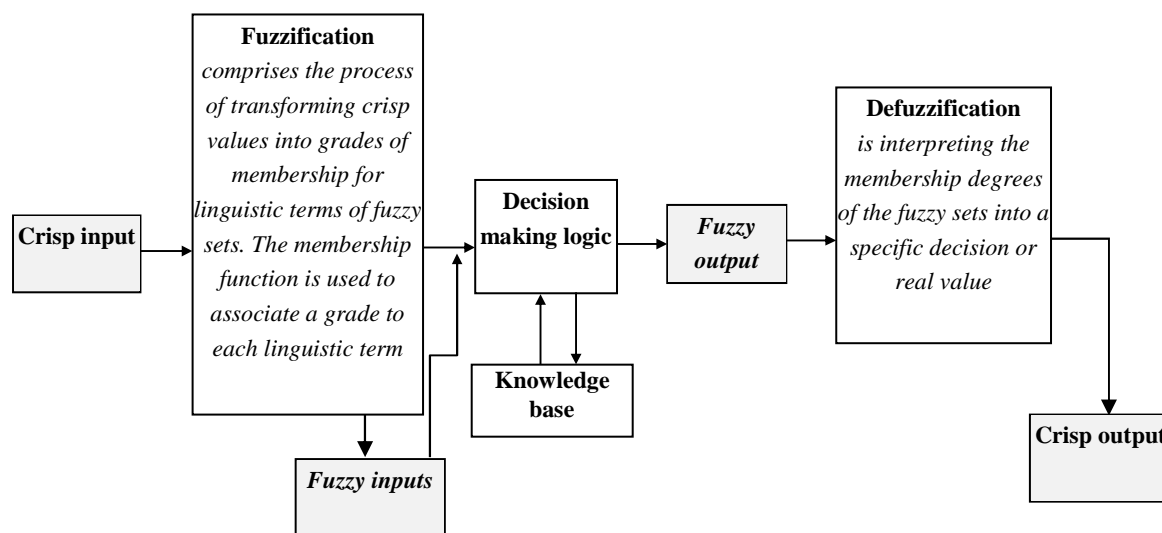

Fig. 4. The idea of fuzzy-logic decision-making system dedicated to measuring the effectiveness of a logistics project
Rys. 4. Idea rozmytego systemu podejmowania decyzji dedykowanego ocenie skuteczności projektu logistycznego

In the next section the proposed fuzzy decision-making system will be illustrated. This approach to measuring logistics project effectiveness will be described via a case study.

CASE STUDY

Let us assume an example of a logistics project P1, which is building a new warehouse. The project was executed by the developer and it was found that the project is 120% over budget and is also 145% behind schedule. There were some problems with suppliers - the deliveries of materials were completed not on time and the quality of materials was low. As a consequence, the enterprise was forced to pay penalties to the contractor. Moreover, the logistics project team had bad relations with the logistics project manager, who lacked professional and technical competences. Monitoring the logistics project was not sufficient either and there were delays in inspection and testing. The result was that the end-user of the project was not satisfied and the owner of the logistics project is disappointed.

The decision-maker wants to obtain the precise information about the effectiveness of the undertaken logistics project. He is interested in building a decision-making system that can evaluate the effectiveness of the project. The decision-maker needs all the necessary input to determine the logistics project effectiveness to obtain the right answer. Based on the expert's experience and data gathered during the execution of logistics project, the authors proposed using fuzzy logic to solve this kind of problem. A fuzzy-logic decision-making system was developed and implemented in the MATLAB environment and the fuzzy logic toolbox of the Matlab program was used to calculate logistics project effectiveness.
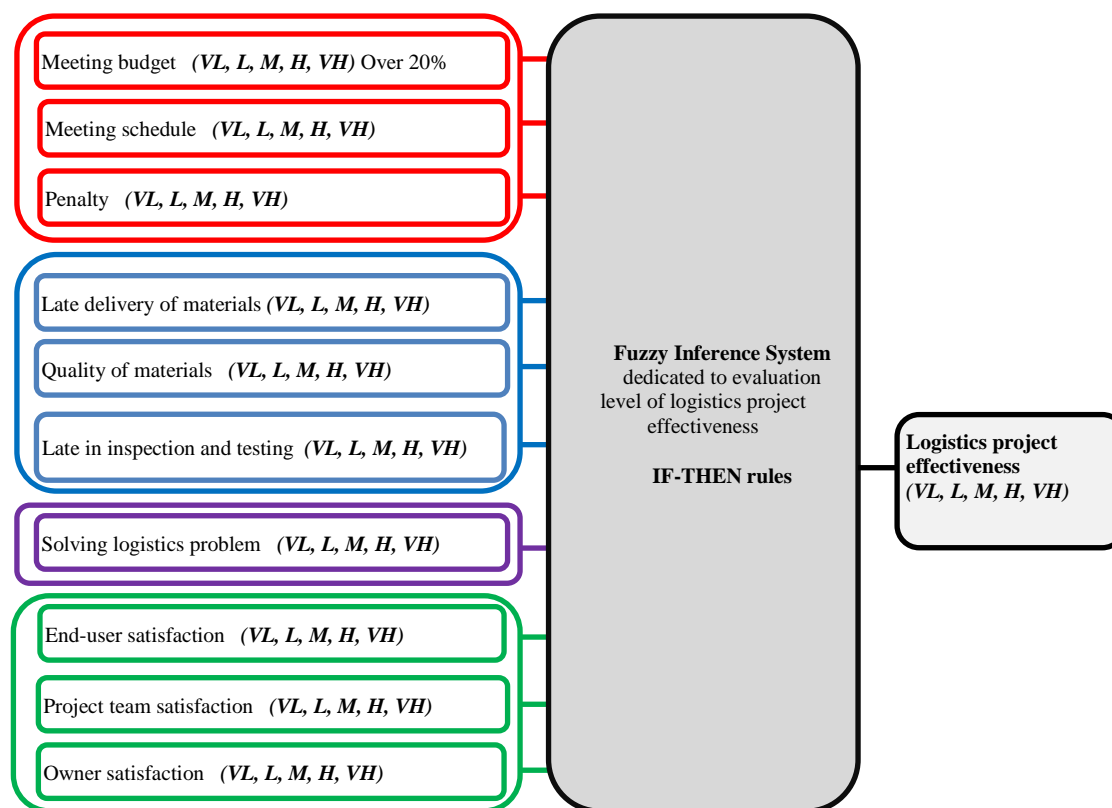
Fig. 5. The Fuzzy Inference System dedicated to evaluate the level of logistics project effectiveness
Rys. 5. Rozmyty system wnioskujący dedykowany ocenie poziomu skuteczności realizacji projektu logistycznego

The idea of a Fuzzy Inference System is presented in Figure 5. The four components of this system can be seen from Fig. 5 and will be explained as follows:

1. The fuzzification interface.

A model was established with 10 inputs and 1 output variable. The inputs and output variables were identified by experts. The input variables and output variable were fuzzified based on experts' subjective judgment, knowledge and experience. These experts used triangular and trapezoidal membership functions to describe input and output values. The experts proposed a 5-level scale for input variables. Represented by triangular and trapezoidal membership functions, these areas are, respectively: very low, low, medium, high, very high. Figure 6 presents an input variable of meeting the budget and meeting costs, respectively. The output parameters are represented on the unit universe [0,1] with triangular and trapezoidal membership functions describing the linguistic variable, i.e. the level of logistics project effectiveness: very low, low, medium, high, very high (Fig. 7).
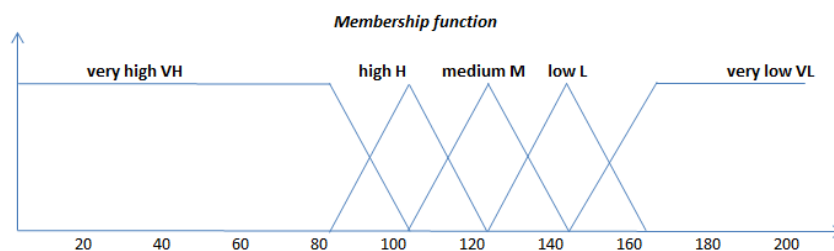

Fig. 6. An example of input variables' membership function
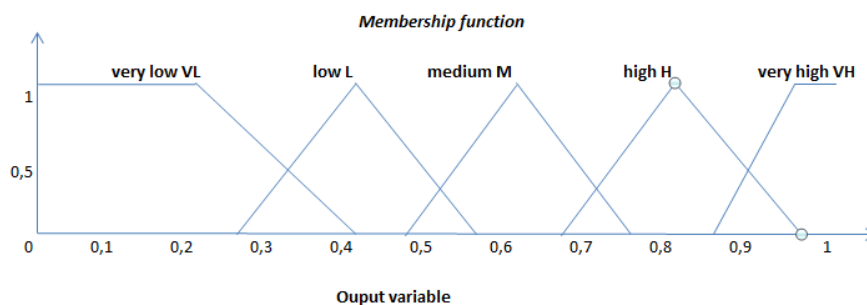Rys. 6. Funkcja przynależności przykładowej zmiennej wejściowej

Fig. 7. Output variable membership function
Rys. 7. Funkcja przynależności zmiennej wyjściowej

2. The knowledge base

The effectiveness of a logistics project is determined from the aggregation of sets of fuzzy rules. The impact of given criteria on the effectiveness of logistics project is evaluated using a set of fuzzy IF-THEN rules. These rules are based on experts' subjective judgment, knowledge and experience. The rules were designed to take into account all possible situations.

Examples of fuzzy rules from the knowledge base are as follows:
IF meeting budget is very low THEN effectiveness is very low
IF meeting budget is low THEN effectiveness is low
IF meeting budget is medium THEN effectiveness is medium
IF meeting budget is high THEN effectiveness is high
IF meeting budget is very high THEN effectiveness is very high
IF meeting schedule is very low THEN effectiveness is very low
IF meeting schedule is low THEN effectiveness is low
IF meeting schedule is medium THEN effectiveness is medium
IF meeting schedule is high THEN effectiveness is high
IF meeting schedule is very high THEN effectiveness is very high
IF meeting end-user satisfaction is very low THEN effectiveness is very low
IF meeting end-user satisfaction is low THEN effectiveness is low

IF meeting end-user satisfaction is medium THEN effectiveness is medium
IF meeting end-user satisfaction is high THEN effectiveness is high
IF meeting end-user satisfaction is very high THEN effectiveness is very high
IF penalty is very low THEN effectiveness is very high
IF penalty is low THEN effectiveness is high
IF penalty is medium THEN effectiveness is medium
IF penalty is high THEN effectiveness is low
IF penalty is very high THEN effectiveness is very low
IF late delivery of materials is very low THEN effectiveness is very high
IF late delivery of materials is low THEN effectiveness is high
IF late delivery of materials is medium THEN effectiveness is medium
IF late delivery of materials is high THEN effectiveness is low
IF late delivery of materials is very high THEN effectiveness is very low
IF quality of materials is very low THEN effectiveness is very low
IF quality of materials is low THEN effectiveness is low
IF quality of materials is medium THEN effectiveness is medium
IF quality of materials is high THEN effectiveness is high
IF quality of materials is very high THEN effectiveness is very high

The experts assumed that all criteria of given groups have the same impact on the level of logistics project effectiveness. In practice,

we can observe that some of the perspectives can have a different impact on effectiveness.

3. The decision-making logic

The evaluation of a fuzzy rule is based on computing the truth value of its antecedent and applying it to its consequent. This results in assigning one fuzzy subset to each output variable true. In Min Inteferencing, where parts of fuzzy rules are labelled with AND logical operation, the fuzzy AND is obtained as the minimum of the membership values of the input variables' membership values. The level of logistics project effectiveness is determined by performing a fuzzy union of the resultant magnitude fuzzy sets [Nasa, Yadav, 2012].

4. The defuzzification interface

The last component is defuzzification. The output variable is defuzzified to get a crisp value. It converts a fuzzy control action into a nonfuzzy control action. The fuzzy result of the output variable - effectiveness of logistics project is composed and defuzzified using one chosen method - the Center of Area COA according to the following formula [Dweiri, Kablan 2006]:

$$y^* = \frac{\sum_{i=1}^{m} y_i \cdot \mu_i}{\sum_{i=1}^{m} \mu_i}$$

where:

m − a number of discrete values of output variable,
y_i − *i-th* value of output variable,
μ_i − value of obtained membership function for i-th value of output variable.
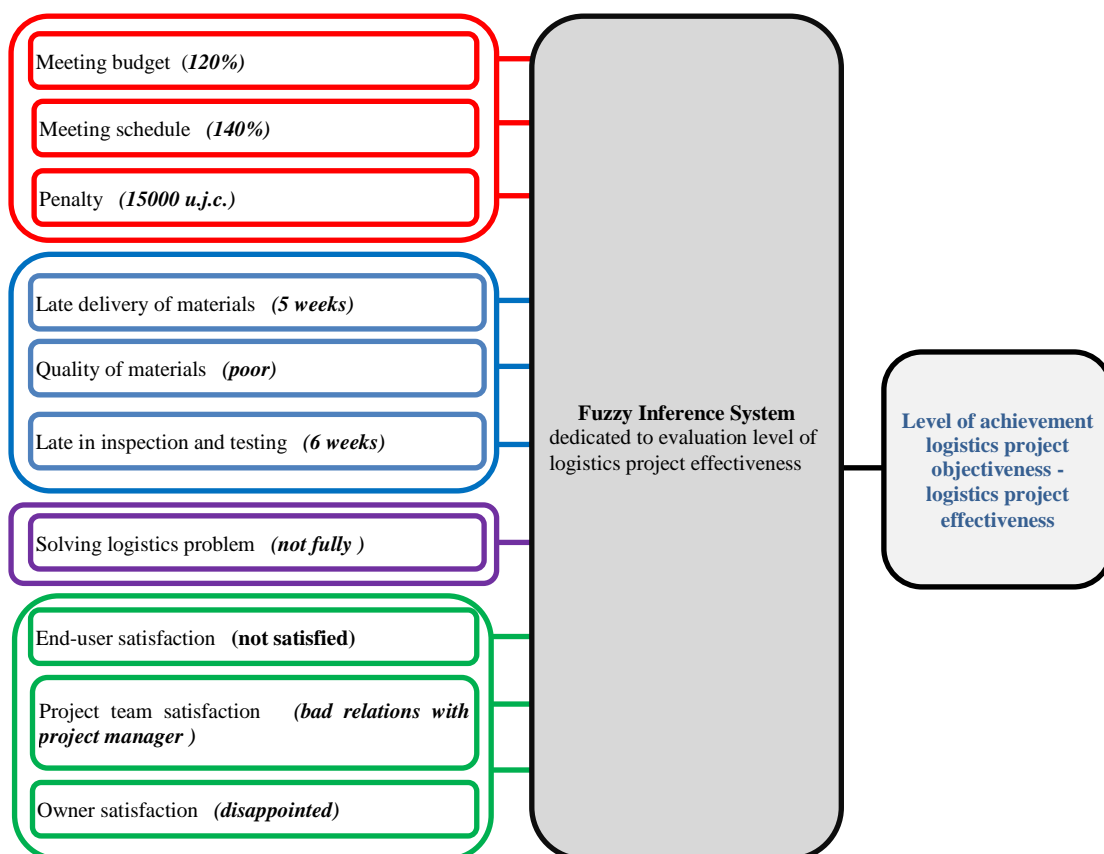

Fig. 8. Input variables of the Fuzzy Inference System
Rys. 8. Definicja zmiennych wejściowych Rozmytego Systemu Wnioskującego

The steps described above are needed to obtain the right information about the effectiveness of the logistics project. The construction of a fuzzy-logic decision-making system is complete and is the result of inferencing and defuzzification. The authors entered information about the logistics project into the developed Fuzzy Inference System designed to evaluate logistics project effectiveness (Fig. 8).

The resulting value of a given logistics project's effectiveness is 0.65. This is a relatively low level of achievement of the logistics project management's internal objectives. The output is a crucial value for logistics project stakeholders and can be treated as an indicator of the level to which logistics project objectives are achieved. The results of effectiveness evaluation indicate the strengths and weaknesses of a given project management. These kinds of information should be used in planning new similar logistics projects, for example, it is a useful value for selecting a logistics project manager, their team, suppliers and materials, etc.

SUMMARY

Effective management of logistics projects is crucial for the development and survival of any enterprise, especially of any supply chain. Enterprises gathered in a supply chain which plan new logistics project are forced to look for a scientific tool that assists them in evaluating their logistics projects. The logistics project management team is responsible for producing the logistics project output. The logistics project managers and their teams must be constantly aware of the project's goal, logistics project purpose and efficiency of the logistics project management. Effective logistics project management is the key for successful accomplishment of sophisticated projects in a single enterprise, and in several enterprises.

The paper presents an approach to the evaluation of the logistics projects effectiveness. This approach allows for a more detailed description of the uncertainty in assessing the effectiveness of logistics projects. Fuzzy logic copies human decision-making

using levels of possibility in a number of uncertain categories. The fuzzy decision-making system proposed here can combine the measurement of different success factors into one measurement to obtain a final value of logistics project effectiveness. Based on the approach in this research, a software tool has been developed. The authors have designed and implemented a model using a fuzzy module in the MATLAB system. The accuracy of this system has been verified using a selected enterprise. This computer application supports the decision-maker in the final evaluation of the logistics project's effectiveness. The knowledge gained through this system is a valuable source of information for logistics project stakeholders. Evaluating logistics project effectiveness serves to provide logistics project managers with information about the level to which a logistics project's objectives are achieved.

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ROZMYTY SYSTEM PODEJMOWANIA DECYZJI DEDYKOWANY OCENIE SKUTECZNOŚCI REALIZACJI PROJEKTÓW LOGISTYCZNYCH

STRESZCZENIE. **Wstęp:** Efektywność projektu jest często utożsamiana z sukcesem projektu. Praca podejmuje zagadnienia związane z pomiarem i oceną skuteczności projektów, w tym przypadku projektów logistycznych. Autorzy dokonali analizy literatury tematu. Wyodrębnili kluczowe mierniki sukcesu projektów logistycznych. Na bazie przeprowadzonych badań zbudowano model skuteczności projektów logistycznych, który następnie zaimplementowano w systemie MATLAB.
Metody: Praca została przygotowana w oparciu o dostępne badania zarówno teoretyczne, jak i praktyczne. Przeprowadzono badania ankietowe w 25 przedsiębiorstwach w Polsce. Wykorzystano studium przypadku celem ilustracji podjętego problemu.
Rezultaty: Przygotowano zestaw mierników umożliwiających dokonanie oceny stopnia skuteczności realizacji celów projektów. Przygotowano model umożliwiający pomiar i ocenę skuteczności działań projektowych, który wykorzystuje logikę rozmytą. Opracowany model został zaimplementowany w systemie MATLAB.
Wnioski: Proponowane podejście umożliwia opis problemu pomiaru i oceny skuteczności realizacji projektów logistycznych. Zaproponowane podejście może zostać wykorzystane przez logistyków, menedżerów projektów w ocenie skuteczności działań podejmowanych przez nich projektów logistycznych..

Słowa kluczowe: projekt, projekt logistyczny, efektywność, skuteczność, sprawność, sukces projektu, rozmyty system podejmowania decyzji, logika rozmyta, komputerowy system MATLAB.

EIN FUZZY-SYSTEM ZUM ENTSCHEIDUNGSTREFFEN BEZOGEN AUF DIE BEWERTUNG VON EFFIZIENZ BEI DER AUSFÜHRUNG VON LOGISTIK-PROJEKTEN

ZUSAMMENFASSUNG. Einführung: Die Projekt-Effizienz wird oft mit dem Erfolg eines Projektes gleichgestellt. Die vorliegende Arbeit spricht die Fragestellungen, die mit der Bemessung und der Bewertung der Projekt-Effizienz, nämlich im besagten Falle der Effizienz bei logistischen Projekten, verbunden sind, an. Die Autoren haben die Gegenstandliteratur einer Analyse unterzogen. Ferner wurden von ihnen die schlüsselhaften Indikatoren und Maßstäbe eines Erfolgs innerhalb von logistischen Projekten ausgewählt. Anhand der durchgeführten Forschungen wurde für die logistischen Projekte ein Effizienz-Modell, das man demzufolge ins MATLAB-System implementierte, aufgestellt.
Methoden: Das Forschungsvorhaben wurde in Anlehnung an die verfügbaren, sowohl die theoretischen als auch die praktischen Erforschungen durchgeführt. Dazu wurden in 25 polnischen Unternehmen entsprechende Umfrage-Untersuchungen vorgenommen. Dabei hat man zwecks der Projizierung des betreffenden Problems eine Fallstudie in Anspruch genommen.
Ergebnisse: Es wurde ein Satz von Indikatoren, die die Bewertung der Effizienz innerhalb der logistischen Projekte ermöglichen, bereitgestellt. Des Weiteren wurde ein die Fuzzy-Logik beanspruchendes Modell für die Bemessung und Bewertung der Effizienz von Projekt-Vorhaben aufgestellt. Das ermittelte Modell wurde ins MATLAB-System implementiert.
Fazit: Die vorgeschlagene Vorgehensweise ermöglicht die Projizierung der Problemstellung der Bemessung und Bewertung der Effizienz bei der Ausführung bestimmter Logistik-Projekte. Die dargestellte Lösung kann von Logistikern als Projekt-Managern bei der Bewertung des Effizienz-Grades bei den von ihnen unternommenen Logistik-Projekten in Anspruch genommen werden.

Codewörter: Projekt, Logistik-Projekt, Effektivität, Effizienz, Fertigkeit, Projekt-Erfolg, Fuzzy-System zum Entscheidungstreffen, Fuzzy-Logik, rechnerunterstütztes MATLAB-System.

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ENTERPRISES' READINESS TO ESTABLISH AND DEVELOP COLLABORATION IN THE AREA OF LOGISTICS

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ABSTRACT. **Background:** Despite the large number of studies on various aspects and forms of supply chain collaboration, the issue is still classified as a relatively poorly recognized research problem in the logistics field. This article is crucial in the discussion on the further directions for the development of cross-organizational collaboration. The main objective of these studies was to assess the readiness of companies to start and develop vertical and horizontal collaboration within logistics.

Methods: The research problem was analysed on the basis of primary and secondary data sources. Primary research was conducted among manufacturing and trade companies as well as logistics service providers. In the statistical description the Mann-Whitney U test and Wilcoxon test were used. It was assumed that the result was statistically significant for $p < 0.05$.

Results: The results show a high readiness of the companies surveyed for further vertical integration and two variables had a statistically significant effect on the assessment of the respondents, i.e. the current level of integration and the role the respondents played in the supply chain. As far as horizontal cooperation is concerned, the readiness of the companies surveyed for further integration was slightly above the average level. Compared to vertical collaboration, the difference between the average rating was statistically highly significant.

Conclusions: The study indicates the need for the companies surveyed to be involved in logistics collaboration. However, it should be emphasized that the respondents prefer collaboration with companies which do not operate at the same level in the supply chain. As far as horizontal collaboration is concerned, the results can be explained by a number of concerns expressed by the respondents regarding the behavior of potential collaborators. Apparently, in this case, an individual approach with a competitive attitude dominates among the respondents.

Key words: logistics collaboration, supply chain collaboration, vertical and horizontal collaboration.

INTRODUCTION

Supply chain collaboration has become the subject of many research papers over recent years [e.g. Scholten et al. 2015, Pomponi et al. 2015, Soosay et al. 2015, Montoya-Torres et al. 2014, Kohli et al. 2010]. Based on the results of these studies, it can be assumed that companies are aware of the need for collaboration and the main triggers leading to this type of activities are current supply chain challenges, e.g.: visibility, cost reduction, growing customer demand and globalisation [Miryala et al. 2015]. Basically, companies decide to collaborate due to their inability to address these challenges alone.

The results of several studies, including research conducted by Soosay and Hyland [2015], based on the analysis of the content of 207 scientific articles on cross-organizational collaboration, show how important and currently relevant this issue is. The authors' analysis revealed that despite major academic efforts in this area, the concept of supply chain collaboration is still not well understood. A similar opinion was also expressed by

Holweg et al. [2005]. Furthermore, it should be emphasized that according to many researchers [Pomponi et al. 2015, Adenso-Díaz et al. 2014, Leitner et al. 2011], horizontal collaboration remains an area very poorly recognizable.

Taking into account the above arguments, this article aims to fill this knowledge gap and provide empirical evidence on the readiness of companies to establish and develop collaboration in logistics. According to the author, the study is one of the first which at the same time provides insight into both horizontal and vertical collaboration from the perspective of two supply chain members.

The article is organized as follows. In the theoretical part based on the research literature, three stages of the supply chain partnership are presented, with special emphasis on collaboration which requires a deeper integration between chain members compared to cooperation and coordination. Then, some of directions in which collaboration takes place are distinguished, also paying attention to collaboration occurring between supply chain links and LSPs. In the empirical part, the article presents the methodology and results of primary research conducted among manufacturing, trade companies and LSPs. The main conclusions, limitations and directions for further research are also presented.

TOWARDS SUPPLY CHAIN COLLABORATION- THEORETICAL APPROACH

Inter-firm relationships can take various forms. Partnership based on the principles of cooperation is considered to be the basic level of supply chain integration. Usually, this type of cooperation is limited to joint implementation of a narrow range of selected functions. In addition, two other forms of supply chain integration are worthy of consideration: coordination and collaboration [Kotzab et al. 2005]. In the first case, the companies that are willing to achieve common goals cooperate involving all necessary business areas, while in the second one it is a matter of even closer cooperation, "closer integration", when the companies treat each

other as "an extension" of their organization [Świerczek 2012]. It should be emphasized that the strength of inter-organizational ties is largely defined by the supply chain members' compatibility towards collaboration. Research by Cruijssen et al. [2007] shows that the choice of partner is of vital importance here and affects the success or failure of collaborative efforts.

There are many definitions of collaboration in the literature of supply chain management. Generally speaking, collaboration is a specific type of long-lasting activity that companies perform together in multiple areas of supply chain management. In particular, a movement towards collaboration requires openness and trust among all partners. [Olorunniwo et al. 2010]. It should be also noted that many scholars consider successful collaboration as a achievement of benefits which can't be reached in a independent way [Niestrój et al. 2015]. A good example of this point of view is the definition proposed by Soosay and Hyland [2015], who understand the concept of collaboration as: "two or more companies working together to create a competitive advantage and higher profits than can be achieved by operating alone". Apart from these motives for collaboration, there are other benefits listed in the literature, i.e.: increased customer satisfaction, shorter lead times, better information visibility and a clearer division of responsibilities among partners [Kohli et al. 2010]. What's more, Kohli et al. [2010] provide empirical evidence that firms which collaborate extensively tend to value the effectiveness of collaboration more highly. Interesting research findings are also cited by Latusek-Jurczak [2011], who indicates that entities generate approximately 25-33% of their current market value thanks to cross-organization collaboration.

Supply chain collaboration may have two directions, i.e. horizontal and vertical. The first refers to collaboration between the units with a similar business profile. In practice, these are companies that are on the same level of the supply chain. This form of relationship is often called coopetition or cooperation between competitors. Wallenburg and Schaffler [2016] emphasize that horizontal collaboration is a common practice among LSPs who form

alliances to meet the growing expectations of supply chain members. Similar conclusions were formulated by Verstrepen et al. [2009], who indicated that through this kind of collaboration LSPs can enjoy many benefits, e.g.: increases the company's productivity on core activities and extending geographical coverage by combining the networks of all LSPs. However, according to Soosay and Hyland [2015], in this case, the scope of horizontal collaboration is largely limited to transportation management.

As far as vertical collaboration is concerned, it is a collaboration established by adjoining businesses. A good example of such collaboration is the dyadic buyer-supplier relation. The literature of logistics also distinguishes lateral collaboration, which is a combination of two of the above-mentioned types [Kersten et al. 2010]. For example, this form of collaboration occurs when a supplier supplies both the customer and the customer's supplier at the same time [New et al. 2004].

An important issue is the collaboration established between the key supply chain links and LSPs. Research shows that the competences of LSPs make them an attractive partner for logistics collaboration [Świtała et al. 2015]. Basically, collaboration with LSPs has a positive effect on the efficiency of logistics performance, which in turn translates into the increased competitiveness of supply chains. Most importantly, as Rydzkowski noted [2011], those inter-firm relations should be based on partnership and mutual trust.

RESEARCH MATERIAL AND METHODS

The research was conducted in 2015 on a sample of 50 business entities. This sample was chosen in a targeted manner. 850 e-mail invitations were sent. Less than 6% of the addressees responded to the invitation. The participants filled out an online questionnaire.

The research questionnaire consisted of several closed questions organized in three topic areas. The first part included two 5-grade ordinal scales and one nominal scale. These scales were used to find out respondents' opinions on the previous conditions of their partnerships in logistics. The second part of the questionnaire included questions designed to assess the degree of readiness of the entities to start building closer collaboration in logistics, and used 5-stage ordinal scales. The last part included questions about the respondents in the form of ratio and nominal scales.

When developing the results, the version 22.0 of SPSS software was used, and for statistical analysis descriptive statistics methods were used, in particular, measures of central tendency and dispersion, as well as two kinds of non-parametric test (the Mann-Whitney U test and Wilcoxon test). The result of $p < 0.05$ was statistically significant.

The respondents were dominated by representatives of the key supply chain links (60%), i.e. manufacturing companies (26%) and trading companies (34%). LSPs, the so-called supporting (specialized) participants, accounted for 40% of the research sample.

The first group was dominated by businesses employing over 250 people. Workers employed in the SME sector accounted for just over 40% of the population. The research was dominated by companies with domestic capital (46%). Foreign capital was declared by 39% of the respondents, and mixed capital by 14%. In terms of the geographical coverage, the segment was dominated by companies operating globally and internationally. On the other hand, activities in the domestic market were indicated by 27% of the research participants. According to the results, all survey entitles outsourced their logistics to external LSPs. The FMCG industry was the main area of these activities.

The group of LSPs was also dominated by large companies. Small and medium-sized companies represented 40% the research sample. The research population was dominated by companies operating internationally (45%). 40% of the respondents were global logistics service providers, and 15% service providers operating on the domestic market. The most numerous group comprised companies with Polish capital

(50%). Foreign capital was declared by 40% of the respondents and mixed capital by 10%. In this case, the highest percentage of entities operated in the FMCG industry (90%).

In both cases, companies participating in the research were represented by senior and mid-level managers responsible for logistics and trade.

RESEARCH RESULTS

The readiness of enterprises to start and develop collaborative relationships (a vertical perspective)

The research findings confirm the readiness of the entities surveyed to become involved in collaboration systems. Specifically, the research participants were asked the following question: "Do you agree with the opinion that while working together with other companies you can accomplish more than by acting alone?". When answering this question, as many as 60% of the respondents chose "I strongly agree" and a total of 92% of the sample confirmed the view of collaboration being superior to a lack of it. The distribution of responses clearly shows a high level of support for organizing and implementing joint activities. It needs to be emphasized that no opposing opinions were recorded in the research and only 8% of the respondents chose

the answer "neither disagree nor agree". This high level of support can be explained to a large extent by the positive experience of the respondents in the area of collaboration (the vast majority of responses indicate the existence of a partnership form between all participants in the supply chain).

Against this background, it is interesting to see the results of research on the readiness of enterprises to integrate more deeply with different participants of the supply chains (Table 1). Interest in strengthening inter-organizational ties dominates in all cases, i.e. in relations with customers, suppliers and subcontractors. Moreover, relatively small standard deviations indicate a small dispersion in these results.

Generally speaking, in each case, the average score on the 5-grade scale oscillated around 4, indicating the respondents' high motivation to establish a partnership with the members of their supply chain, while the most frequently chosen answer confirming a high and very high degree of readiness was the willingness of the respondents to integrate further with cargo recipients (86%). What is important, when compared with the results concerning the development of relationships with suppliers (72%), the difference in the result is statistically significant.

Table 1. Readiness of the respondents to integrate further in the supply chain
Tabela 1. Gotowość respondentów do dalszej integracji w ramach łańcucha dostaw

No	Description	$\bar{x}$	σ	1 Very low	2 Low	3 Average	4 High	5 Very high	Total
				%					
1.	In collaboration with suppliers	3.84	0.91	2.0	6.0	20.0	50.0	22.0	100.0
2.	In collaboration with customers	4.18	0.85	2.0	2.0	10.0	48.0	38.0	100.0
3.	In collaboration with subcontractors	4.00	0.85	0.0	6.0	18.0	46.0	30.0	100.0
Statistical description: 1.1.-1.2. Z=-2.456, p=0.01*; 1.1.-1.3. Z=-1,095 p=0.274; 1.2.-1.3. Z=-1.578 p=0.115.									

This research also shows that the eagerness to integrate further is not varied between subgroups distinguished in terms of the type of business activity, the origin of the capital or geographical coverage. To some extent this is determined by the current level of integration and the role played by the entity in the supply

chain. It transpires that the respondents indicating a partnership model express greater readiness to develop relations with their partners than companies declaring the transactional approach. This is particularly evident when analyzing the results showing the tendency of respondents towards further

integration with cargo suppliers, where the average score in the first group was 4.09, while in the second this stood at 3.31. The Mann-Whitney U test results prove that these differences are highly statistically significant (U=126.000, **p=0.001). Statistically significant differences in the responses are also seen between the key and supporting participants in the supply chain (Figure 1).
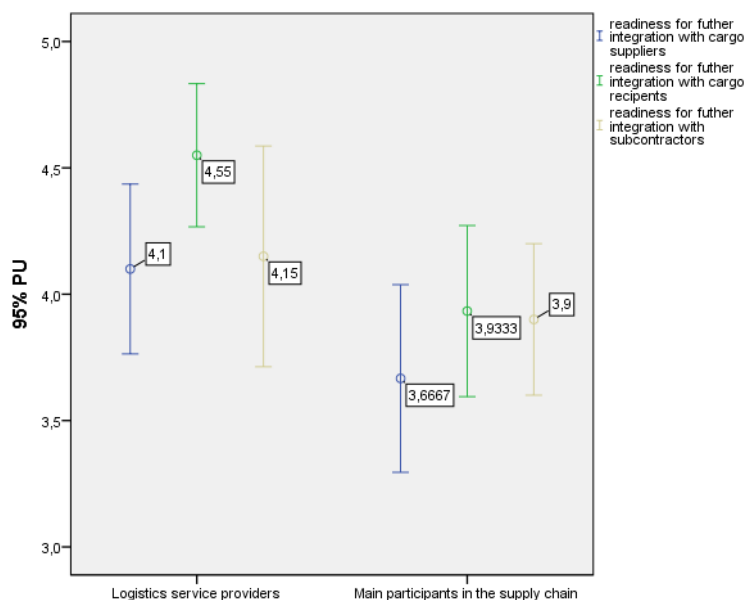

Fig. 1. Readiness of respondents for further integration, taking into account the role played by them in the supply chain

Rys. 1. Gotowość respondentów do dalszej integracji z uwzględnieniem roli pełnionej w łańcuchu dostaw

The respondents were also asked to identify the areas of logistics in which they would be ready to undertake collaboration. Their opinions revealed that the highest readiness to collaborate was recorded in the field of reverse logistics related to waste transportation, storage, recycling and disposal. It should be noted that so far these actions have not often constituted the subject of logistics outsourcing. Additionally, over 80% of the respondents declared high and very high readiness for further integration in the field of transportation and storage. The respondents are also interested in logistics collaboration in the field of research and development. In this case, they mean the joint implementation of logistics projects. At the same time, as many as ⅔ of the respondents were in favor of implementing a set of modular containers. In this regard, the majority of the respondents declare very high interest in the new delivery system, thanks to which their vehicles, railway wagons or sea containers can be loaded more fully and which at the same time will reduce the time of handling operations.

The readiness of enterprises to start collaboration with competitors

Collaboration based on the principle of full integration also includes relationships occurring between competitors, and therefore it applies to collaboration between the main links acting at the same stage of the supply chain, as well as between LSPs providing services to these entities. Among the total number of enterprises, the average score in the 5-grade scale was 3.33, which means that the eagerness to enter into relationships with competitors is at a slightly above average level. For comparison, the readiness to become engaged in deeper collaboration with non-competing entities was 4.47 (Figure 2). The results of the Wilcoxon test show that the difference

between the average score is highly statistically significant (Z=-3.632, p=0.000**). At the same time, it is worth noting that similar results were recorded in the group of LSPs (3.45) and in companies representing the main supply chain links (3.23). As we can see, the difference in the assessment is small and not statistically significant (Table 2).
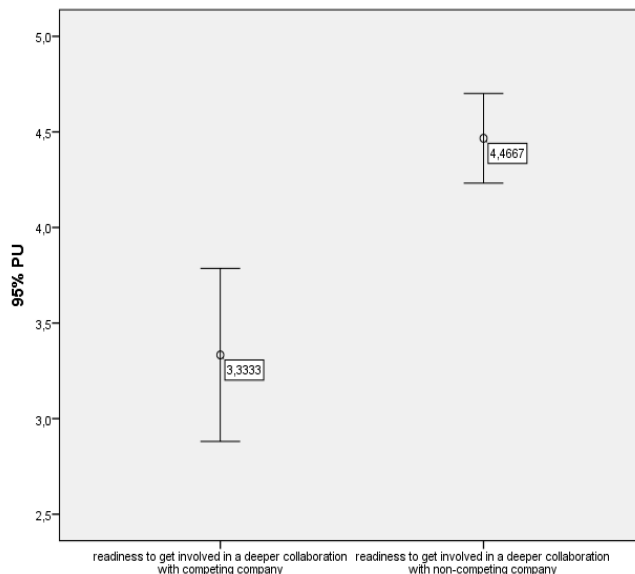

Fig. 2. Preferences of collaboration with the participants of supply chains
Rys. 2. Preferencje w zakresie współpracy z uczestnikami łańcucha dostaw

Table 2. Readiness of the respondents to enter into horizontal collaboration
Tabela 2. Gotowość respondentów do zaangażowania się we współpracę horyzontalną

No	Description	$\overline{x}$	σ	Main participants in the supply chain		Supporting participants in the supply chain		Statistical description
				$\overline{x}$	σ	$\overline{x}$	σ	
1.	Readiness to get involved in a deeper collaboration with the competitors	3.33	1.16	3.23	1.21	3.45	1.09	U=270,000, p=0.535
2.	Readiness to share resources with the competitors	3.22	1.22	3.07	1.31	3.45	1.05	U=245,000, p=0.258
3.	Readiness to use resources owned by the competitors	3.32	1.18	3.13	1.30	3.60	0.94	U=234,500, p=0.177

The above results are confirmed by answers to the following questions, which were designed to verify whether the collaborating respondents would be ready to share with other entities their own resources, and whether at the same time they would use the resources owned by collaborating entities. It appears that in this case most opinions focused on the value 3, which indicates that the readiness of respondents to make such decisions is rather limited. This time, however, slightly more pronounced differences between two groups (although not statistically significant) were

recorded. Therefore, one can assume that LSPs are slightly more ready to collaborate than production and trade enterprises.

CONCLUSIONS

The paper investigates enterprises' readiness to establish and develop vertical and horizontal collaboration in logistics. The study indicates a need for companies to become involved in logistics collaboration. However, it should be emphasized that the respondents

prefer to collaborate with companies which do not operate at the same level in the supply chain.

In terms of vertical collaboration, special attention should be paid to the willingness of the companies surveyed to further develop their collaboration in the area of logistics. The research shows that in all cases analysed, i.e. with respect to transportation, storage, purchasing and inventories, packaging and reverses logistics, the dominance of high prices over low ones is evident, which confirms that closer logistics partnership is needed. The results also show that although in both cases the level of readiness to strengthen relations is relatively high, it seems that the pressure to start and develop logistics collaboration is stronger in the group of LSPs, which may indicate their weaker position in the supply chain.

In the second case, i.e. with regard to horizontal collaboration, the results indicate insufficient preparation on the part of the companies surveyed to share their supply network and logistics operations with competitors. One should note the fact that the respondents' caution to engage in this type of system exists even on the assumption that this collaboration can lead to significant cost savings and will improve competitiveness against other competitors. Importantly, this is evident both in the case of major links of the supply chain, i.e. manufacturing and trading companies, and in the case of LSPs who are generally more open to a closer collaboration. These findings can be explained by the numerous concerns of the respondents regarding the behavior of potential collaborators. On the one hand, this may be a fear that the competitors will gain relevant information on their activities, which will then be used to gain a competitive advantage. On the other hand, the respondents may be unwilling to relinquish control of logistics services. We can guess that in relation to the competitors, the companies surveyed are dominated by an individualistic approach with a focus on enduring rivalry. It seems that this attitude has its sources in the fact that such relationships are characterized by a simultaneous occurrence of two opposing qualities, i.e. trust and conflict [Cygler et al.

2013]. From this point of view, it will be rather difficult for the businesses to achieve a high degree of openness towards horizontal collaboration.

It is worth mentioning that the findings of this study are consistent with those of other studies suggesting the existence of many difficulties in strengthening inter-organizational relationships [e.g. Fawcett et al. 2015, Holweg et al. 2005, Barratt 2004]. Particularly noteworthy are the results of a study conducted by Holweg et al. [2005], who based the study on observation of different collaboration projects, have identified the main factors responsible for the course of collaboration. In this case, the authors draw special attention to the significance of three elements: geographical dispersion of customers and supplier plants, consumer demand and product characteristics (i.e. selling periods, shelf life and market value).

The research described in this paper has several limitations. Firstly, one should note the small size of the survey sample, which adversely affects the accuracy and reliability of the results. This is especially important when interpreting the results of a comparative analysis of the two groups distinguished from the survey sample. Secondly, the scope of the research is limited to the overall assessment of the degree of readiness to work together in ways which are both horizontal and vertical. In terms of the collaboration with competitors, this topic was examined to a lesser extent and certainly requires further exploration. The research did not take into account a wide range of conditions that may affect the decisions of companies taken on the issues raised in this article. More specifically, the determinants that can provide an incentive for the enterprises to start collaboration should be better understood, as well as the factors that may be perceived by the respondents as a barrier to this kind of partnership. It is also important to identify the influence of these factors on the opinions of the companies surveyed. Among the factors that can have a positive impact on the collaboration one can find the following: shorter delivery time, improvements in key logistics indicators, reduction of fixed assets, empty runs, drivers' working time, and also reductions in greenhouse gas emissions. As

regards the threats, apart from the aforementioned aspects, more research is needed to understand the determinants adversely affecting the readiness to start collaboration. In this regard, special attention should be paid to the reluctance of companies to make their scarce resources and skills available to others.

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GOTOWOŚĆ PRZEDSIĘBIORSTW DO PODJĘCIA I ROZWOJU KOLABORACJI W OBSZARZE LOGISTYKI

STRESZCZENIE. **Wstęp:** Pomimo dużej liczby badań poświęconych różnym aspektom i formom współpracy zachodzącej w łańcuchu dostaw, zagadnienie to nadal zaliczane jest do stosunkowo słabo rozpoznanych problemów badawczych. Wobec powyższego, niniejszy artykuł stanowi głos w dyskusji poświęconej dalszym kierunkom rozwoju współpracy międzyorganizacyjnej. Głównym celem podjętych badań była ocena gotowości przedsiębiorstw do podjęcia i rozwoju kolaboracji w obszarze logistyki.

Metody: Podjęty problem badawczy zrealizowano na podstawie wtórnych i pierwotnych źródeł danych. Badania pierwotne przeprowadzono wśród przedsiębiorstw produkcyjnych, handlowych oraz usługodawców logistycznych. W statystycznej analizie wyników badań użyto dwóch testów nieparametrycznych. Przyjęto, że wynik jest istotny statystycznie dla p<0,05.

Wyniki: Wyniki badań wskazują na wysoką gotowość badanych przedsiębiorstw do rozwoju współpracy wertykalnej, a statystycznie istotny wpływ na oceny respondentów miały tu dwie zmienne, tj. model dotychczasowej współpracy oraz rola, którą badani pełnili w łańcuchu dostaw. Jeśli chodzi o kolaborację horyzontalną to gotowość badanych firm do jej podjęcia nie jest tak wyraźnie zauważalna jak przy współpracy wertykalnej. Różnica między średnimi ocen okazała się tu być wysoce istotna statystycznie.

Wnioski: Przeprowadzone badania wskazują na potrzebę kolaboracji w obszarze logistyki wśród ankietowanych przedsiębiorstw, choć należy podkreślić, że badani preferują współpracę z firmami znajdującymi się na innym poziomie łańcucha dostaw. W odniesieniu do współpracy horyzontalnej otrzymane wyniki można tłumaczyć licznymi obawami respondentów dotyczącymi zachowań potencjalnych kolaborantów. Najprawdopodobniej, w tym przypadku, wśród respondentów dominuje podejście indywidualistyczne z nastawieniem rywalizacyjnym.

Słowa kluczowe: współpraca logistyczna, kolaboracja w łańcuchu dostaw, kolaboracja wertykalna i horyzontalna.

DIE BEREITSCHAFT VON UNTERNEHMEN ZUR AUFNAHME UND ENTWICKLUNG EINER ZUSAMMENARBEIT IM BEREICH DER LOGISTIK

ZUSAMMENFASSUNG. Einführung: Trotz der Mehrzahl von Untersuchungen, die verschiedenen Aspekten und Formen der in der Lieferkette bestehenden Zusammenarbeit gewidmet wurden, ist das betreffende Untersuchungsproblem im Bereich der Logistik immer noch nicht genügend erkannt. Daher ist der vorliegende Artikel als Diskussionsbeitrag zu weiteren Entwicklungstrends der Zusammenarbeit zwischen Teilnehmern der Lieferkette gedacht. Das Hauptziel der unternommenen Untersuchungen war die Bewertung der Unternehmensbereitschaft zur Aufnahme und Entwicklung der Zusammenarbeit im Bereich der Logistik.

Methoden: Das betreffende Untersuchungsproblem wurde aufgrund von sekundären und primären Datenquellen durchgeführt. Die Primäruntersuchungen wurden unter Herstellungsunternehmen, Handelsunternehmen und Logistikdienstleistern durchgeführt. In der statistischen Analyse der Untersuchungsergebnisse wurden zwei nichtparametrische Tests angewendet. Man hat angenommen, dass das Ergebnis statistisch signifikant $p<0,05$ ist.

Ergebnisse: Die Untersuchungsergebnisse weisen auf eine hohe Bereitschaft der untersuchten Unternehmen zum Starten einer vertikalen Zusammenarbeit hin. Statistisch gesehen hatten hier zwei Variablen den wesentlichen Einfluss auf die Bewertungen der Befragten, d.h. deren bisherige Erfahrung im Bereich der Zusammenarbeit und die Rolle, die sie in der Lieferkette gespielt haben. Wenn es sich um die horizontale Zusammenarbeit handelt, lag bei den untersuchten Unternehmen die Bewertung ihrer Bereitschaft zur weiteren Integration etwas höher als durchschnittliches Niveau. Im Vergleich zu der vertikalen Zusammenarbeit hat sich der Unterschied zwischen dem Bewertungsdurchschnitt statistisch als eindeutig wesentlich erwiesen.

Fazit: Die durchgeführten Untersuchungen bestätigen das Bedürfnis der Aufnahme einer logistischen Zusammenarbeit unter den befragten Unternehmen. Man soll unterstreichen, dass die Befragten die Zusammenarbeit mit den Unternehmen, die sich nicht an der gleichen Stelle in der Lieferkette befinden, bevorzugen. In Bezug auf die horizontale Zusammenarbeit lassen sich die erzielten Ergebnisse damit erklären, dass die Befragten eine Furcht vor dem Verhalten der potenziellen Mitspieler empfinden. Wahrscheinlich dominiert unter den Befragten im besagten Falle ein individualistischer, durch ihre Rivalitätsausrichtung determinierter Ansatz.

Codewörter: Zusammenarbeit in der Logistik, Zusammenarbeit in der Lieferkette, vertikale und horizontale Zusammenarbeit.

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THE ROLE OF KAIZEN IN CREATING RADICAL PERFORMANCE RESULTS IN A LOGISTICS SERVICE PROVIDER

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ABSTRACT. **Background:** This study investigates the role of an incremental change in organizational process in creating radical performance results in a service provider company. The role of Kaizen is established prominently in manufacturing, but is nascent in service applications. This study examines the impact of introducing Kaizen as an ODI tool-how it is applied, how it works, and whether participants believe it helps service groups form more effective working relationships that result in significant performance improvements.

Methods: Exploring the evolving role of Kaizen in service contexts, this study explores a variety of facets of human communication in the context of continuous improvement and teamwork inter-organizationally. The paper consists of an archival study and an action research case study. A pre-intervention study consisting of observations, interviews, and submission of questionnaires to employees of a manufacturing and air-sea freight firm was conducted. A Kaizen intervention occurred subsequently, and a post-intervention study was then conducted.

Results: Radical improvements in both companies such as 30% financial growth, 81% productivity improvement and more are demonstrated in this paper.

Conclusions: Findings offer unique insights into the effects of Kaizen in creating radical performance improvements in a service company and its customer. Both qualitative and quantitative results of business, satisfaction, and productivity suggest time invested in introducing Kaizen into a service organization helps the companies improve relationships and improve the bottom line dramatically.

Key words: Kaizen, continuous improvement, collaboration, service organization, motivation.

INTRODUCTION

As the reader reads more about the companies involved later in the article, a better understanding will developed of how Kaizen helped creating radical performance results for both companies with very small incremental changes. For years, Logistica was researching a unique selling point to enter Sporty's list of logistics providers, with little success. It was difficult for Logistica to differentiate itself from competitors and gain needed trust in its capabilities beyond supply chain management solutions. The Kaizen ODI changed that radically.

Kaizen is a process of continuous improvement implemented in organizations worldwide. The original Kaizen philosophy was a Japanese life philosophy that suggests human life and lifecycle can be improved constantly. According to Colenso [2000], Kaizen means "change and good", suggesting that the philosophy of much of business is "if it ain't broke, don't fix it." Kaizen takes this concept and extends it to suggest, "If it ain't broke, don't ignore it because it will break one day." This attitude, with emphasis on fixing or modifying problems before they develop, has another corollary: bad business ignores signs of problems, but good business sees a train wreck coming and changes tracks. Businesses

worldwide adopted Kaizen as a way of doing business, and the Kaizen-driven business looks down the track continually and makes corrections to avoid a potential train wreck; a traditional business waits until the train is visible and then takes steps to avoid a crash. This allegory suggests it is far easier to monitor and correct a track than wait until a train appears, and then try to avoid a collision and get back on track. Worldwide, businesses find that continuous improvement is much more beneficial, and certainly more cost effective, than belated corrections.

As Hammer, Champy, and Tathan [1993] describe, Kaizen leads to a process-oriented view of a system since processes must be improved before better results can be achieved. Improvement divides into two categories: continuous and innovation. Kaizen suggests small improvement steps are based on continuous efforts to sustain the status quo, and innovation requires large investments in technology or radical changes to processes; the two compare to evolution (Kaizen) and revolution (innovation). Although Kaizen was developed for use in manufacturing, it now appears in a variety of venues, including governments, banking, and healthcare [Bahensky, Roe, & Bolton, 2005]. Kaizen is characterized by daily actions that entail improvements to all aspects of an organization, and involves all employees from top to bottom. Laraia, Moody, and Hall [1999] suggest that Kaizen is all encompassing, and includes "participation of workers in the improvement". Without worker buy-in, Kaizen does not work. Organizational collaboration complicates issues related to Kaizen and continuous improvement exponentially. A system normally complex within the context of a single organization becomes far more intricate as other organizations are added to areas of operation. The best way to understand the complexity of this collaboration is to consider how difficult mergers between two companies can be. During a merger, two companies meld systems and methods of operation; if they do it correctly, the company survives and prospers, and if they do not, the joint company fails. During inter-organizational collaboration, companies work together as closely as merged companies, but do not officially meld systems. Instead, they

work together in collaboration, keeping systems separate but overlapping.

During a merger, the new company decrees what types of systems will be used, whose method of operation will be utilized (and whose will be dropped), what procedures will remain the same (and which will change). Changes to the culture of one or the other of the merging companies are made so workers operate under one goal, vision, and mission. During collaboration, an air of unity does not exist because the companies remain separate, yet complexity is still present because the organizations must work together to succeed. Neither company has the capacity to order the other to comply with a directive. Instead, they must negotiate rights and responsibilities. In a sense, inter-organizational collaborations provide the requirement to achieve without providing the authority to make changes to meet the requirement. Inter-collaboration is complex, and cannot happen unless all companies involved agree to make the relationship work. Huxham [1993] states:

Collaborative advantage is achieved when something unusually creative is produced-perhaps an objective is met-that no single organization could have produced and when each organization is able to achieve its own objectives better than it could alone. In some cases, it should also be possible to achieve some higher-level…objectives for society as a whole, rather than just for the participating organizations.

Two goals of for-profit organizations are to make profit and achieve competitive advantages. The goals of collaborative advantage and competitive advantage are complementary, according with competitive advantage. Huxham [1996] points out that collaborative advantage results from synergy between collaborating organizations. Companies seek this synergy since they continually improve not only their own organizations, but also connections and collaborations between organizations.

COMPANIES UNDER STUDY

Since this study focuses on performance results of both logistics Service Company and its customer, more than one company was investigated. To protect confidentiality, all companies name are masked. The main company, Logistica, is a logistics company under a large group of companies. Logistica is one of the world's leading providers of freight forwarding and supply chain management services. For more than a hundred years, it has provided customers with transportation and logistics solutions that support the way they want to do business, wherever they are in the world. With more than 10,000 professionals in nearly 300 offices worldwide, Logistica manages more than 2.3 million containers of ocean freight and supply chain management volumes, and more than 230,000 tons of airfreight, annually.

The second company, Sporty, is a multinational cooperation engaged in design, development, outsourced manufacturing, and marketing of footwear and apparel, including sports equipment and services. Besides a focus on growing its business into a multi-billion-dollar cooperation, the company invests heavily in being environmental friendly; its environmental programs ranks among the top in the world. Since Logistica is one of the largest supply chain management service providers in the world, Sporty was one of Logistica's customers under this product. There was little trust in Logistica's logistics capabilities such as air or ocean freight. During the pre-ODI stage, Sporty was already a strong supporter and implementer of Kaizen and lean methodologies; as a manufacturer, the company benefited strongly from running continuous improvements techniques. Logistica did not use Kaizen; it used teams of process excellence (PEX) managers who examined processes and improved them without involving the people who ran those processes. The teams had a few successes, but no game changers. At that point, the companies had no more than simple customer/service provider relationships.

Throughout the course of Kaizen introduction as an OD tool at Logistica and to the services the company provided,

relationships grew stronger and the companies started to cooperate and later collaborate on many projects. Joint training and workshops built trust, and results from Kaizen initiatives helped Logistica introduce its air and ocean logistics services and gain more confidence from customers. Many Kaizen projects grew beyond improving current services; it extended to helping customers achieve global goals (e.g., reducing CO_2 footprints the entire supply chain emitted). Simple steps of Kaizen intervention helped both companies achieve radical performance results. From Logistica's side, participants were customer service and operation staff members, and supervisors, in both Thailand and Vietnam offices. On Sporty's side, manufacturing employees in Thailand and Vietnam, and staff members and managers in European distribution centers, participated in the study. Figure 1 illustrates the various participants.

Fig. 1. Company participants
Rys. 1. Uczestnicy firmowi

RESEARCH PURPOSE, QUESTIONS AND OBJECTIVES

The purpose of this research is to determine the impact of Kaizen in creating radical performance results and whether it can be effective to service groups to form more effective working relationships. While planning this study, a number of general questions evolved and led to exploration. For example, the study questions what Kaizen is, and how it enhances performance in service companies. How is Kaizen applied best to services offered between companies? What is the meaning of quality? Research questions

developed from the initial study related to planning the final study:

1. To what extent does Kaizen influence business results of a logistics service company and its manufacturing customer?
2. Do participants believe the Kaizen methodology is effective in helping service groups form effective working relationships?
3. What does quality mean for the companies participating in the study?
4. Can Kaizen lead to improved collaboration?

In order to answer these questions, the following objectives set forward:

1. To determine the situation in the company before the Kaizen intervention in terms of financial and business growth, productivity and; customer and employees' satisfaction.
2. To design set of activities based on Kaizen that would be used as an OD intervention to engender high performance results.
3. To monitor the effect of the Kaizen activities on the company's financial and business growth, productivity and; customer and employees' satisfaction.
4. To determine observable differences between pre and post ODI on financial and business growth, productivity and; customer and employees' satisfaction.

Research Hypothesis is as follow:

The null hypothesis is H0: The Kaizen-based OD activities will not make much of a difference in the financial and business growth, productivity and customer and employees' satisfaction.

H1: The Kaizen-based OD activities will improve business results of the two companies,

H2: The Kaizen-based OD activities will improve customers' satisfaction,

H3: The Kaizen-based OD activities will improve employees' productivity.

LIMITATIONS OF THE RESEARCH

This study's limitations relate to the sample of workers. Within every organization, there are workers who believe in ways that are contrary to the opinions of managers. The same condition applies to this study. The inability of the researcher to participate without influencing behaviors and responses was a limitation. Other limitations relate to validity. In qualitative studies, validity is confirmed through triangulation [Bush 2002], and according to Denzin [1984], there are four kinds:

– Triangulation by multiple researchers
– Theory triangulation
– Data investigation for triangulation
– Triangulation by approach to data

Regarding triangulation by multiple researchers, multiple investigators research a phenomenon simultaneously. If the researchers achieve the same results, findings are valid. During theory triangulation, researchers who hold disparate perspectives review material and reach conclusions. If they reach the same conclusions, results are valid. In the third type, data from multiple sources are reviewed for consistency. This study uses this method. Another follows one approach to analyzing data. In determining validity by these methods, the question is whether the literature review supports findings. Results of a literature review are compared to reports from participants, both pre- and post-study, and in this manner, data are triangulated. If results agree, they are empirically valid [Denzin 1984]. The companies under investigation were only one set of companies, and might not have represented the complete picture of the context. This limitation was inevitable due to time constraints.

LITERATURE REVIEW

This literature review examines studies of Kaizen and inter-organizational collaboration, and implications to both, in supply chains.

Kaizen

As pointed out by Suárez-Barraza and Manuel [2014], Glover et al [2013] and de Silva [2014] process innovation and Kaizen remains important in today's controlling organizations efficiently in both manufacturing and service organizations despite the shortage

of studies in the field especially in service environment.

A distinction exists between Kaizen as practiced in Japan and its approach to change as implemented in the majority of businesses worldwide. Imai [1997] points out that Kaizen as practiced in Japan means continuous improvement, or as Colenso [2000] suggests: good change. In Japan:

[Kaizen] assumes that our way of life-be it our working life; our social life, or our home life-should focus on constant-improvement efforts. Although improvements under kaizen are small and incremental, the kaizen process brings about dramatic results over time. [Imai, 1997].

Imai continues, comparing disparities in Japanese Kaizen with the way of doing business in the West. Conducting business in the West relies on innovation, or major changes. "Innovation is dramatic, a real attention getter. Kaizen, on the other hand, is often undramatic and subtle" [1997]. Kaizen allows companies to make slow, subtle changes at very low cost, which translates to low risk. One advantage of Kaizen is that "Managers can always go back to the old way without incurring large costs" [1997]. Kaizen, then, is not about retooling, redeveloping, or investing heavily in the latest technologies. Kaizen is an overall business concept that entails a number of quality concepts developed steadily [Imai 1997]. It is a way of life in Japan, and thus not prone to dramatic change. Imai [1997] suggests three building blocks of Kaizen, encompassed in a concept known as QCD (quality control, cost control, and delivery system control):
  - A quality assurance system that is continually improving and evolving;
  - A cost management system that is continually improving and evolving;
  - A delivery system that is continually improving and evolving.

The building blocks are based on the concepts of 5S: tidiness (Seiri), orderliness (Seiton), cleanliness (Seiso), standardization during cleanup (Seiketsu), and discipline (Shitsuke) [Imai 1997]. Imai asserts that if the

five steps-based on housekeeping-are kept faithfully, work becomes less complex, and workers and stakeholders address the working process while saving money. Productivity, zero tolerance for defects, just-in-time production, and total quality control are aspects of Kaizen, and can be distributed among quality assurance, cost management, and delivery systems. According to Imai [1997], there are five steps to developing an excellent kaizen strategy. The first is for managers to understand they play a major role: to maintain the current system, and improve it. All current systems must be maintained, whether management, operations, or technological. Standard operating procedures (SOPs) are developed to help employees understand what they must do. Simultaneously, improvements must occur, and current standards must be honed constantly.

The second step is to emphasize process versus results. By planning, doing, checking, and acting (PDCA), a process of continuity is established. Planning embodies always having a plan for continuous improvement. Doing is the process of implementing the plan, and checking refers to determining whether the company is on track with continuous improvement. Acting involves performing new actions that are efficacious during planning and developing of new standards [Imai, 1997]. The SDCA (standardize, doing, checking and acting) cycle requires standardizing actions, conducting the actions to ensure standards are correct, checking them, and acting. It is managers' responsibility to formalize these steps.

According to Imai [1997], managers must always put quality first; if necessary rejecting deals that appear lucrative if they cannot be produced with high. This involves the case of whether a product is a good or process/service. Mangers "speak with the data" in a cycle of collection, verification, and analysis to ensure directions the company is taking are correct for productivity and profit. Both internal and external customers are given the opportunity to review a product and provide feedback [Imai 1997]. From Barraza, Smith, and Dahlgaard&Park [2009], three techniques relate to Kaizen that have a direct effect on the processes and management systems in public

service sector: 5S, gemba kaizen workshops, and process mapping. These techniques improve processes and quality of public services provided by public councils. According to Tye and Chen [2005], contemporary companies must capture and maintain competitive advantages. By cutting costs and increasing quality, Kaizen offers this opportunity. Dated but relevant, Friedman [1970] suggests that businesses have a moral imperative to shareholders to acquire and maintain profit. Companies are becoming increasingly global, and as the nature of business changes from local to national and finally to global, so must methods of conducting business. In the case examined in this study, inter-organizational collaboration is investigated as playing a role in Kaizen. Do participants believe it helps service groups form more effective working relationships?

Implications to Supply Chains

Lia, Ragu-Nathanb, Ragu-Nathanb and Raob [2004] suggest that an effective supply chain helps company secure competitive advantages. An effective chain improves organizational performance because it shortens times between orders out and in, improves turnover, decreases space needed for supplies, and commits fewer assets to stock (Lia et al., 2004). The interrelationship of supply chain management and the overall ability of a company to compete influence the company's degree of global competitiveness [Su & Yang, 2010].

Interdependence, Coordination, and Collaboration

According to Ketchen and Giunipero [2004], interactions between supply chain management and strategic management represents an intersection of knowledge. This intersection benefits all parts of the organization, not just areas part of the supply chain. As the degree of complexity of interchanges between organizations increases, so do benefits to the organizations, and as interactions increase, so do structures processes [Rockwell & Bennett 2004]. From networking-representing the lowest common interactions between organizations-to collaboration-raising interactions to co-

workers or partners-each additional degree of interaction offers increasing degrees of strategic advantages. Although companies sometimes fear cooperating with organizations they regard as competitors for fear of losing advantages, the opposite appears to be true; collaborating with other organizations, even within the same structures, increases competitiveness and offers strategic advantages by increasing the value chain [Gunasekaran, Lai, Cheng, 2008].

Various forms of interdependence might have different forms of coordination and commonality; Thompson [1997] suggests the interdependence might be pooled, sequential, or reciprocal. Pooled interdependence might involve mediating technology, while sequential interdependence long-linked technology and reciprocal interdependence might also involve intensive technology. Thompson further defines three types of coordination: standardization, planned, and mutual adjustment. During standardized coordination, there are rules to coordination, developed to improve the company's bottom line and reflect improved performance by unit cost since clear rules for how to deal with each other are established. Confusion is eliminated, and time and money are saved. Planned coordination accomplishes the same, but the planning is conducted based on circumstances of, for example, the production of a user's manuals. Finally, mutual adjustment can be used if neither of the other two techniques are appropriate. To be effective, mutual adjustment must be conducted in an environment of constant communication [Thompson 1997].

Thompson's discussion of interdependence also includes task processes. During pooled interdependence, every member of an organization (or the task) contributes to the whole, and information is then pooled. Although the product depends on each individual doing his/her own job effectively, individual pieces of the work do not depend on each other. Sequential interdependence means one person's work depends on correct finishing of another person's. During reciprocal interdependence, products relate and must be finished in a coordinated manner [Thompson 1997]. Task processes can be long-linked,

mediated, or intensive. Long-linking requires linking of various tasks over a period, for example, on an assembly line. The mediating process links people for mutual benefit such as groups that wish to sell diapers overseas. One group makes the diapers, another sells them. The mediating process is the link. Intensive processes are devoted to changing an item, and changes are made depending on feedback regarding the item. An example of an intensive process is a company's competition in a professional contest during which each level must be achieved before the company progresses to the next level. According to Thompson, a link exists between coordination and task, but the link to collaboration is less clear [Thompson, 1997]. Rockwell and Bennett [2004] suggest this might not be the case.

Relation to Supply Chain Performance

Extant research demonstrates that supply chains can be measured, but various forms of measurement must be applied to nodes of the chain [Niemi, Pekkanen, Huiskonen, 2007]. Since little empirical evidence exists that relates to supply chains, applying Six Sigma or Kaizen to a chain is more difficult since the concept behind these methodologies is measurement and improvement [Anthony, 2004]. Sheffi [2002] suggests that most of the savings or improvements that result from collaborative planning and forecast replenishment (CPFR) come from decreasing time inventory is decoupling, or between processes. Companies must ensure retailers do not face out-of-stock (OOS) situations, while keeping excess stock to a minimum. A number of collaboration processes were developed throughout the years, though emphasis on collaborative planning and forecasting began in the early 1960s and survives in one iteration or another today [Sheffi, 2002]. Daugherty et al. [2006] suggest that when companies are willing to take the time and effort to work together to develop supply chains, collaboration pays. Kimberly Clark, Tesco, Wal-Mart, Sara Lee, and others developed supply chains through collaboration [Daughtery et al., 2006]. In the airline industry, Southwest achieved continued excellence and profitability by collaborating with both employees and other organizations to organize

flights and suppliers [Maxon, 2010, Southwest Airlines Cargo 2010].

To stay competitive, companies engaged in manufacturing must adapt to market changes quickly, and companies with close relationships with suppliers are better able to accomplish these changes. Companies that work collaboratively with partners that are experienced increase efficiency and decrease variability [Wu, Katok, 2006]. Sheffi [2002] points out that inventory, which refers to inventory held by a manufacturer or supplier, is either being processed or decoupled. Decoupled inventory (inventory between processes) takes up the most time. Decoupled inventory time decreases unless time to process the inventory through the chain decreases. The difficulty is determining how to decrease processing. Since decoupling time can occur anywhere in a chain, it is necessary to involve all parts of an organization when decreasing processing.

Collaborative planning, forecasting, and replenishment (CPFR) developed over the years. Bose was one of the first suppliers to establish collaboration with suppliers. The company freed employees and cut production costs when it moved suppliers in-house as part of a purchasing and materials team [Dong, Carter, Dresner, 2001]. An additional benefit was that in-house suppliers were better able to see customers' needs, and thus were in a better position to make not only practical suggestions, but suggestions that might result in direct benefits to customers [Sheffi 2002]. Bose's experiment was called JIT-II, or Just-in-Time II. Although results suggested success, the process did not become standard because companies were leery of full implementation. With contemporary technology, it is possible for companies involved in collaboration to view operations virtually, and make recommendations, in essence acting as interested consultants, without displacing existing staff members or adding to the home company's costs.

After JIT-II was developed, the efficient customer response (ECR) movement evolved, concentrating on better responses. From there evolved high customer service, with emphasis on product replenishment. The change was

termed continuous replenishment programs (CRP) [Sheffi, 2002], but was discarded quickly as the idea of quick response times rose. The overriding business goal at this point was to shorten the cycle time, and in doing so preserve corporate resources during the process of taking items from raw materials to end use. Companies gradually began to understand that any real improvement would necessarily include collaboration, in one form or another, with suppliers, transportation, and logistics suppliers, and even buyers. However, collaboration was difficult because logistics had to be calculated manually or through multi-step processes; at the time, there existed few logistics software [Sheffi 2002]. An added complication was that companies within the process clashed over priorities since each company struggled to accomplish its own ends. The solution appeared to be vendor managed inventory (VMI), in which a manufacture could provide a buyer with sales and order forecasts. The vendor received a great benefit: salaries for sales workers were lowered and suppliers/vendors were better able to predict cycles of sales and losses. However, manufacturing companies that used VMI received little real benefit. Although VMI pointed the way to collaboration, at the time it operated in one direction, from manufacturer to buyer. Claassen, van Weele, and van Raaij

[2008] argue that a two-stage process, with communication down the supply chain and then back up, was more beneficial.

THEORETICAL FRAMEWORK AND CONCEPTUAL PROCESS DIAGRAM

Literature on Kaizen-how it works, its performance improvement role, how participants in supply chains regard use of Kaizen during supply chain manipulation, and how participants regard use of Kaizen during collaboration-was written within frameworks of total quality management, systems theory, and CPFR (Collaborative planning and forecast replenishment) Theories from Bertalanffy (1976) were investigated in relation to systems theory and supply chain management. As Brown [2010] mentioned there are many tools to build success in organization thru high performance systems (HPS), Kaizen was chosen from the various quality improvement tools be used during intervention. Its small improvement cycles were perceived as beneficial to identify radical performance changes. The diagram in Figure 2 represents potential tools for high performance systems under study, from which Kaizen was selected.
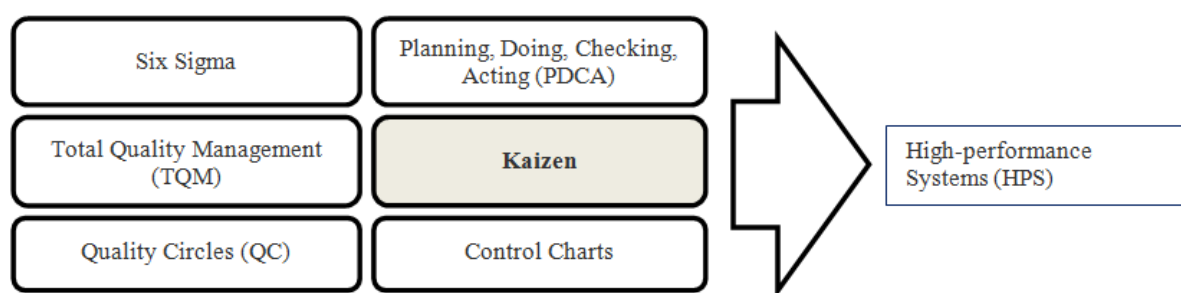
Fig. 2. Theoretical framework with Kaizen as the HPS tool
Rys. 2. Teoretyczny schemat Kaizena jako narzędzie HPS

Saunders, Lewis, and Thornhill [2009] characterize conducting research as similar to peeling layers of an onion. As each layer of an onion is peeled, more information is revealed until the core of a subject is reached. The layers include epistemological stances, ontological approaches, research strategies, timeframes, and data collection methods. The

epistemological stance chosen for this study was positivist, with elements of interpretivism. This stance allowed the researcher to use scientific approaches to investigation while interpreting human actions involved in making business decisions. Positivism is used most frequently in quantitative studies, so a combination of positivism and interpretivism

is appropriate for mixed methodologies [Riley, Schouten, Cahill, 2003].

The ontological approach chosen was inductive reasoning, or analytic induction. Analytic induction allows a researcher to question what he/she knows constantly. It is used commonly with interpretivism, and allows a researcher to modify theories and hypotheses during research as new information is gathered. This factor makes analytic

induction ideal for business applications in which the field changes rapidly [Saunders et al., 2009]. Yin [2006] suggests that a mixed methodology might be more appropriate; mixed methodologies allow for investigations within investigation, which leads to convergence of data. Thomas [2003] suggests that qualitative and quantitative studies can be mixed.
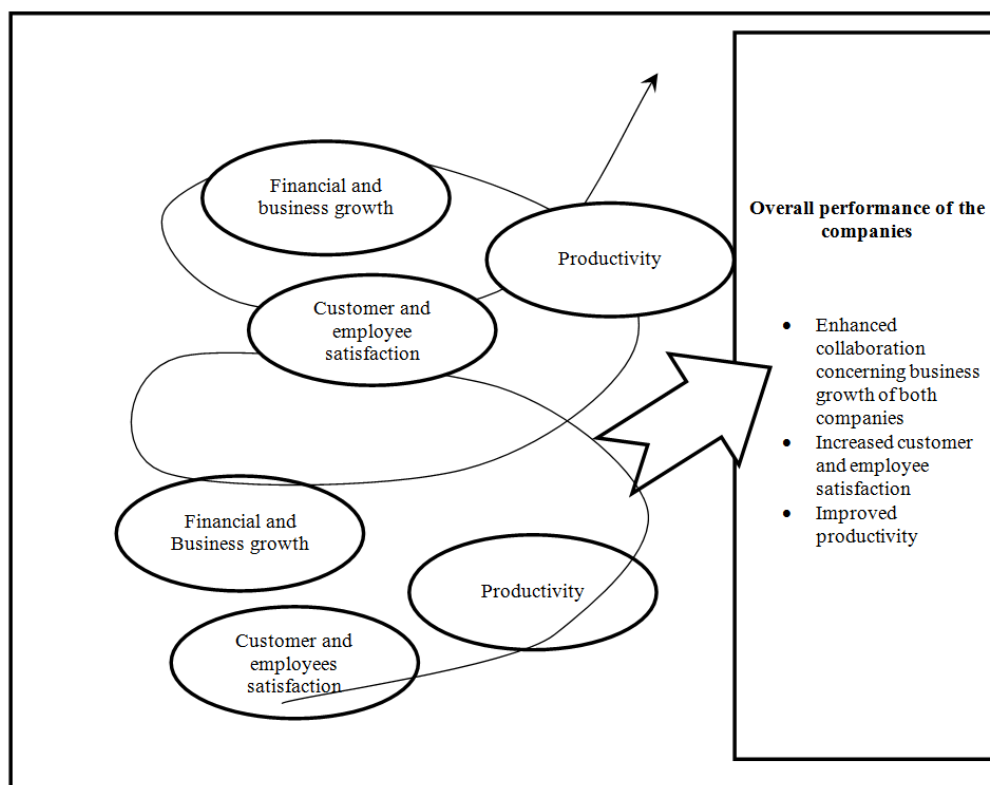

Fig. 3. Conceptual process flow of the action research
Rys. 3. Koncepcja przepływu procesu podlegającego badaniom

The research strategy defines the strategy used to investigate a question. The strategy can include experiments, action research ethnography, or case studies. The action research model of a pre- and post-ODI design in the context of a case study was chosen as the research strategy. Yin [2009] suggests that the case study be used to investigate a process or problem while searching for an explanation of information, so the case study is an appropriate research strategy [Yin, 2009]. By combining a case study, action research, and a literature review, study materials triangulate more easily. The timeframe addresses whether a study covers a single point in time or a situation over

a period [McEligot, 2005]. Longitudinal research allows a researcher to conduct a study that reviews how a situation changes over time. This study included repeated observations of the same variable so as a short-term, longitudinal study it addresses more than one period since the case study began with a pre-ODI design and concluded with a post-ODI design. The company's situation was assessed prior to a development initiative, and a baseline was established. After a Kaizen intervention, a post-ODI review was conducted, and similarities or differences were compared. Changes were evaluated and

recommendations for future research were developed.

Data collection included a variety of methods, including observations, interviews, and secondary research. By combining a variety of data collection methods, materials triangulate more easily [Saunders et al. 2009]. Jeerapaet [2009] suggests that researchers conducting action research in the context of ODI should identify problem areas, develop and implement intervention techniques, and monitor and evaluate results. These were methods were used during this study. The diagram shown in Figure 3 shows the direction of each company before and after a Kaizen intervention.

Through a thorough evaluation of the financial and business results of both companies, employee productivity of the service provider, and satisfaction of both external and internal customers before and after the ODI, the researcher examined performance results resulting from Kaizen from the two collaborative companies.

ACTION RESEARCH FRAMEWORK

The pre-ODI investigation determined how Kaizen can be used as an intervention to create radical performance results among organizations in a supply chain. The company was expected to recognize that it needed to rework its supply chain to better use methods of Kaizen, combined with collaboration. The pre-ODI investigation was repeated as a post-intervention assessment to determine what changes occurred. Figure 4 shows the action research framework used in this study.
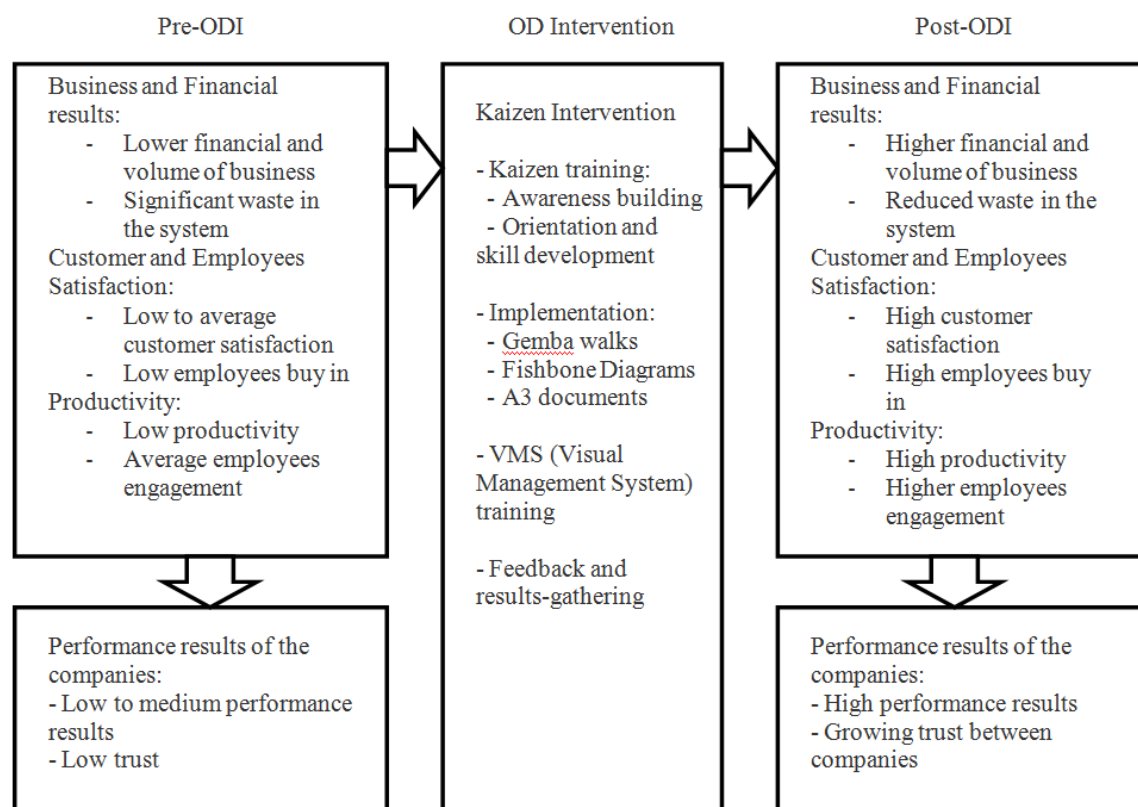
Fig. 4. Action research frameworks
Rys. 4. Schemat badań

To allow the organization to embrace the needed change, the intervention lasted one year, starting with two days of Kaizen training, which included the theory and need of Kaizen, and hands-on exercises in a form of Gemba walks in groups and individually. Teams were asked to work together with the manufacturing company to identify needed improvements monthly. Two months after initial training, the teams underwent visual management system

(VMS) training to provide them with another tool to identify and present problems to be solved. Regular Gemba walk, Fishbone diagram, and A3 documents were expected and delivered by teams to document PDCA cycles of improvements.

The ODI framework's actions are very much in line with the traditional "8 steps for organizational development interventions". Setting teams of people to run the Kaizen events is a strategic intervention with interim measurements of control that helps eliminate the hierarchical decision making and shift the decision to the team. It also helps ensuring a focus on the group rather the individual. The small changes at a time that Kaizen introduces benefit building trust as if mistake happen, it is easy to roll back with minimal effect. Working in teams assist to reduce unnecessary competition and ensure active participation of all team members. Building the skills of Kaizen and reducing waste in the team's work is a direct investment in employees.

RESEARCH METHODS

This study used mixed qualitative and quantitative methods to evaluate the role of using Kaizen to boost performance results, including how it is applied, how it works, and whether it is effectiveness. A pre-intervention study consisting of observations and interviews, and submission of questionnaires to employees of the manufacturing firm and the firm's freight forwarder, was conducted. An intervention was conducted, and a post-intervention study was repeated. Pre- and post-intervention interviews and questionnaires were the same.

A purposive sample, or total population of 10 people of the involved teams, has been selected from employees of Logistica's staff and supervisors from its Thai and Vietnamese branches. From Sporty, the research conducted with 28, randomly selected, participants from their management and employees in Vietnam and Thailand factories as well as European distribution center. Questionnaires, reports and internal documentations have been reviewed and compared before and after the ODI.

AS previously established, participants have been observed as the research participates alongside them in day to day operation. Worker attitudes and opinions have been determined during the daily work as well as in the interviews or questionnaires. All workers who participate have been asked the same questions, using a script and have been asked to fill out a questionnaire that is the same as the script. The flexibility is necessary because some of the workers in supply chain partners may be accessible only by phone or internet while workers who are known to the participant may feel more comfortable answering the questions in a verbal fashion.

Instruments

Two types of data were used in this study: interviews or questionnaires submitted to employees of subject companies, and secondary data consisting of archival materials and materials provided by the companies under studied. A number of resources were used when conducting searches for secondary data. Academic websites, governmental websites, and peer-review journals, and current technical and news sites, were used. Primary instruments included a variety of notebooks, reports, and questionnaire answers. Archival materials and the interviews were evaluated separately. Statistics have been used to run Cronbach Alfa validity test as well as Student t-test on the appropriate data results. For other results, statistics were inappropriate since the action research undertaken in this study used an intervention to assess whether change was significant. Thus, construct validity was expected to suggest multiple sources of evidence in triangulation verified an explanation of causality. Data were available for review by another researcher to determine whether the researcher arrived at the same conclusions. Table 1 summarizes the research instruments, tools, and techniques for each data type (i.e., qualitative and quantitative).

As part of the ODI implementation the set of instruments and techniques that have been used to identify the needed change were the Kaizen tools: Gemba walks, A3 documents and fishbone diagrams.

Table 1. Research Instruments, Tools, and Techniques
Tabela 1. Instrumenty, narzędzie i techniki badań

Research Topic	Data Type	Research Instruments, Tools, and Techniques
Business Results	Quantitative	**For service provider:**
		1. Financial results of the business compared before ODI and after ODI
		2. Total volumes received from the manufacturing customer compared before and after the ODI
		For manufacturing customer:
		Any available business results compared before and after ODI. Examples of business results include CO_2 emissions, document waste, etc.
	Qualitative	Open-ended questions given before and after ODI for both service providers and manufacturing employees to determine how they view the benefits to each company
Customer Satisfaction	Quantitative	Likert-style questionnaires given to both sides before and after ODI
		Customer satisfaction survey (CSS) results compared before and after ODI
	Qualitative	Open-ended questionnaires given as part of the CSS; analyzed before and after ODI
Productivity	Quantitative	The amount of files per person and work waste compared before and after ODI
	Qualitative	Results of employees engagement surveys (EES) compared before and after ODI

DISCUSSION OF THE FINDINGS

Based on the conceptual framework, the researcher identified three aspects to assess: business results, customer satisfaction, and productivity. So the researcher understood the influence of ODI on the organizations, similar aspect assessments using same tools were conducted after ODI was complete. In all three aspects, the small cycles of change that Kaizen introduced created radical performance improvements. Subsequent sections discuss findings from those assessments.

BUSINESS RESULTS

The effect on business results was a key element to measure and evaluate. Financial and volume results, working waste and CO_2 emissions, and the opinions of participants involved in the study were revisited and measured. When the researcher examined various company reports, the following details were observed: revenue of the service provider from the manufacturing customer business was USD$21.503 million, airfreight yearly volume was at 3,819 tons, SCM income was documented at 1,901,000 million cbm per year, and the ocean business recorded 2,668 TEUs for that year. Comparing results after ODI to results before ODI yielded an interesting observation: revenue grew from USD$15 million to USD$21 million, 30% growth. The airfreight volume grew from zero to the substantial amount of 3,819 tons. SCM, which was already identified by the customer as a strong cooperation point, developed from 1.6 million cbm to 1.9 million cbm, and the ocean freight business advanced from 675 TEUs to 2,668 TEUs. Table 2 compares business results before and after ODI.

Table 2. Business Results Comparison before and after ODI
Tabela 2. Porównanie rezultatów biznesowych przed i po ODI

	Pre-ODI results	Post-ODI results	Percent change	% Industry level during same period
Revenue (USD M)	15.106	21.503	30%	
Air freight volume (tons)	0	3,819	-	3.1%
SCM volume (000 cbm)	1,596	1,901	16%	
Ocean volume (TEUs)	675	2,668	75%	-9.9%

The increase of business given to the service provider demonstrates greater trust of the customer in the service provider's capabilities. Since ODI focused on the air and

ocean warehousing departments, there is only one conclusion that an increase from zero to 3,819 tons and 75% in air and ocean volumes, respectively, suggests: direct connection between Kaizen implementation and growth of business. Considering the manufacturing customer's related business results, the researcher found that the number of shipments with irrelevant documents was 1%, documents

were filed at the office for an average period of 3 months, and only 1 document per shipment was stored in a warehouse for later retrieval if needed. Electronic messages between systems, EDI, resulted in 99.6% on-time deliveries, and from the manufacturing sustainability report, the researcher found that CO_2 emissions were at 0.87 million tons per year (Table 3).

Table 3. Manufacturing Customer-related Business Results
Tabela 3. Rezultaty biznesowe produkcji zorientowanej na klienta

	Pre-ODI results	**Post-ODI results**	**Percent Change**
Amount of shipments with extra or non-required documents	10%	1%	90%
Filing time of document is the office (months)	9	3	-67%
Documents to be processed into a storage warehouse	All documents (averaged to be 12 pages per shipment)	Only Certificate of Origin (C/O) (1 page)	-92%
CO_2 emission (Million tons)	1.4	0.87	-38%
EDI transmission within timeline	87.3%	99.6%	14%

There is a clear indication that Kaizen events created a more efficient working environment, and waste was removed from the system in a form of fewer non-essential documents, faster document filing, and fewer documents sent to long-term storage. Errors reduced so EDI transmission grew to an accuracy of 99.6%. One of the greatest achievements was analysis of the manufacturing supply chain using new tools that brought life to the service provider's slogan: "We want your air cargo, because we want to help you reduce it." By finding new solutions, some of the air freight business shifted to less-polluted ocean freight or combined sea-air solutions. The last step to evaluating the business report was to confirm whether these results accorded with participants' opinions. Staff members from both companies completed similar questionnaires.

The first question, regarding benefits to the manufacturing company, was described in participants' answers as a business advantage that helped the company dominate the market due to less risk and more competitiveness. The second question, regarding advantages for the service provider company, received replies such as improved standards, longer partnerships with customers, reduced costs,

identified as best-in-class in the market, and improved productivity. When asked about the degree of collaboration between the companies in relation to the Kaizen implementation, participants described it as high, moving forward with high commitment from both sides. To a question concerning beliefs that Kaizen can be used to improve inter-organizational collaboration, participants responded affirmatively.

When replies were compared with the pre-ODI assessment, the researcher noticed that people started to use stronger words to describe the benefits to both companies. To growth and save money words they added business advantage, market domination, and best-in-class. Their views on the degree of collaboration changed from mixed reactions of good and needs improvement to still growing and high commitment between the companies. This indicates that participants felt that introducing Kaizen helped both companies and improved collaboration. There was no change in feelings regarding the impact of Kaizen; both before and after ODI, people felt Kaizen could advance collaboration. Table 4 shows a comparison of answers.

The business results are clearly indicating that the working hypothesis H1 is valid.

Table 4. Pre- and Post-ODI People's Opinions
Tabela 4. Opinie przed i po ODI

Question	Pre-ODI Reply Summary	Post-ODI Reply Summary
In your opinion, what is the advantage to the manufacturing company regarding whether the service provider company is part of process improvement and the Kaizen initiative?	- Save money - Improve supply chain - Higher level of service - Better efficiency	- Business advantage - Reduced risk - competitiveness - Market domination
In your opinion, what is the advantage to the service provider company regarding whether it is part of process improvement and the Kaizen initiative?	- Business and income growth - Increase productivity - People development	- Standards improvements - Longer partnership with customers - Cost reduction - Better productivity - Become best-in-class in the market
From your point of view, what is the current degree of collaboration between the companies in terms of moving forward with implementing Kaizen?	- Mix reactions from good to needs improvement	- High level and moving forward - High commitment from both side

Table 5. Pre-and Post-ODI CSS Results
Tabela 5. Wyniki przed i po ODI CSS

Question		Extremely likely									Not at all likely	
		10	9	8	7	6	5	4	3	2	1	0
Based on your experience with the logistics company, how likely are you to recommend them to a business associate or colleague?	Pre-ODI	22%	35%	22%	13%	4%	4%	0%	0%	0%	0%	0%
	Post-ODI	18%	45%	27%	6%	0%	4%	0%	0%	0%	0%	0%
Question		Strongly Agree		Agree		Don't Know		Disagree		Strongly Disagree		
I consider the logistics company an expert in global transportation/supply chain design and optimization.	Pre-ODI	50%		45%		0%		5%		0%		
	Post-ODI	43%		52%		0%		4%		0%		
I can trust the logistic company to deliver consistently on their commitments.	Pre-ODI	41%		59%		0%		0%		0%		
	Post-ODI	18%		64%		0%		18%		0%		
I see opportunities for doing more business with the logistic company.	Pre-ODI	59%		32%		0%		9%		0%		
	Post-ODI	64%		36%		0%		0%		0%		
Compare to competitors, how would you rate the logistic company in airfreight?	Pre-ODI	0%		9%		18%		73%		0%		
	Post-ODI	0%		91%		0%		9%		0%		
Compare to competitors, how would you rate the logistic company in ocean freight?	Pre-ODI	27%		32%		9%		32%		0%		
	Post-ODI	45%		36%		0%		19%		0%		
Compare to competitors, how would you rate the logistic company in customs brokerage?	Pre-ODI	8%		32%		5%		55%		0%		
	Post-ODI	9%		36%		0%		55%		0%		

CUSTOMER SATISFACTION

Both external customer satisfaction results and internal customer voice were re-examined to identify changes in reactions after intervention. Similar questions were chosen from the new yearly Customer Satisfaction Survey (CSS) and results are presented juxtaposed with pre-ODI results in Table 5. As the survey has been given to the external customer, Sporty, 28 randomly selected employees and managers were selected to answer the same questions before and after the ODI.

As Sporty working with more than one logistics provider, its employees and managers could answer the questions comparing the service level of the different products to competitors with the right point of view independently.

When the researcher compared results before and after ODI, the following was observed: The service provider was more likely to be recommended to other colleagues

or business associates; Answers to few of the questions grew from 79% to 90%. Capabilities of the service provider as a supply chain expert and its portfolio remained neutral on "agree" and "strongly agree," with 90% and 95%, respectively. Under primary products that received attention during the Kaizen intervention, the air and ocean products, the researcher observed improvements in best-in-class and industry level. Air products moved up by 82% from 9% to 91%, and ocean products moved from 59% to 81%. This aligns with the trust the customer gave to the service provider by increasing business in these two products. For customs brokerage product that was not part of the Kaizen ODI, we can barely see any improvement; the fact that not all products gone thru the Kaizen ODI also influenced two other questions.

The researcher used two statistical tools to verify this questionnaire: Cronbach Alfa and Student t-test. To determine the consistency and reliability of the questionnaire the researcher test it by Cronbach Alfa validity test and got a results of $\alpha = 0.943$, a clear indication of high level of internal consistency.

Table 6. t-Test: Paired Two Sample for Means
Tabela 6. Test t par średnich

	Variable 1	Variable 2
Mean	106.5714286	119.7143
Variance	281.3650794	179.3968
Observations	28	28
Pearson Correlation	0.335237963	
Hypothesized Mean Difference	0	
df	27	
t Stat	-3.949108129	
P(T<=t) one-tail	0.000253137	
t Critical one-tail	1.703288446	
P(T<=t) two-tail	0.000506274	
t Critical two-tail	2.051830516	

In order to reject the null hypothesis for the small sample of 28 informants, and due to the fact that same group received the questions before and after the ODI, the researcher also used the paired t-test method on the results. Results of the t-test are shown in table 6. We can see that t = -3.949 meaning that the post ODI results has higher mean than the pre ODI; and that the p-value of the results, P (two-tail) = 0.0005 which is much smaller than the

chosen significant level of 0.05 (or 5% variance) meaning that the t value is significant enough to reject the null hypothesis.

By the survey results, the null hypothesis H0 is rejected and H2: The Kaizen-based OD activities will improve customers' satisfaction, is proven to be valid working hypothesis.

PRODUCTIVITY

Pre- and post-ODI investigations of the last element suggest productivity divided into two parts: looking at average files per person per month and EES results. The number of files after ODI was 56 per person per month, a growth of 81% from the 31 files before ODI (Table 7). The high increase of 81% in productivity by itself validating the working hypothesis H3: The Kaizen-based OD activities will improve employees' productivity.

Table 7. Pre- and Post-ODI Productivity
Tabela 7. Produkcyjność przed i po ODI

	Pre-ODI	Post-ODI	Change
Average Files/Person/ Month	31	56	81%

The researcher chose the same questions from the new yearly employee engagement survey to identify changes in perceptions regarding employees' satisfaction with work and the company. A small increase in satisfaction from employees toward the company (the first 3 questions) was identified, and a larger increase of 24% was observed when employees compared the company to competitors. There was also an increase in satisfaction regarding employees' daily work environment, and a decrease was observed in perceptions toward policies and practices, attributable to the fact that pre-ODI participants previously worked as they wish, and after ODI there was more structure that required them to work in certain ways. Table 8 details results of pre- and post-ODI.

Table 8. Pre- and Post-ODI EES Results
Tabela 8. Rezultaty ESS przed i po ODI

Item	Pre-ODI satisfactory %	Post-ODI satisfactory %
Overall, I am extremely satisfied with my company as a place to work.	81%	86%
I would gladly refer a good friend or family member to my company for employment.	67%	79%
I am proud to work for my company.	81%	86%
My company is better than our competition at responding rapidly to changes in the market.	42%	66%
I have access to the resources (e.g., materials, equipment, technology, etc.) I need to do my job effectively.	68%	74%
There is good teamwork and cooperation between different teams.	54%	67%
My company listens to and understands our customers.	76%	87%
My company is innovative and seeks out new ideas.	67%	73%

OBSERVATIONS AND REFLECTIONS ON THE PROCESS

Initially, participants were curious of whether a way of life such as Kaizen benefits them and the organization, but were also enthusiastic to implement it. Team members took intense learning steps, and when they noticed the results, they were proud of both themselves and their work. The researcher had to identify various elements that isolated the situation as much as possible, and conclude whether Kaizen plays a role in the collaboration between companies to improve performance. Based on post-ODI results, the researcher answered the original questions asked during the preparation stage:

1. To what extant did Kaizen influence the performance of a logistics service company and its manufacturing customer? Kaizen helped transform both companies' results to a much higher degree; financial growth was recorded for both companies, better productivity was observed, and large reductions in waste, CO2 emissions, and errors were achieved.
2. Did participants believe that the Kaizen methodology was effective in helping service groups form more effective working relationships? Although not all questions resulted in higher satisfaction due to the fact that not all services run under the Kaizen ODI initiative, participants indeed demonstrated support and beliefs in Kaizen's capabilities to help grow trust and relationships between the companies.
3. What did quality mean for the companies involved in the study? Based on participants' answers, the meaning of quality was reduction in waste and fewer mistakes that lead to repetitive work. Better financial and business results were also viewed as better quality.
4. Did Kaizen lead to improved collaboration between companies? By engaging in Kaizen, the companies began to improve performance and reduce both mistakes and waste in the system, leading to greater trust between companies and allowing the relationship to move from customer/service provider to collaboration.

Going back to the original null hypothesis that Kaizen-based OD activities will not make a difference in the three elements of financial and business growth, productivity and customer and employees' satisfaction, the researcher found that based on observable differences in the results of these elements before and after the ODI, the null hypothesis is rejected as the finding marks significant observable impact.

Improvements appear in two forms: small, continuous improvements (Kaizen) or drastic changes of innovation. This study examines how Kaizen, with minimal effort and small changes, influences performance radically. During ODI, the companies learned to identify what quality means to them, and how Kaizen can improve each of their objectives.

SUMMARY OF FINDINGS

The most salient finding was how Kaizen-with its small change cycles that create an evolution in the process and eliminate waste and unnecessary work-produce radical performance. Kaizen transformed relationships between the companies from customer/service provider to collaboration, and built trust between the companies that led to more interactions and more business between them. Both companies benefited from Kaizen; they achieved better financial results, fewer errors that lead to delays and business advantages for both companies. The purpose of this study was to determine the role of Kaizen in creating radical performance for a service company and its customer. The researcher identified 3 business elements that point to conclusions: business results of the two companies, customer satisfaction, and productivity.

The first element of business results involved comparing financial results, volume, working waste, and opinions. The researcher found that revenue increased by 30%, and volume by 100% for airfreight, 16% for SCM, and 75% for ocean freight, all far above industry level. This validates increasing trust of the manufacturing customer regarding the ability of the service provider to service it, confirming Kaizen actually creates radical performance results. Looking at the manufacturing customer's business results, the researcher found a reduction of 9% in unnecessary documents, and the filling time of documents improved 300%, saving space in long-term storage (120% improvement). EDI transmission errors improved by 12.3%, and CO_2 emissions reduced by 62%. These positive results helped the manufacturing customer see the benefits from Kaizen that the service provider implemented during ODI. Participants shared beliefs and perceived greater benefits for both companies, and they believed collaboration improved after the ODI.

Both external and internal customers were assessed regarding satisfaction toward the company and new context. Manufacturing customer satisfaction results showed an increase of 11% in questions related to the ability of the service provider, and its likelihood to recommend the provider to others. Results from a question concerning views of the provider's capabilities suggest an increase in airfreight (82%) and ocean (22%) products. These results accord with business growth, trust, and increased collaboration. Internal customers reported better knowledge and understanding concerning how to use Kaizen as a tool to improve work processes, and demonstrated greater beliefs in Kaizen as a tool to improve performance dramatically.

The third element, employee productivity and engagement, suggests 81% improvement in the average number of files processed per person per month. The researcher observed an increase of 24% in perceptions that the service company is better than competitors, and an increase in satisfaction from daily work environments.

CONCLUSION

This paper assesses the power of Kaizen regarding relationships between companies and its effectiveness in creating drastic performance improvements. Findings offer unique insights into the effects of Kaizen in creating radical performance improvements in a service company and its customer. Both qualitative and quantitative results of business, satisfaction, and productivity suggest time invested in introducing Kaizen into a service organization helps both companies improve relationships, and subsequently improve the bottom line. Kaizen-with its simple way of life, improving small problems continually-influenced results of both companies greatly. Such small fixes and improvements resulted in radical performance shifts.

There was a direct relationship between Kaizen and financial/volume results of the two companies. There was also a direct impact on waste reduction, productivity, and satisfaction of both customers and employees. With simple steps and training, companies can benefit greatly. Two companies evolved from having a simple customer/service provider relationship to collaboration, through a shared vision of how the future needed to look and how it could be achieved. Both companies defined the

meaning of quality, and were able to improve it.

The answer to the question "What is the role of Kaizen in creating radical performance results, and can it be effective to service groups to form more effective working relationships?" is clearly yes for the second part of the question. The role of Kaizen is to guide the mindsets of both companies toward one direction; improvement of processes, waste reduction, and efficiency are ways forward to improve the bottom line, and through them, radical performance can be achieved easily for both companies. Although many companies in the logistics industry focus on creating their own performance improvement techniques (e.g., PEX teams at Logistica) or building only an ISO capable organization, research suggests that organizations in the service industry, and logistics especially, should add Kaizen to their toolboxes.

RECOMMENDATIONS

Recommendations for the companies

During intervention, small Kaizen event changes led to results improvements. It would be wise to extend the scope of the study to include more departments and customers. Kaizen should continue to be the method of improvement and waste reduction in the company. Participants could also benefit from Kaizen as a personal development tool that leads to a personal mindset of Kaizen, or change for good. It is also recommended to further explain Kaizen methods with examples of savings to employees not involved to achieve buy-in and spread change faster. The Gemba walk interval can be conducted more frequently and with more people, even people who are unrelated to a job or process, offering fresh insights into process evaluations.

Recommendations for Future Research

Although this study identifies Kaizen as a tool to enhance collaboration between companies, it also creates opportunities for future research:

- Prioritizations of improvement projects during the study appeared as subjective conclusions from each individual. Although selection of the right project is crucial for success of Kaizen, especially during early stages, only a few tools exist to assist with it.
- This study examines specific business results and productivity measurements. It is important to identify and add more elements to verify the correctness of conclusions.
- Non-standardized Kaizen training leads to varying capabilities of people, and to varying degrees of results. It is important to search for and identify a base line for Kaizen training that includes service companies and processes that intersect multiple companies.
- Kaizen has been researched in relation to manufacturing processes greatly, but in much less volume universities teach Kaizen in service industries. More research on Kaizen in service companies is needed, and focus on companies' collaboration under Kaizen's influence would benefit the literature.

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ROLA KAIZENA W TWORZENIU RADYKALNYCH WYNIKÓW DZIAŁALNOŚCI U DOSTARCZYCIELA USŁUG LOGISTYCZNYCH

STRESZCZENIE. **Wstęp:** W pracy zaprezentowano badania nad postępującymi zmianami w procesie organizacyjnym dla otrzymania radykalnych wyników działalności dostarczyciela usług logistycznych. Znaczenie stosowania systemu Kaizen jest szeroko znana i stosowana w procesie produkcyjnym, ale nie w usługach. Praca bada wpływ wprowadzenia Kaizena jako narzędzia ODI, sposobu pracy i jego wpływu na polepszenie oferowanych usług dla grup docelowych i w rezultacie wpływu na wzrost efektywności pracy.
Metody: Badając ewolucyjną rolę Kaizena w obszarze usług, przeanalizowano wiele aspektów komunikacji w kontekście ciągłej jej poprawy oraz wpływu na poprawę organizacji pracy grupowej. Praca składa się z dwóch części: analizy zrealizowanych wcześniej prac na ten temat oraz analizy przypadku. Dane były zbierana poprzez proces obserwacji, przeprowadzania wywiadów i ankiet wśród pracowników produkcji oraz firmy oferujące przewozy morskie i powietrzne. Następnie wprowadzono zasady Kaizena i przeanalizowano ich wpływ.
Wyniki: W obu przedsiębiorstwa zaobserwowano wzrost 30% w obszarze finansowym oraz 81% wzrostu produktywności.
Wnioski: Otrzymane wyniki dają unikalne obraz efektów Kaizena dla poprawy efektywności działalności u dostawcy usług logistycznych. Otrzymane jakościowo i ilościowo wyniki finansowe, poprawy zadowolenia klientów oraz wzrostu produktywności po wprowadzeniu Kaizena pozwalają firmom na istotną poprawę stosunków biznesowych oraz opłacalności działalności.

Słowa kluczowe: Kaizen, ciągłe udoskonalanie, współpraca, usługi organizacyjne, motywacja

DIE ROLLE DES KAIZEN-SYSTEMS BEI DER ERZIELUNG RADIKALER BETRIEBSERGEBNISSE BEI LIEFERANTEN VON LOGISTISCHEN DIENSTLEISTUNGEN

ZUSAMMENFASSUNG. Einleitung: Im Rahmen der vorliegenden Arbeit wurden die Forschungen zu fortschreitenden Veränderungen im Organisationsprozess für die Erzielung radikaler Betriebsergebnisse bei Lieferanten von logistischen Dienstleistungen projiziert. Die Bedeutung der Anwendung des Kaizen-Systems ist in Produktionsprozessen durchaus bekannt und es wird auch dort sehr oft in Anspruch genommen, dagegen aber nicht innerhalb des Dienstleistungsbereiches. Die Erforschung ermittelte den Einfluss der Betätigung des Kaizen-Systems als eines ODI-Tools, dessen Funktionsweise und dessen Einfluss auf die Verbesserung der angebotenen Dienstleistungen für unterschiedliche Zielgruppen und letztendlich den Einfluss auf die Erhöhung der Arbeitseffektivität in Unternehmen.

Methoden: Indem man die evolutionsmäßige Rolle des Kaizen-Systems im Bereich der Dienstleistungen erforscht hatte, analysierte man viele Aspekte der Kommunikation hinsichtlich deren ständigen Verbesserung sowie des Einflusses auf die Verbesserung der Organisation von Gruppenarbeit. Der betreffende Beitrag setzt sich aus zwei Teilen zusammen, nämlich aus der Auswertung der zu diesem Schwerpunkt früher realisierten Forschungsarbeiten sowie einer Fallstudie. Die betreffenden Daten wurden durch die Verfolgung von Betriebsprozessen, durch Interviews und Umfrage-Untersuchungen unter den produktiven Mitarbeitern und innerhalb von Firmen, die die See- und Luftfrachtdienstleistungen anbieten, erfasst. Demzufolge wurden die Kaizen-Prinzipien eingeführt und deren betreffende Beeinflussung ist auch einer Analyse unterzogen worden.

Ergebnisse: In den beiden Unternehmen wurde ein Anstieg von 30% im finanziellen und von 81% im produktiven Bereich wahrgenommen.

Fazit: Die erzielten Ergebnisse ergaben ein eigenartiges Bild der Kaizen-Effekte für die Verbesserung der Unternehmungsleistung beim Lieferanten logistischer Dienstleistungen. Die nach der Einführung des Kaizen gewonnenen, quantitativen und qualitativen Finanzergebnisse, die Erhöhung der Zufriedenstellung der Kunden und die Produktivitätssteigerung ermöglichen den Firmen, die geschäftlichen Verhältnisse und die Rentabilität ihrer Geschäftstätigkeit wesentlich zu verbessern.

Codewörter: Kaizen, ständige Vervollkommnung, Zusammenarbeit, organisatorische Dienstleistungen, Motivation

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PROCESSES OF CONCENTRATION OF WHOLESALE TRADE IN POLAND IN THE LIGHT OF EMPIRICAL RESEARCH

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ABSTRACT. **Background:** The increasing role of trade as the integrator of distribution channels has been observed in Poland recently. Retail companies have gained a competitive advantage in relationships with both suppliers and recipients. The natural questions are, how the situation of the wholesale trade looks at present in such a situation and what prospects it has for the future. The main aim of this paper is to identify and describe the influence of new conditions on the development of the wholesale trade as part of the supply chain. The hypothesis was assumed that this development is determined by processes related to the concentration of trade companies, which were also visiblerecently in Poland.

Methods: The main concentration processes in Polish trade were identified based on a literature review and previous research. Then, based on the results of a survey and data obtained from the Central Statistical Office, the influence of these trends on the development of wholesale trade was evaluated. The further directions of changes in Polish wholesale trade were also indicated. Empirical research was conducted by the use of a direct interview with a random sample of 108 wholesale companies, both independent and as part of chains. The research focused on wholesalers' opinions of market trends and integration processes in Polish wholesale trade and cover the years 2014-15.

Results: The results show the key market processes with regard to trade concentration. The biggest threats to the development of the wholesale trade are the processes of the horizontal concentration in retail. The concentration of retail companies leads to a shortening of the distribution channels and direct purchases from producers omitting the wholesale stage. Despite these threats, wholesalers describe their situation as good, and their opinion can be confirmed in data provided by the Central Statistical Office.

Conclusions: The market processes identified must be taken into consideration in formulating the strategies of wholesale companies in Poland. The author believes that one of possible solutions which should be implemented by wholesalers is multichannel sales, as described in this paper.

Key words: trade company, wholesale trade, multichannel trade, omnichannel sale.

INTRODUCTION

The tendency towards a transformation of supply chains has been observed recently in Poland. The development of information technology, the globalization of trade, the introduction of new management standards and many other factors have led to changes in the performance of companies belonging to supply chains - trade companies, wholesale and retail companies. A change in the importance and function of separate elements of distribution channels has been observed. The role of trade as an integrator of distribution channels has increased and trade companies have gained a competitive advantage in relationships with both suppliers and clients. Therefore the question is how the situation of the wholesale trade looks in such an environment and what prospects for the further development of this segment of trade market are.

Due to continuous changes in wholesale trade, it is necessary to continue conducting research in this market segment. It should be

emphasized that there is only a limited amount of research available on wholesale trade. Additionally, the quantity of such studies is much smaller than in the case of the retail trade. However, the wholesale trade is an important part of the supply chain, which significantly affects its effectiveness. This situation became the inspiration for the Author to conduct empirical research in this area of trade.

The main aim of this paper was to identify and describe the influence of new conditions on the development of wholesale trade as an element of the supply chain. The author's hypothesis was that the development of the wholesale trade is determined by the concentration of trade companies. These processes have also been observed recently in Poland. The results of empirical research into wholesale companies formed the basis of the analysis, and covered both independent companies and those in chains . Research focused on the market tendencies and integration processes occurring in Polish wholesale trade and covers Poland between 2014-15.

Table 1. Method of sample selection
Tabela 1. Metoda doboru próby

No	Specification	Description
1.	Methods of data collection	interview by the use of the questionnaire – electronic questionnaire and direct interviews
2.	Main population	wholesale companies (of all types) operating in Wielkopolska region
3.	Interviewees	managers, responsible for the whole strategy of the company
4.	Sample size	108 subjects
5.	Method of sample selection	random

Source: own work

The process of the sample selection is presented in the Table 1. The research was conducted on the sample of 108 wholesale companies. The branch structure of the sample is presented in the Table 2.

Table 2. Branch structure of the sample
Tabela 2. Struktura próby według branż

No	Branch	Share in sample
1	Food	22,2%
2	Construction	16,7%
3	Chemical	11,1%
4	Clothing	8,3%
5	AGD	8,3%
6	Electrotechnical	8,3%
7	Pharmaceutical	8,3%
8	Packaging	5,6%
9	Products for animals	5,6%
10	Automotive	5,6%
	Total	**100,0%**

Source: questionnaire survey

As was mentioned previously, the sample consisted of both independent wholesalers and chain wholesalers from various sectors. The structure of the sample with regard to company type is presented in Table 3.

Table 3. The structure of the sample with regard to company type
Tabela 3. Struktura próby według rodzaju hurtowni

No	Branch	Quantity	Structure
1	Chain wholesalers	15	13,9 %
2	Independent wholesalers	93	86,1 %
	Total	**108**	**100,0%**

Source: questionnaire survey

Inductive reasoning was the basic research method used in the analysis.

There are several different definitions of the wholesale trade to be found in the literature. It is an exchange of large batches of goods. The wholesale trade is a connecting element between a producer and a consumer within the distribution channel [Rosenbloom 2013]. At the level of wholesale trade, the transfer of goods from the production occurs, which are then split in smaller batches and transferred to retail clients, production plants, group consumers and even individual consumers [Urban, Olszańska 1998].

According to the Central Statistical Office (CSO), wholesale trade is the sale of already acquired goods on own account to other recipients (not the end user, e.g. other wholesalers, retailers, producers). This sale can be conducted both from the company's own warehouse or another in which the goods belonging to the wholesaler are stored.

According to CSO wholesale is also the value of the sale realized on the basis of a direct payment or a contract (agents, auction dealers), as well as the value of the sales conducted on the basis of an 'indirect transfer' (the transfer of goods directly from the supplier to the receiver without the warehouses which complete the delivery) [CSO 2015].

The development of wholesale companies results from big demand for such services as these help overcome the barriers which a producer might face during the process of distributing their goods. These barriers could be: differences in the place of production and the place of consumption, different production batches, different consumption batches, different times of production and consumption. Wholesale trade eliminates these barriers and allows goods to be provided to retailers. An important function of each wholesale company is to organize the physical flow of goods, i.e. the management of deliveries, loading, preparing transport documentation and insuring the goods. It is important to mention that wholesalers finance the process of the sale of goods by buying these goods. Additionally, they cover the cost of their transport, storing them and clients lending [Specht, Fritz, 2005].

There are various types of wholesale activities, with the main types of them being presented in Figure 1.
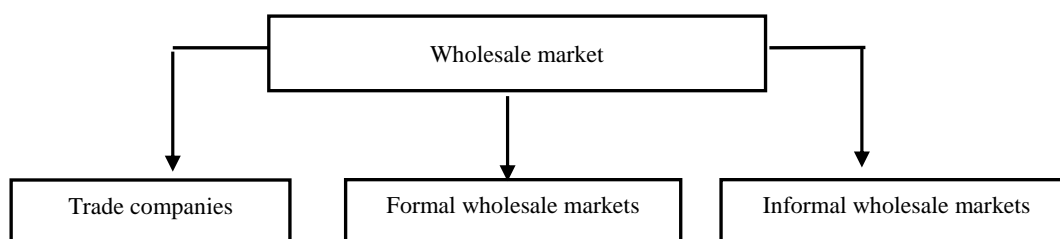
Source: own work based on Szulce, Chwałek, Ciechomski, 2008

Fig. 1. Classification of agency types of wholesale trade
Rys. 1. Klasyfikacja form pośrednictwa w ramach handlu hurtowego

As can be concluded from the Figure 1, the organizational types of wholesale activities and the area covered by them are diverse. These wholesale companies can be divided in two groups. The companies from the first group provide a wide range of services, while the second group provides only a limited range of services. These two groups of companies were the subject of the empirical research.

DEVELOPMENT TRENDS IN POLISH TRADE

The dynamic changes in Polish trade, which could be observed significantly since the beginning of the economic transformation, also cover wholesale trade. According to the scientific literature, the most important tendencies in the Polish wholesale trade are as follows [Szumilak 2007]:

– creation of business groups as the effect of capital concentration in the wholesale trade,
– decreasing the number of individual business entities due to the increasing professionalization of such activities,
– integrating wholesalers by organizing associations, groups and other agreements,
– assortment specialization of wholesale companies,
– increase in foreign capital as an effect of the internalization of wholesale trade,
– implementation of the experience of foreign companies in logistics services of clients,
– introduction of modern information systems.

As mentioned above, most of these tendencies are connected with concentration processes in wholesale trade. Such a situation

has been observed in Poland for many years. This concentration on the market can take various forms. The most important ones are:
- horizontal concentration - consists in the conjunction of companies operating at the same level, e.g. the conjunction of wholesale companies or the conjunction of retail chains,
- vertical concentration - consists in the conjunction of companies operating at different levels, e.g. the conjunction of a wholesale company with a retail company.

Concentrating (vertical and horizontal ones) trade changes the structure of entities on the market and has a significant influence on the relationships among suppliers and trade companies [Ciechomski 2010].

The list of market tendencies connected with the concentration process in wholesale trade were prepared in connection with the above-mentioned facts as well as on the basis of the literature and results of previous empirical research. The processes subject to analysis were divided according to the level of the turnover at which they occur. Therefore they are:
- processes of concentration at the level of producer,
- processes of concentration at the level of wholesaler,
- processes of concentration at the level of retailer,
- processes of concentration connected with the development of online trade in Poland.

The first part of the research was to identify concentration processes occurring in the production sector and influencing the relationships between producers and trade companies. Therefore wholesalers were asked whether they observe a market tendency of the conjunction of producers. The processes of the conjunction at the same level of turnover, otherwise known as horizontal integration, are very important due to the fact that they it changes the competitive situation of both individual companies and the sector as a whole. This issue is an important part of the model of Porter's five forces. It assumes that in the supplier-recipient relationship, the higher the level of concentration on one of the sides, the greater its weight in terms of tender procedures, which is manifested in the ability to impose particular trade conditions during the negotiation process. Opinions about tendencies in the area of production are presented in Table 4.

Table 4. The opinions about development tendencies in the area of the production
Tabela 4. Opinie respondentów na temat trendów rozwojowych w obszarze produkcji

No	Specification	Evaluation				
		I agree totally	I agree	difficult to say	I do not agree	I completely disagree
1	Producers connect with each other and therefore their number decreases (the concentration at the level of producers)	13,9%	22,2%	22,2%	**38,9%**	2,8%
2	Producers create distribution centers and take over the functions of the wholesale trade	11,1%	**55,6%**	11,1%	22,2%	0,0%

Source: questionnaire survey

As can be concluded from the answers, the wholesalers admitted that they do not notice any process of producers merging, which would increase the negotiation strength of producers. Therefore, this occurrence is positive for trade companies. Respondents pointed out another market trend, which is a threat for the wholesale trade. They highlighted the growing tendency for producers to create their own distribution centers and therefore taking over some functions, realized by wholesale trade. By investing in distribution channels and their own distribution centers,producers are in a sense competing with wholesalers. The process of shortening distribution channels, defined as decreasing turnover levels in trade and direct relationships between producers and retailers has been observed for years. Such activities are to the benefit of producers, due to

the fact that they increase both effectiveness and control over sales channels. This shortening of distribution channels is also positive for final clients within supply chains. Decreasing the functional costs of these channels results from the process of shortening distribution channels, which leads directly to lower retail prices.

This phenemenon is very dangerous for the wholesale trade as the previously mentioned functions and tasks of the wholesale trade are taken over by other participants of the distribution channels. It can be assumed that such a situation will force wholesale companies to change their strategies and the tools they use.

The development tendencies in the retail trade were taken into consideration during this research. The opinions of wholesalers are presented in Table 5.

Table 5. The opinions about development tendencies in the retail trade in Poland
Tabela 5. Opinie respondentów na temat trendów rozwojowych w handlu detalicznym w Polsce

No	Specification	Evaluation				
		I agree totally	I agree	difficult to say	I do not agree	I disagree entirely
1	The number of super- and hypermarkets (shops) will increase in the next three years	16,7%	**36,1%**	27,8%	16,7%	2,8%
2	The number of operators (owners) of retail chains will increase in the next three years	5,6%	27,8%	22,2%	**38,9%**	5,6%
3	Retailers take over other retailers (horizontal concentration at the retail level)	25,0%	**38,9%**	19,4%	16,7%	0,0%
4	The proportion of goods purchasing directly from producers will increase	19,4%	**44,4%**	13,9%	22,2%	0,0%

Source: questionnaire survey

The market trend related to producers setting up distribution centres is also connected with other trends occurring in the retail sector. As it can be concluded from the answers presented in the table, wholesalers recognize the towards horizontal concentration in the retail trade, which consists mainly in the merging of retail companies. As in the case of producers, it increases the competitive strength of retailers and therefore the ability to negotiate better commercial conditions.

Additionally, the negotiation capability of retailers is increased by another tendency observed by respondents, i.e. the increase in the number of self-service shops in Poland. According to the wholesalers interviewed, the number of self-service shops will increase during the next three years. At the same time, they do not expect that new supermarket chains will appear on the Polish market, in fact, the opposite is true: according to most respondents, there will be fewer supermarket chains.

The respondents' answers confirm the trend observed in Poland for several years of growing a number of self-service shops and a simultaneous decrease in the number of operators of supermarket chains [Ciechomski, Strojny 2009]. This tendency towards the horizontal integration of large-format stores in Poland further increases the role of those retail chains already functioning on the Polish market. The increase in the number of self-service shops also increases the role of chains as a distribution channel for producers, due to the fact that a greater proportion of income is created by this sales channel. At the same time, the decrease in the number of supermarket chain operators increases the concentration level of this part of the market and strengthens retailers' negotiation position of. The described tendency is the negative occurrence and provides the threat for the development of the wholesale trade in Poland.

The tendency for retailers to purchase directly from the producers is another dangerous factor for the development of the wholesale trade on the Polish market. This tendency was recognized and confirmed by 64% of the wholesalers interviewed. It is also confirmed by the Central Statistical Office. It

is another confirmation of previously given statement of shortening of distribution channels and establishing direct relationships between producers and retailers without the level of the wholesale trade. It will force a change in the competition strategy and whole business model of wholesale trade.

The increasing use of private label brands by trade companies is a good example a such a situation. The private label brands are an important competitive instrument for trade companies. They enable customer loyalty to be built for these brands. In this way, trade companies make themselves independent of

suppliers, which are usually producers. This tendency started a few years ago by retail chains in Poland and is still developing. It was also confirmed in the study, where 94% of respondents indicated that the proportion of private label brands is still growing across the entire assortment range of trade companies.

The market tendencies occurring in the wholesale companies were another issue analyzed in this research. These opinions are the key regarding the main aim of this research. As can be concluded from Table 6, a few distinct tendencies can be observed in the wholesale market in Poland.

Table 6. The opinions about development tendencies in wholesale trade in Poland
Tabela 6. Opinie respondentów na temat trendów rozwojowych w handlu hurtowym w Polsce

No	Specification	Evaluation				
		I agree totally	I agree	difficult to say	I do not agree	I disagree entirely
1	The number of independent wholesale companies in Poland will decrease	27,8%	**44,4%**	22,2%	5,6%	0,0%
2	Wholesalers in Poland will take over other wholesalers (concentration at the wholesale level)	19,4%	**41,7%**	25,0%	13,9%	0,0%
3	Wholesalers in Poland will take over retailers (vertical concentration)	5,6%	**36,1%**	27,8%	30,6%	0,0%

Source: questionnaire survey

The first trend is the decrease in the number of wholesale companies. 71% of respondents confirmed such an opinion. Taking this into account, the development possibilities of wholesale companies are limited.

At the same time, more than 60% of respondents recognized the horizontal concentration in the wholesale market in Poland, which consists in the conjunction of wholesale companies in Poland. It can be assumed that this merging is the answer to previously described market situation. The process of the horizontal integration within the wholesale trade can have various shapes and ranges, from a purchase group to full business integration. Such tendencies will become stronger and stronger.

At the same time, there is no unambiguous opinion among respondents on vertical integration. Only a small proportion of those interviewed agreed that wholesale companies will take over or merge with retail companies.

This process has been visible in the last 25 years (following the economic transformation at the beginning of the nineties) and affected the formation of several trade networks in Poland, consisting mainly of small retail shops. It can be assumed that this tendency is decreasing and there will be no significant changes in this area during the next years.

The respondents were asked to give an opinion about the level of turnover on the wholesale market in Poland in the next three years. It should be pointed out that according to data from the Central Statistical Office, wholesale trade turnover in Poland in the period of last four years in Poland stayed at a similar level. The wholesale turnover in 2014 was 1,018.3 billion zł, 0.8% higher than in the previous year. It should be pointed out that the wholesale turnover of companies with more than 50 employees constituted 47.1% of total turnover, as in previous years (Central Statistical Office 2015]. The respondents' opinions on this subject are presented in Table 7.

Table 7. Opinions about prospects for developing their own companies
Tabela 7. Opinie respondentów na temat perspektyw rozwoju własnej firmy

No	Specification	Evaluation				
		I agree totally	I agree	difficult to say	I do not agree	I disagree entirely
1	Wholesale turnover in Poland will decrease	11,1%	27,8%	**30,6%**	27,8%	2,8%
2	The turnover of our company will grow in next 3 years	25,0%	27,8%	**41,7%**	5,6%	0,0%

Source: questionnaire survey

The data presented in Table 7 show that the respondents were not in agreement as to whether the turnover of wholesale companies in Poland will increase or decrease. This is understandable, taking into account the analysis conducted, which shows that respondents see many threats to the development of the wholesale trade in Poland. At the same time, it should be emphasized that respondents were rather optimistic about the increase in the turnover of their own companies. Therefore the respondents see better prospects for their own companies rather than for wholesale trade as a whole.

At the end, the respondents were asked to give an opinion about the development of Internet trade in Poland. Their answers are presented in Table 8.

Table 8. The opinions about perspectives of development of the Internet trade in Poland
Tabela 8. Opinie respondentów na temat trendów rozwojowych w handlu internetowym w Polsce

No	Specification	Evaluation				
		I agree totally	I agree	difficult to say	I do not agree	I do not agree totally
1	Wholesalers create their own Internet shops	27,8%	**61,1%**	8,3%	2,8%	0,0%
2	Turnover in Internet trade in Poland will increase in next 3 years	44,4%	**52,8%**	2,8%	0,0%	0,0%

Source: questionnaire survey

As it can be assumed from the table that the respondents recognize the trend of wholesalers setting up their own Internet shops. This opinion was confirmed by 89% of those interviewed . Therefore, it is one of the most recognized and unambiguous market tendencies. It is closely related to the opinion expressed by 97% of respondents that Internet trade turnover will grow during the next three years. This creates new challenges for wholesalers and at the same time, it presents a chance for wholesalers to increase turnover and enter the retail sector. Internet trade allows companies to omit the retail level and reach individual consumers directly. But it requires wholesalers to acquire new skills and often to change the whole business structure of the company.

DIRECTIONS OF CHANGES IN THE WHOLESALE TRADE IN POLAND

The researches show trends in wholesale trade and allow developments to be pointed out. Some occurrences, which should be treated as threats, are especially noticeable.

The process of centralization is very characteristic for Polish trade as a whole, as is the tendency towards horizontal concentration. This is manifested by the merging of wholesales with other wholesalers as well as that of retailers in big trade chains. Similar processes can be observed among producers, although to a lesser degree. It should be also pointed out that respondents do not notice any tendencies of vertical concentration, e.g. the merging of wholesalers with retailers.

The centralization of retail trade is the most important threat to the development of wholesale trade. According to empirical research, more than 52% of respondents agree that the number of large format stores in Poland will grow during the next three years. Therefore, it can be concluded that the proportion of supermarkets in total retail sales in Poland will increase. It should be noted that respondents do not agree whether the number of operators will grow or not. Therefore, it can be concluded that new supermarkets will be created by operators who are already active on the Polish market.

The centralization of trade leads to the shortening of distribution channels. This constituets a significant threat to wholesale companies, which is also confirmed by Central Statistical Office data, i.e. big retail companies, especially those of a foreign origin, supply themselves directly at the producers or importers.

At the same time, wholesalers evaluate their own competitive position as good and assume a further increase in their turnover. Again, these statements are confirmed by data of Central Statistical Office, which indicate the stable situation of wholesale companies with regard to turnover during the last few years.

The next significant trend in Polish trade is the dynamic development of Internet trade. According to empirical research, the respondents are convinced of further increases in e-commerce turnover. Wholesalers increasingly use this modern sales channel, which creates a chance for them to develop and also to reach new customer groups without the retail level directly.

The development of multichannel sales should be pointed out as a direction of further development of trade in Poland, including wholesale trade. Multichannel sales are more and more used in the business practice, both by trade and production companies. Meanwhile, in contrast to the foreign literature, there is still a lack of such research in the Polish scientific literature.

The development of e-commerce technology motivates companies which have so far only operated in traditional sales channels to use this type of channel. On the other hand, companies which are active in Internet trade also consider starting businesses by the use of traditional channels. In this case, we can also call it a multichannel sale. The phases of the development of sales are presented in Figure 2.

The multichannel sale is admitted to be the company strategy which uses for sale purposes both traditional channels as well as its own Internet channel. Therefore, both traditional and electronic sale channels are used in multichannel sale. Besides, the returns are possible only by the use of the same channel where a client bought a product previously. The databases of clients of various channels are not fully integrated in this type of sale [Fost 2014].
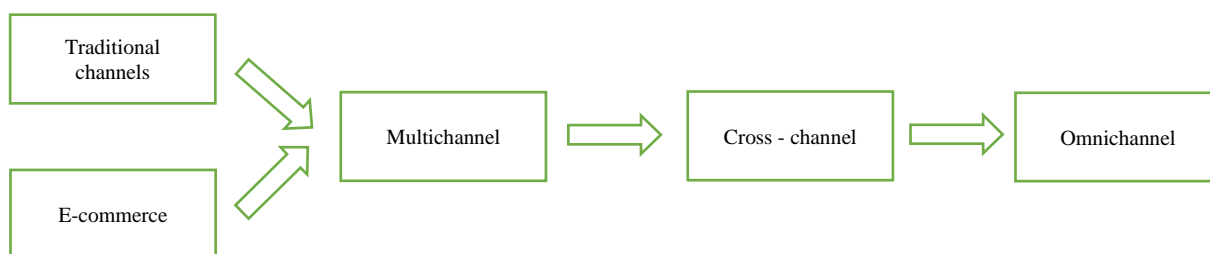
Source: own work

Fig. 2. Phases of the development of multichannel sale
Rys. 2. Etapy rozwoju sprzedaży wielokanałowej

The next phase is what is known as 'cross-channel sales'. This phase is treated as a temporary one between multichannel and omnichannel sales. In general, this solution is closer to the multichannel sales, but there is already one database of clients for the whole

company. Returns are accepted through the channels where the client previously bought a product. Therefore, from the client's point of view, there is no practical difference between multichannel and cross-channel sales [Heinemann 2013].

Finally, omnichannel sales means the full integration of sale channels and communication channels. A company allows clients to contact them and eventually to buy in the form most suitable at the moment. Returns are also conducted in the way most suitable for the client at present. Therefore, the omnichannel strategy is the most sophisticated and, at the same time, the most expensive one. It is the exemplification of the marketing philosophy. The client is the one who decides on the place, time and form of the purchase, and on the place, time and form of delivery and possible returns.

The development of the multichannel sales influences effectively the shape and the structure of distribution channels of producers and trade companies. From the point of view of a wholesale company, the introduction of new sales channels by the producer will constitute a threat, because the importance of wholesalers as the sole sales channel will decrease.

On the other hand, wholesalers also have possibility to use an additional sales channel, a fact confirmed by empirical research. It will create a chance to gain new clients and increase incomes.

The implementation of a new sales channel requires significant financial input. Therefore, it is essential to conduct an analysis of the effectiveness of individual sales channels. It can be assumed that there are some synergy effects among channels in omnichannel sales but these are very difficult to analyze. However, this will not change the fact that the omnichannel sales provide one of biggest opportunities for development, also for wholesale companies.

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PROCESY KONCENTRACJI W HANDLU HURTOWYM W POLSCE W ŚWIETLE BADAŃ EMPIRYCZNYCH

STRESZCZENIE. **Wstęp:** W ostatnich latach wzrasta rola handlu, jako integratora kanałów dystrybucji w Polsce. Przedsiębiorstwa handlu detalicznego, uzyskały przewagę konkurencyjną zarówno w relacjach z dostawcami, jak i w relacjach z odbiorcami. Powstaje pytanie, jak w tym kontekście wygląda sytuacja handlu hurtowego i jakie są perspektywy dalszego rozwoju tego segmentu działalności handlowej. Głównym celem pracy była identyfikacja i określenie wpływu nowych uwarunkowań rozwoju handlu hurtowego, jako elementu łańcucha dostaw. Autor przyjął hipotezę, że rozwój handlu hurtowego jest zdeterminowany przez procesy koncentracji przedsiębiorstw handlowych, które są zauważalne w Polsce w ostatnich latach.

Metody: Na podstawie literatury oraz wcześniejszych badań zidentyfikowano podstawowe procesy koncentracji w polskim handlu. Następnie, w oparciu o wyniki badań ankietowych oraz dane GUS, dokonano oceny wpływu tych trendów na rozwój handlu hurtowego oraz wskazano kierunki dalszych przemian w polskim handlu hurtowym. Badania empiryczne przeprowadzono metodą wywiadu bezpośredniego na losowo dobranej próbie 108 przedsiębiorstw handlu hurtowego. Zakres podmiotowy badania, obejmował zarówno hurtownie niezależne jak i hurtownie sieciowe. Przedmiot badań stanowiły opinie hurtowników dotyczące tendencji rynkowych oraz procesy integracyjne zachodzące w polskim hurcie. Zakres przestrzenny badań obejmował obszar RP, a zakres czasowy obejmował lata 2014 - 2015.

Wyniki: Wyniki badań prezentują kluczowe procesy rynkowe, związane z koncentracją w handlu. Jak wynika z przeprowadzonych badań, największym zagrożeniem dla rozwoju handlu hurtowego, są procesy koncentracji poziomej na szczeblu detalu. Koncentracja firm detalicznych prowadzi do skracania się kanałów dystrybucji i bezpośrednich zakupów dokonywanych przez sieci handlowe u producentów, z pominięciem szczebla hurtu. Kolejnym istotnym zagrożeniem dla hurtu jest rozwój handlu internetowego. Pomimo tych zagrożeń, hurtownicy oceniają aktualną sytuację swojej firmy, jako dobrą, co z kolei znajduje potwierdzenie w danych GUS.

Wnioski: Zidentyfikowane procesy rynkowe muszą zostać uwzględnione w strategiach działania przedsiębiorstw handlu hurtowego w Polsce. Zdaniem autora, jednym z rozwiązań, które firmy hurtowe powinny zastosować może być wdrożenie opisanej w artykule koncepcji sprzedaży wielokanałowej.

Słowa kluczowe: przedsiębiorstwo handlowe, handel hurtowy, handel wielokanałowy, sprzedaż multichannel, sprzedaż omnichannel

KONZENTRATIONSPROZESSE IM GROßHANDEL IN POLEN IN ANSEHNUNG VON EMPIRISCHEN FORSCHUNGEN

ZUSAMMENFASSUNG. Einleitung: In den letzten Jahren wächst die Rolle des Handels, der als Integrator von Distributionskanälen in Polen angesehen wird. Einzelhandelsunternehmen erlangten eine Wettbewerbsfähigkeit, sowohl im Verhältnis zu ihren Lieferanten, als auch zu ihren Empfängern. Angesichts dessen entsteht also die Frage, wie in diesem Zusammenhang die Situation innerhalb des Großhandels aussieht und welche Perspektiven für die weitere Entwicklung des Segmentes von Handelstätigkeit bestehen. Das Hauptziel der Arbeit war es, den Einfluss neuer Voraussetzungen auf die Entwicklung des Großhandels als des Bestandsteiles der Lieferkette zu identifizieren und zu ermitteln. Der Autor ließ sich von der Hypothese leiten, dass die Entwicklung des Großhandels durch die in den letzten Jahren in Polen erfolgenden Konzentrationsprozesse von Handelsunternehmen determiniert wird.

Methoden: Aufgrund der Gegenstandsliteratur und früherer Forschungen wurden die grundlegenden Konzentrationsprozesse innerhalb des polnischen Handels ermittelt. Ferner wurde anhand der Ergebnisse von Umfrageforschungen und statistischen Daten die Bewertung des Einflusses solcher Trends auf die Entwicklung des Großhandels vorgenommen und auf die Richtungen weiterer Veränderungen innerhalb des polnischen Großhandels hingewiesen. Die empirischen Untersuchungen wurden anhand der Methode des direkten Interviews in einer Losgröße von 108 Großhandelsunternehmen durchgeführt. Der betreffende Untersuchungsbereich umfasste sowohl unabhängig wirkende Großhandelsunternehmen, als auch Netz-Großhandelseinrichtungen. Zum Forschungsgegenstand gelangten die von Großhändlern projizierten Erachten, die die Marktrends sowie die innerhalb des polnischen Großhandels auftretenden Integrationsprozesse anbetrafen. Der Forschungsraum umfasste das Gebiet der Republik Polen und die Forschungen fanden im Zeitraum 2014 - 2015 statt.

Ergebnisse: Die Ergebnisse stellen schlüsselhafte Marktprozesse, die mit der Konzentration im Handel verbunden sind, dar. Wie aus den durchgeführten Forschungen hervorgeht, stellen die horizontalen Konzentrationsprozesse auf der Stufe des Einzelhandels die größte Gefährdung für die Entwicklung des Großhandels dar. Die Konzentration der Einzelhandel-Firmen führt zur Verkürzung von Distributionskanälen und zu den Einkäufen von Handelswaren, die durch die Handelsnetze direkt bei Produzenten und bei der Vermeidung der Großhandel-Ebene betätigt werden. Eine nächste Gefährdung für den Großhandel stellt der E-Handel dar. Trotz dieser Gefährdungen finden die Großhändler die Situation ihrer Firmen gut, was demzufolge in den betreffenden statistischen Daten seine Bestätigung findet.
Fazit: Die ermittelten Marktprozesse müssen in den Strategien für die Betätigung von Großhandelsunternehmen in Polen berücksichtigt werden. Nach Ansicht des Autors kann die Einführung des im Beitrag projizierten Konzeptes für den Mehrkanal-Absatz, das die Großhandel-Firmen in Anspruch nehmen sollten, eine der Lösungen in diesem Bereich sein.

Codewörter: Handelsunternehmen, Großhandel, Mehrkanal-Handel, Multichannel-Verkauf, Omnichannel-Verkauf.

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ACTIVITY OF SMALL BUSINESSES IN THE PROCESS OF BUILDING RELATIONSHIPS IN THE SUPPLY CHAIN

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ABSTRACT. **Background:** Multilateral cooperation is an inherent part of any business and one of the most important factors in the success of modern enterprise. Therefore, in this paper the author addresses the problem of building relationships with partners in a supply chain and focuses on the development of relational abilities as well as inter-organizational ties, and his exploration and considerations are applied to small businesses.

Methods: In the empirical part of the work the author aims to identify the scope and intensity of the involvement of small businesses in taking measures to build relationships with supply chain partners. The basic source of data is the results of empirical research conducted by the author in 2014 by means of mail and personal surveys. A questionnaire specially designed for this purpose was sent out to 500 randomly selected small businesses from the kujawsko-pomorskie region (Poland).

Results: The author provides a positive verification of the formulated hypotheses, which imply that small businesses take action to develop both their ability to establish and maintain relationships and the actual relationships with partners in the supply chain. However, they take various activities into account, but not all, and this is mostly done in a manner that is not systematically, particularly in relation to those undertakings which require more sophisticated skills and tools.

Conclusions: Propagating the theory of relational abilities among small businesses and the concepts indicating the forms of their development and use appears to be justified, even if these companies seem to be aware of the impact of the quality of relationships with supply chain partners on the effects of cooperation with them.

Key words: inter-organizational relationships, cooperation, relational abilities, supply chain, small businesses.

INTRODUCTION

According to the definition developed by the European Committee for Standardisation, the supply chain is a sequence of processes to add value to the product during its movement and processing of raw materials, through all the intermediate forms, to a form consistent with the requirements of the end customer [European Committee for Standardisation 1997]. It can therefore be considered from various perspectives, such as, for instance, the perspective of material flows and entities regulating them, the activities performed within this scope and mechanisms of co-coordinating them by co-operators, or systems of codeciding [Grzybowska 2015]. However, a supply chain is also, and perhaps above all, a structure of relationships between partners that jointly build them. These relationships determine the process of supply chain management. Such management, in turn, should be understood as integrating key business processes throughout the supply chain, from suppliers to the final consumer, including information flows [Croxton et al. 2001].

Therefore, in a supply chain we are not only dealing with flows of goods and accompanying information, or financial means, but also with the flow of benefits and risks occurring

between partners. Benefits would not be achievable without the contribution of specific partners and the occurrence of risk, which in turn is a natural consequence of the interaction with them [Glabiszewski 2013]. In particular that aspect of supply chain management highlights the importance of inter-organizational relationships which are based on mutual trust and the ability to build them. Lambert and other researchers clearly underline the fact that relationships within the framework of cooperation must be based on openness, mutual trust and the sharing of risks and benefits to allow a better result of the joint action [Lambert et al. 1996].

Recognizing the exceptional importance in today's economic reality of cooperation between companies within different networks, the author of this study decided to explore the problem of building relationships with business partners operating within a supply chain. In his research and deliberations, the author focuses on small businesses, for which it is much harder to develop partnerships with well-established entities mainly because of their limited ability to use targeted actions in this area and because of their potential that is usually not very impressive for their partners. Moreover, in theoretical considerations, as a rule, it is assumed that small businesses play a subordinate role to large ones, which are usually the leaders in a supply chain, and meticulously meet the obligations imposed by them [e.g., Noori and Lee 2006]. However, the perspective of small companies often seems to be quite different. They do not consider their participation in a supply chain from the perspective of their marginal significance and hierarchical subordination, but from the perspective of the interest being pursued, which may become significant for both sides. Furthermore, cooperation with large companies, as seen from the point of view of small businesses, rather ennobles than depreciates them.

THE ESSENCE AND SIGNIFICANCE OF INTER-ORGANIZATIONAL RELATIONSHIPS

The essence of cooperation between enterprises is to connect them in relationships that seem to be the most important part of the supply chain, and yet the most difficult part to manage and this determines the effectiveness and efficiency of the whole system. Inter-organizational relationships should be understood as relationships between entities within which the following are assumed [Sudolska 2011]:
- obtaining mutual benefits by partners,
- employing specific resources,
- their long-term orientation towards cooperation,
- their high propensity to adapt to the conditions of cooperation.

The difficulty in forming desirable relationships within a supply chain results mainly from the heterogeneity of the organizations which are cooperating. It must be remembered that a supply chain is a group of organizationally autonomous and legally independent companies making joint efforts with a view to optimizing the manner of inter-organizational coordination of logistics processes. These entities differ substantially due to their abilities, attitudes and expectations that directly affect the reinforced mutual behaviours determining the pattern of relationships between them. The shape of the relationship existing between partners is also reflected by their personality, which is shaped both by past experiences and by forward-looking aspirations.
- The basic premise of building relationships with other enterprises is to gain benefits from this cooperation. If these benefits are at the level established by the partners' expectations, then their relationship should be deemed their success. The success of the relationship is often interpreted as a combination of [Bodi-Schubert 2014] :smooth cooperation,
- continuous reduction of administrative and transaction costs,
- an increase in co-created value,
- reducing the dependency of one side on the other,
- and providing a balance of power.

The major factors of the success of relationship partners understood in this way include a two-way exchange of information, the involvement of senior management in the

development of relationships, common goals accepted by all parties in the relationship, a mutual exchange of examples of success achieved in relationships with other entities, and maintaining the status quo, in which each partner contributes to the value added to the relationship [Bodi-Schubert 2014, Grzybowska 2012].

A success factor in the relationship that reflects the scale of benefits resulting from the co-operation is undoubtedly the level of the quality achieved by partners in the relationship. The quality of relationships is often expressed as a level of mutual trust and partners' commitment. This measures the degree to which the trust and commitment of one company is correlated with the trust and commitment of its partner [Chi-Shiun et al. 2009]. The quality of the relationship is, in turn, determined by the company's ability to build and maintain inter-organizational ties, an ability which consists of the company's competences for cooperation. These are primarily a function of effective action in the field of mutual communication, coordinating joint actions and building mutual trust [Sivadas and Dwyer 2000]. It is in these areas that key opportunities to build relationships with supply chain partners must be sought.

METHODOLOGY OF EMPIRICAL RESEARCH

In the empirical part of the work, the author aims to identify the scope and the intensity of the involvement of small businesses in taking measures to build relationships with their supply chain partners. It is to be achieved through the realisation of the following three objectives:
1. to identify the scope and frequency of actions taken with a view to building the ability to establish relationships with partners in the supply chain.
2. to identify the scope and frequency of actions taken with a view to building the ability to maintain relationships with partners in the supply chain.
3. to identify the scope and frequency of the activities undertaken within the direct building of relationships with partners in the supply chain.

The statistical and descriptive analyses conducted by the author were to verify the following three hypotheses:

H1. Small businesses make efforts to develop their ability to establish relationships with partners in the supply chain.

H2. Small businesses make efforts to develop their ability to maintain relationships with partners in the supply chain.

H3. Small businesses take action with a view to developing the relationship with partners in the supply chain.

The basic source of data necessary to verify these hypotheses is empirical research conducted by the author in 2014 by means of mail and personal surveys. A questionnaire specially designed for this purpose was sent out to 500 small businesses from the kujawsko-pomorskie region (Poland) that had been randomly selected by the Provincial Statistical Office in the city of Bydgoszcz. According to the data provided by the Statistical Office, the general population amounted to 183,592 small businesses operating in the private sector, including 178,156 microenterprises. When preparing random research sampling, the criteria that were used were the company size and its belonging to one of the following three sectors: manufacturing, trade and service. As a result of the research undertaken, information was obtained from 119 small businesses, including 85 micro-enterprises. Among the entities surveyed, 39% were trade companies, 33% service companies and 28% - manufacturing ones.

SHAPING RELATIONAL ABILITIES - EMPIRICAL VERIFICATION

The basic premise of establishing and building relationships with other companies in a supply chain are potential benefits resulting from cooperation. The research conducted by the author indicates that even the vast majority (71%) of small businesses are aware of the impact of the quality of relationships connecting them with partners in the supply

chain on the effects of cooperation with them. As a result, they recognize an objective need for deliberate relationship-building with other entities. This raises the question of whether this awareness translates into real action in this regard. The search for the answer to this question must begin with a diagnosis of enterprises' involvement in developing their potential, proving their abilities in terms of building relationships. It seems natural that a company with higher relational abilities will expect more value from the relationships with their partners [Smirnova et al. 2011]. As a result, guided by an economic criterion a company should be interested in developing their ability to build such relationships that will

later guarantee their high quality and consequently, the scale of resultant benefits.

Accordingly, in the first phase of the research the author asked managers how often during the last 3 years they had made efforts to develop their abilities to build relationships with supply chain partners and grouped them into specific abilities to establish or to maintain inter-organizational relationships. Respondents answering this question had the following three answer options: 'never', 'occasionally', and 'systematically'. The research findings reflect respondents' subjective assessment and are presented in table 1.

Table 1. Involvement of businesses in building their relational abilities
Tabela 1. Zaangażowanie przedsiębiorstw w budowanie swoich zdolności relacyjnych

No.	Ability to build relationships	Systematic action	Occasional action	No action
		(% of responses)		
Abilities to establish relationships				
1	The existing network of relationships	58	33	9
2	The company's reputation	43	32	25
3	Motivation to establish relationships	28	56	16
4	Ability to communicate effectively	28	27	45
5	Strategic assumptions concerning relationship-building	18	36	46
6	Culture of openness to cooperation	12	39	49
7	The propensity to take risks in relationships	11	23	66
8	Monitoring the company's environment	8	76	16
Abilities to maintain relationships				
	Professional competence	62	38	0
2	Experience in cooperation	33	61	6
3	Infrastructure available for coordinating actions	28	28	44
4	Negotiating skills	18	52	30
5	Abilities to coordinate joint actions	16	38	46
6	Conflict-solving skills	14	50	36
7	Infrastructure in the field of communication	13	55	32
8	The propensity to invest in the relationship	9	43	48
9	Co-decision making skills	6	38	56
10	Knowledge of the principles of building trust	2	30	68

These results suggest that small businesses are involved in building their pro-relational potential concerning both establishing and maintaining relationships with partners in the supply chain, which confirms hypotheses H1 and H2. This is indicated by the scope of activities undertaken in this regard as well as by their frequency.

As part of developing the ability to establish relationships companies most often take action to expand networks with other entities, which are a source of experience and,

consequently, the knowledge and the skills used in the process of establishing business contacts (91% of the surveyed companies take such action and 58% do so 'systematically'). This activity seems to be the most understandable, since on the one hand, it is a tool for developing relational abilities, and on the other hand, it is an inherent part of current economic activities and the conscious source of potential business benefits. Moreover, the respondents frequently take action to increase the motivation to establish relationships (84% of the companies surveyed)

and inspiring them to search for and monitor potential partners in the environment (84%), as well as forming a reputation which is distinctive and well regarded in the environment (75%), and which creates trust and clearly makes it easier to establish relationships with new organizations. Most small businesses are also involved in developing their employees' communication skills (55%) and in disseminating those values within the organization that emphasise the meaning and promote the need for cooperation with other entities (51% of the companies surveyed). In addition, they include in their strategic objectives the need to build relationships with business partners (54%).

As shown by the data presented in Table 1, among the entities surveyed there are also such companies, and there are a significant number of them which do not admit to any activity within these areas of strengthening abilities to establish relationships. The lowest number of companies declares taking action aimed at increasing their propensity to take risks related to interactions with new entities. Moreover, even if they declare such activity, it often has the character of ad hoc procedures, rather than systematically implemented tactics.

Small businesses' activity in developing individual abilities to maintain relationships with partners in the supply chain is quite intensive, though very differentiated. According to our findings, professional competence is the focus of the respondents' attention. When asked about developing this component of pro-relational potential, the entire sample declared taking deliberate action in recent years, and it was usually designated as 'systematic'. Such a large commitment would most likely be explained by the fact that those competences are treated by companies not so much as a manifestation of the ability to maintain relationships, but as a basic tool used in current operations. Nevertheless, a high level of professional competence is undoubtedly a very important factor inducing other entities in the supply chain to engage in permanent and close cooperation. Moreover, as regards building experience in inter-organizational cooperation, the managers surveyed declared that they undertake common activity (94% of companies) but not as

systematic (33% of companies) activity, which is a source of the extremely valuable knowledge that conditions the future quality of relationships, due to the fact that this knowledge has been verified in practice. However, not all areas of these abilities are very popular among small businesses. Most do not make any effort, and only few of them engage systematically in the development of decisionmaking skills applied in cooperation with other entities and in the acquisition of knowledge relating to the scientific principles of building trust.

SHAPING RELATIONSHIPS WITH PARTNERS - EMPIRICAL VERIFICATION

Shaping the ability to build relationships with supply chain partners makes sense only if they are properly used in the course of cooperation with them, and are undertaken and carried out in the normal course of business. Only then will they have a chance to enjoy concrete benefits from the interaction of entities in the supply chain. Therefore, in the latter part of the research, managers were asked about the frequency of taking action designed to shape directly the relationships with supply chain partners during the last 3 years. Again, they were given three answer options: 'never', 'occasionally, and 'systematically'. The answers are shown in Figure 1.

Based on these findings, hypothesis H3 should be considered as valid. According to the hypothesis, small businesses take action with a view to developing the relationship with partners in the supply chain and in a fairly wide range. Unfortunately, in most of the areas analysed, these actions are occasional rather than systematic. In the case of such an elementary operation seeking to establish contacts with selected partners, most of the companies (58%) admitted undertaking systematic activities, and a further 35% - sporadic. An equally large proportion, i.e., 92% of the companies declare that they take their partners' expectations into account in their day-to-day activities, which is also not surprising, since such behaviour seems to be a prerequisite for maintaining relationships.

What is quite puzzling is the fact that 8% of those companies do not do this, especially that being a small business only it is difficult to dictate one's own terms of cooperation. A high level of activity is also shown by the companies surveyed in terms of establishing mechanisms to coordinate cooperation with partners (88%) and adapt their own resources to the conditions of cooperation (86%).
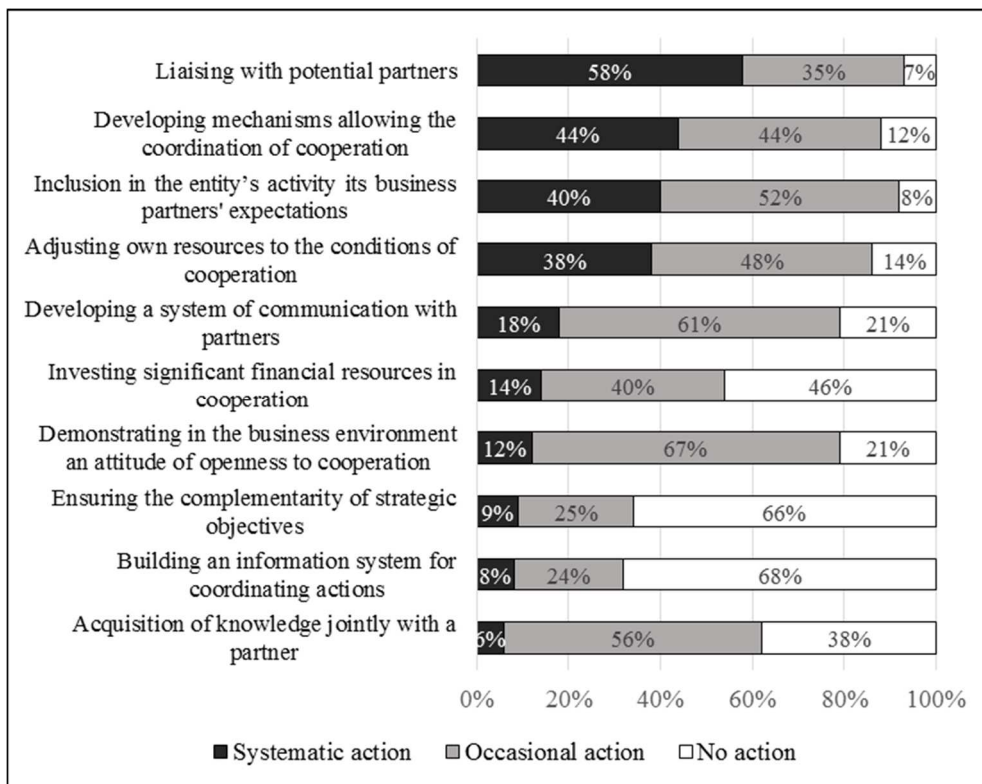

Fig. 1. The involvement of companies in building relationships with supply chain partners (% of responses)
Rys. 1. Zaangażowanie przedsiębiorstw w budowanie relacji z partnerami w łańcuchu dostaw (% wskazań)

Small businesses exhibit the most passive attitude with regard to ensuring the complementarity of their strategic objectives relative to their partners and building a computer system to coordinate joint actions. These activities seem to be more demanding, both for reasons of competence and finance, which in the case of small businesses is reflected in the absence of that activity. Furthermore, for financial reasons a significant part of the companies (46%) do not make a significant investment in developing cooperation within the supply chain, which could affect the size of its benefits. Another distressing aspect is the very limited involvement of small businesses in the systematic acquisition of knowledge together with a partner, especially in terms of the importance of this aspect of building relationships, which is frequently signalled in the literature. it transpires that the joint efforts made by the buyer and the supplier in order to acquire knowledge not only impact directly on the effects of their relationship, but also the willingness to make investments in specific assets and skills to the benefit of the cooperation, which, in turn, further increases the scale of the effects of this relationship [Mesquita et al. 2008].

CONCLUSION

In the study the author addresses the research of building relationships with business partners operating in a supply chain and focuses on small businesses.

When analysing the empirical material, it must be assumed that small businesses are involved in building their pro-relational

potential relative both to establishing and maintaining relationships with partners in a supply chain. This commitment, however, is differentiated in various areas of this potential and is often a short-term operation rather than systematically implemented actions. Moreover, the companies surveyed exhibit the largest pro-developmental activity in relation to those elements that are not only about the ability to build relationships but are also used in current operations, such as the professional competence, experience in cooperation, or a previously formed network of relationships.

A similar situation can be seen in the case of the involvement of the companies in the direct formation of desired relationships with supply chain partners. They undertake various activities in this regard, but not all of them, and mostly not systematically, particularly in relation to those undertakings which require more sophisticated skills and tools. This seems to be understandable due to the fact that they are small companies with limited capabilities, both intellectual and material.

This means that companies that even declare their commitment to the development of relational abilities do not necessarily take intentional actions to achieve this, especially those that are demanding and focused on developing specific abilities within a separate and clearly identified pro-relational potential. Therefore, propagating the theory of relational abilities and the concepts indicating the forms in which they might be developed and used among small businesses appears to be justified, even if these companies seem to be aware of the impact of the quality of relationships with supply chain partners on the effects of cooperation with them. This postulate is even more legitimate since it refers to an obvious need for multidimensional cooperation between companies in the supply chain and in the case of small companies with well-established entities from the business environment.

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AKTYWNOŚĆ MAŁYCH PRZEDSIĘBIORSTW W PROCESIE BUDOWANIA RELACJI W ŁAŃCUCHU DOSTAW

STRESZCZENIE. **Wstęp:** Wielostronne współdziałanie jest immanentnym elementem każdej działalności gospodarczej i jednocześnie jednym z najważniejszych czynników sukcesu współczesnego przedsiębiorstwa. Dlatego też autor w niniejszym opracowaniu podejmuje problem budowania relacji z partnerami w łańcuchu dostaw, koncentrując się na kształtowaniu zdolności relacyjnych i więzi międzyorganizacyjnych, przy czym swoje poszukiwania i rozważania odnosi do małych przedsiębiorstw.
Metody: W części empirycznej swego opracowania autor stawia sobie za cel dokonanie identyfikacji zakresu i intensywności zaangażowania małych przedsiębiorstw w podejmowanie działań na rzecz budowania relacji z partnerami w łańcuchu dostaw. Podstawowe źródło danych niezbędnych do realizacji przyjętego celu stanowią wyniki badania empirycznego przeprowadzonego przez autora w 2014 r. metodą ankiety w wersji pocztowej i osobistej. Przygotowany w tym celu kwestionariusz ankiety został skierowany do losowo wybranych 500 małych przedsiębiorstw regionu kujawsko-pomorskiego.
Wyniki: W artykule autor pozytywnie weryfikuje przyjęte przez siebie hipotezy, w ramach, których zakłada, że małe przedsiębiorstwa podejmują działania mające na celu rozwój zarówno swych zdolności do nawiązywania oraz utrzymywania relacji, jak również samych relacji z partnerami w łańcuchu dostaw. Niemniej jednak ich zaangażowanie w tym zakresie jest istotnie zróżnicowane i raczej niesystematyczne, zwłaszcza w odniesieniu do tych przedsięwzięć, które wymagają zastosowania bardziej wysublimowanych kompetencji i narzędzi.
Wnioski: Uzasadnionym wydaje się propagowanie wśród małych przedsiębiorstw teorii zdolności relacyjnych oraz koncepcji wskazujących formy ich rozwijania i wykorzystywania, nawet, jeśli przedsiębiorstwa te wydają się być uświadomione, co do wpływu jakości relacji z partnerami w łańcuchu dostaw na efekty współpracy z nimi.

Słowa kluczowe: relacje międzyorganizacyjne, współpraca, zdolności relacyjne, łańcuch dostaw, małe przedsiębiorstwa

AKTIVITÄTEN VON KLEINUNTERNEHMEN BEIM HERSTELLEN VON BEZIEHUNGEN IN LIEFERKETTEN

ZUSAMMENFASSUNG. Einleitung: Gemeinsames Wirken ist jeder wirtschaftlichen Tätigkeit immanent und ist auch gleichzeitig einer der wichtigsten Erfolgsfaktoren eines modernen Unternehmens. Im vorliegenden Beitrag wird dem Problem der Beziehungen zu Partnern in Lieferketten Rechnung getragen. Der Autor konzentriert sich dabei auf die Entwicklung von unternehmensbezogenen Beziehungskompetenzen und interorganisationalen Netzwerken, wobei er bei seinen Erwägungen und seiner Suche kleine Unternehmen unter die Lupe nimmt.
Methoden: Mit dem empirischen Teil der Studie bezweckt der Autor die Identifizierung von Umfang und Stärke des Engagements von kleinen Unternehmen bei ihren Maßnahmen zur Herstellung von partnerschaftlichen Beziehungen in Lieferketten. Die grundlegende Quelle der zur Realisierung des Vorhabens notwendigen Daten sind die Ergebnisse einer vom Autor im Jahre 2014 elektronisch und persönlich durchgeführten Umfrage. Der für diese Umfrage entwickelte Fragebogen wurde an 500 stichprobeweise ausgewählte Kleinunternehmen der Region Kujawien-Pommern (Polen) verschickt.
Ergebnisse: In dem Beitrag werden die vom Autor aufgestellten Hypothesen positiv verifiziert. Es wurde angenommen, dass kleine Unternehmen gezielt Maßnahmen ergreifen zur Entwicklung ihrer Fähigkeiten, Beziehungen aufzunehmen und aufrechtzuerhalten sowie zur Entwicklung und Stärkung der bereits bestehenden Partnerbeziehungen innerhalb der betreffenden Lieferketten. Nichtsdestotrotz ist zu bemerken, dass ihr Engagement sehr differenziert und eher als unregelmäßig zu bezeichnen ist, insbesondere bei solchen Maßnahmen, die sublimere Kompetenzen und Tools erfordern.

Fazit: Es scheint begründet zu sein, bei Kleinunternehmen Theorien über Beziehungskompetenzen sowie Konzepte zu deren Entwicklungs- und Gebrauchsformen zu verbreiten, auch wenn sich diese Unternehmen selbst des Einflusses der Qualität von Partnerbeziehungen in Lieferketten auf die Ergebnisse der gegenseitigen Zusammenarbeit bewusst sind.

Codewörter: interorganisationale Beziehungen, Zusammenarbeit, Beziehungskompetenzen, Lieferkette, Kleinunternehmen.

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A FRAMEWORK FOR AN INVENTORY MODEL FOR DETERIORATING ITEMS WITH EXPIRATION UNDER TRAPEZOIDAL-TYPE DEMAND AND PARTIAL BACKLOGGING

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ABSTRACT. **Background:** As in the case of deteriorating items, expiration plays a major role in inventory management, a generalized approach is studied based on an inventory model for deteriorating items with expiration dates.
Methods: In this paper, the demand rate during the cycle time is assumed to be trapezoidal. Shortages are allowed and partially backlogged. An inventory replenishment strategy is formulated for trapezoidal demand rates and backlogging rates in general for retailers; with the support of fundamental concepts of calculus.
Results: The method is illustrated with the support of numerical examples along with sensitivity analysis with respect to major parameters.
Conclusion: This generalized approach provides a platform to develop a strategy using different demand functions and backlogging rates.

Key words: Inventory, deteriorating items with expiration, trapezoidal demand rate, partial backlogging.

INTRODUCTION

In the present business environment, the effect of a deterioration on items cannot be ignored in the inventory system. Deterioration is defined as any process which decreases the present value or utility of an item and prevents it from being used for its original use because of continuous spoilage, degradation, evaporation. Such items not only deteriorate but also have their expiration dates. For example, fruits, vegetables and other foodstuffs deteriorate due to spoilage occuring during storage, while electronic goods and photographic film deteriorate because of a gradual loss of utility with time. A significant deterioration occurs during routine storage periods, and as a result, the loss must be taken into account while formulating models.

Therefore, many researchers have considered the effect of deterioration when developing inventory policies. An exponentially decaying inventory model was first developed by Ghare and Schrader [1963], who observed that some items shrink with time by a proportion which can be estimated using a negative exponential function of time. Whitin [1957] considered fashion goods to go out of fashion at the end of some period. At the initial studies in this field, most models were developed with a constant deterioration rate, such as Aggarwal [1978], Bhunia and Maiti [1999] etc. Recently, however, many researchers have formulated models for deteriorating inventory systems in different scenarios. A literature survey by Nahmias [1982], Raafat [1991], Shah and Shah [2000], Goyal and Giri [2001] and Bakker et al. [2012] produced an up-to-date review of deteriorating inventory models. However, none

of the above articles were formulated for deteriorating items with expiration. Wang et al. [2014], Chen et al. [2013] and Shah et al. [2014] considered expiration of a deteriorating item into account.

For the first time, Hill [1995] formulated an inventory model with a ramp-type demand rate. In the case of ramp-type demand rate, the rate of demand increases linearly at the beginning, then remains constant until the end of the replenishment cycle. Such a demand pattern is mostly observed in new brand consumer goods which are likely to be introduced in market. The demand rate of such products is generally an increasing function of time to some extent, then it becomes constant. Many researchers have studied inventory models with ramp-type demand. Cheng and Wang [2009] extended this idea from ramp-type demand to trapezoidal-type demand. Cheng et al. [2011] extended the model to deteriorating items and by allowing shortages, with partial backlogging.

Here, we consider an inventory system for deteriorating items with expiration dates or with a maximum life time during the ordering cycle. For products like fashionable commodities, mobile phones, drugs and other with a short life cycle, the rate of demand increases at the beginning up to a particular level, then stabilizes and become constant. After some time, it starts decreasing due to either the presence of a competitive product or expiration. i.e. the demand rate is assumed to be a continuous trapezoidal function of time. At present, during the stockout period, depending upon the waiting time for the next replenishment, some customers are willing to wait, while others may be impatient and go elsewhere as the waiting time increases. To take account of the effect of shortages, we assume shortages are allowed and partially backlogged with a backlogging rate depending upon the waiting time for the next replenishment. By analyzing this inventory system, we propose an algorithm to define the optimal replenishment policy with the assumption mentioned above. The mathematical formulation is supported by numerical examples and sensitivity analysis is carried out with respect to the major

parameters. The outline for the rest of this article is as follows: Section 2 deals with a list of assumptions with notations; section 3 comprises a mathematical formulation of the problem. To support this formulation, the problem is illustrated numerically in section 4. Sensitivity analysis is carried out in section 5. The authors' conclusions are presented in section 6.

ASSUMPTIONS AND NOTATIONS

Notations and assumptions used in the formulation of a model in mathematical form and considered in this article are given below.

1. The inventory system deals with a single item. The replenishment rate is infinite and the lead time is zero or negligible. The planning horizon is assumed to be infinite.
2. Function I(t) represents the level of inventory at any point in time t, where $0 \le t \le T$
3. T is the length of fixed ordering cycle.
4. The demand rate is a positive and trapezoidal type function of time is defined as follows:

$$D(t) = \begin{cases} f(t) & ; \quad 0 \le t \le \lambda_1 \\ D_0 & ; \quad \lambda_1 \le t \le \lambda_2 \\ g(t) & ; \quad \lambda_2 \le t \le T \end{cases} \quad (1)$$

i.e. $t=\lambda_1$ is the time when increasing demand function *f(t)* turn out to be a constant demand function D_0. And $t = \lambda_2$ is the time when constant demand function D_0 becomes a decreasing function $g(t)$
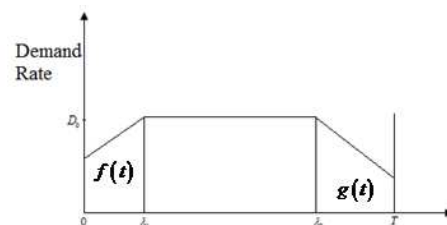

Fig. 1. Trapezoidal type function for demand
Rys. 1. Trapezoidalny typ funkcji popytu

5. During cycle time item does not only deteriorate, but it has maximum life, say *m*.

Therefore, we define the deterioration rate as:

$$\theta(t) = \frac{1}{1+m-t}, \quad 0 < t \le m. \qquad (2)$$

Remark: If $t = m$ then item deteriorates completely as $\theta(t) = 1$. Also consider either $T < m$ or $m \le T$. Here, $T < m$ shows the inventory will deteriorate completely after the cycle time, i.e. it can be used to satisfy demand up to the cycle time with an increasing rate of deterioration. However in case of $m \le T$ inventory deteriorates completely before or up to the cycle time. This case needs to be given greater importance when setting up the cycle time.

6. t_1 is the time at which the level of inventory becomes zero during the ordering cycle.

7. Shortages are allowed and partially backlogged. During stockout period, the backlogging rate is variable depending upon the length of the waiting time for the next refill. The proportion of customers who willing to accept backlogging at time t with a waiting time $(T - t)$ for the next refill. So, we assume backlogging rate as $B(t)$ during $t_1 \le t \le T$.

8. I_M is the maximum level of inventory for each ordering cycle. And I_B is total number of units backordered. Hence, economic order quantity is $Q = I_M + I_B$

9. We consider: C_d is the cost of deterioration/unit, C_h is the holding cost/unit /time unit, C_b is the backorder cost /unit, C_L is cost due to lost sale/unit.

10. $TC_i(t_1)$, $i = 1, 2, 3$ is the average total cost of an inventory system under different circumstances, respectively.

MATHEMATICAL MODEL

In this section, a mathematical model for the inventory system is developed from the retailer's viewpoint. It is assumed that the inventory system starts with no shortages. The flow of an inventory during ordering cycle is expressed in the Figure 2. At time $t = 0$, replenishment occurs and the retailer's opening inventory level is I_M units. This maximum level of inventory reduces to zero at $t = t_1$ with combined effect of deterioration and demand. Shortages occurs during (t_1, T), during this stockout period, demand is partially backlogged with rate B(t).
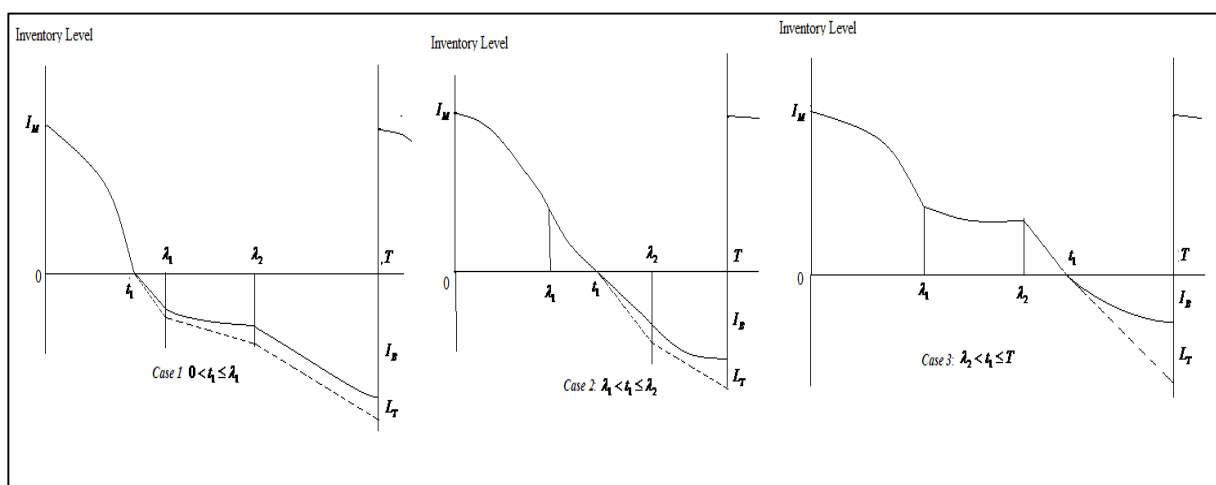

Fig. 2. Inventory level during ordering cycle with different cases
Rys. 2. Poziom zapasów w trakcie cyklu zamawiania w rozpatrywanych sytuacjach

Next, we consider three different cases, which depend on the values of t_1, λ_1 and λ_2. These three cases are summarized as follows:

Case 1: $0 < t_1 \leq \lambda_1$

From (2), the differential equations which govern the inventory model are as follows:

$$\frac{dI(t)}{dt} = \begin{cases} -\theta(t)I(t) - f(t) & ; \quad 0 < t < t_1 \\ -B(t)f(t) & ; \quad t_1 < t < \lambda_1 \\ -B(t)D_0 & ; \quad \lambda_1 < t < \lambda_2 \\ -B(t)g(t) & ; \quad \lambda_2 < t < T \end{cases} \tag{4}$$

Using boundary conditions solution of equations (4) is,

$$I(t) = \begin{cases} (1+m-t)\displaystyle\int_t^{t_1} \frac{f(x)}{1+m-x}dx & ;0 < t < t_1 \\ -\displaystyle\int_{t_1}^t B(x)f(x)dx & ;t_1 < t < \lambda_1 \\ -\displaystyle\int_{t_1}^{\lambda_1} B(x)f(x)dx - D_0\int_{\lambda_1}^t B(x)dx & ;\lambda_1 < t < \lambda_2 \\ -\displaystyle\int_{t_1}^{\lambda_1} B(x)f(x)dx - D_0\int_{\lambda_1}^{\lambda_2} B(x)dx - \int_{\lambda_2}^t B(x)g(x)dx & ;\lambda_2 < t < T \end{cases} \tag{5}$$

Now, using condition, $I(0) = I_M$, we have an initial level of inventory as:

$$I_M = (1+m)\int_0^{t_1} \frac{f(x)}{1+m-x}dx \tag{6}$$

The total amount of deterioration during cycle time is,

$$D_T = I_M - \int_0^{t_1} D(x)dx = \int_0^{t_1} \frac{xf(x)}{1+m-x}dx \tag{7}$$

The total amount of inventory H_T present during the interval $[0, t_1]$ is,

$$H_T = \int_0^{t_1} I(t)dt = \int_0^{t_1} (1+m-t)\left(\int_t^{t_1} \frac{f(x)}{1+m-x}dx\right)dt \tag{8}$$

The total shortages occurring during time duration $[t_1, T]$ are,

$$B_T = -\int_{t_1}^T I(t)\,dt$$

$$= \int_{t_1}^{\lambda_1}\left[\int_{t_1}^t B(x)f(x)dx\right]dt + \int_{\lambda_1}^{\lambda_2}\left[\int_{t_1}^{\lambda_1} B(x)f(x)dx + D_0\int_{\lambda_1}^t B(x)dx\right]dt$$

$$+\int_{\lambda_2}^{T}\left[\int_{t_1}^{\lambda_1}B(x)f(x)dx+D_0\int_{\lambda_1}^{\lambda_2}B(x)dx+\int_{\lambda_2}^{t}B(x)g(x)dx\right]dt \qquad (9)$$

Total loss of sales during $[t_1,T]$ is,

$$L_T=\int_{t_1}^{T}(1-B(x))D(x)dx$$

$$=\int_{t_1}^{\lambda_1}(1-B(x))f(x)dx+\int_{\lambda_1}^{\lambda_2}(1-B(x))D_0dx+\int_{\lambda_2}^{T}(1-B(x))g(x)dx \qquad (10)$$

Maximum backordered inventory during $[t_1,T]$ is,

$$I_B=-I(T)=\int_{t_1}^{\lambda_1}B(x)f(x)dx+D_0\int_{\lambda_1}^{\lambda_1}B(x)dx+\int_{\lambda_2}^{T}B(x)g(x)dx \qquad (11)$$

As $Q=I_M+I_B$

$$=(1+m)\int_{0}^{t_1}\frac{f(x)}{1+m-x}dx+\int_{t_1}^{\lambda_1}B(x)f(x)dx+D_0\int_{\lambda_1}^{\lambda_2}B(x)dx+\int_{\lambda_2}^{T}B(x)g(x)dx \qquad (12)$$

Hence, the total average cost per time unit can be defined as follows:

$$C_1(t_1)=\frac{1}{T}\left[A+C_pQ+C_dD_T+C_hH_T+C_bB_T+C_LL_T\right]$$

$$=\frac{A}{T}+\frac{C_P}{T}\left[(1+m)\int_{0}^{t_1}\frac{f(x)}{1+m-x}dx+\int_{t_1}^{\lambda_1}B(x)f(x)dx+D_0\int_{\lambda_1}^{\lambda_2}B(x)dx+\int_{\lambda_2}^{T}B(x)g(x)dx\right]$$

$$+\frac{C_d}{T}\left[\int_{0}^{t_1}\frac{xf(x)}{1+m-x}dx\right]+\frac{C_h}{T}\int_{0}^{t_1}(1+m-t)\left(\int_{t}^{t_1}\frac{f(x)}{1+m-x}dx\right)dt$$

$$+\frac{C_b}{T}\left[\int_{t_1}^{\lambda_1}\left[\int_{t_1}^{t}B(x)f(x)dx\right]dt+\int_{\lambda_1}^{\lambda_2}\left[\int_{t_1}^{\lambda_1}B(x)f(x)dx+D_0\int_{\lambda_1}^{t}B(x)dx\right]dt\right]$$

$$+\frac{C_b}{T}\left\{\int_{\lambda_2}^{T}\left[\int_{t_1}^{\lambda_1}B(x)f(x)dx+D_0\int_{\lambda_1}^{\lambda_2}B(x)dx+\int_{\lambda_2}^{t}B(x)g(x)dx\right]dt\right\}$$

$$+\frac{C_L}{T}\int_{t_1}^{\lambda_1}(1-B(x))f(x)dx+\int_{\lambda_1}^{\lambda_2}(1-B(x))D_0dx+\int_{\lambda_2}^{T}(1-B(x))g(x)dx \qquad (13)$$

Case 2: $\lambda_1<t_1\leq\lambda_2$

$$\frac{dI(t)}{dt}=\begin{cases}-\theta(t)I(t)-f(t) & ; \quad 0<t<\lambda_1 \\ -\theta(t)I(t)-D_0 & ; \quad \lambda_1<t<t_1 \\ -B(t)D_0 & ; \quad t_1<t<\lambda_2 \\ -B(t)g(t) & ; \quad \lambda_2<t<T\end{cases} \qquad (14)$$

Using the boundary conditions solution of equations (14) is,

$$I(t) = \begin{cases} (1+m-t)\left[\int_t^{\lambda_1} \dfrac{f(x)}{1+m-x}dx + D_0\log\left(\dfrac{1+m-\lambda_1}{1+m-t_1}\right)\right]; & 0 < t < \lambda_1 \\[3mm] D_0\log\left(\dfrac{1+m-t}{1+m-t_1}\right) & ; \lambda_1 < t < t_1 \\[3mm] -D_0\int_{t_1}^t B(x)dx & ; t_1 < t < \lambda_2 \\[3mm] -D_0\int_{t_1}^{\lambda_2} B(x)dx - \int_{\lambda_2}^t B(x)g(x)dx & ; \lambda_2 < t < T \end{cases}$$ (15)

Now, using the condition, $I(0) = I_M$, we have the initial level of inventory as:

$$I_M = (1+m)\left[\int_0^{\lambda_1} \frac{f(x)}{1+m-x}dx + D_0\log\left(\frac{1+m-\lambda_1}{1+m-t_1}\right)\right]$$ (16)

The total amount of deterioration during the cycle time is,

$$D_T = I_M - \int_0^{t_1} D(x)dx = D_0\left[\log\left(\frac{1+m-\lambda_1}{1+m-t_1}\right) - (t_1-\lambda_1)\right] + \left[\int_0^{\lambda_1} \frac{xf(x)}{1+m-x}dx\right]$$ (17)

The total amount of inventory H_T present during the interval $[0, t_1]$ is,

$$H_T = \int_0^{t_1} I(t)dt = \int_0^{\lambda_1} I(t)dt + \int_{\lambda_1}^{t_1} I(t)dt$$

$$= \int_0^{\lambda_1} (1+m-t)\left\{\int_t^{\lambda_1} \frac{f(x)}{1+m-x}dx + D_0\log\left(\frac{1+m-\lambda_1}{1+m-t_1}\right)\right\}dt$$

$$+ \int_{\lambda_1}^{t_1} D_0\left\{\log\left(\frac{1+m-t}{1+m-t_1}\right)\right\}dt$$ (18)

The total shortages occurring during the time duration $[t_1, T]$ are,

$$B_T = -\int_{t_1}^T I(t)\,dt$$

$$= \int_{t_1}^{\lambda_2}\left\{D_0\int_{t_1}^t B(x)dx\right\}dt + \int_{\lambda_2}^T\left\{D_0\int_{t_1}^{\lambda_2} B(x)dx - \int_{\lambda_2}^t B(x)g(x)dx\right\}dt$$ (19)

The total loss of sales during $[t_1, T]$ is,

$$L_T = \int_{t_1}^T (1-B(x))D(x)dx = \int_{t_1}^{\lambda_2} (1-B(x))D_0 dx + \int_{\lambda_2}^T (1-B(x))g(x)dx$$ (20)

Maximum backordered inventory during $[t_1, T]$ is,

$$I_B = -I(T) = D_0\int_{t_1}^{\lambda_2} B(x)dx + \int_{\lambda_2}^T B(x)g(x)dx$$ (21)

As $Q = I_M + I_B = \left[\int_0^{\lambda_1} \frac{(1+m)f(x)}{1+m-x}dx + D_0(1+m)\log\left(\frac{1+m-\lambda_1}{1+m-t_1}\right)\right]$

$$+D_0 \int_{t_1}^{\lambda_2} B(x)\,dx + \int_{\lambda_2}^{T} B(x)\,g(x)\,dx \tag{22}$$

Hence, the total average cost per time unit can be defined as follows:

$$C_2(t_1) = \frac{1}{T}\left[A + C_p Q + C_d D_T + C_h H_T + C_b B_T + C_L L_T \right]$$

$$= \frac{A}{T} + \frac{C_P}{T}\left[\int_0^{\lambda_1} \frac{(1+m)\,f(x)}{1+m-x}\,dx + D_0(1+m)\log\left(\frac{1+m-\lambda_1}{1+m-t_1}\right) + D_0 \int_{t_1}^{\lambda_2} B(x)\,dx \right]$$

$$+ \frac{C_P}{T}\left[\int_{\lambda_2}^{T} B(x)\,g(x)\,dx \right] + \frac{C_d}{T}\left[D_0\left[\log\left(\frac{1+m-\lambda_1}{1+m-t_1}\right) - (t_1 - \lambda_1)\right] + \left[\int_0^{\lambda_1} \frac{x\,f(x)}{1+m-x}\,dx \right]\right]$$

$$+ \frac{C_h}{T}\left[\int_0^{\lambda_1}(1+m-t)\left\{ \int_t^{\lambda_1} \frac{f(x)}{1+m-x}\,dx + D_0\log\left(\frac{1+m-\lambda_1}{1+m-t_1}\right)\right\}dt + \int_{\lambda_1}^{t_1} D_0\left\{\log\left(\frac{1+m-t}{1+m-t_1}\right)\right\}dt\right]$$

$$+ \frac{C_b}{T}\left[\int_{t_1}^{\lambda_2}\left\{ D_0\int_{t_1}^{t} B(x)\,dx \right\}dt + \int_{\lambda_2}^{T}\left\{ D_0\int_{t_1}^{\lambda_2} B(x)\,dx - \int_{\lambda_2}^{t} B(x)\,g(x)\,dx\right\}dt\right]$$

$$+ \frac{C_L}{T}\left[\int_{t_1}^{\lambda_2}(1-B(x))D_0\,dx + \int_{\lambda_2}^{T}(1-B(x))\,g(x)\,dx \right] \tag{23}$$

Case 3: $\lambda_2 < t_1 \le T$

$$\frac{dI(t)}{dt} = \begin{cases} -\theta(t)I(t) - f(t) & ; \quad 0 < t < \lambda_1 \\ -\theta(t)I(t) - D_0 & ; \quad \lambda_1 < t < \lambda_2 \\ -\theta(t)I(t) - g(t) & ; \quad \lambda_2 < t < t_1 \\ -B(t)g(t) & ; \quad t_1 < t < T \end{cases} \tag{24}$$

Using the boundary conditions solution of equations (25) is,

$$I(t) = \begin{cases} (1+m-t)\left[\int_t^{\lambda_1} \frac{f(x)}{1+m-x}\,dx + D_0\int_{\lambda_1}^{\lambda_2} \frac{1}{1+m-x}\,dx + \int_{\lambda_2}^{t_1} \frac{g(x)}{1+m-x}\,dx\right] ; \ 0 < t < \lambda_1 \\[6pt] (1+m-t)\left[\int_t^{\lambda_2} D_0\frac{1}{1+m-x}\,dx + \int_{\lambda_2}^{t_1} \frac{g(x)}{1+m-x}\,dx\right] \qquad\qquad ; \lambda_1 < t < \lambda_2 \\[6pt] (1+m-t)\int_t^{t_1} \frac{g(x)}{1+m-x}\,dx \qquad\qquad\qquad\qquad\qquad ; \lambda_2 < t < t_1 \\[6pt] -\int_{t_1}^{t} B(x)\,g(x)\,dx \qquad\qquad\qquad\qquad\qquad\qquad\quad ; t_1 < t < T \end{cases} \tag{25}$$

Now, using the condition, $I(0) = I_M$, we have an initial level of inventory as:

$$I_M = \left[\int_0^{\lambda_1} \frac{(1+m)\,f(x)}{1+m-x}\,dx + D_0(1+m)\log\left(\frac{1+m-\lambda_1}{1+m-t_1}\right) + \int_{\lambda_2}^{t_1} \frac{(1+m)\,g(x)}{1+m-x}\,dx \right] \tag{26}$$

The total amount of deterioration during the the cycle time is,

$$D_T = I_M - \int_0^{t_1} D(x)\,dx$$

$$= \left[\int_0^{\lambda_1} \frac{x f(x)}{1+m-x}\,dx + D_0 \left\{ (1+m)\log\left(\frac{1+m-\lambda_1}{1+m-t_1}\right) - (\lambda_2 - \lambda_1) \right\} + \int_{\lambda_2}^{t_1} \frac{x g(x)}{1+m-x}\,dx \right] \quad (27)$$

The total amount of inventory H_T present during the interval $[0, t_1]$ is,

$$H_T = \int_0^{t_1} I(t)\,dt = \int_0^{\lambda_1} I(t)\,dt + \int_{\lambda_1}^{\lambda_2} I(t)\,dt + \int_{\lambda_2}^{t_1} I(t)\,dt$$

$$= \int_0^{\lambda_1} \left\{ (1+m-t)\left[\int_t^{\lambda_1} \frac{f(x)}{1+m-x}\,dx + D_0 \int_{\lambda_1}^{\lambda_2} \frac{1}{1+m-x}\,dx + \int_{\lambda_2}^{t_1} \frac{g(x)}{1+m-x}\,dx \right] \right\} dt$$

$$+ \int_{\lambda_1}^{\lambda_2} \left\{ (1+m-t)\left[\int_t^{\lambda_2} D_0 \frac{1}{1+m-x}\,dx + \int_{\lambda_2}^{t_1} \frac{g(x)}{1+m-x}\,dx \right] \right\} dt \quad (28)$$

$$+ \int_{\lambda_2}^{t_1} \left\{ (1+m-t)\int_t^{t_1} \frac{g(x)}{1+m-x}\,dx \right\} dt$$

The total shortages occurring during time duration $[t_1, T]$ are,

$$B_T = -\int_{t_1}^{T} I(t)\,dt = \int_{t_1}^{T} \left\{ \int_{t_1}^{t} B(x) g(x)\,dx \right\} dt \quad (29)$$

The total loss of sales during $[t_1, T]$ is,

$$L_T = \int_{t_1}^{T} (1-B(x)) D(x)\,dx = \int_{t_1}^{T} (1-B(x)) g(x)\,dx \quad (30)$$

Maximum backordered inventory during $[t_1, T]$ is,

$$I_B = -I(T) = \int_{t_1}^{T} B(x) g(x)\,dx \quad (31)$$

As $Q = I_M + I_B = \left[\int_0^{\lambda_1} \frac{(1+m) f(x)}{1+m-x}\,dx + D_0(1+m)\log\left(\frac{1+m-\lambda_1}{1+m-t_1}\right) + \int_{\lambda_2}^{t_1} \frac{(1+m) g(x)}{1+m-x}\,dx \right]$

$$+ \int_{t_1}^{T} B(x) g(x)\,dx \quad (32)$$

Hence, the total average cost per time unit can be defined as follows:

$$C_3(t_1) = \frac{1}{T}\left[A + C_p Q + C_d D_T + C_h H_T + C_b B_T + C_L L_T \right]$$

$$= \frac{C_p}{T}\left[\int_0^{\lambda_1} \frac{(1+m) f(x)}{1+m-x}\,dx + D_0(1+m)\log\left(\frac{1+m-\lambda_1}{1+m-t_1}\right) + \int_{\lambda_2}^{t_1} \frac{(1+m) g(x)}{1+m-x}\,dx + \int_{t_1}^{T} B(x) g(x)\,dx \right]$$

$$+ \frac{A}{T} + \frac{C_d}{T}\left[\left[\int_0^{\lambda_1} \frac{x f(x)}{1+m-x}\,dx + D_0 \left\{ (1+m)\log\left(\frac{1+m-\lambda_1}{1+m-t_1}\right) - (\lambda_2 - \lambda_1) \right\} + \int_{\lambda_2}^{t_1} \frac{x g(x)}{1+m-x}\,dx \right] \right]$$

$$+\frac{C_h}{T}\begin{bmatrix}\int\limits_0^{\lambda_1}\left\{(1+m-t)\left[\int\limits_t^{\lambda_1}\frac{f(x)}{1+m-x}dx+D_0\int\limits_{\lambda_1}^{\lambda_2}\frac{1}{1+m-x}dx+\int\limits_{\lambda_2}^{t_1}\frac{g(x)}{1+m-x}dx\right]\right\}dt\\ +\int\limits_{\lambda_1}^{\lambda_2}\left\{(1+m-t)\left[\int\limits_t^{\lambda_2}D_0\frac{1}{1+m-x}dx+\int\limits_{\lambda_2}^{t_1}\frac{g(x)}{1+m-x}dx\right]\right\}dt+\int\limits_{\lambda_2}^{t_1}\left\{(1+m-t)\int\limits_t^{t_1}\frac{g(x)}{1+m-x}dx\right\}dt\end{bmatrix}$$

$$+\frac{C_b}{T}\left[\int\limits_{t_1}^T\left\{\int\limits_{t_1}^t B(x)g(x)dx\right\}dt\right]+\frac{C_L}{T}\left[\int\limits_{t_1}^T(1-B(x))g(x)dx\right] \tag{33}$$

From (13), (24) and (33), we can define the total average cost of inventory per time unit over time duration $[0,T]$ as follows:

$$TC(t_1)=\begin{cases}C_1(t_1) & 0<t_1<\lambda_1\\ C_2(t_1) & \lambda_1<t_1<\lambda_2\\ C_3(t_1) & \lambda_2<t_1<T\end{cases} \tag{34}$$

To derive the optimal ordering policy, we need to locate the optimal value of t_1, say t_1^*, which minimizes the total average cost of an inventory system. To locate the optimal value t_1^* we follow the algorithm given below:

Algorithm:

Step 1: Compute t_1 by solving $\dfrac{dC_1(t_1)}{dt_1}=0$. If $t_1\in(0,\lambda_1)$ & $\dfrac{d^2C_1(t_1)}{dt_1^2}>0$, then $C_1(t_1)$ is minimum, else go to step 2.

Step 2: Compute t_1 by solving $\dfrac{dC_2(t_1)}{dt_1}=0$. If $t_1\in(\lambda_1,\lambda_2)$ & $\dfrac{d^2C_2(t_1)}{dt_1^2}>0$, then $C_2(t_1)$ is minimum, else go to step 3.

Step 3: Compute t_1 by solving $\dfrac{dC_3(t_1)}{dt_1}=0$. If $t_1\in(\lambda_2,T)$, $\dfrac{d^2C_3(t_1)}{dt_1^2}>0$, then $C_3(t_1)$ is minimum.

Step 4: Evaluate the optimal values of order quantity Q and the total average cost of the inventory system TC at the optimal value of t_1.

NUMERICAL EXAMPLE

To validate the mathematical model proposed, we consider the following examples for each case. Costs are defined in $ and time in months.

Example 1 $(0<t_1\leq\lambda_1)$: We consider $f(t)=a_1+b_1 t$, $g(t)=a_2-b_2 t$ and $B(t)=e^{-\delta(T-t)}$ Abad (1996) Also, $a_1=100$, $b_1=5$, $a_2=220$, $b_2=10$, $A=200$, $C_d=3$, $C_h=10$, $C_b=5$, $C_L=10$, $D_0=120$, $T=12$, $m=12$, $\lambda_1=4$, $\lambda_2=10$, $\delta=0.05$ which gives optimal value $t_1^*=2.803836502$ This leads EOQ $Q=1201.83$ units and $TC(t_1)=2148.20439$. The graphical relationship between the total cost of the inventory system with respect to t_1 time is given in Figure 3. Convexity validates optimality.

Example 2 ($\lambda_1 < t_1 \leq \lambda_2$): We consider $f(t) = a_1 + b_1 t$, $g(t) = a_2 - b_2 t$ and $B(t) = e^{-\delta(T-t)}$ Also, $a_1 = 100$, $b_1 = 5$, $a_2 = 155$, $b_2 = 10$, $A = 200$, $C_d = 3$, $C_h = 10$, $C_b = 5$, $C_L = 10$, $D_0 = 105$, $T = 12$, $m = 12$, $\lambda_1 = 1$, $\lambda_2 = 5$, $\delta = 0.05$ which gives optimal value $t_1^* = 2.035152959$. This leads EOQ $Q = 835.12$ units and $TC(t_1) = 1888.19093$. The graphical relationship between the total cost of the inventory system with respect to t_1 time is given in Figure 4. Convexity shows optimality again.

Example 3 ($\lambda_2 < t_1 \leq T$): We consider $f(t) = a_1 + b_1 t$, $g(t) = a_2 - b_2 t$ and $B(t) = e^{-\delta(T-t)}$ Also, $a_1 = 100$, $b_1 = 5$, $a_2 = 125$, $b_2 = 10$, $A = 200$, $C_d = 3$, $C_h = 10$, $C_b = 5$, $C_L = 10$, $D_0 = 105$, $T = 12$, $m = 12$, $\lambda_1 = 1$, $\lambda_2 = 2$, $\delta = 0.05$ which gives optimal value $t_1^* = 2.803836505$. This leads EOQ $Q = 674.97$ units and $TC(t_1) = 1323.41104$. The graphical relationship between the total cost of the inventory system with respect to t_1 time is given in Figure 5. Again optimality can be observed.

Example 4 To illustrate different approaches, we consider $f(t) = a_1 t^{b_1}$, $g(t) = a_2 t^{-b_2}$ be nonlinear demand functions and $B(t) = (1 + \delta(T - t))^{-1}$ (Ouyang 2005) where $a_1 = 30$, $b_1 = 2$, $a_2 = \dfrac{10}{3}$ $b_2 = 6$, $A = 200$, $C_d = 3$, $C_h = 10$, $C_b = 5$, $C_L = 10$ $D_0 = 120$, $T = 12$, $m = 12$ $\lambda_1 = 2$, $\lambda_2 = 6$, $\delta = 0.05$. Hence optimal value $t_1^* = 2.922957278$ leads EOQ $Q = 529.70$ units and $TC(t_1) = 1288.1846$. The graphical relationship between the total cost of the inventory system with respect to t_1 time is given in Figure 6 to present optimality conditions.
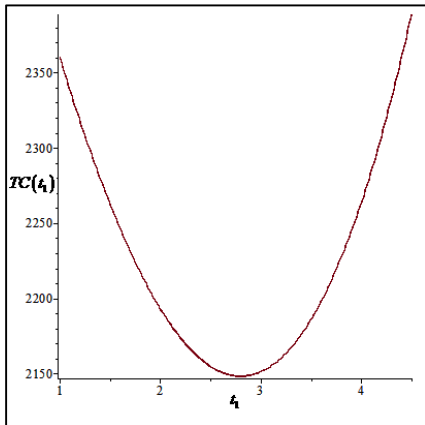

Fig. 3. $t_1 \rightarrow TC(t_1)$ (Example 1)
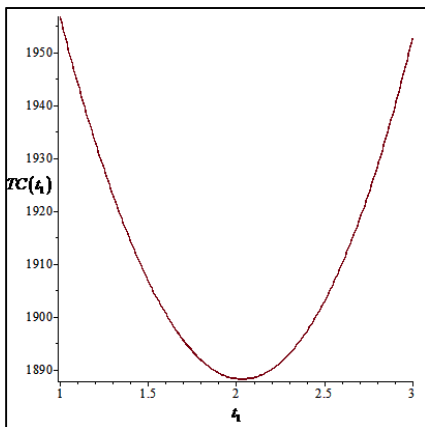
Rys. 3. $t_1 \rightarrow TC(t_1)$ (Przykład 1)

Fig. 4. $t_1 \rightarrow TC(t_1)$ (Example 2)

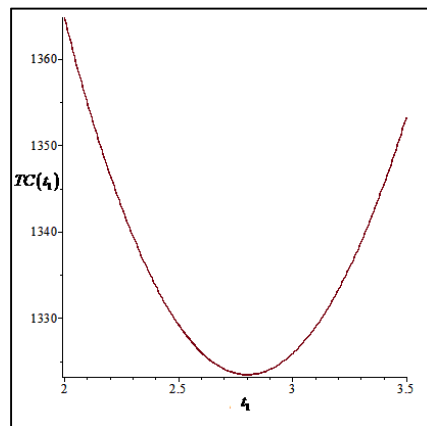Rys. 4. $t_1 \rightarrow TC(t_1)$ (Przykład2)

Fig. 5. $t_1 \rightarrow TC(t_1)$ (Example 3)

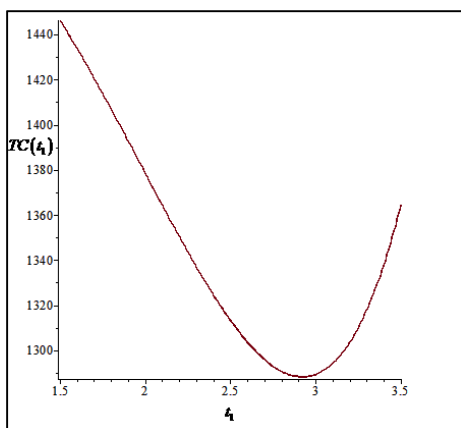Rys. 5. $t_1 \rightarrow TC(t_1)$ (Przykład 3)

Fig. 6. $t_1 \rightarrow TC(t_1)$ (Example 4)

Rys. 6. $t_1 \rightarrow TC(t_1)$ (Przykład 4)

SENSITIVITY ANALYSIS

Variation with respect to different parameters are presented in the following tables.

Using Table 1 and Table 2 we may observe following:

Increase in the value of t_1 is due to an increment in $m, C_b \& C_L$ and for other parameter it decreases. Moreover, an increase in value of TC due to all costs per unit per time unit and for rest it decreases. Similarly, an increase in the value of Q due to $C_b \& C_L$ only. The variations are the same pattern for all cases.

Table 1. Variation with respect to parameters m, δ and C_d

Tabela 1. Wariancja w odniesieniu do parametrów m, δ oraz C_d

Parameters	m			δ			C_d		
	8	10	12	0.05	0.10	0.15	3	5	7
t_1	2.636	2.734	2.804	2.804	2.183	1.710	2.804	2.769	2.735
TC	2169.61	2157.04	2148.20	2148.20	1870.11	1647.42	2148.20	2154.59	2160.78
Q	1208.6	1204.8	1201.8	1201.8	980.84	799.21	1201.8	1199.3	1196.8

Table 2. Variation with respect to parameters C_h, C_b and C_L

Tabela 2. Wariancja w odniesieniu do parametrów C_h, C_b oraz C_L

Parameters	C_h			C_b			C_L		
	10	12	14	3	5	7	8	10	12
t_1	2.804	2.445	2.166	1.983	2.804	3.489	2.756	2.804	2.851
TC	2148.20	2215.32	2266.12	1483.48	2148.20	2730.11	2111.87	2148.20	2184.20
Q	1201.8	1176.3	1157.7	1145.9	1201.8	1255.6	1198.3	1201.8	1205.3

CONCLUSIONS

In this paper, we study an inventory system for deteriorating items with a trapezoidal-type demand rate. From market information, we observed that many items do not merely deteriorate but also have a maximum lifetime. We propose a general model for deteriorating items with maximum lifetime. Shortages are allowed and partially backlogged. By replacing different demand functions, variations may be observed in different scenarios. The optimal ordering policy is derived with generalized approach and illustrated through numerical examples with the assumption that the maximum lifetime is either less or equal to the total cycle time. The sensitivity analysis is conducted with respect to the various parameters. This paper provides an interesting area for further study of such type of models. One might consider problemsrelated to (1) inventory systema with a finite replenishment rate (2) imperfect production systems for future research.

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MODEL POZIOMÓW ZAPASÓW ASORTYMENTÓW ULEGAJĄCYCH ZUŻYCIU O TRAPEZOIDALNYM TYPIE POPYTU Z CZĘŚCIOWYM ZAPASEM BEZPIECZEŃSTWA

STRESZCZENIE. **Wstęp:** Uwzględniając fakt, że w przypadku produktów łatwopsujących się, okres przydatności odgrywa istotną rolę przy zarządzaniu zapasem, Praca prezentuje ogólne podejście do modelu zarządzania zapasem dla tego typu asortymentów, posiadających daty przydatności do spożycia.

Metody: Założono, że popyt jest typu trapezoidalnego. Dozwolone zostały braki oraz założono częściowo zapasy bezpieczeństwa. Sformułowano metodę uzupełniania zapasów dla popytu trapezoidalnego do stosowania w handlu detalicznym.
Wyniki: Prezentowaną metodą wsparto przedstawieniem przykładów liczbowych oraz analizą wrażliwości przy wsparciu ich prezentacją graficzną w odniesieniu do podstawowych kryteriów.
Wnioski: Zaprezentowane ogólne podejście dostarcza podstawy do tworzenia strategii stosujące różne funkcje popytu i różne zapasy bezpieczeństwa.

Słowa kluczowe: zapasy, towary podlegające zużyciu z terminami przydatności, trapezoidalny typ popytu, częściowe zapasy bezpieczeństwa.

EIN MODELL FÜR DIE NIVEAUS VON VERDERBLICHEN SORTIMENT-VORRÄTEN VOM TAPEZOIDFÖRMIGEN NACHFRAGETYPUS MIT EINEM TEILHAFTEN SICHERHEITSBESTAND

ZUSAMMENFASSUNG. Einleitung: Angesichts der Tatsache, dass bei den leichtverderblichen Produkten das Mindesthaltbarkeitsdatum beim Bestandsmanagement eine große Rolle spielt, stellt die Arbeit eine allgemeine Vorgehensweise an das Bestandsmanagement-Modell für eine solche Art von Sortimenten, die Mindesthaltbarkeitsdaten besitzen, dar.
Methoden: Es wurde angenommen, dass die Nachfrage einen trapezoidförmigen Typus aufweist. Es wurden bei der Analyse Mängel zugelassen und man ging vom teilhaften Sicherheitsbestand aus. Es wurde eine Methode für die Ergänzung von Vorräten für die trapezoidförmigen Nachfrage für die Anwendung im Kleinhandel formuliert.
Ergebnisse: Die projizierte Methode wurde mit einer Anführung von Zahlenbeispielen sowie mit der Empfindlichkeitsanalyse für deren Unterstützung anhand einer grafischen Darstellung in Bezug auf die grundlegenden Kriterien unterstützt.
Fazit: Die projizierte allgemeine Vorgehensweise bildet eine Grundlage für die Erstellung von Strategien, die verschiedene Nachfragefunktionen und unterschiedliche Sicherheitsbestände in Anspruch nehmen.

Codewörter: Vorräte, verderbliche Waren mit Mindesthalbarkeitsdaten, trapezoidförmiger Nachfragetypus, teilhafte Sicherheitsbestände.

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LOCATION OF AIRPORTS - SELECTED QUANTITATIVE METHODS

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ABSTRACT. **Background:** The role of air transport in the economic development of a country and its regions cannot be overestimated. The decision concerning an airport's location must be in line with the expectations of all the stakeholders involved. This article deals with the issues related to the choice of sites where airports should be located.
Methods: Two main quantitative approaches related to the issue of airport location are presented in this article, i.e. the question of optimizing such a choice and the issue of selecting the location from a predefined set. The former involves mathematical programming and formulating the problem as an optimization task, the latter, however, involves ranking the possible variations. Due to various methodological backgrounds, the authors present the advantages and disadvantages of both approaches and point to the one which currently has its own practical application.
Results: Based on real-life examples, the authors present a multi-stage procedure, which renders it possible to solve the problem of airport location.
Conclusions: Based on the overview of literature of the subject, the authors point to three types of approach to the issue of airport location which could enable further development of currently applied methods.

Key words: airport location, optimization, ranking variations.

INTRODUCTION

Within the last twenty years there has been a rapid development in air transport not only in Poland but in other European countries. After a drop in the number of passengers in 2009, since 2010 there has been an increase in the number of passengers interested in this type of transport in Poland, as well as in all 28 European Union member states (see Fig.1a). Within four years (2009-2013), the annual number of passengers increased by over 6.2 million in Poland and by almost 90 million in the EU, reaching the level of 23.2 million in Poland and 842.2 million in the EU (28 countries). Interestingly, this increase in passenger transport was notably higher in Poland than in other European Union countries and in the peak year (2011), the increase

exceeded 12%. Slightly higher dynamics of change occurred in freight transport. In the years 2009 - 2013, the weight of goods transported by road in Poland dropped on two occasions (in 2009 and 2012), while in the European Union the same problem occurred three times (in 2009, 2012 and 2013) - see Fig. 1b. Regarding air transport, in 2013 the total weight of goods transported in the 28 countries of the European Union increased by almost 2 million tons compared to 2009 (up to 13.5 million tons). In the same period in Poland, this amount increased by 25,400 tons (up to 78,700 tons). In 2013 the share of Polish air transport in total air transport within the EU (28) amounted to 1.3% as regards freight transport and 2.8% for passenger transport.

a)

b)

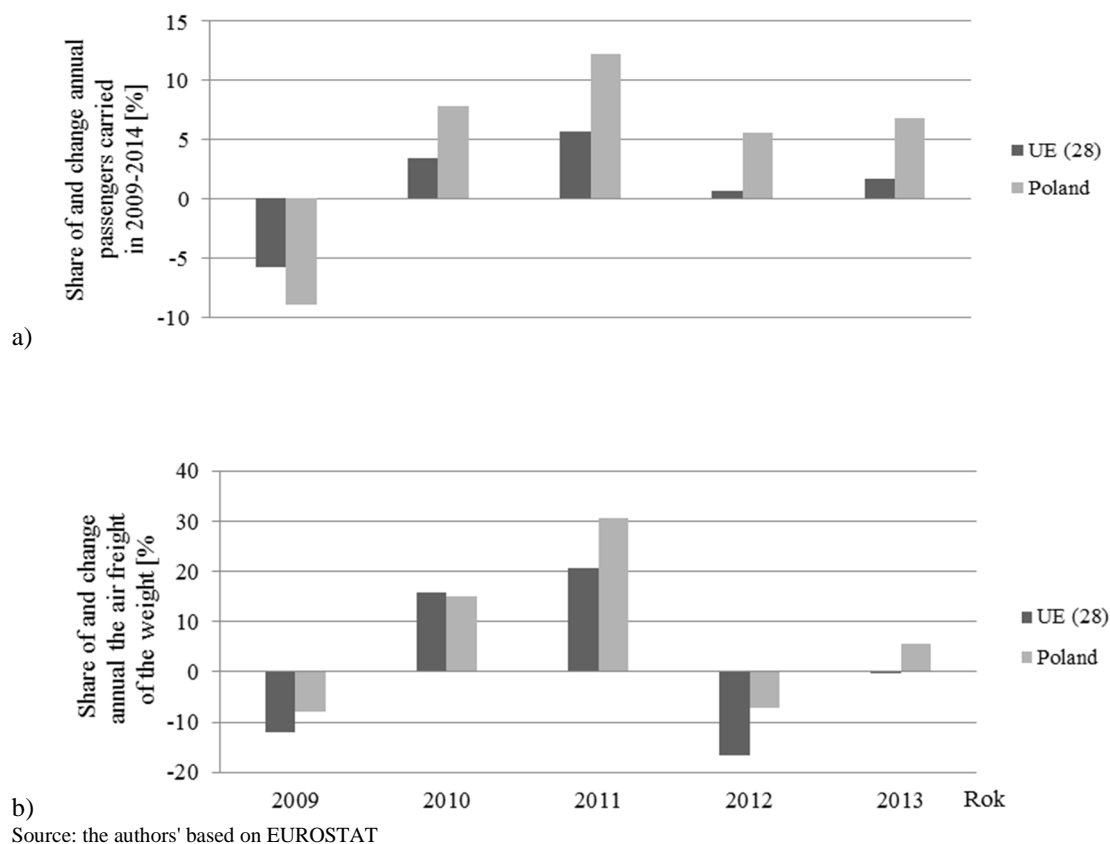Source: the authors' based on EUROSTAT

Fig. 1. Dynamics of change in the volume of air freight transported in Poland and in the 28 countries of the European Union in the years 2009-2013: a) air transport of passengers, b) freight and mail transport.

Rys. 1. Dynamika zmian wielkości przewozów transportem lotniczym w Polsce oraz 28 krajach Unii Europejskiej w latach 2009-2013: a) transport pasażerski, b) transport towarowy.

It must be stressed that this increase was caused by continuous improvements in economic conditions, new technologies and in the case of passenger air transport, a substantial development in tourism. For those who travel long distances, the key criterion is travelling time. Due to its central location in Europe and relatively poor road and rail network, especially for high-speed trains which could compete with air transport as far as travelling time is concerned, Poland is a natural area for the development of air transport. Regarding passenger transport, amongst the most frequently mentioned motives are work, study, tourism and socializing (family and friends). Globalization has also an impact in this respect [Chakuu et al. 2012], and consequently, the tendency for migration. This means that the demand for travelling longer and longer distances is growing continuously.

Due to its speed, air transport satisfies the needs of the more demanding clients. In this particular respect, the authors analysed passenger air transport. As has been stressed, the demand for air transport services is growing, therefore developed countries transform their largest airports into hubs which are the points where passengers change planes when travelling from their regional airports [Adler et al. 2003, Neves Juncioni and Oliveira 2015, Postorino and Pratico 2012]. This approach is very efficient as it rationalizes the use of the means of air transport and decreases the costs of operation of minor regional airports. However, opening regional airports, might pose several threats including:

− Increased exposure to noise due to the higher number of take-offs and landings [Kupfel et al. 2016, Gaetano et al. 2014]

− Spreading various diseases, e.g. pandemics [A. Warren et al. 2012].

In Poland, the feasibility of and need to build a central airport has been discussed on numerous occasions, yet it is extremely difficult to justify such a need nowadays.

Importantly, the development of this sector of transport is triggered by the fact that its operations are regulated by legal acts which pertain to all those who participate in the process including the airports themselves [Silva et al. 2015]. There are numerous organizations and associations which supervise this branch of transport, e.g. Airports Council International, International Civil Aviation Organization, International Air Transport Association [Beary 2011] [Chakuu et al. 2012].

The location of an airport is a key factor in making it possible for the above organizations to achieve their statutory goals. Due to the fact that planning is time-consuming and the financial support required is substantial, the location decision is definitely a strategic issue. Difficulties start at the stage of analysing the question of choosing an airport location which must account for all organizational, financial and social issues. The location should consider the interests of five main groups of stakeholders (see Fig.2). Thus, regarding the users of such airport (including passengers), convenient roads to the facilities must be ensured [Stevens et al. 2010], as well as the quality of services offered by the airport [Pabedinskaité and Akstinaité 2014, Pantouvakis and Renzi 2016]. This pertains to regional transport (at the level of województwo (provinces) in Poland), but also to connecting the airport with the city (urban area and suburbs). Depending on the category of users, public transport must be ensured (e.g. buses, trams, underground, municipal railway, local air transport) as well as individual transport such as taxis. Moreover, one needs to take into account such factors as parking facilities, which should be adjustable to changing needs [Budd et al. 2014] and potential companies providing cargo services [Kupfer et al. 2016].
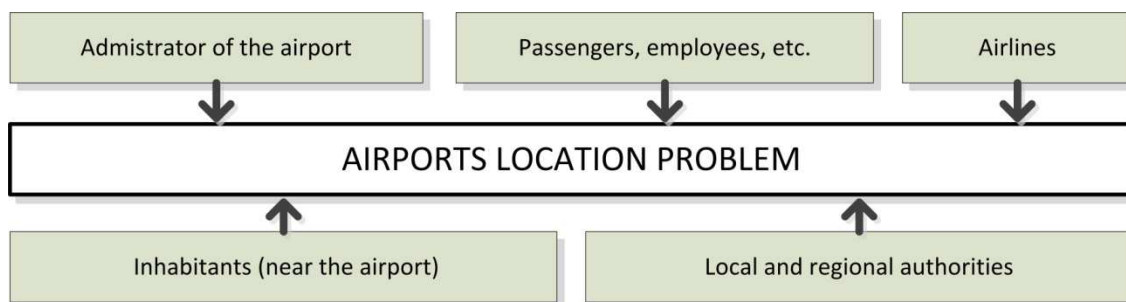
Source: authors' research

Fig. 2. Stakeholders interested in the issue of location of airports
Rys. 2. Interesariusze w problemie lokalizacji portów lotniczych

Based on real-life observations, the authors stress the complex and problematic nature of passenger airport location in Poland. In fact, a complete and all-embracing analysis which would aim to indicate optimal airport locations has not yet been carried out. The Ministry of Transport points to the need to make use of existing airport facilities as potential location of airports [Ministry of Transport, 2007]. In this situation it is advisable to carry out an analysis of available methodological solutions, which will allow an original solution to be developed, which would serve as a tool in the process of selecting airport locations.

PROBLEMS CONCERNING THE LOCATION OF INFRASTRUCTURAL FACILITES

The location of infrastructural facilities is one of key elements in strategic planning of any organization's operation. Generally, this

issue involves selecting the best location for an infrastructural facility (e.g. premises, site or building) for a specific entity (private or public) in a defined area, with certain references of the interested parties as well as numerous limitations which might occur. The location of objects always involves long-term investments, since the process of obtaining funding is complex, the time of implementation is enormous and the facility is to operate for a very long time. The decision maker must indicate the best location, accounting for the changing conditions to which the facility might have to adjust in the future. These include market trends, the development of trade and industry, demographic changes as well as environmental changes. The following elements must be considered in the process of determining the best location of airports:
− the number of analysed facilities,
− geographical location,
− size (area),
− assumed demand,
− their importance at the local/regional/ national/international level.

There might be several approaches to solving this problem, which might be found in the literature on the subject, for instance, solutions related to:
− centres of distribution [Nozick and Turnquist 2001],
− cranes on construction sites [Abdelmegid 2015],
− heat and power plant [Barda et al. 1990],
− airports [Landa-Silva 2009, Yang et al. 2014],
− warehouses [Wan et al. 1998] logistic centres [Chen et al. 2014, Turskis and Zavadskas 2010],
− shopping malls [Chen et al. 2007, Alnahhal and Noche 2015],
− sites of vehicle recycling [Merkisz-Guranowska 2011, 2012, 2013],
− cargo ports [Lirn et al. 2012],
− car parks [Bieńczak et al. 2009],
− fire stations [Badri et al. 1998],
− hospitals [Daskin 1995],
− cargo terminals [Bagoius et al. 2014],
− tram terminals [Kupka and Sawicki 2015],
− manufacturing plants [Badri et al. 1995].

One solution involves the issue of coverage, where the distance constitutes the decisive parameter; the shortest distance between the demand generating point and the one that offers supply, the better. It is usually assumed that the distance cannot exceed a certain value. This definition might be expanded with the aim of serving all the clients at the smallest possible number of service points.

If the definition of the problem is to be further expanded to include cost optimization, a group of P-median problems appears, where the minimization of distance, costs and the number of objects plays an important role [Daskin 1995, Owen and Daskin 1998]. The methods prepared for solving the issue of location are based on mathematical programming techniques, classification or variation ranking [Sikora 2008]. The mathematical programming model of facility location involves formulating several functions of the aim with several, frequently contradictory, criteria. Most of these are to be done by computer software. On the other hand, formulating the problem of location as one of variation ranking or classification calls for constructing models characteristic for facilitating multicriteria decisions. In this case, two approaches to creating variations are possible:
− heuristic (expert) construction of variations, or
− designing a procedure (method) for generating sets of solutions to the problem.

It needs to be clearly stated that both mathematical modelling and applyin a ranking method merely support the decision makers and analysts in the process of decision making and do not exempt them from assuming full responsibility for their choices and actions.

OVERVIEW OF SOLUTIONS TO THE ISSUE OF AIRPORT LOCATION, INCLUDING A CLASSIFICATION OF CASES OF DETERMINING SUCH LOCATIONS

The issue of airport location constitutes a special case of the location problems discussed below. The first work on the subject

of location is a monograph written by Alfred Weber in 1909, although some researchers believe that this issue's roots reach back as far as the 17th century [Farahani et al. 2010]. In the literature, one might encounter two different approaches to the issue of airport location. In the first, known as airport site selection, the best of all known options is chosen. This constitutes a special instance of the problem of choice in which the possible options or variations are ranked so that the best one can be chosen. In the other approach. The

best location on a particular territory must be found and initially no particular options are specified. This is a special instance of the optimization problem. The differences between these approaches, based on the AHP method – – Analytic Hierarchy Process [Saaty 1980] and the multicriteria programming were described in detail by Min and Melachrinoudis [1997] and are presented in Table 1. Both these approaches to the problem of location are elaborated upon in this article.

Table 1. Comparison of ranking and optimization methods for solving the problem of location
Tabela 1. Porównanie metod rankingowych oraz optymalizacyjnych dla problemu lokalizacji

Feature	Ranking methods	Optimization methods
Type of problem	Selecting the location	The choice of location which may be combined with allocating the nearby objects (cities) to be served by the airport under discussion
Methodology	Evaluation based on the decision maker's preferences	Optimization within the set of allowed solutions
Solutions	Hierarchical	Non-hierarchical
Limitations	Not required	Required
Limitation regarding airport capacity	No	Yes
Subjective evaluation of the decision maker	Applied	Not applied
Deciding on dynamic (time related) aspects	Difficult	Relatively easy

The problem of selecting an airport location

The issue of selecting the location of an airport is widely discussed in the literature. Before making the choice of location, the usefulness of such an airport for the air transport system must analysed. As Kazda and Cavese [2007] claim, this is due to the fact that in almost every case it is easier to modernize existing airports than to build a new one on a site previously designated for other purposes. Moreover, the choice of a new location should not influence current traffic negatively [Stevens et al. 2010] (which is especially important in view of the demand for airlines in the vicinity of airports) [Wells 2000]. Whilst doing this type of analysis, the key is to forecast the growth of passenger traffic accurately (including that regarding tourist traffic [Fragoudaki and Giokas 2016]) and cargo [Kazda and Caves 2007, Kupfer et al.

2016, Walls 2000]. Once this issue is analysed, can one move on to solving the problem of airport location.

The complete procedure of selecting a new airport location, used in designing, involves ten basic steps:
1. Estimate the area needed to construct the airport.
2. Evaluate the factors determining the location.
3. Conduct a preliminary selection of possible locations.
4. Analyse and evaluate each of the preliminary choices of location.
5. Evaluate the environmental impact of these airport locations.
6. Conduct another evaluation of each of the possible locations.
7. Prepare drawings of potential airports for each of the locations being considered.

8. Evaluate the potential costs as well as the potential income; airport profitability analysis.
9. Make the final selection of airport location.
10. Prepare the final report with recommendations for the airport location selected.

All stakeholders must participate in this procedure, i.e. the investor, local authorities andthe inhabitants of the regions which are to be served by the airport [Kazda and Caves 2007, Silva et al. 2015, Stevens et al. 2010, Walls 2000]. This results from the fact that this sort of decisions are usually of a political nature. Moreover, as Stevens et al. [2010] sees it, one must consider both public and private interests, as well as spatial planning at various levels.

In the procedure of selecting the airport location, the choice of criteria used for evaluating particular locations is key. Kazda and Caves [2007] and also Silva et al. [2015] point to a set of factors which should be decisive whilst selecting airport locations. These include:

1. The maximum capacity of the airport which can be achieved in each location. At the same time, the airport needs to fulfil certain minimum requirements, such as the ability to serve certain streams of passengers [Bezić et al. 2010, Ha et al., 2010].
2. The impact on the surroundings, i.e. people and the natural environment [Daley 2010, Gaetano et al. 2014, Silva et al. 2015] (the environmental criterion)
3. The aspects related to the security of aviation operations at a specific location. The relevant factors include meteorological conditions (the strength and directions of the wind, visibility, etc.) [Kassomenos et al. 2005, Kazda and Caves 2007], threats of collisions with birds which have their habitats in particular potential locations or which migrate over this particular location [Blackwell et al. 2009, Kazda and Caves 2007].
4. The cost of construction (including the cost of land to be purchased from its current owners) [Walls 2000], levelling the land and removing obstacles, as well as building the necessary infrastructure [Kazda and

Caves 2007, Silva et al. 2015]), operating and maintaining the airports in a given location.

Generally, when selecting airport locations, one should consider the options incurring the lowest possible costs and the least negative impact on people and natural environment [Kazda and Caves 2007, Silva et al. 2015]. Based on the above, it may be said that the issue under discussion encompasses multiple criteria, which shall be further discussed in this article.

Both Kazda and Caves [2007] and Wells [2000] claim that the procedure of selecting a location is an intuitive process (expert) and is carried out without any need to use multicriteria decision aids. Martel and Aouni [1992], however, suggest using a method similar to PROMETHEE [Brans and Mareschal 2005]. Ballis [2003] and Togatlian et al [2007] suggest using the AHP method [Saaty 1980]. Van der Kleij et al [2003] combine AHP [Saaty 1980] with the Monte Carlo method in order to model uncertainty while evaluating each of the variations.

Min and Melachrinoudis [1997] present a slightly different approach as they suggest a dynamic model of solving the problem of airport location based on multicriteria integer programming (MIP). The evaluation criteria in this approach include cost, noise, impact on the economic development of the region, and also accessibility (measured as road congestion between the airport and residential areas). The values of these criteria were assessed in an assumed time span. The problem was solved using solvera hyper-lindo, which helped to generate a set of non-dominated solutions (pareto optimal). When solving a real problem for the region of Massachusetts, seven preliminary selected locations were evaluated. Therefore, the problem formulated in this manner positions itself between the typical location selection problems using multicriteria analysis (predefining the possible location) and the typical problems of optimization, which are of continual nature (the optimization methods used) and which are discussed below.

The problem of airport location

The issue of airport location can be perceived as a special instance of the location problem in general. The task at hand is to find the best site for a given facility (an airport and its infrastructure) on a given area using e.g. the methods of optimization. All of the potential locations are evaluated by defining a calculable criterion (a single-criterion task) or a set of criteria (a bi-criterion or a multiple criterion task) of evaluation and limitations. Thus this issue is continual (no predefined potential locations – the new airport may be located at any site of the area under consideration). To solve the issue, optimization methods (algorithms) are used. Notably, in the literature, airports are considered to be partially semi-obnoxious and semi-desirable objects [Farahani et al. 2010, Brimberg and Juel 1998, Fernández et al. 2000, Skriver and Andersen 2003]. In the case of such facilities, the decision maker intends to locate them as close to the air transport demand/supply generating sites as possible (in order to bring down the costs/time of travelling to and from the airport). On the other hand, airports generate unwanted phenomena such as noise, which is perceived as a serious problem for nearby communities. Thus such objects should be located as far from residential areas as possible. The above factors are at the root of the conflict to which decision makers are exposed.

Fernández et al. [2000] suggest a single criterion planar model, i.e. one based on minimizing the aversion of residents in the cities located in the region under discussion. Additionally, the above authors assume a limitation preventing them from building an airport in the vicinity of cities. Within this criterion, the size of a given community and its distance from the planned site are important factors. To solve this problem, the method of branch and bound is suggested [Hillier and Lieberman 2012]).

Skriver and Andersen [2003] suggest two bi-criteria models - planar and network - for solving the issue of locating semi-desirable facilities, and present an example of applying this in the case of an airport in Denmark. For the planar model, the first optimization criterion was minimizing the weighted sum (the sum of products) of the distance from nearby communities raised to a negative exponent, where the weight is the size of each community's population. This criterion reflects the negative impact of the airport on the population. In the other criterion, the weighted sum of the distance between the planned location and the existing objects is minimized, which reflects transport costs. In this case, the weight is the population of the city to be served by the airport multiplied by the weight of the region where this city is located. The smaller the weight of the region, the further it is located from the planned airport location (in this case the city of Århus, which the new airport was to serve), which is to reflect a situation where passengers from distant locations prefer another airport, and thus intend to use this particular one less frequently. The authors suggest solving the planar problem by means of the Big Square Small Square (BSSS) algorithm, which is close to the branch and bound method and which allows solutions similar to the optimum one to be obtained. In the case of the network problem, the Edge Dividing (ED) algorithm was suggested, which is close to the idea of the BSSS.

CONCLUSIONS

The above overview of approaches towards solving the problem of airport location reveals the following aspects:
1. Due to the resulting complications of a political nature, the issues under consideration should be viewed as multicriteria problems [Owen and Daskin 1998]. Clearly, there are several groups of decision makers (the investor, the administrative authorities, local communities, economic entities) who have various expectations regarding the location of a given airport.
2. There are two different types of approach towards solving the problem. These are presented as ranking problems to be solved by means of the methods of multicriteria analysis as well as location problems to be solved by means of multicriteria optimization.

3. Due to the substantial computational complexity of the problems, the methods of approximation (e.g. heuristic methods) should be applied for solving location problems.

4. Both approaches to solving the problem of airport location have some drawbacks. In the case of problems related to choosing the location, it is essential to predefine the potential locations which are to be subsequently evaluated, although it is possible to unintentionally overlook some potentially good solutions. On the other hand, in the case of location problems, the set of criteria which are used for solving the problem seems to be too narrow. In the literature, the only factors considered are the size of the population and the distance from the airport.

In view of the above, the authors prepare three types of approach which would make it possible to develop the currently applied methods and alleviate their downsides. These concepts point to the directions of further research related to the issue of airport location.

The first concept assumes expanding the issue of location, so that it could consider additional criteria such as the environmental criterion. In this approach, the suggestion is to use metaheuristic methods, which constitute an extension of the method presented in this article. Additionally, developing the genetic algorithm is also suggested, so that it is possible to make use of the possibilities of multi-core processes which are currently standard even in PCs. In line with the concept presented by Luque et al. [2008], simultaneous computations might result in an almost linear reduction of computation time.

The second concept constitutes a development of methods for solving the location problem. The authors suggest using more modern methods based on fuzzy set theory, e.g. the fuzzy-AHP method or the theory of approximated set, such as jRank [Szeląg et al. 2010, 2014]. This concept assumes a preselection of sites to be considered using multicriteria classification problems.

The third concept is a development of the method suggested by Min and Melachrinoudis [1997]. It assumes preliminary generation of non-dominated solutions using generators of efficient solutions such as Megros. This set is to be subsequently evaluated by the decision maker using some interactive methods such as BIPOLAR [Konarzewska-Gubała 1989], INSDECEM – INteractive Stochastic DECision Making Procedure [Nowak 2006], LBS – Light Beam Search method [Jaszkiewicz and Słowiński 1999], STEM-DPR – STEp Method for Discrete Decision Making Problems under Risk [Nowak 2008]. Moreover, the authors point to the fact that it is possible to implement many other methods of multicriteria decision analysis [Trzaskalik 2014], for instance, those based on reference points, e.g. DEMATEL – – DEcision Making Trial and Evaluation Laboratory [Gabus and Fontela 1973], VIKOR (Serb. VIsekrzterijumska Optimizacija i Kompromisno Resenje) or to combine the DEMATEL+ANP+VIKOR methods [Tzeng and Huang 2011].

In all of the above concepts it is assumed that geographic information systems (GIS) will be used in order to facilitate data input and to improve the presentation of results.

To sum up, it must be stressed that the approaches suggested are but a part of the wide range of methods which might be applied in selecting the best airport locations.

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LOKALIZACJA PORTÓW LOTNICZYCH - WYBRANE METODY ILOŚCIOWE

STRESZCZENIE. **Wstęp:** Transport lotniczy obecnie odgrywa ważną rolę, jeśli chodzi o rozwój gospodarczy zarówno kraju, jak i danego regionu. Ewentualna decyzja o jego lokalizacji powinna w maksymalnym stopniu spełniać oczekiwania interesariuszy. Niniejszy artykuł podejmuje tematykę związaną z wyborem lokalizacji portów lotniczych.
Metody: W artykule przedstawiono dwa główne ilościowe nurty (podejścia) związane z problematyką lokalizacyjną portów lotniczych (PL), tj. problem optymalizacji wyboru lokalizacji PL oraz problem wyboru lokalizacji spośród z góry zdefiniowanego zbioru. Pierwszy z nich związany jest z programowaniem matematycznym i sformułowaniem problemu jako zadania optymalizacyjnego drugi natomiast zszeregowaniem wariantów Z uwagi na różne podłoże metodyczne autorzy przedstawili wady i zalety obu podejść oraz wskazali tą, która ma obecnie swoje praktyczne zastosowanie.
Rezultaty: W artykule, opierając się na rzeczywistych przykładach, zaprezentowano procedurę wieloetapową pozwalającą na rozwiązywanie problemu lokalizacji portów lotniczych.
Wnioski: W artykule, wskazano na bazie przeglądu literaturowego trzy koncepcje podejścia do problematyki lokalizacji PL, dzięki którym możliwe byłoby rozwinięcie obecnie stosowanych metod.

Słowa kluczowe: lokalizacja portów lotniczych, optymalizacja, szeregowanie wariantów

DAS PRBLEM DER LOKALISIERUNG VON FLUGHÄFEN - AUSGEWÄHLTE QUANTITATIVE METHODEN

ZUSAMMENFASSUNG. Einleitung: Der Lufttransport spielt derzeit eine wichtige Rolle, wenn es sich um die wirtschaftliche Entwicklung sowohl des Landes als auch der Region handelt. Jede Entscheidung über dessen Beschaffenheit sollte im maximalen Ausmaße den Erwartungen der Interessenten gerecht werden lassen. Dieser Artikel betrifft die Problematik der Auswahl einer optimalen Standort-Platzierung für Flughäfen an.
Methoden: Im Artikel stellte man zwei wichtige quantitative Trends (Ansätze) im Zusammenhang mit der Frage der Lokalisierung von Flughäfen dar, d.h. man projizierte das Problem der optimalen Auswahl eines Flughafen-Standortes sowie das Problem der Auswahl dessen aus einer im Voraus definierten Menge. Das erste ist mit mathematischer Programmierung und der Problemstellung als einer Optimierungsaufgabe verbunden, das andere dagegen mit der Einstufung der einzelnen Varianten. Angesichts der unterschiedlichen methodischen Vorgehensweisen stellen die Autoren die Vor- und Nachteile der beider Ansätze dar und wiesen auf den, der zur Zeit eine praktische Anwendung findet, hin.

Ergebnisse: Basierend auf konkreten Beispielen präsentiert der Artikel ein mehrstufiges Verfahren, das die Problemstellung der Lokalisierung der Flughäfen zu lösen vermag.

Fazit: Gestützt auf die grundlegende Übersicht der Gegenstandsliteratur zeigte man im Artikel drei Vorgehensweisen an die Problematik der Lokalisierung der Flughäfen auf, dank derer die weitere Entwicklung der heutzutage angewendeten Methoden möglich wäre.

Codewörter: Lokalisierung von Flughäfen, Optimierung, Einstufung von Varianten

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ASSESSING TRANSPORT SUSCEPTIBILITY OF RAPESEED MEAL FRACTIONATION PRODUCTS

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ABSTRACT. **Background:** Having considered increasing production of liquid and solid biofuels from rapeseed and bearing in mind its stable and unquestionable position in the food and animal feed industries, a rational approach towards technologically and logistically efficient utilization of by-products from rapeseed processing is required. The aim of the research presented in the article is to assess the transport susceptibility of rapeseed meal fractions, varying according to particle size and chemical composition.

Methods: Resistance to changes stimulating self-heating has been assumed as the main criterion of transport susceptibility. The following diagnostic variables have been experimentally determined: total protein, crude fat and crude fiber content, porosity, and water activity in the fraction of examined meal. In order to organize a set of particles and to indicate their optimal applications according to criteria chosen with regard to both utilization and transportation, two aggregate indicators have been calculated.

Results: It has been proved that medium-sized particle fractions (0.075-0.4 mm) exhibit the lowest transport susceptibility, whereas the those with the largest granulations (>3 mm) -have the highest. One significant relationship is the decline of feeding value and concurrent increase in the transport susceptibility of meal fractions, which in practice means that those fractions least-favoured by the animal feed industry can be least cumbersome to transport.

Conclusions: It has been suggested that there should be a division of rapeseed meal into two products with different applications and different transport susceptibility. The fractioning of meal can bring numerous, measurable benefits for the meal industry and logistics processes for solid biofuels, where storage and transport properties have considerable importance, alongside commodity price and transport costs.

Key words: self-heating, transport of biomass, sustainable energy logistics, solid biofuels, utilization of rapeseed.

INTRODUCTION

Over the last three decades, there has been a steady increase in the volume of agri-bulk cargoes carried by sea [Maritime Knowledge Centre, 2012]. Those loose materials of plant origin that due to the scale of production are traded in bulk consist mainly of unprocessed grains, oil-seeds, legumes, as well as various products resulting from their processing, such as cake and meal, which are the protein source in the production of compound feed. One of these cargoes which is transported by land and sea in increasing volumes in the EU is rapeseed meal of double-low varieties (RM 00) which is a byproduct of de-oiling rape, currently used alternatively as feedstuff or solid biofuel in green energy production [Ucar and Ozkan 2008, Leśmian-Kordas and Bojanowska 2010]. In 2013 domestic rapeseed production amounted to 1.28 million tons, which was the highest level for over ten years and double that of 2004, according to data published by Fediol [2015]. Poland is currently the third largest producer of rapeseed in Europe by volume, after Germany and France and is a major supplier to the EU internal market. About 50% of rapeseed meal produced in Poland is exported to the countries of

Western and Northern Europe, predominantly by sea.

Natural cargo transport susceptibility is defined as the resistance of cargoes to changes in their properties affected by the conditions and duration of transport processes resulting from chemical, physical and biological properties of the cargoes. Loads of perishables, dangerous and hygroscopic properties as well as those sensitive to mechanical damage possess the lowest natural transport susceptibility. One of the properties of rapeseed meal is its propensity to self-heating, which is the basis for listing this cargo (under common name Seed Cake) in international transport rules in class 4.2. of dangerous goods [IMDG 2014, IMSBC 2013]. In the case of oilseed meal, self-heating processes are preceded and then accompanied by a series of changes resulting from fermentation, decomposition of compounds, oxidation of fatty acids, microbial growth, gradual evaporation of water and further thermal decomposition of organic matter [Becker 1996, Sturaro et al. 2003]. The oxidation of unsaturated fatty acids with heat, water and carbon dioxide release and increased microbial activity in the initial stage of the process (35°C-70°C) are considered to be direct causes of self-heating, taking place in seed cake containing residual fat, with a water content above the critical level [Bowes 1984, Becker 1996, Ramirez-Gómez et al. 2009].

Fractionation of rapeseed meal, which improves its nutritional value considerably through the removal of larger particles with a lower protein content and a higher anti-nutritional dietary fiber content [Mińkowski 2002], has not so far been applied on an industrial scale, mainly due to the problems with the utilization of fractions with a lower feeding value. However, there is a possibility of using coarse fractions of rapeseed meal as a renewable source of energy, mainly lumped parts of seed pulp and the plant's coats . The consequence of dividing rapeseed meal into fractions with different functional properties and alternative applications is that products with different technological and transport characteristics, including a propensity to self-heating processes, can be obtained.

The present work aims at diagnosing the susceptibility of chemically different rapeseed meal fractions to self-heating processes, using multiple comparative analysis methods: linear ordering of multivariate objects [Sokołowski 2009].

MATERIAL AND METHODS

The research material was post-extraction rapeseed meal produced in "ADM Szamotuły" Sp. o.o. Fractionation of the rapeseed meal by sieving was performed in accordance with PN-ISO 2591-1: 2000, using a set of Multiserw Morek control sieves. The equivalent diameter of each fraction was calculated as the geometric mean of marginal particle sizes in accordance with PN-89/R-64798. The content of the basic chemical components of rapeseed meal and its fractions (moisture, crude protein, crude fiber, crude fat) was determined by the near infrared spectroscopy (NIRS) method, on a spectrometric FT-NIR MPA- Multi Purpose Analyzer, Bruker. The camera was equipped with a rotating integrating sphere for loose, heterogeneous products. Quantitative results related to the selected chemicals, corresponding to the absorbance spectra obtained, were calculated on the basis established by the camera manufacturer's calibration model for rapeseed meal, using the OPUS 6.0 program. The results were expressed as grams of the component per 100 g of dry matter (g·100g^{-1} d.m.). The water activity was determined by the static method, involving measurements of sorption of water vapor at t = 25°C and at a relative humidity of 60%, 75% and 90%. Samples of 5 g were kept in Petri dishes in a climatic chamber type 60 U Mytron, until its constant weight was achieved. The change in the weight of each sample was monitored every day to an accuracy of 0.0001 g. The porosity of the meal and its fractions was determined by the following formula:

$$\varepsilon = \frac{\rho_{rz} - \rho_n}{\rho_{rz}}\ 100\% \qquad (1)$$

where:
ε - porosity (%);
ρ_{rz}- true density (g·cm^{-3});
ρ_n- bulk density (g·cm^{-3}).

The true density was determined by the Erdmenger - Mann method by measuring the volume of a sample of a known mass through the progressive replenishment of the flask with a liquid (ethyl alcohol). Bulk density measurements for natural meal and its fractions, except the smallest, were carried out according to PN-EN 1236:1999. Bulk density of dust with a particle size of less than 0.075 mm was determined in accordance with PN-EN 50281-2-1:2002. All measurements were made in duplicates of six.

THEORY AND CALCULATIONS

A synthetic approach to selected properties of rapeseed meal fractions was used to order particle collections with different dimensions, according to their transport susceptibility and, furthermore, to indicate the most favorable application of fractions due to the criteria adopted: usability value as a feed component and transportation properties. Linear ordering of rapeseed meal fractions was done according to the level of resistance to unfavorable chemical changes, initiating self-heating and the level of feeding value. The aggregate indexes <0;1>, as a point measure, were calculated using the following formula:

$$W_i = \frac{1}{m} \sum_{j=1}^{m} \alpha_j \, x'_{ij} \qquad (2)$$

W_i - aggregate index,
m –number of selected properties,
$\alpha_{j\,-}$ weight of j-variable,
$x'_{ij\,-}$ normalized values of individual attributes (feature values converted to mutual comparability).

The normalized values of variables were calculated by the unitarization method, in which the interval of a particular value to the observed extreme value (the "worst" in terms of the kind of analysis) is divided by the differential between the maximum and minimum values of the j-variable. The diagnostic variables are qualified as stimulants or destimulants, according to whether their high levels are desirable (S) or undesirable (D) from the point of view of the phenomenon concerned. The following diagnostic variables were selected for calculating the "level of resistance to changes initiating self-heating" (RL) index:

X_1: fat content (% d.m.) - a destimulant - high fat content favors exothermic oxidation processes [Bowes 1984];

X_2: protein content (% d.m.) - a destimulant - high protein content favors microbial growth, especially at water activity above 0.7 [Sikorski 2001];

X_3: water activity at temperature of 25°C and at moisture content (m.c.) of samples equal to 12.5% (The maximum permissible moisture content for extracted oil seed meals according to Polish Standard PN-80/R-64773) – a destimulant - higher water activity enables the microbial activity [White and Jayas, 1989];

X_4: porosity (%) - a stimulant - higher porosity facilitates removal of pointwise cumulated heat [Horabik 2001].

In the case of the "level of feeding value" (FL) index, the following diagnostic measures were used:

X_5: protein content (% d.m.) - a stimulant – a high protein content enhances feeding value, also as a result of an increase in the amino acid concentration [Messerschmidt et al. 2014];

X_6: fat content (% d.m.) - a stimulant - a high fat content increases energy value, as well as essential fatty acid concentrations [Smulikowska and Nguyen 2003];

X_7: fiber content (% d.m.) - a destimulant – a high fiber content decreases feed digestion and metabolic energy [Smulikowska and Nguyen 2003];

X_3: water activity at a temperature of 25°C and at m.c. of samples of 12.5% - destimulant - higher water activity, particularly above 0.7 may increase the degree of protein and amino acid degradation, which lowers feed quality [Pastuszewska and Raj 2003];

X_8: particle size (mm), expressed as the equivalent diameter of the particles - stimulant - excessive fragmentation of the feed is not desirable because of the possibility of respiratory diseases developing and excessive blowing during feed intake by animals.

Due to the fact that experts in the literature have not established weights for the features selected, as well as the lack of a universally accepted formal statistical method for weighing features, in the analysis it was assumed that attributes are equally important from the point of view of the phenomena under consideration and their coefficients of validity are $\alpha j = 1$.

RESULTS AND DISCUSSION

The results obtained using multivariate linear ordering of objects in the form of RL and FL indexes are presented in table 1. The higher the aggregate index, the more the values of the selected diagnostic variables are similar to the state of the most desirable (index value of 1). The mutual distances of the points for each fraction on the axis of linear hierarchy are a measure of their similarity, due to the properties analyzed (Fig.1a).

Table 1. Aggregate indexes of the level of resistance to changes initiating self-heating (RL) and the level of the feeding value (FL) for rapeseed meal and its fractions
Tabela 1. Wskaźniki agregatowe poziomu odporności śruty rzepakowej i jej frakcji na przemiany stymulujące samozagrzewanie (RL) oraz poziomu wartości paszowej (FL)

Fraction (mm)	Mass (%)	Level of resistance to changes initiating self-heating (RL) index	Level of feeding value (FL) index
> 3	12.0	0.7190	0.5657
1.2-3	6.3	0.6127	0.4549
0.4-1.2	56.9	0.6754	0.3810
0.2-0.4	18.9	0.4023	0.5802
0.075-0.2	5.8	0.3320	0.6360
<0.075	0.1	0.6343	0.2248
Natural RM	100	0.4956	0.5394

Source: Own studies
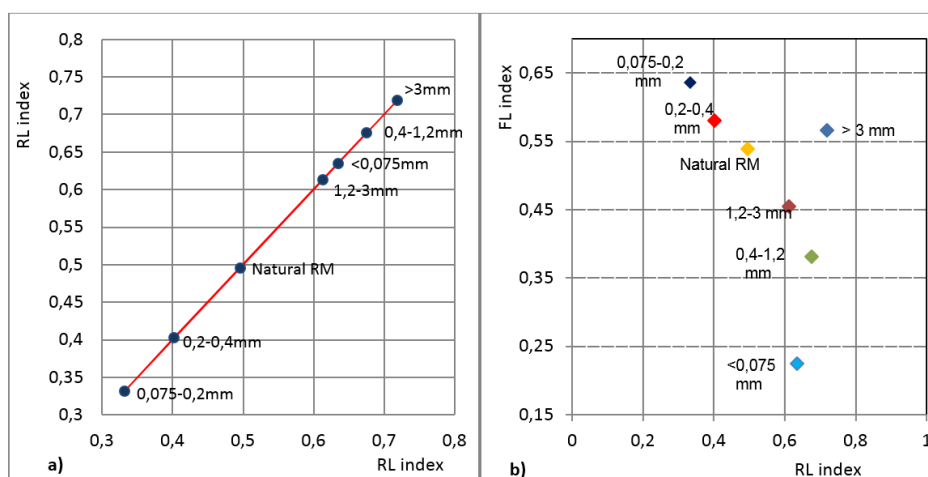
Source: Own studies

Fig. 1. a) "Level of resistance to changes initiating self-heating" (RL) index
b) Correlation between the level of resistance to changes initiating self-heating (RL index) and the level of feeding value (FL index) for rapeseed meal (RM) and its fractions
Rys. 1. a) Wskaźnik poziomu odporności na przemiany stymulujące samozagrzewanie
b) Zależność między poziomem odporności na przemiany stymulujące samozagrzewanie a wartością paszową śruty rzepakowej i jej frakcji

Dust fractions (0.075-0.2 mm and 0.2-0.4 mm) have the greatest potential susceptibility to the development of adverse changes, while fractions with a particle size greater than 3 mm have the lowest (w> 3 = 0.7190). The lowest RL indexes values of particles with a size

between 0.2-0.4 mm and 0.075-0.2 mm are the result of cumulative, disadvantageous effects: low porosity, a relatively large concentration of protein (40.6% d.m. and 43.4% d.m.) and a relatively high content of residual fat, of 5.6% d.m. and 5.1% d.m., respectively (Table 2). Dust with a particle size of less than 0.075 mm is characterized by lower propensity to self-heating than coarser dust fractions, due to their lower fat content (3.3% d.m.) and higher porosity (64.2%) (Table 2).

A high level of the RL index for fractions with a particle size above 3 mm is caused primarily by relatively low water activity (0.77) at the moisture content of the material (12.5%) and the relatively low fat content (3.6% d.m.). The lower propensity to negative changes in the case of fractions in the particle size range 0.4-1.2 mm compared to powdery fractions is in turn associated with a lower protein content (34.2% d.m.) and greater porosity, which allows for the dissipation of

heat, being locally accumulated during self-heating processes.

In practice, an important role in the self-heating intensification is attributed to dust fractions, especially at higher temperatures, due to the release rate of various volatile compounds from powdery particles [Bowes 1984, Ramirez-Gómez et al. 2010]. The studies conducted showed that dust fractions may also enhance these changes at lower temperatures due to different chemical composition and higher water activity relative to unfractionated meal. An important observation is the fact that fractions which are the most desirable as animal feed (Figure 1b) may be simultaneously the most burdensome in transport. Potential resistance to chemical and biochemical deterioration stimulating self-heating decreases, with an increase in the feeding value, except for the two marginal fractions i.e. with a particle size greater than 3 mm and less than 0.075 mm.

Table 2. The values of diagnostic variables for rapeseed meal and its fractions
Tabela 2. Wartości zmiennych diagnostycznych śruty rzepakowej i jej frakcji

Fraction (mm)	Crude protein (g·100 g⁻¹ d.m.)	Crude fiber (g·100 g⁻¹ d. m.)	Crude fat (g·100 g⁻¹ d. m.)	Water activity	Porosity (%)
> 3	37.7	11.5	3.6	0.77	59.9
1.2-3	38.2	11.8	4.8	0.79	60.3
0.4-1.2	34.2	13.7	7.4	0.80	63.7
0.2-0.4	40.6	9.4	5.6	0.79	58.0
0.075-0.2	43.4	7.9	5.1	0.81	58.1
<0.075	38.5	9.8	3.3	0.92	64.2
Natural RM	37.0	11.8	6.3	0.77	58.4

Source: Own studies

Fine and coarse dust (0.075-0.2 mm and 0.2-0.4 mm) containing a high concentration of protein and low percentages of anti-nutritional fiber have the highest value for the feeding industry. A fraction of particle size greater than 3 mm is also highly suitable for utilization in animal feeding. This is caused mainly by the degree of fragmentation and the hygroscopic properties of this fraction. The permissible water content of meal, accepted in trade at the level of 12.5%, corresponds to this fraction with water activity aw = 0.77, while in the finest fraction of dust, at the same water content, water activity is 0.92. The finest dust has a very low FL index, which is associated

with the high water activity compared to the other fractions at the same water content, low fat content and high degree of fineness. The low feeding usefulness of the fraction with a particle size of 0.4-1.2 mm is, on the other hand, determined by the relatively low protein content and high crude fiber content.

Sorting rapeseed meal fractions according to their tendency to unfavorable changes (Figure 1a) reflects the characteristics of each set of particles, where all the analyzed attributes are equally important. Assuming that oxidation of meal's residual fat is the main process which initiates heat accumulating and

giving a higher coefficient of validity to the diagnostic variable "fat content", fraction positions would have been changed. Studies on the processes of self-heating taking place in oilseed meals [Bowes 1984, Becker 1996, Sturaro 2003] indicate that the assumption of the biochemical character of heating processes in post-extraction meals and of its equally important role compared to the chemical oxidation of polyunsaturated fatty acids seems appropriate. The German Insurance Association qualifies toasted oilseed meals as materials which are biotic active and which undergo microbiological processes leading to changes in the quality and stimulating exothermic reactions [Container Handbook, 2015]. The author's own studies (unpublished) showed that the growth of microflora on the surface of rapeseed meal samples stored at different temperatures and at a relative humidity of 80% is dependent mainly on protein content. However, according to

transport regulations (IMSBC, IMDG Codes), the residual fat content and further moisture content in meals are the only criteria to assign cargo to one of four groups, including three dangerous ones (Seed Cake: UN 1386 a, 1386 b UN or UN 2217).

Table 3 shows the classification of fractions of rapeseed meal with a given moisture content and residual oil based on the criteria contained in the IMSBC Code. According to these criteria, only two fractions, i.e. one with a particle size above 3 mm and the other below 0.075 mm with a certain moisture and oil content could be classified as safe in transport in terms of self-heating. Other collections of particles, as well as unfractionated rapeseed meal, meet the requirements for the classification set of seed cakes prone to self-heating (class 4.2. of dangerous goods, UN 1386 (b)).

Table 3. The classification of fractions of rapeseed meal according to IMSBC Code
Tabela 3. Klasyfikacja badanych frakcji śruty rzepakowej wg Kodeksu IMSBC

Fraction (mm)	Moisture content (M) (%)	Residual oil content (O) (% d.m.)	Moisture + residual oil content (%)	Dangerous cargo class 4.2/group B UN 1386 (b)*	Cargo classified as non-hazardous**
>3	10.9	3.6	14.5		•
1.2-3	9.5	4.8	14.3	•	
0.4-1.2	10	7.4	17.4	•	
0.2-0.4	9.2	5.6	14.8	•	
0.075-0.2	7.7	5.1	12.8	•	
<0.075	7.8	3.3	11.1		•
Natural RM	10.9	6.3	17.2	•	

*Classification criteria: O (residual oil) <10% and when M (moisture content) > 10% then M+O <20%
** Classification criteria: O (residual oil) <4% and O+M<15%

The comparison of results obtained by multivariate analysis with the data presented in table 3 shows that aggregate indexes (RL) for each fraction mostly coincide with the classification states (dangerous/safe), according to marine transport regulations. Resistance-level indexes of fractions classified as safe in transport were high (w> 3 = 0.7190 and w <0.075 = 0.6343). For the remaining fraction, which are classified as dangerous goods according to the IMSBC Code, these indicators were correspondingly lower, with the exception of fractions with a particle size in the range of 0.4-1.2 mm (w0.4-1.2 = 0.6754). The reason for this discrepancy is the oil

content of this fraction, which exceeds 4% d.m. and thus prejudges qualifying this group of particles to class 4.2 of dangerous goods. Simultaneously, this fraction has the lowest protein concentration and the highest porosity, which contributes to its higher position in the hierarchy of collections of particles by increasing the level of resistance to unfavorable changes initiating self-heating.

CONCLUSIONS

It can be concluded that it is beneficial to divide rapeseed meal into two fractions in

terms of both the utility of meal as well as its transportation properties: finer meal, which might be used exclusively for the domestic animal feeding industry and a thicker one, used as a biofuel to be utilized locally and due to greater resistance to quality changes, exported in bulk by sea, in the case of production oversupply . With each ton of rapeseed meal, about 250 kg of fine fraction meal (d <0.4 mm) is obtained, with a protein content of more than 40% d.m. and structural polysaccharide content reduced to the level of 7.9-9.4% d.m. (vs 11.8% in the natural meal). However, this fraction has very low transport susceptibility (the influence of the fraction with a particle size less than 0.075 mm on the transport susceptibility of mixed dust fractions can be omitted because of its weight participation of only 0.1%). During long journeys by sea, the benefits of fractionating the natural meal may be reduced by the quality of such a product dropping quickly, especially with unmodified, averaged standards for permissible moisture content. In transport processes, such a product will be more susceptible to self-heating than natural meal and will pose a real risk of explosion [Bojanowska and Leśmian-Kordas 2009]. It would therefore be useful to use transport packaging for domestic carriages of fractionation meal products intended for the fodder industry.

Fractions with a particle size above 0.4 mm, obtained in amounts of about 750 kg per ton of meal, could instead be used as a renewable energy source. We can assume with a high probability that such a product, as compared to unfractionated meal, would be characterized by greater transport susceptibility, and also would pose a much smaller risk of explosion in technological and transportation processes. The experience with agro-biomass in the green energy sector, including rapeseed meal, has shown that the delivery logistics as well as transportation attributes of solid fuels, such as hygroscopic properties, explosiveness of dust or susceptibility to self-heating, are as important as their functional characteristics (elemental composition, heating value, emission of gases and particles etc.). It has not been ruled out that the fractionation of meal may also bring benefits for the combustion processes, because of the lower protein content in coarser fractions (and thereby probably lower emissions of nitrogen oxides NO_x), which together with the transport susceptibility presented in this paper, can inspire experimental research on the effect of the fractionation on the properties of solid biofuels originating from rape seed.

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OCENA PODATNOŚCI TRANSPORTOWEJ PRODUKTÓW FRAKCJONOWANIA ŚRUTY RZEPAKOWEJ

STRESZCZENIE. **Wstęp:** Wzrastająca produkcja biopaliw płynnych i stałych z nasion rzepaku, przy stałym znaczeniu tej rośliny w przemyśle spożywczym i paszowym, wymaga racjonalnego, a zwłaszcza efektywnego technologicznie i logistycznie zagospodarowania produktów ubocznych technologii przerobu rzepaku. Celem badań przedstawionych w artykule była ocena podatności transportowej zróżnicowanych ze względu na wielkość cząstek oraz skład chemiczny frakcji śruty rzepakowej.

Metody: Jako kryterium podatności transportowej przyjęto odporność frakcji śruty na przemiany stymulujące samozagrzewanie. Wytypowano i oznaczono doświadczalnie następujące zmienne diagnostyczne: zawartość białka ogólnego, tłuszczu surowego oraz włókna surowego, porowatość, a także aktywność wody w poszczególnych frakcjach śruty. W celu uporządkowania zbiorów cząstek, a następnie wytypowania najkorzystniejszych ich zastosowań ze względu na przyjęte kryteria - cechy użytkowe i technologiczno-transportowe, obliczono dwa wskaźniki agregatowe.

Wyniki: Stwierdzono, iż najmniejszą podatność transportową wykazują średnie frakcje pyłowe (0,075-0,4 mm), największą zaś frakcja o największej granulacji (d> 3 mm). Istotną zależnością jest spadek wartości paszowej frakcji śruty wraz ze wzrostem podatności transportowej, co oznacza w praktyce, że frakcje najmniej pożądane w przemyśle paszowym, mogą być najmniej uciążliwe w transporcie.

Wnioski: Zaproponowano podział śruty rzepakowej na dwa produkty, różniące się przeznaczeniem oraz podatnością transportową. Frakcjonowanie śruty może przynieść wymierne korzyści zarówno dla przemysłu paszowego, jak i w sferze logistyki dostaw biopaliw stałych, w której obok kosztów surowca i jego transportu, istotną rolę w wykorzystaniu biomasowych źródeł energii odgrywają cechy przechowalniczo-transportowe.

Słowa kluczowe: samozagrzewanie, transport biomasy, logistyka energii odnawialnej, biopaliwa stałe, wykorzystanie rzepaku.

DIE BEWERTUNG DER TRANSPORTEIGNUNG VON FRAKTIONS-PRODUKTEN DES RAPSSCHROTES

ZUSAMMENFASSUNG. **Einführung**: Die ständig wachsende Produktion von flüssigen und festen Biokraftstoffen aus Rapssamenkörnern erfordert angesichts der kontinuierlichen Bedeutung dieser Pflanze in der Lebensmittel- und Futterindustrie eine rationelle und vor allem technologisch und logistisch effiziente Bewirtschaftung von technologisch bedingten Nebenprodukten, die bei der Rapsverarbeitung entstehen. Die Bewertung der Transporteignung der wegen der Größe differenzierten Partikeln und die chemische Zusammensetzung der Rapsschrotfraktion waren der Zweck der im Artikel präsentierten Forschungen.

Methoden: Als Transporteignungskriterium wurde die Abhärtung der Schrotfraktion gegen die Wandlungen, die Selbstaufheizung deren stimulieren, angenommen. Man hat experimentell folgende Variablen wie: den Inhalt des Proteins, des Rohfettes und des Rohfadens, die Porosität als auch die Wasseraktivität in den einzelnen Schrotfraktionen markiert. Um die Partikeln-Mengen einzuordnen und anschließend ihre günstigsten Anwendungen angesichts der angenommenen Kriterien wie Nutz-, Technologie- und Transporteigenschaften auszuwählen, hat man zwei Sammel-Indizes berechnet.

Ergebnisse: Es wurde festgestellt, dass die mittlere Staubfraktion (0,075-0,4mm) die niedrigste Transporteignung aufweist, dagegen die höchste die Fraktion mit der größten Granulation (d> 3mm). Als eine wesentliche Abhängigkeit gilt der Wertrückgang der Schrotfutterfraktion samt dem Transporteignungsanstieg, was in der Praxis bedeutet, dass die in der Futterindustrie am wenigsten erwünschten Fraktionen für den Transport aber am meisten geeignet sein können.

Fazit: Man hat die Aufteilung des Rapsschrotes in zwei Produkte, die sich bezüglich der Bestimmung und der Transporteignung unterscheiden, vorgeschlagen. Das Fraktionieren des Schrotes kann messbare Nutzen sowohl für die Futterindustrie als auch im Bereich der Biokraftstofflieferung bringen, in dem, neben den Rohstoff- und Transportkosten, die Lager- und Transporteigenschaften die Hauptrolle bei der Inanspruchnahme von Biomassenenergiequellen spielen.

Codewörter: Selbsterhitzung, Transport von Biomasse, Logistik für erneuerbare Energien, biogene Festbrennstoffe, Inanspruchnahme von Raps

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THE USE OF INSTRUMENTS OF LOGISTICS AND MARKETING IN TRANSPORT ENTERPRISES IN LUBUSKIE VOIVODESHIP

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ABSTRACT. **Background:** The aim of the article is to verify the logistics and marketing instruments used in transport enterprises in Lubuskie voivodeship. The article presents the results of surveys of transport companies. Based on these studies in transport enterprises in Lubuskie, the current level of the use of logistics and marketing instruments was determined. Logistics and marketing instruments were separated to study the needs of transport companies in Lubuskie voivodeship. The choice of these instruments gave rise to a study f the possibility of using them in the implementation of business operations. From the findings it can be inferred that they are useful for the voivodeship, and that such a system can be implemented in the whole country.

Methods: The study was conducted in the second half of 2014 and 140 transport enterprises in Lubuskie. Based on the research results, classifications of instruments were developed using logistics and marketing division at their levels.

Results: On the basis of these findings and observations, the authors have analysed the levels of identification instruments, logistics and marketing. On this basis, it was possible to identify the instruments used by logistics and marketing in these companies.

Conclusions: Based on the study of transport companies in Lubuskie voivodeship, a selection of logistics and marketing instruments were identified, along with a classification of the logistics and marketing instruments used. With the implementation of the above steps to classify the usage level of logistics and marketing instruments, the ability to match these levels to data transport companies was established.

Key words: transport companies, instruments, logistics, marketing tools, transport.

INTRODUCTION

Since Poland's accession to the European Union, there has been a rapid increase in the activity of transport companies in international markets, generating a significant amount of revenue. Not only are Polish companies meeting import and export orders for domestic and foreign customers, they are also moving goods between EU countries and opening their own representative offices abroad, both in the original fifteen and in the new member states.

Transport companies face numerous obstacles and restrictions in their activities [Witkowski 2015]. One of the key factors hindering the development of such companies is rising operating costs, primarily fuel prices and labour costs. The increase in labour costs is related to an increasingly visible shortage of qualified workers.

Attention is frequently drawn to unfair competition and the lowering of rates. In recent years, especially since 2005, the number of companies operating in the market has increased exponentially. Small companies with one or two vehicles are not able to provide customers with a high standard of service, but compete primarily on price. To make informed decisions, it is necessary to have knowledge of the market environment; its current state,

direction of development, political and social transformations. Surrounding businesses create unequal conditions, depending on the region, industry sector, the size of these companies, their form of ownership, and many other factors [Gierszewska, Romanowska 2003].

It is worth noting that the factors which are related to the business environment are independent of the company and, to a large extent, derived from the policy of the state and market regulation mechanisms. These are influenced by both the overall health and economic situation in the country, and the wider world economy. On the other hand, internal factors associated with the activities undertaken by the company are related to its financial condition, material resources, intellectual capital, organizational structure, development strategy, management methods, entrepreneurship, innovation and quality of products and services [Borowiecki 2010].

THE IMPORTANCE OF LOGISTICS AND MARKETING ACTIVITIES OF ENTERPRISES

In Poland, demand for transport services is growing rapidly [Kauf 2010], and thus the knowledge of logistics and marketing instruments plays an important role.

The number of Polish publications [Szołtysek, Sadowski 2013] devoted to the problems of logistics and marketing instruments has also increased in recent years.

Analyzing a number of definitions, it should be noted that logistics combines more aspects and has increased in importance in more and more areas of the economy. "Logistics can be considered as a new economic function performed by the company" [Nowicka-Skowron 2000]. According to M. Soltysik [Sołtysik 1994], "Logistics is a field of knowledge of logistics processes in the economy and the art of effective management of these processes".

According to M. Ciesielski, the fairly widely accepted understanding of logistics, which now includes over one hundred definitions, can be reduced to one of three meanings: [Ciesielski 2006]
- Logistics is an area of economic knowledge on flows of goods and information in the economy;
- Logistics is the concept of process management of such flows based on an integrated approach;
- Logistics processes concern the physical flow of material goods - raw materials, semi-finished products and finished products, as well as related information, occurring both within companies and between them.

To determine the importance of logistics, it is important to identify the structure of logistics processes (Figure 1).

The illustration indicates the modern understanding of the processes that consolidate streams of property and information flows, and their cost efficiency. This concept of logistics processes takes customer service into account; quality, the level of efficiency and customer satisfaction [Skowronek, Sarjusz-Wolski 2003]. These tangible and intangible elements of logistics processes should meet the needs of customers in any location, time or quantity and ensure their proper use.

Logistics management consists of strategy formulation, planning, control and monitoring (which takes place in an effective way and minimizes global costs) of process flow and storage of raw materials, inventory, work in progress, finished goods and related information from the point of origin to the point of consumption in order to adapt to customer needs and satisfy them as well as possible [Witkowski, Kużdowicz 2003].

Some authors, such as H. Ch. Pfohl [Pfohl 1972] and Christopher M. [Christopher 1998] indicate the importance of logistics and management functions with what S. Abt [Abt 2001] and M. Sołtysik [Sołtysik 2000] called logistics management.
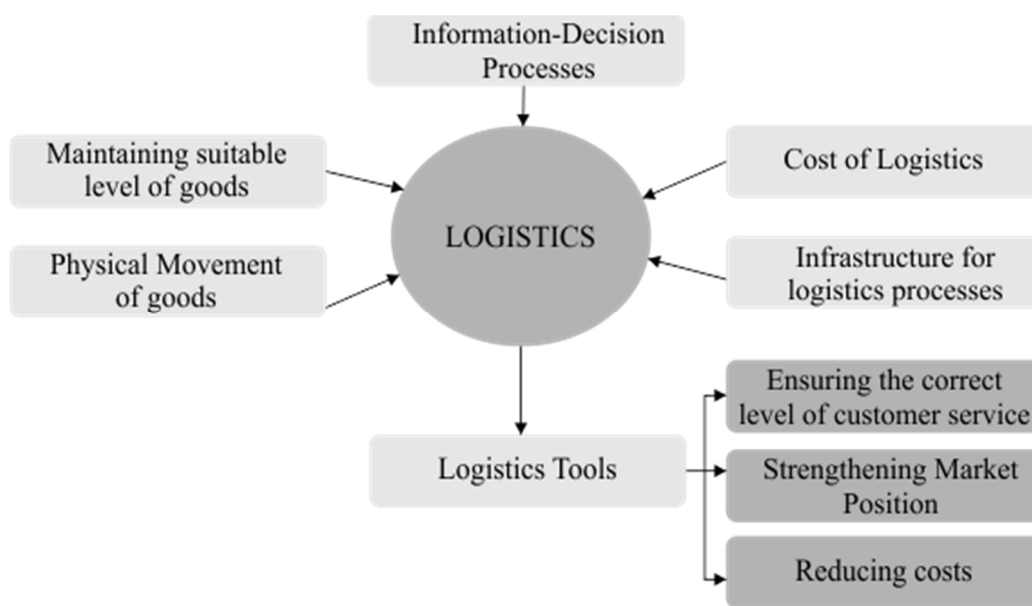
Fig. 1. The main components of logistics processes
Rys. 1. Podstawowe składniki procesów logistycznych

Many definitions of marketing have also been formulated. Ph. Kotler, G. Armstrong, J. Saunders and V. Wong define it as follows: "This is a management and social process by which individuals and groups obtain what they need and want through creating and exchanging products and mutual values". They cite several other definitions of the term [Pabian 2004]:

- marketing is the process of planning and implementing the concept, pricing, promotion and distribution of ideas, goods and services for a replacement to serve achieve objectives of organizations and individuals;
- marketing is the creation of utility associated with time, place and possession;
- marketing is the provision of relevant goods and services to the right people at the right time and place, at the right price, using the proper communication and promotion;
- marketing is the creation and delivery of standards of living.

Marketing includes all activities and instruments whose immediate goal is to identify, define and create potential market effects and shape the company's success. In logistics, however, it is mainly concerned with the creation and use of potential efficiency and system support for market-oriented companies, and its integration is focused on creating benefits for clients.

Both elements are up against each other in the form of coupled possibilities for efficient use of the potentials and capacities, contributing to the achievement of the required level of service and long-term customer satisfaction and loyalty, and an appropriate level of profit in the strategic dimension.

An expanded range of aims in marketing and logistics in terms of their integration in the management of logistics and marketing is shown in Figure 2.

The specification and structure of the aims presented here take into consideration the fundamental dimensions of their qualifications and hierarchy, i.e. size of market, company and society [Nowicka-Skowron 2000].
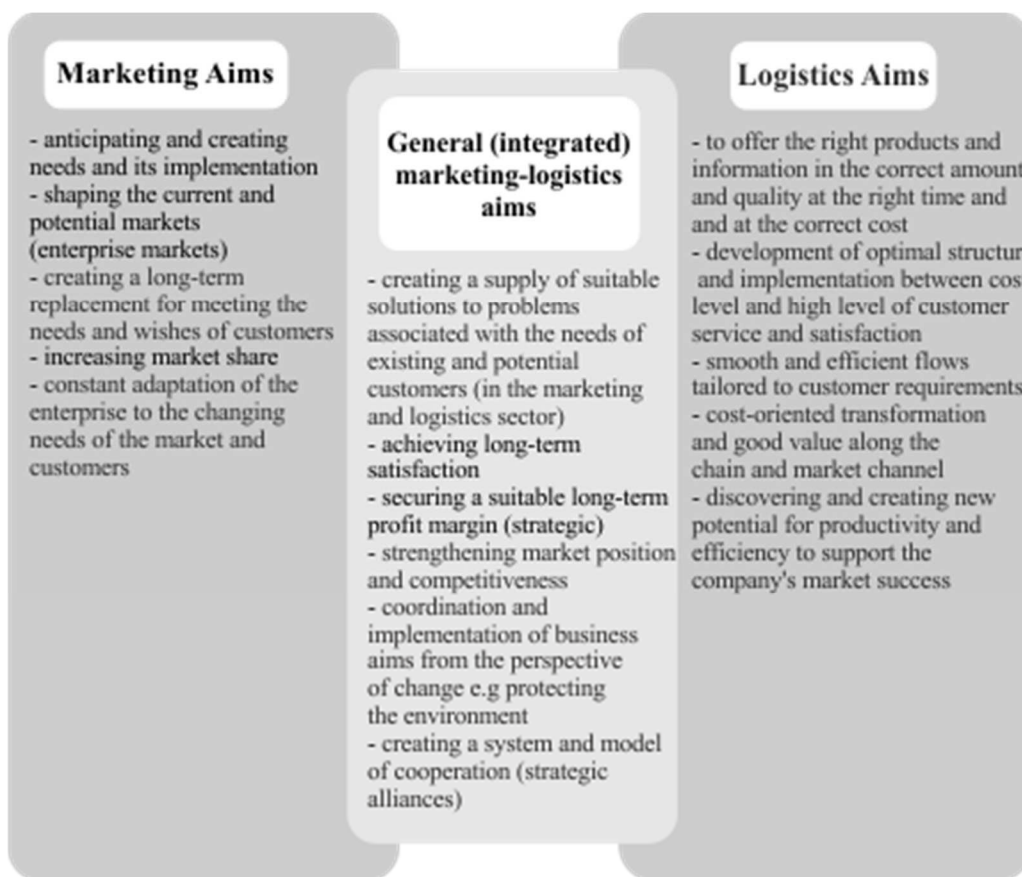
Fig. 2. The main objectives of marketing and logistics
Rys. 2. Podstawowe cele marketingowo-logistyczne

These integrated objectives include bringing the company to the forefront of the market (from the point of view of the customer), separated objectives of creating demand and the optimization of the supply chain (the structure of benefits to customers), solving specific customer problems in marketing and logistics market segments, as well as targets for the achievement of long-term satisfaction and customer loyalty [Pabian 2015].

The main objectives of marketing and logistics considered in the context of the company include the development of an optimal structure of added value and reducing costs along the marketing and logistics value chain, developing an appropriate amount of profit in the long run, and strengthening the company's competitive position in the market, etc. [Blaik, Matwiejczuk 2005]. It is also important to refer to business models [Brzóska, Jelonek 2015]

The described terminology will be used to present knowledge of the logistics and marketing instruments used in transport enterprises in Lubuskie voivodeship.

ANALYSIS OF THE TRANSPORT COMPANIES SURVEYED

Surveys were carried out to assess the scale and mechanisms of use of logistics and marketing instruments. The study included 95 small transport companies and 14 medium-sized transport companies. The study did include any large companies. The reason for this is the lack of large transport companies operating within Lubuskie voivodeship.

The selection of logistics and marketing instruments was based on literature studies, analysis, interviews and a questionnaire. The break-down of logistics and marketing instruments is presented in the table below (Table 1).

Table 1. Logistics and Marketing Instruments
Tabela 1. Instrumenty logistyczne i marketingowe

Instruments			
Logistics	Electronic exchanges	ECR	QR	JUST-IN-TIME
Marketing	Form of promotion of enterprises	Form of identification of enterprises	Production Strategy	Pricing Strategy

This table shows four logistical instruments and four marketing instruments. Based on the observation of transport companies in Lubuskie, we created a model to identify those instruments, which can function separately in different functional areas of companies. In contrast, a new phenomenon in the area of management, especially in the transport enterprises, is to use them as instruments of logistics - marketing. The allocation of instruments to each group is presented in Figure 3.

Fig. 3. Model of logistics and marketing instruments
Rys. 3. Model instrumentów logistyczno-marketingowych

The illustration indicates that all the instruments of both logistics and marketing may represent a general attempt by transport companies that use these instruments to examine the classification. On the basis of empirical studies, a division of logistics and marketing instruments can be made based on the intensity of their use. The analysis also takes into account other factors; the development of these enterprises, including their competitive position, their technical infrastructure, the company's image and how it is perceived by competitors and other stakeholders etc. Based on a survey and subsequent analysis, transport companies were classified into four levels. The degree to which individual instruments are used is presented in Table 2.

Table 2. Classification of enterprises taking into account the levels of use of logistics and marketing instruments
Tabela 2. Klasyfikacja przedsiębiorstw z uwzględnieniem poziomów wykorzystywania instrumentów logistycznych i marketingowych

	Logistics instruments	**Marketing instruments**
Level I (lowest)	Transport Exchange	Forms of Promotion (min.1) Forms of identifying enterprises (min.1)
Level II	Transport Exchange	Forms of Promotion Forms of identifying enterprises strategy used (product strategy and pricing)
Level III	Transport Exchange and/ or ECR and/ or QR	Forms of Promotion Forms of identifying enterprises strategy used (product strategy and pricing)
Level IV (highest)	Transport Exchange ECR QR Just In Time	Forms of Promotion Forms of identifying enterprises strategy used (product strategy and pricing)

Table 2 presents the classification of instruments which are used by transport companies in Lubuskie voivodeship. This classification takes into account the levels of intensity of logistics and marketing instruments, ranking them as follows:

− Level I assumes the use of a single logistics instrument and two marketing instruments. These are freight exchanges and forms of promotion and identification of business. This assumption is determined by a low financial and organizational cost, and a low level of knowledge about the concepts of logistics and marketing applied amongst executives.
− Level II shows the use of at least one logistics instrument and three or four marketing instruments. These are: freight exchanges, forms of promotion and forms of identification of business, pricing strategy and/or product. It can be argued that at this level of the use of logistics and marketing instruments, management personnel within companies are aware of the importance of their application and have the necessary skills to use them in practice.
− Level III shows the use of at least one logistics instrument (e.g. Freight Exchange, QR or ECR) and the use of marketing instruments taking forms such as promotion and forms of identification of business along with pricing or product strategy. Transportation companies using these instruments have the knowledge and ability to use the instruments of logistics and marketing.
− Level IV classifies companies that go beyond the logistics and marketing

instruments already mentioned (freight exchanges, ECR, QR, forms of promotion, forms of identification, pricing strategy or product) and use the philosophy of Just In Time. The study shows that a higher level of awareness of management is demonstrated in the use of JIT. These companies use it to manage at least one freight exchange and the concept of ECR or QR and all marketing instruments. Hence it can be concluded that this level will indicate the highest degree of utilization of logistics and marketing instruments.

The levels described above are illustrated in Figure 4. This shows the classification levels of logistics and marketing instruments used, where Level I is the lowest with the smallest intensity of instruments used, whilst Level IV indicates the highest level of use of these instruments.

Enterprises classified on the last level have the highest intensity of use of the instruments of logistics and marketing. These are companies in which the owners, most often acting as managers, have the necessary knowledge and skills to use these instruments.

Below is table 3, which takes into account the levels of use of instruments of logistics and marketing. The analysis was carried out on the entire sample of 109 surveyed companies. The purpose of this was to analyze the use of logistics and marketing instruments by respondents and formulate the above classification based on the intensity of the instruments used.
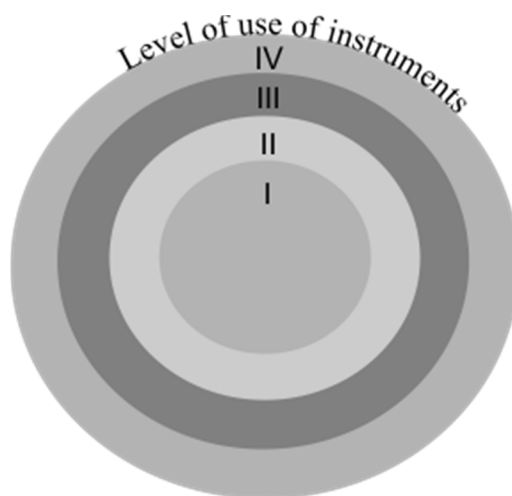
Fig. 4. Levels of classification of the use of logistics and marketing instruments
Rys. 4. Poziomy klasyfikacji wykorzystania instrumentów logistyczno-marketingowych

Table 3. Analysis of levels of identification of logistics and marketing instruments for the companies surveyed
Tabela 3. Analiza poziomów identyfikacji instrumentów logistyczno-marketingowych na przykładzie badanych przedsiębiorstw

Instruments	P1	P2	P3	P4	...	P109
Transport Exchange	■	■	■	■	■	■
ECR		■	■			■
QR		■	■		■	■
JIT					■	
Internet	■	■	■	■	■	■
Email					■	■
Press						
Leaflets						
Billboard						
Logo	■	■	■	■	■	■
Website	■	■	■	■	■	■
Letterheads		■	■	■	■	■
Business Cards		■	■		■	■
Promotional Brochures						■
Other						
Product Strategy	■	■	■		■	■
Pricing Strategy	■	■	■		■	■
Level of implementation of logistics-marketing instruments	Level II	Level III	Level III	Level I	Level IV	Level III

■ The use of instruments

This division was made on the basis of the above-described Table 3 and Figure 1. The number of enterprises classified at various levels of use of instruments of logistics and marketing is shown in the table below (Table 4).

Table 4. Classification of the companies surveyed, taking into account the level of use of logistics and marketing instruments
Tabela 4. Klasyfikacja badanych przedsiębiorstw z uwzględnieniem poziomów wykorzystywania instrumentów logistyczno-marketingowych

Logistics Instruments	Marketing Instruments	Number of Enterprises
Level I		
Transport Exchange	Forms of promotion (min.1) Forms of identifying enterprises (min.1)	**4**
Level II		
Transport Exchange	Forms of promotion Forms of identifying enterprises strategy used (product strategy and pricing)	**49**
Level III		
Transport Exchange and/or ECR and/or QR	Forms of promotion Forms of identifying enterprises strategy used (product strategy and pricing)	**42**
Level IV (HIGHEST)		
Transport Exchange ECR QR Just In Time	Forms of promotion Forms of identifying enterprises strategy used (product strategy and pricing)	**15**

From fundamental research it can be shown that the fewest enterprises are on the lowest level of use of logistics and marketing instruments (only four companies). This shows a general awareness among transport companies of the existence of these instruments. A significantly greater number of companies were positioned higher - 49 have been classified as level II and 42 as level III. The largest number of companies falls just above the basic level. This means that entrepreneurs are knowledgeable in the field of logistics and marketing instruments used, and the scope of their use by transport companies in Lubuskie voivodeship is at the initial stage of development. This can also be demonstrated by the large number of businesses located on the second level of use of these instruments. It should also be noted that between level III and level IV there is a big gap in the instruments used. 15 companies were located at the fourth position, but the differences in the instruments used are so great that the group may only be used to representatively illustrate the present level of development of these units to a small degree. Overall, we can say that these transport companies are at the initial stage of development due to the logistics and marketing instruments used, and there is the prospect of further development in this industry.

CONCLUSIONS

Based on the study of transport companies in Lubuskie voivodeship, a number of logistics and marketing instruments were identified, along with a classification of the logistics and marketing instruments used. With the implementation of the above steps for the classification of levels of use of instruments of logistics and marketing, the ability to match these levels for data transport companies was established. Knowledge of logistics and marketing instruments in transport enterprises has a significant impact on the market. Research indicates that transport undertakings are reaching the highest level in the use of logistics and marketing instruments. In order to gain a competitive advantage, companies must not only care about their image, developing their business and analyzing the competition, but must also pay an attention to logistics management. Competitive advantage, meeting customer needs more effectively, faster and more efficient operations, a more efficient supply chain and its optimal functioning are just some of the benefits of maintaining a high level of logistics management in the enterprise, including the use of logistics and marketing Instruments. The greater the knowledge, awareness and application of instruments of marketing logistics and transport companies, the greater their contribution to the competitiveness of the Polish market.

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WYKORZYSTANIE INSTRUMENTÓW LOGISTYCZNO-MARKETIN-GOWYCH W PRZEDSIĘBIORSTWACH TRANSPORTOWYCH WOJEWÓDZTWA LUBUSKIEGO

STRESZCZENIE. **Wstęp**: Celem artykułu była weryfikacja stosowanych instrumentów logistyczno-marketingowych w przedsiębiorstwach transportowych w województwie lubuskim. W artykule przedstawiono wyniki badań ankietowych przedsiębiorstw transportowych. Aktualnie na podstawie przeprowadzonych badań w przedsiębiorstwach transportowych w województwie lubuskim określono wykorzystywanie instrumentów logistyczno-marketingowych. Wyodrębnienie instrumentów logistyczno-marketingowych było stworzone na potrzeby przebadania przedsiębiorstw transportowych w województwie lubuskim. Taki dobór tych instrumentów dał podstawę do przestudiowania możliwości wykorzystywania ich przy realizacji działalności przedsiębiorstw. Z wyników badań można wywnioskować, iż są one przydatne dla województwa lubskiego, oraz że taki zestaw może być realizowany w skali całego kraju.

Metody: Badania zostały przeprowadzone w drugiej połowie 2014 roku, w 140 przedsiębiorstwach transportowych w województwie lubuskim. Na podstawie wyników badań, opracowano klasyfikacje wykorzystywanych instrumentów logistyczno-marketingowych z podziałem na ich poziomy.

Wyniki: Na podstawie wyników tych badań i obserwacji, autorzy opracowali analizę poziomów identyfikacji instrumentów logistyczno-marketingowych na przykładzie badanych przedsiębiorstw. Na tej podstawie możliwa była identyfikacja wykorzystywanych instrumentów logistyczno-marketingowych w tychże przedsiębiorstwach.

Wnioski: Na podstawie przeprowadzonych badań przedsiębiorstw transportowych województwa lubuskiego stworzono dobór instrumentów logistyczno-marketingowych, utworzono klasyfikację wykorzystywanych instrumentów logistyczno-marketingowych.

Słowa kluczowe: przedsiębiorstwa transportowe, instrumenty logistyczne, instrumenty marketingowe, transport.

EINSATZ VON INSTRUMENTEN DES LOGISTIK-MARKETING IN TRANSPORTUNTERNEHMEN IN DER WOIWODSCHAFT LEBUS

ZUSAMMENFASSUNG. **Einleitung:** Das Ziel dieses Artikels war es, die Instrumente von Logistik und Marketing in Transportunternehmen in der Woiwodschaft Lebus zu bewerten. Der vorliegende Artikel stellt Ergebnisse von Umfrage-Forschungen, die in den Transportunternehmen durchgeführt wurden, dar. Aufgrund der in den Transportunternehmen durchgeführten Untersuchungen wurde der aktuelle Einsatz von Instrumenten des Logistik-Marketing in der Woiwodschaft Lebus ermittelt. Die Ermittlung der betreffenden Tools kam zwecks der Bewertung der im Lebuser Lande tätigen Transportunternehmen zustande. Durch eine entsprechende Auswahl der brauchbaren Instrumente ergab sich eine Möglichkeit, sie bei der effektiven Betätigung der Unternehmen in Anspruch zu nehmen. Den Ergebnissen der Forschungsarbeiten ist zu entnehmen, dass sie sowohl innerhalb der Woiwodschaft Lebus als auch in einer solchen Konfiguration im ganzen Lande brauchbar sind.

Methoden: Die betreffenden Untersuchungen wurden in der 2. Hälfte 2014 in 140 Transportunternehmen in der Woiwodschaft Lebus durchgeführt. Anhand der Forschungsergebnisse wurde eine Klassifizierung der angewendeten logistischen Marketing-Instrumente samt der Aufteilung auf deren Niveaus ausgearbeitet.

Ergebnisse: Auf der Grundlage dieser Erkenntnisse und Wahrnehmungen haben die Autoren eine Analyse der Ebenen für die Identifizierung der logistischen Marketing-Instrumente am Beispiel der befragten Unternehmen entwickelt. Anhand dessen war es möglich, die verwendeten Tools des Logistik-Marketing in den betreffenden Unternehmen zu identifizieren.

Fazit: Gestützt auf die durchgeführte Erforschung der genannten Fragestellungen innerhalb der Transportunternehmen in der polnischen Woiwodschaft Lebus wurde eine Vorgehensweise an die Auswahl der logistischen Marketing-Instrumente konzipiert und eine Klassifikation der Tools für das Logistik-Marketing ausgearbeitet.

Codewörter: Transportunternehmen, Logistik-Instrumente, Marketing-Tools, Transport.

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ANTIMICROBIAL PACKAGING WITH NATURAL COMPOUNDS – A REVIEW

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ABSTRACT. **Background:** Packaging problems are an integral part of logistics and the implementation of packaging significantly affects the effectiveness of logistics processes, as a factor which increases the safety and the quality of products being transported. Active packaging is an area of technology needed to meet the requirements of the contemporary consumer. Active packaging creates additional opportunities in systems for packing goods, as well as offering a solution in which the packaging, the product and surroundings interact. Furthermore, active packaging allows packaging to interact with food and the environment and play a dynamic role in food preservation. The main role of antimicrobial packaging is to inhibit the growth of microorganisms that reduce the quality of the packaged product.
Methods: The application of natural antimicrobial agents appears to be safe for food products. Also, these compounds have potential applications as a natural preservative in the food packaging industry. This study presents some antibacterial agents, namely chitosan, nisin and pectins.
Results and conclusion: Natural substances used in active packaging can eliminate the danger of chemical substances migrating to food.

Key words: logistics, antimicrobial packaging, natural antibacterial agents.

INTRODUCTION

The principal function of packaging is protection from heat, light, the presence or absence of moisture, oxygen, pressure, enzymes, microorganisms, insects, dirt and dust particles, gaseous emissions, and other things which might damage the product [Brody et al. 2001]. Antimicrobial packaging is a promising form of active packaging. Active packaging refers to the incorporation of certain additives into packaging film or within packaging containers, with the aim of maintaining and extending product shelf life [Day 1989]. Moreover, active packaging, sometimes referred to as interactive packaging, is intended to sense internal or external environmental change and to respond by changing its own properties and hence the internal package environment [Brody et al., 2001].

Antimicrobial agents may be incorporated directly into packaging materials for slow release into the food surface or may be used in vapour form [Wilson 2007]. Antimicrobials reduce the growth rate and maximum population of microorganisms (spoilage and pathogenic) by extending the lag phase of microbes or inactivating them [Quintavalla, Vicini 2002]. The use of packaging films containing antimicrobial agents could be more efficient than the direct addition of these compounds into food. The nature of the antimicrobial agents is very diverse [organic acids, enzymes, bacteriocins, fungicides, natural extracts, ions, ethanol etc.] as well as

the nature of the materials into which they are included, such as papers, plastics, metals or combinations of these materials [Dainelli et al., 2008].

ANTIMICROBIAL AGENTS

According to Nilsson et al. [2000] antimicrobial packaging technology that has the potential to modify headspace atmosphere creates an effective hurdle against bacterial cells. An antimicrobial in gaseous form is evenly distributed in the headspace of a packaging structure and functions more effectively compared to antimicrobials in solid or liquid forms. The most commonly used antimicrobial gas in food application is CO_2, which inhibits both Gram-positive and Gram-negative microorganisms. Also, an alternative method of generating antimicrobial gas would be the removal of molecular O_2 from the headspace of a packaging structure. Molecular O_2 encourages the growth of obligate aerobic, facultative anaerobic, and microaerophilic microorganisms and causes the development of off flavor and off-color, as well as the loss of nutritional components of packaged food products [de Kruijf et al. 2002].

Antimicrobial effects which are achieved by adding antimicrobial agents into the packaging system or using antimicrobial polymeric materials generally function in one of three ways: release, absorption or immobilisation [Han 2003]. Also, the choice of an antimicrobial agent depends primarily on its activity against the targeted microorganisms [Han, 2000 2005]. Many other factors, however, need to be considered when designing antimicrobial packaging systems, such as specific activity, resistance of microorganisms, controlled release mechanisms, the chemical nature of foods and antimicrobials, storage and distribution conditions, film/container casting process conditions, physical and mechanical properties of antimicrobial packaging materials, organoleptic characteristics and toxicity of antimicrobials, and corresponding regulations [Han 2000]. All these factors should be carefully considered according to the corresponding regulations in order to design an effective active packaging [Sadaka et al. 2014].

As a result, there are many antimicrobial agents that exist and are widely used. Antimicrobial agents have different activities and affect different microorganisms. This is due to the characteristic antimicrobial mechanisms and also to the various physiologies of microorganisms. Therefore three groups of antimicrobial agents can be used: chemical agents, natural agents, and probiotics. Antibacterial agents of natural origin include chitosan, nisin and pectins.

CHITOSAN

Chitosan is natural antimicrobial polymer obtained by deacetylation of chitin obtained commercially from shrimp and crab shell. Also, in literature chitosan has been reported as an antibacterial agent against a wide variety of microorganisms [Entsar et al. 2003, Wu et al. 2005]. The antimicrobial mechanism for chitosan is related to interactions of the cationic chitosan with the anionic cell membranes, increasing membrane permeability and eventually resulting in rupture and leakage of the intracellular material. Moreover, it has been reported that bulk chitosan and its nanoparticles are ineffective at pH<6, probably because of the absence of protonated amino groups [Qi et al. 2004]. The applications of chitosan in food packaging are mainly justified by their antimicrobial and antifungal activities against pathogenic and spoilage microbes. Chitosan-based active films allow food preservation to be extended and the use of chemical preservatives to be reduced [Aider 2010]. According to Rabea et al. [2003], chitosan exhibits greater antimicrobial activity than chitin, due to the greater number of free amino groups, which respond to the antimicrobial activity upon protonation. Cellulose and chitosan are the two most abundant biorenewable natural materials and have shown great promise for their application in food packaging. These naturally-occurring polymers have the ability to form films and moderate oxygen and moisture permeability [Byun et.al. 2012, Mi et al. 2006, Pereda et al 2011, Souza et al. 2010, Vargas et al. 2011]. Yu et al. [2013] prepared packaging films from water-soluble chitosan [N,O-carboxymethyl chitosan, NOCC] and cellulose [methylcellulose, MC]. They prepared active

packaging films with caffeic acid which was incorporated into the composite films in fixed and releasable types. The caffeic acid-incorporated films showed 20-fold increases in antioxidant activity and 6-fold increases in antibacterial activity as compared to the caffeic acid-free composite films. The releasable caffeic acid could be continuously released from the composite films and showed a significant inhibitory effect on lipid oxidation of menhaden oil-in-water emulsion. The chitosan antifungal action was evaluated against Alternaria alternata, Aspergillus niger, and Rhyzopus oryzae [Ziani et al. 2009]. Cruz-Romero et al. [2013] presented antimicrobial activity of chitosan, organic acids and nano-sized solubilisates for potential use in smart antimicrobially-active packaging for potential food applications. Abdou et al. [in press] demonstrated that a plasma pretreated polypropylene surface treated with chitosan could impart antibacterial and antifungal properties, since chitosan has been shown to possess efficient antimicrobial abilities.

One of the most promising active bio-films is the one based on chitosan combined with different materials, such as plant and animal proteins, polysaccharides and antimicrobial peptides [bacteriocin] such as nisin and divergicin, a new class of bacteriocin produced by Carnobacterium divergens [Tahiri et al. 2004, Tahiri et al. 2009]. Moreover, Elsabee et al. [2008] studied tomato packing in bags of transparent polypropylene film coated with twelve non-nanoscale alternating layers of chitosan and pectin, in view of a new concept of active packaging for fruit preservation. Chitosan and pectin can interact at pH 5.6. However the gel behaviour depends upon the degree of esterification of the pectin. In fact the polyelectrolyte complex formation requires ionized carboxylate 015groups of pectin and protonated amino groups of chitosan [Lehr et al. 1992].Wang et al. [2015] prepared antibacterial packaging film containing chitosan/poly[vinyl alcohol] [Nisin-CS/PVA]. The experimental results showed antimicrobial activity films against S. aureus which may have potential as an active film in food packaging. Duran et al. [2016] presented the use of nisin, natamycin, pomegranate and grape seed extracts in chitosan coating to extend the shelf life of strawberries.

Antimicrobial agents were added to chitosan at a concentration of 1% w/v. The results showed that all coatings have a good effect on the quality of strawberries during the storage period.

NISIN

Nisin is an antimicrobial peptide with 34 amino acids and a molecular weight of 3.5 kDa, produced by strains of Lactococus lactissubsp. lactis [Mulders et al. 1991]. Moreover, is the most common bacteriocin, tested for many applications. This peptide has antimicrobial properties, especially against the food-borne pathogens Listeria monocytogenes, Staphylococcus aureus or Bacillus cereus [Brewer et al. 2002, Lopez-Pedemonte et al. 2003]. Due to its effect on the important Gram positive food-borne pathogens, many studies have focused on the incorporation of nisin into various kinds of films made of cellulose, nylon, whey protein isolate, hydroxypropyl methylcellulose, zein etc. and their use as nisin delivery system packaging films to reduce undesirable bacteria in foodstuffs [Chollet et al. 2008, Coma et al. 2001, Gadang et al. 2008, Ko et al. 2001, Kristo et al. 2008, Natrajan Sheldon 2000, Neetoo et al. 2008, Nguyen et al. 2008, Teerakarn et al. 2002]. Studies have also been published by a number of authors on the use of nisin as an antimicrobial in a wide variety of food products [Delves-Broughton et al. 1996]. Nguyen et al. [2008] prepared nisin-containing bacterial cellulose film to inhibit Listeria monocytogenes on processed meats. This cellulose film containing nisin was developed and used in a proof-of-concept study to control Listeria monocytogenes and total aerobic bacteria on the surface of vacuum-packed frankfurters. Additionally, many studies have shown that nisin may be efficiently incorporated into cellulose-based packaging films and used for controlling pathogens in food products [Ming et al. 1997, Scannell et al. 2000, Franklin et al. 2004, Luchansky & Call 2004].

Ercolini et al. [2010] studied the spoilage-related microbial populations of beef and to investigate the effect of nisin-activated antimicrobial packaging on the development of beef spoilage at low temperatures.

The combination of chill temperatures and antimicrobial packaging proved to be effective in enhancing the microbiological quality of beef cuts by inhibiting LAB, carnobacteria and Brochothrix thermosphacta in the early stages of storage and by reducing the loads of Enterobacteriaceae. Economou et al. [2009] presented the effect of nisin and EDTA treatments in increasing the shelf-life of raw poultry products stored under modified atmosphere packaging at 4°C. Neetoo et al. [2008] used nisin-coated plastic films to control Listeria monocytogenes on vacuum-packaged cold-smoked salmon. The effect of storage temperature, nisin concentration on low-density polyethylene [LDPE] film, and inoculation level on the growth and survival of Listeria monocytogenes was investigated. At 4°C [low and high inoculum levels] and 10 °C [low inoculum level], it was found that the degree of inactivation or growth inhibition of Listeria monocytogenes was directly related to the concentration of nisin. The fact that nisin delayed the growth of Listeria monocytogenes populations in smoked salmon at both low and high inoculum levels show that nisin might be used to control post-processing contamination of Listeria monocytogenes in cold-smoked salmon. Cao-Hoang et al. [2010] presented the effectiveness of the nisin-coated sodium caseinate films against Listeria innocua in cheese during storage at refrigerated temperatures, indicating that combining nisin into sodium caseinate films is a promising method to enhance the safety and extend the shelf life of processed cheeses.

PECTIN

Pectin is a natural polysaccharide, poly [1,4-galacturonic acid], which is obtained from the cell walls of terrestrial plants and exhibits polyanionic behaviour [Farris et al. 2011, May 1990]. It is now known that pectin is a major component of the plant cell wall and the most complex macromolecule in nature [Voragen et al., 2009]. Pectin is also a high-molecular weight, biocompatible, non-toxic, and anionic natural polysaccharide extracted from cell walls of higher plants [Zouambia et al. 2009]. Gopi et al. [2014] extracted pectin from banana peel. The experimental results revealed that the hydroxyapatite HAP nanoparticles synthesized

in the presence of an optimized concentration of pectin are pure, low crystalline, spherical and discrete particles with reduced size. Ravishankar et al. [2012] studied films based on pectin and apple, carrot or hibiscus. The films were treated with carvacrol or cinnamaldehyde and their antimicrobial activity was tested against Listeria monocytogenes on contaminated ham and bologna.

Physical or chemical modification of pectin can lead to new products with significant functional properties. The applications of pectin have been also extended greatly from food and food additives to various fields, such as drug delivery [Mishra et al. 2008, Souto-Maior et al. 2010], antithrombotic agents [Cipriani et al. 2009], and mucoadhesive [Sharma, Ahuja 2011] and antimicrobial substances in materials for packaging food. Moreover, Tripathi et al. [2010] developed an antimicrobial chitosan/poly [vinyl alcohol]/pectin ternary film for food packaging applications. It exhibited significant antimicrobial activity against various pathogenic bacteria such as Escherichia coli, Staphylococcus aureus, Bacillus subtilis, Pesudomonas and Candida albicans. Pectin is a general term for a group of valuable natural polysaccharides extracted from edible plant material where they occur as structural materials. Its main sources are citrus peel and apple pomace [Stasse-Wolthuis et al. 1980, Thibault, Ralet 2001]. Gorrasi et al. [2012] prepared films containing pectins obtained from apples. The films showed antimicrobial activity, indicating the potential application of prepared complexes in the packaging field and the potential usage of pectin-antimicrobials as coating agents for a wide number of packaging polymers. The antimicrobial activity of pectin edible films incorporated with nisin and its combination with treatment of ionizing radiation was used to control Listeria monocytogenes on a ready-to-eat [RTE] turkey meat by Jin et al. [2009]. The combination of irradiation with pectin film containing nisin resulted in a 3.95 log CFU/cm^2 reduction at 1 kGy and a 5.35 log CFU/cm^2 reduction at 2 kGy; indicating a synergistic effect on Listeria viability on the surface of RTE turkey meat. In the same year, Jin et al. [2009] tested pectin-polylactide [PLA] composite films

treated with with nisin against Listeria monocytogenes. Alves et al. [2011] developed model composite films based on commercial pectin and carrageenan, containing organically modified nanoclays. The barrier properties to water vapour and CO_2 of a polymeric matrix composed by kappa-carrageenan and pectin [66.7% kappa-carrageenan], with the inclusion of nanoclays, was studied. The effect of particle content of the films on water vapour permeability [WVP] was dependent on the driving force applied.

SUMMARY

Traditional food packaging is designed to mechanically support otherwise non-solid food, and to protect food from external influences. Antimicrobial packaging appears to be one of the most promising applications of active food packaging technology.

Natural compounds that do not have any significant medical or environmental impact could potentially serve as effective alternatives to conventional antibacterial or antifungal agents. Therefore, the preparation of antimicrobial materials with natural substances is a huge challenge to researchers and producers of packaging food.

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AKTYWNE OPAKOWANIA Z NATURALNYMI ZWIĄZKAMI ANTYBAKTERYJNYMI

STRESZCZENIE. **Wstęp:** Problematyka opakowań jest elementem logistyki, zaś zastosowane opakowania istotnie wpływają na efektywność procesów logistycznych, jako czynnik zapewniający bezpieczeństwo i zwiększający jakość transportowanych wyrobów. Opakowania aktywne są obszarem technologii wychodzącym na przeciw wymaganiom stawianym przez współczesnego konsumenta. Opakowania aktywne stwarzają nowe możliwości w zakresie systemów pakowania towarów oraz stanowią rozwiązanie, w którym to opakowanie, produkt oraz otoczenie wzajemnie na siebie oddziałują. Poza tym opakowania aktywne w wyniku zachodzących oddziaływań z wewnętrzną atmosferą i produktem prowadzą do przedłużenia jego trwałości. Główną rolą opakowania przeciwbakteryjnego jest hamowania wzrostu drobnoustrojów, które obniżają jakość produktu.
Metody: Stosowanie naturalnych środków przeciwbakteryjnych wydaje się być bezpieczne dla produktów spożywczych. Ten typ związków ma potencjalne zastosowanie jako naturalne środki konserwujące w przemyśle spożywczym. W niniejszej pracy przedstawiono niektóre ze stosowanych środków przeciwbakteryjnych, min. chitozan, nizyny i pektyny.
Wyniki i podsumowanie: Naturalne substancje przeciwbakteryjne stosowane w opakowaniach aktywnych eliminują niebezpieczeństwo konsumentów w zakresie migracji chemicznych substancji do żywności.

Słowa kluczowe: logistyka, opakowania antybakteryjne, naturalne substancje antybakteryjne

ANTIBAKTERIELLE VERPACKUNGEN MIT NATÜRLICHEN VERBINDUNGEN

ZUSAMMENFASSUNG. Einleitung: Aktive Verpackungen stellen einen Technologie-Bereich dar, der den Anforderungen der gegenwärtigen Verbraucher gerecht zu werden vermag. Die aktiven Verpackungssysteme schaffen neue Möglichkeiten auf dem Gebiet des Verpackens von Waren und somit bilden sie eine Lösung, innerhalb deren die Verpackung, das Produkt und die Umwelt in Wechselwirkung miteinander treten. Darüber hinaus führen die aktiven Verpackungen infolge der aktiven Wechselwirkung der Innenatmosphäre mit dem betreffenden Produkt zur Verlängerung dessen Lebensdauer. Die Hauptrolle der Anwendung von antibakteriellen Verpackungen beruht auf der Hemmung des Wachstums von Mikroorganismen, die die Qualität des Produktes vermindern.

Methoden: Die Verwendung von natürlichen antimikrobiellen Mitteln erscheint für Lebensmittel sicher zu sein. Diese Art von Verbindungen erfährt potentielle Anwendung als natürliches Konservierungsmittel in der Nahrungsmittelindustrie. Dieser Beitrag stellt einige Beispiele der Verwendung von antimikrobiellen Mitteln, wie Chitosan, Nisin und Pektin dar.
Ergebnissen und Fazit: Die natürlichen antimikrobiellen, in den aktiven Verpackungen verwendeten Substanzen beseitigen zugunsten der Verbraucher die Gefahr der Migration von chemischen Stoffen zu Lebensmitteln.

Codewörter: Logistik, antibakterielle Verpackungen, natürliche antibakterielle Substanzen

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HOW TO MANAGE SUSTAINABLE SUPPLY CHAIN? THE ISSUE OF MATURITY

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ABSTRACT. **Background:** The issue of managing sustainability in supply chain seems to be more and more complex. There are many aspects that need to be taken into consideration when planning, implementing and monitoring environmental and social conditions of supply chains. Despite many works, already published, on the concept of sustainable development (SD) is seems that the issue of assessment and especially the issue of maturity in the light of the SD concept is still not developed enough.

Methods: The general aim of the paper is the analysis of the maturity issue in the context of sustainability. The main objective is to conceptualize the idea of maturity in sustainable supply chain. Beside the literature research the own proposition of theoretical model was described.

Results: The article describes the issue of maturity as an element of managing sustainable development in the supply chain. The author presented a theoretical model of the maturity. Moreover the author gave some recommendations how to manage the sustainability issues in supply chain in more mature approach and introduced some useful tools among which are: certification, code of conduct and code of ethics, audits, projects etc.

Conclusions: The issue of maturity seems to be very useful for proper understanding the idea of sustainable development in supply chain. The developed model can be used as self-assessment method to check at which level of implementation the idea of SD is analyzed in supply chain. Furthermore, the next phase of the planned research in form of practical verification of the model was advised as well as a research of identification of new factors and tools in analyzed area.

Key words: logistics, sustainable supply chain, sustainable supply chain management, maturity, sustainable supply chain maturity model.

INTRODUCTION

Sustainable development (SD) is getting more and more popular concept. It is also treated as an important element of management of supply chains. The special term describing the issue of SD in supply chain is used. The concept of Sustainable Supply Chain is quite good described in literature [Carter, Rogers, 2008a, Carter and Rogers, 2008b, Beske, Seuring 2014, Svensson 2007, Holt, Ghobadian, 2009, Green et al., 2012, Zaabi et al. 2013, Cruz 2013, Azadeh et al. 2016]. It can be understood as "the management of material, information and capital flows as well as cooperation among companies along the supply chain while taking goals from all three dimensions of sustainable development, i.e. economic, environmental and social, into account which are derived from customer and stakeholder requirements" [Seuring, Müller 2008]. The cited definition put attention on two important elements: management of the network and three dimensions of sustainable development. It means that sustainability in supply chain can be only achieve in the situation in which, the noneconomic aspects are imprinted in the management system and visible at every stage from strategy to single operations.

But it is still challenging how to assess the scale of managing the supply chain in sustainable manner. It seems to be very crucial problem for corporations. They need to know the minimum guidelines and requirements in which their supply chain can be classified as sustainable and what kind of actions can be taken to improve it. The issue of maturity, to some extent, gives the answer for above critical questions.

On the level of single entity the mature organization can be characterized as "fully formed with typical features or getting the excellence [Dictrionary, website]". Maturity in supply chain is understood as "engagement in extensive collaboration across wide arc of supply chain partners in order to implement appropriate integrative practices." [Done 2011]. Combining the definition of sustainable supply chain and maturity in supply chain the author proposes a new definition. Maturity in sustainable supply chain can be defined as: level of engagement of the whole cooperative network and quality of management of social, environmental and economical dimensions of supply chain visible in its flow of material, information and capital. In other words it is the readiness to plan, implement and monitor sustainability issues in the whole life cycle of offered products. It shows the achievement of noneconomic goals and gaps to improve. The more mature approach to sustainable development the better flow of material and information and stronger cooperative bonds in the network. Proposed model is rather a framework that should be taken into consideration in organization that tries to manage the sustainable development. It is starting point of further improvements of the sustainable excellence in supply chain.

SUSTAINABLE SUPPLY CHAIN MATURITY MODEL

Model consists of six drivers: knowledge, impact, social risk, environmental risk, cooperation and communication. Each category is assessed from 1 to 5 points (table 1). The proposed model can be used as a self-assessment tool.

Knowledge is a critical driver for the formation of transparent supply chain. Thanks to clear processes and procedures it is easy to monitor the whole network, build trust among consumers and implement mechanisms of rapid alert system is something is going wrong. On the other side sharing knowledge allows to improve skills and abilities among business partners. It is very important especially among smaller companies that are not so sensitive and conscious about environmental and social issues. Transparency is a very important word for describing the current supply chain management. It is also strictly related to the knowledge sharing. Transparency is needed to avoid risk of losing reputation. It is also a very important factor of building open relations with stakeholders and involving them to sustainability actions [Turker et al. 2014].

Impact should be understood as the ability to make changes and have influence on key decisions. In another words changes for sustainability need to happen in the whole structure. The final effect is the sum of activities taken on level of single organization. If the company attempts to achieve certain goals and make a lasting transformation of the supply chain but suffers from the lack of support from individual links and the lack of enforcement of some solutions it may make plans difficult or even impossible to realize.

The problem of risk is a quite well-known category in supply chain [e.g. Małyszek 2015, Jüttner 2005, Cucchiella, Gastaldi 2006, Tang 2006]. From the perspective of sustainability additional kinds of risk can be distinguished. The key risks are: risk related to human rights and work conditions, environmental risks including emissions, pollution, waste, dangerous substances and products etc.

The next issue is cooperation which can be understood as relations created between the whole network. It goes beyond formal agreements. The issue of communication is crucial for implementation of the idea of sustainability. It will be not possible to achieve common goals if partners will not know what are the expected results or future plans. The process of communication need to be extended also to customers. Special channels to inform and to making the feedback possible are needed to be designed.

Table 1. Areas of assessment of the maturity level
Tabela 1. Obszary oceny poziomu dojrzałości

Poor (1 point)	Sufficient (2 points)	Good (3 points)	Very good (4 points)	Excellent (5 points)
Knowledge				
There is no knowledge about processes and relations in supply chain. Little or no knowledge about subsuppliers and II/III row suppliers	Processes in life cycle are identified. The knowledge about suppliers and their partners about social and environmental aspects is limited	Suppliers in the whole supply chain are known. There is stuctured knowledge about processes and procedures in the whole supply chain	The whole life cycle is known. Processes are transparent. Social and environmental aspects are included in the maps of processes.	Supply chain is transparent. It it easy to idenify the location of all links, each supplier and way of processing at each stage of life cycle. Knowledge is shared with customers.
Impact				
Lmited impact on processes in supply chain	Impact on processes limited to the business relations with first row suppliers	Impact on the processes limited to the first row supplier including noneconomic apsects	Strong position in supply chain, impact on social and environmental aspects	Huge impact on a whole supply chain (including customers). Organization can decide about the policy and direction of further development
Social risk				
Not identified	Identified	Identified and managed (strategy)	Identified, managed and evaluated	Identified, managed, evaluated, independent assessment, certified
Environmental risk				
Not identified	Identified	Identified and managed (strategy)	Identified, managed and evaluated	Identified, managed, evaluated, independent assessment, certified
Cooperation				
Instable relations with suppliers	Transaction based cooperation	Clear business rules established. cooperation aims at longterm relationship built on trust	Regular meeting with suppliers, education and training, ethical principles	Common goals, social and environmental projects aim at development of noneconomic issues of supply chain, KPIs known and monitored
Communication				
Flow of information limited to the official agreements	Two sides communication limited to the official agreements	Structured system of communication, social dialog with suppliers	Good system of communication in the whole supply chain, whistleblowing policy, special channel to communicate about unethical cases	Two side flow of information, clients and users included in the process (feedback), social and environmental KPIs publicly available, different channels of communication available

Source: own elaboration

Table 2. Levels of maturity in sustainable supply chain management
Tabela 2. Poziomy dojrzałości w zarządzaniu zrównoważonym łańcuchem dostaw

Level of maturity	Description
starting	There are organizations that do not manage their supply chains. They are only focuse on short terms relations with suppliers. Non compliance actions (social/environmental) appear. There is no detailed knowledge about processes and relations in supply chain. The issue of sustainability is not taken into consideration as an important element of business strategy.
aware	organizations are aware of social and environmental aspects of their supply chains but they are charcterized by reactive attitude. They identify potential risks but have no strategy how to manage them.
aspiring	organizations know about sustainability but it is not their priority. They manage social and environmental risks and include noneconomic aspect into supply chain management system.
sustainable business leaders	processes in supply chain are known, managed and controlled. There is a set of measures to assess the level of achivement of noneconomic KPIs. Organizations identify and manage their risks. The impact on processes is huge so organizations can influence the way suppliers behave. Sustainability is a main orientation of their development.
masters of sustainability	the most sustainable organizations in the industry. Sustainability is an element of their business models and is the main factor of supply chain management. They manage the sustainability issues but also communicate about it. They are independently assessed and certified. They educate their partners in supply chains. New projects and goals are set to improve KPIs.

Source: Own elaboration

The method of assessment could be included in the enterprise system of business self- improvement as a monitoring tool of supply chain. There are five different levels of maturity proposed. The more complex and comprehensive approach the higher level of maturity in supply chain. Table 2 presents levels of maturity and their short descriptions.

Starting level means that organization gather less than 6 points (4-6 answers have only 1 point). At the level of being aware: 4-6 answers have 2 points. To reach the name of "aspiring": 4-6 answers must have 3 points. To become sustainable business leaders: 4-6 answers need to have 4 points and masters of sustainability for 4-6 answers gather 5 points. In the situation that organization will gain 3 points from one category and 3 from the second it stays at lower level. There is also the possibility to gain very dispersed results between more than two levels. It means that the management system is not coherent and requires more careful approach in neglected areas.

HOW TO IMPROVE MATURITY LEVEL?

Full formation of all aspect related to the sustainability is a long lasting process. Taking into consideration main aspect of sustainability like e.g. environmental protection, human rights, social inclusion, diversity management etc. business organizations need to be planned and join with the business model and strategy of the whole network. It seems to be very difficult when considering a single organization and it is much more complex among many entities with different cultures, norms, values or standards. On the other side there are some well known methods, tools and initiatives that support the process of change. It is worth to mentioning some of them:
 – certification systems,
 – audit systems,
 – measurement system
 – stakeholder management system including social dialog,
 – ethical infrastructure,
 – formal and informal education system.

There are different certifications systems that can be implemented successfully in supply chain like e.g. ISO 9001, ISO 14001, ISO 28000, supply chain risk management standards etc. There are also some systems that address specific types of industry like: automotive, food or textile. Even if they are not directly dedicated to the sustainability issues they improve the knowledge about processes and products. Next to the general standards there are available systems aimed at organizing the non-economic issues under the sustainability or social responsibility framework like: ISO 26000, AA1000 series, SA 8000 or Global Compact. Independent certification system is a kind of credibility for all interested parties. One can assume that verified systems work better what means they have more mature approach to business systems and can cope more efficient with challenges related to the environment and society. However it must be clearly stated that the implemented system is not just present but actively managed and perceived as a source of additional benefits for all partners.

Auditing scheme is very important in the process of monitoring and evaluating sustainability issues in supply chain. Usually there are some challenges to cope with such as: "managing information from the supply chain, motivating suppliers to pay for audits and complete questionnaires, the third is responding to audit results uncovering ethical violations in the supply chain, and the fourth is increasing awareness for a responsible supply chain among buyers." [Gonzales-Padron 2016]. However "the role and power of audits has grown significantly over the last decade, as audits have evolved from a tool that companies used to track internal organisational performance into a central mechanism of non-state efforts to measure and strengthen corporate accountability globally. Increasingly seen as a way to monitor and improve labour and environmental standards within production, reliance on the audit regime is deepening in the face of inadequate and declining state involvement in global corporate governance." [Lebaron, Lister 2015].

Performance measurement regarding sustainable supply chain is available in current scientific discussion [Taticchi et al. 2013, Schalteger, Burritt 2014, Ahi, Searcy 2015]. Some KPIs are developed including the most popular set of indicators from Global Reporting Initiative [GRI website] which can be also used to assess the current position of supply chains. The main challenge in this area is the implementation of coherent system of metrics that cover the whole life cycle of the products and will be unified for all links of supply chain. The more information about supply chains is gathered the easier process of setting the goals or making strategic decisions.

Stakeholder management can be identified as model of relationships with different groups of stakeholders by using different marketing and communicating methods and tools. There are many different groups and individuals that can influent our business operations like e.g. customers, workers, competitors, natural environment or suppliers. Stakeholders can in many cases worsening the image of organization or decrease selling of key products. They can cooperate and improve the competition advantage on the other hand. It is the reason why organizations decide to map and manage relations with stakeholders [Rudnicka 2012]. Suppliers are a specific group of stakeholders because of the huge impact on final product. They are directly responsible for the quality and safety of materials or subproducts. It is the reason why the stage of choosing and evaluation of suppliers very often is based on social and environmental criteria [Jasiulewicz-Kaczmarek et al. 2015]. In building and managing relations with suppliers the concept of social responsibility is often used [Urbaniak, 2015]. Ethical sphere is one of dimension needed to improve sustainability issues in supply chain. Different ethical tools exist in a mature organization (like for example: codes of conducts, manuals for suppliers, ethical lines, anticorruption policies, diversity management, ethical procedures and audits). If organization is making an effort to be more mature and have better sustainability results it should recognize the potential of minimum two things: codes of ethics and conduct and whistelblowing policy

as strategic elements. Code of conduct limits unethical behaviour in supply chain and underline the strategic points for all links to follow. Code of ethics "specify the minimum acceptable standards in corporate processes and procedures for them to be successfully implemented, employees need to be both aware of the standards and committed to achieving them." [Haugh, Talwar 2010]. Codes organize relationships in the supply chain. They note the core values and norms and are the basis for building the culture of accountability. Whistleblowing is understood as "disclosure by persons employed in the organization of information on actions taken by the other, may be unethical, illegal or unauthorized that may affect the functioning and effects of company [Hersch 2002]. Disclosure of information in planned and safe way is prerequisite for effective risk management, build trust and lower the number of unwanted events. Workers involvement is essential for making system live (by assuring the confidentiality of information, communication channels and protection of individual interests).

Suppliers will follow the rules if they will know what to do and how to do. Education in supply chain should be permanent element of business cooperation. Projects addressed to suppliers are of the much importance especially among smaller organizations. The mature approach is characterized by a willingness to share knowledge and learning in the best possible way to achieve common goals and multiply benefits.

Table 3 presents exemplary elements that can support management of maturity issues in sustainable supply chain related to different drivers of proposed model.

The optimum combination of available solutions gives the opportunity to improve and sustain the maturity of analysed network. The scale and diversity of methods depend on an industry, length of the chain, the complexity of products or level of maturity that has been already achieved.

Table 3. Exemplary elements that helps to improve the maturity in sustainable supply chain
Tabela 3. Przykładowe elementy pomocne doskonaleniu dojrzałości zrównoważonego łańcucha dostaw

Aspect	Element
Knowledge	- clear criteria of choosing suppliers - short supply chain with small numeber of links (local production systems) - mearuring systems - monitoring system - labor and safety and heatlh standards evaluation - implemented CSR standards - feedback from employees
Impact	- certification systems - social and environmental projects (with real impact on stakeholders) - sustainability criteria during choosing and evaluation suppliers - code of conduct and code of ethics - implemented CSR standards -common social and environmental goals
Risk management	- workshops - trainings - implemented certification system - monitoring system -ethical infrastructure
Communication	- social dialog - internal newsletters, newspapers and leaflets - whistleblowing policy - common social and environmental goals - different chanells to diferrent groups of stakeholders
Cooperation	- common strategy - noneconomic reporting - stakeholder management -common social and environmental goals - shared responsibility - common benefits strategy (win-win approach) - knowledge shared and disrtibuted in whole supply chains

Source: Own elaboration

CONCLUSIONS

The level of maturity testifies preparing the organization to take new challenges. For the sustainable supply chain maturity means a willingness to integrate social and environmental management system into business operations, plans and strategies. The more components of sustainable development is defined the greater level of maturity is achieved. Maturity is the ability to take advantage of the ready-made solutions and tools that help manage the sustainability. A more efficient and conscious creation of business reality is the result of their implementation. The company based on sustainable business approach must meet many, sometimes contradictory, goals and objectives. The key point is to treat in the same way economic, environmental and social values what in the case of such a complex structure as the supply chain can be very difficult. Hence, it is good to fit a set of tools to the actual needs of the supply chain. The maturity issue is - like sustainability - the process that can be achieved via several steps. The proposed checkpoints in described model show what and to what extent should be improved in supply chain to make it more sustainable.

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JAK ZARZĄDZAĆ ZRÓWNOWAŻONYM ŁAŃCUCHEM DOSTAW. ISTOTA DOJRZAŁOŚCI

STRESZCZENIE. **Wstęp**: Problematyka zarządzania zrównoważonym rozwojem w łańcuchu dostaw wydaje się być coraz bardziej złożona. Istnieje wiele aspektów, które muszą być brane pod uwagę przy planowaniu, realizacji i monitorowaniu warunków środowiskowych i społecznych w łańcuchach dostaw. Mimo dużego dorobku naukowego dotykającego problematyki zrównoważonego rozwoju (ZR) w łańcuchu dostaw kwestia oceny, a zwłaszcza poziomu dojrzałości nie jest jeszcze wystarczająco rozwinięta.
Metody: Głównym celem artykułu jest analiza kwestii dojrzałości w kontekście zrównoważonego rozwoju. Obok przeglądu literatury autorka prezentuje własną propozycję modelu teoretycznego.
Wyniki: W artykule nakreślono istotę dojrzałości w kontekście zarządzania zrównoważonym łańcuchem dostaw. Autorka przedstawiła teoretyczny model dojrzałości. Dodatkowym elementem są rekomendacje uzupełnione o narzędzia, które można wykorzystać w praktyce jak np.: system certyfikacji, kodeksy postępowania, kodeksy etyczne, audyty czy projekty.
Wnioski: Włączenie kwestii dojrzałości do problematyki zarządzania zrównoważonym łańcuchem dostaw wydaje się bardzo potrzebne. Dzięki niej organizacjom łatwiej jest rozumieć istotę zrównoważonego rozwoju. Zaproponowany model użyty jako metoda samooceny dodatkowo pozwala sprawdzić, na jakim poziomie wdrożenia jest obecnie analizowany przez organizację łańcuchu dostaw. W kolejnej fazie planowanych badań zweryfikowany zostanie model teoretyczny. Dodatkowym kierunkiem badań opisywanej problematyki jest identyfikacja kluczowych czynników sukcesu i ich weryfikacja na podstawie badań empirycznych.

Słowa kluczowe: logistyka, zrównoważony łańcuch dostaw, zarządzanie zrównoważonym łańcuchem dostaw, dojrzałość, zrównoważony model dojrzałości łańcucha dostaw.

WIE DIE AUSGEWOGENE LIEFERKETTE ZU MANAGEN IST. DAS WESEN VON LIEFERKETTEN-REIFE

ZUSAMMENFASSUNG. **Einleitung**: Die Problemstellung des Managements der ausgewogenen Entwicklung innerhalb einer Lieferkette scheint immer komplexer zu sein. Es gibt viele Aspekte, die bei Planung, Abwicklung und Verfolgung von sozialen und Umfeld-Gegebenheiten in Lieferketten beachtet werden müssen. Trotz der weitgehenden wissenschaftlichen Erforschung der Problemstellung der ausgewogenen Entwicklung innerhalb von Lieferketten ist die Beurteilungsfrage, insbesondere die des Reife-Niveaus einer Lieferkette nicht ausreichend etabliert.

Methoden: Das Hauptziel der Arbeit ist es, die Frage der Lieferketten-Reife im Zusammenhang mit der ausgewogenen Entwicklung zu analysieren. Neben der Literatur-Übersicht präsentiert die Autorin ihren eigenen Entwurf eines theoretischen Modells.

Ergebnisse: Im Artikel wurde das Wesen der Lieferketten-Reife im Kontext des Managements der ausgewogenen Lieferkette projiziert. Die Autorin stellte ein theoretisches Reife-Modell dar. Ein zusätzliches Element ergeben die um entsprechende Tools ergänzten Empfehlungen, wie z.B. Zertifizierungssystem, ethische Kodexe, Verhaltensnormen und -ordnungen, Audits und Projekte, die man praktisch umsetzen kann.

Fazit: Die Anbindung der Lieferketten-Reife an die Problemstellung des Managements der ausgewogenen Lieferkette vermag sehr brauchbar zu sein. Dadurch fällt den dafür interessierten Wirtschaftseinrichtungen leichter, das Wesen der ausgewogenen Entwicklung zu nachvollziehen. Das vorgeschlagene und als Mittel für die Selbsteinschätzung angewendete Modell lässt ferner den Stand der Einführung einer Neuorganisation innerhalb der Lieferkette ermitteln. In der nachfolgenden Phase der geplanten Forschungen wird das theoretische Modell verifiziert werden. Eine zusätzliche Ausrichtung bei der Erforschung der betreffenden Fragestellungen stellen die Ermittlung von schlüsselhaften Erfolgsfaktoren und deren Verifizierung anhand von empirischen Forschungen dar.

Codewörter: Logistik, ausgewogene Lieferkette, Management der ausgewogenen Lieferkette, Lieferketten-Reife, ausgewogenes Modell der Lieferketten-Reife

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SEAMLESS COMMUNICATION IN SUPPLY CHAINS BASED ON M2M TECHNOLOGY

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ABSTRACT. **Background**: Access to information is the key element in the successful and efficient organization of transport & logistic processes. The importance of real-time access to information is confirmed by a panel workshop carried out with support of design thinking methodology. There are two ways of gaining access to the right information - manual, where human agency is needed and fully automatic, where new M2M technology is implemented. Implementation of such technology improves seamless communication during transport execution and allows real-time access to needed information. The aim of the paper is to evaluate the influence of the effectiveness of using M2M technology and traditional way of communication as well as data gathering in order to ensure seamless communication in the supply chain.

Methods: Survey, design thinking, desk research and real case study results were used in the paper.

Results and conclusions: Seamless communication and implementation of M2M technology within the whole supply (including modes of transport and transport units) chain is a backbone of the lean and reliable digital supply chain.

Key words: logistics, digital supply chain, seamless communication, M2M, supply chain visibility, time slots management, accounting of transport costs.

INTRODUCTION

Access to information is the key element in the successful and efficient organization of transport & logistic processes. At present, there are solutions that allow real-time communication between shippers and logistics service providers during the purchasing of services and planning. There is also a second group of solutions that allows the tracking and tracing of vehicle execution monitoring. As a result, transport & logistics services providers and their users need to use different systems in order to obtain information about the real-time execution of the process. Moreover, due to the technical constraints and roaming charges (in particular outside EU) track&trace of vehicles and cargo is difficult and expensive. Therefore, in order to manage the whole transport chain, enable communication with clients, drivers and vehicles, transport and logistics service providers are currently forced to use at least three independent solutions, including phone calls. As a result, seamless communication within the supply chain does not exist.

In addition to this, companies operate in large national and international networks in order to enlarge market reach. The challenge lies in the smooth management of data, proper execution of trade and transport with its complexities of distance and time, language and cultural barriers, and its dependency of national and international rules and regulations.

At the same time, energy, transport and increased human intervention in the environment have proven to be major contributors to climate change over recent decades. The European Union has planned to implement an ambitious target for emissions reduction for years. It is now confident of achieving its goal of cutting greenhouse gas emissions by 20 % in 2020 and has recently doubled its target, to bring about at least a 40 % reduction compared to 1990 levels, to be achieved by 2030 [Eurostat, 2015]. This relates not only to modal shift and use of more environmentally-friendly modes of transport, but also the way transport and logistics processes are organized.

Recent developments in communications technology allow automatization of data exchange between participants of the supply chains. This allows human errors to be eliminated in data exchange, as well as to significantly speed up access to the selected information and reduce the time needed to execute the whole transport process within the supply chain.

Therefore, the paper's objective is to present results of the authors' study on the effectiveness of using M2M technology and the traditional way of communication as well as data gathering in order to ensure seamless communication in the supply chain. Machine-to-Machine (M2M) communication can be said to be a form of data communication that involves one or more objects that do not mandatorily require human intervention in their communication process [Aslekar, Londhe, Gaikwad, 2016, Wu, Geng, 2011, Boswarthick, David, Omar Elloumi, 2012].

MARKET DEMAND FOR SEAMLESS COMMUNICATION

Authors made a panel study of the market demand in transport and logistics sector during dedicated workshops organised in Poznan, Krakow, Sopot and Bologna, attended by businesspeople and representatives of the scientific community. In total, 30 senior logistics staff took part in the panel. Logistics managers represents the following companies: Agri Plus, Animex, Azoty, Aluplast, Bakalland, CAT, Codognotto, Dachser, DB Schenker, DHL, Europapier, Kuehne+Nagle, Nova Trading, Onninen, Palmolive, PKP Cargo, Onninen, Pepsico, Raben, Rossmann, Volkswagen, Uni Logistics, Uniq Logistics, Speedbergx, Solid, Logit One, Dachser, Rail-Mag, Symlog, Infinity Management.

Panel participants were asked to design an ideal transport process which would eliminate their current bottlenecks. During the panel, a not only to modal shift and use of more environmentally-friendly modes of transport, but also the way transport and logistics processes are organized. design thinking approach was used. The Design Thinking process first allows panelists to define the problem and then implement the solutions, always with the needs of the user demographic at the core of concept development. This process focuses on needfinding, understanding, creating, thinking, and doing. At the core of this process is a bias towards action and creation: by creating and testing something, you can continue to learn and improve upon your initial ideas.

The design thinking process consists of these 5 steps:
- EMPATHIZE: Work to fully understand the experience of the user for whom you are designing. Do this through observation, interaction, and immersing yourself in their experiences.
- DEFINE: Process and synthesize the findings from your empathy work in order to form a user point of view that you will address with your design.
- IDEATE: Explore a wide variety of possible solutions through generating a large number of diverse possible solutions, allowing you to step beyond the obvious and explore a range of ideas.
- PROTOTYPE: Transform your ideas into a physical form so that you can experience and interact with them and, in the process, learn and develop more empathy.
- TEST: Try out high-resolution products and use observations and feedback to refine prototypes, learn more about the user, and refine your original point of view.

This process were used during individual workshops for need finding, understanding, creating, thinking, and doing [Brown, Tim, Jocelyn, 2015, Johansson-Skoldbelrg, Woodila, Çetinkaya, 2013, Dym, Clive, 2005]. Analysis of needs resulting from the panel shows that there is a demand for solutions enabling real-time transport management and for monitoring order completion progress in real time as part of the global supply chains. Companies are particularly interested in monitoring the progress of order completion and automatic conveyance of such data to customers.

As a main need, panellists stated that the ideal solution for the management of transport and logistics processes should eliminate the following problems of existing solutions:

– Global visibility of supply chains - global tracking of smart cargos and vehicles makes it possible to determine the status of a specific logistics service accurately. Companies who order the services of carriage or haulage companies who carry high-value goods (alcohol, paper, electronic equipment) indicate that it is necessary to determine accurately whether or not e.g. a driver pulled over or parked in an unauthorised car park.

– The time slots problem and the issue of deliveries to chain stores - another problem indicated by manufacturers who deliver goods to chain stores. Chain stores determine time windows for their suppliers (e.g. from 2 pm to 4 pm). If a manufacturer/supplier delays delivery, a chain store may impose a fine on them. Up until now, no solution has been available on the market which would allow accurate determination of the time a cargo or a vehicle is ready for loading.

– Automatic accounting of transport costs - this need was underlined by transport service providers and transport service users. Currently, to account transport services companies must wait for signed proof of delivery. In most cases this document is a paper document where the receiver confirms the delivery to the driver. In the next step the driver sends the document back to the forwarder or to his own company. Based on the proof of delivery companies can account transport costs. The whole process can last up to 4 weeks from the moment when the goods were delivered to the receiver.

– Production stoppages resulting from unavailability of information on the delivery status in real time. This problem was voiced by companies using the "Just in Time" system, meaning that delivered products are sent directly to the assembly line. In the event that goods are not delivered on time or a delay is not notified early enough, the entire assembly line is stopped as there are no materials for the line to work further.

– The missing cargo problem. This issue was raised by companies operating in Africa, Asia and South America. Solutions enabling cargo monitoring in these continents are virtually unattainable due to the limitations resulting from the inaccessibility of a GPRS channel and high GSM charges. The problem of high costs and other inefficiencies of using GPRS channel for data transmission is confirmed by other researchers [Ming, Fang, 2012, Sharma, Archana, Vineet Kansal, 2015, Hajdul, Kawa, 2015].

– Temperature and moisture monitoring in real time. This issue was raised by health-care sector companies who, in accordance with the latest best practice for drug distribution published by the European Commission, are obliged to monitor cargo temperature and moistness in real time and make these data available, also in real time, to all transport chain participants (shipper, consignee, carrier).

The first three points were mentioned by all panellists as being crucial ones that should be solved by an ideal solution for transport and logistics management. All of the points tackle aspects of access to data during the execution of transport. That is why most of the panellists stated that there is a need for improvements in communication between all actors involved in the supply chain. As a result, the panellists design an ideal supply chain system that allows seamless communication between services users, service providers and machines taking part in the execution of transport.
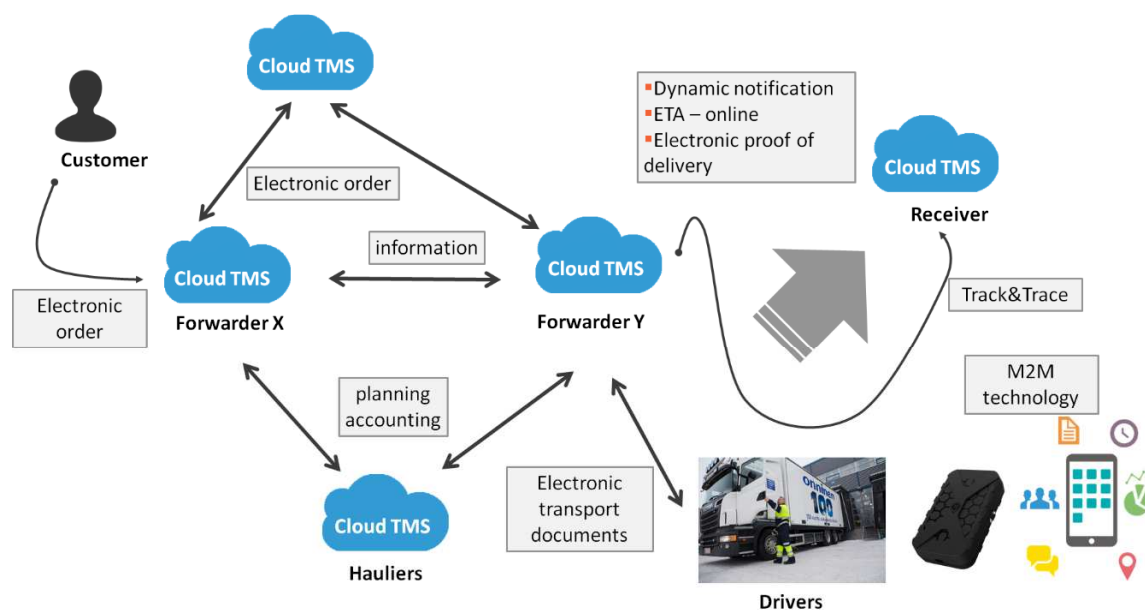
Source: own study

Fig. 1. Concept of the open transport management system that allows seamless communication
Rys. 1. Koncepcja otwartego systemu zarządzania transportem, który umożliwia bezproblemową komunikację

The main aim of the reference system drafted on figure 1 is to support seamless communication between users in the supply chain. All data needed are aggregated and stored in the cloud, with all users having access to authorized parts of the cloud. In particular, the panel participants underlined the importance of receiving the following real-time information during execution of transport:
− electronic order (booking),
− confirmation of receiving order,
− electronic notification about order status,
− electronic notification about ETA (estimated tome of arrival of goods),
− electronic transport order and documents transferred to the service provider/driver,
− electronic proof of delivery,
− electronic settlement of services within partners involved in the chain.

Panelists define the following generic data as crucial to be received automatically for track&trace transport execution:
− date and hour of reaching loading point,
− date and hour of loading of goods,
− real-time location of transport asset,
− date and hour of reaching unloading point,

− receiving proof of delivery from the driver.

Once these data are received, the process of settling services can be also organized automatically in a standardized digital format.

The next three chapters present a comparison of the current way of monitoring transport execution with a new approach to collecting data. In the current approach, all data are requested and distributed by humans. In the new approach, however, M2M technology is implemented in the vehicle executing transport. The basic version of M2M technology that can be implemented in transport is a simple GPS tracker connected to an online system that allows open access to process users. This allows human work in selected part of the processes to be eliminated. Moreover, automatically receiving information about transport execution allows the manager/forwarder better planning and synchronizing other transport orders [Mes, Martijn, 2016].

REAL-TIME VISIBILITY OF TRANSPORT PROCESSES

Currently, to collect information about real-time location and status of the transport there is a need to involve at least two persons (forwarder and driver). When information about the current location of a transport-asset is needed, the forwarder has to call the driver in order to check this. Figure 2 presents the AS-IS situation, based on the process analysis done in Speedbergx forwarding company operating in Europe. Figure 3 presents the TO-BE situation, where the whole process has be automatized by implementing M2M technology.
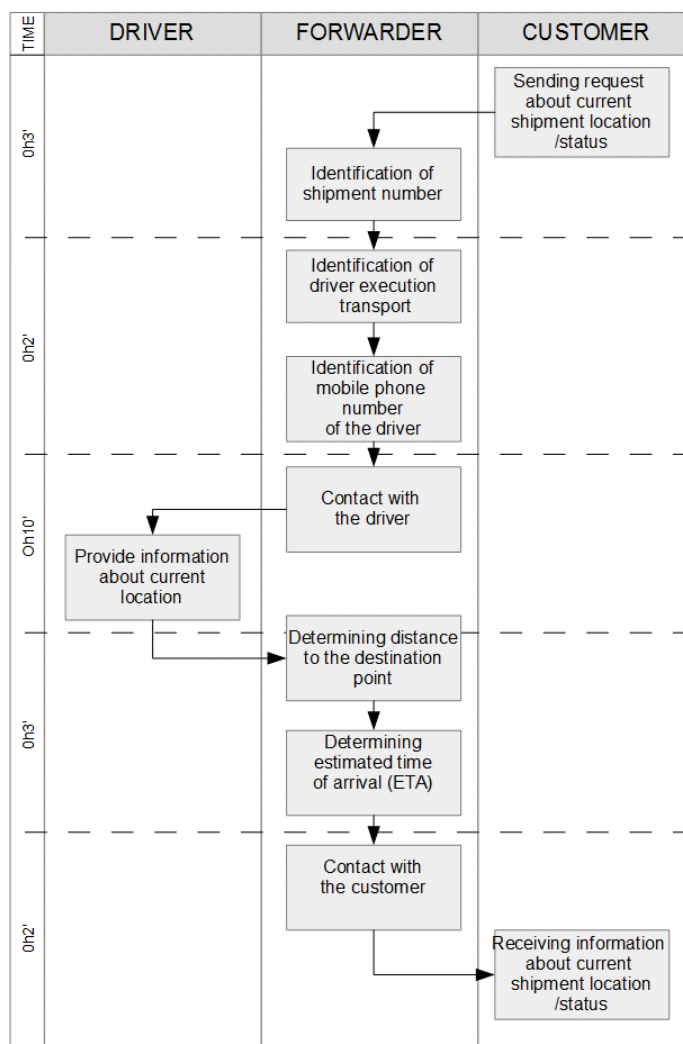
Source: own study

Fig. 2. AS-IS process allowing monitoring of shipment execution (visibility)
Rys. 2. Bieżący proces identyfikacji stopnia realizacji przewozu

Moreover, during analysis of the AS-IS and TO-BE situations at Speedbergx, the MTM method was used to measure real time needed to execute specific tasks in the process. MTM stands for Methods-Time Measurement. It is a predetermined motion time system that is used primarily in industrial settings to analyse the methods used to perform any manual operation or task and, as a result of that analysis, set the standard time in which a worker should complete that task [Manns, Wallis, and Deuse, 2016, Nur, Nurhayati, 2015].

In the TO-BE situation, simple GPS trackers provided by Nova Tracking company were installed in Speedbergx vehicles (figure 3). Trackers sent data to T-Traco platform that

allows real-time transport process management and seamless communication between the forwarder, customer, driver and the vehicle.

Time measurements in AS-IS and TO-BE situations were carried out according to M2M methodology and are averages for specific actions in the process. Figure 4 presents the TO-BE situation, where M2M technology was used to collect necessary data. Figure 5 presents visualised data received from the GPS device in the on-line TMS T-Traco system.
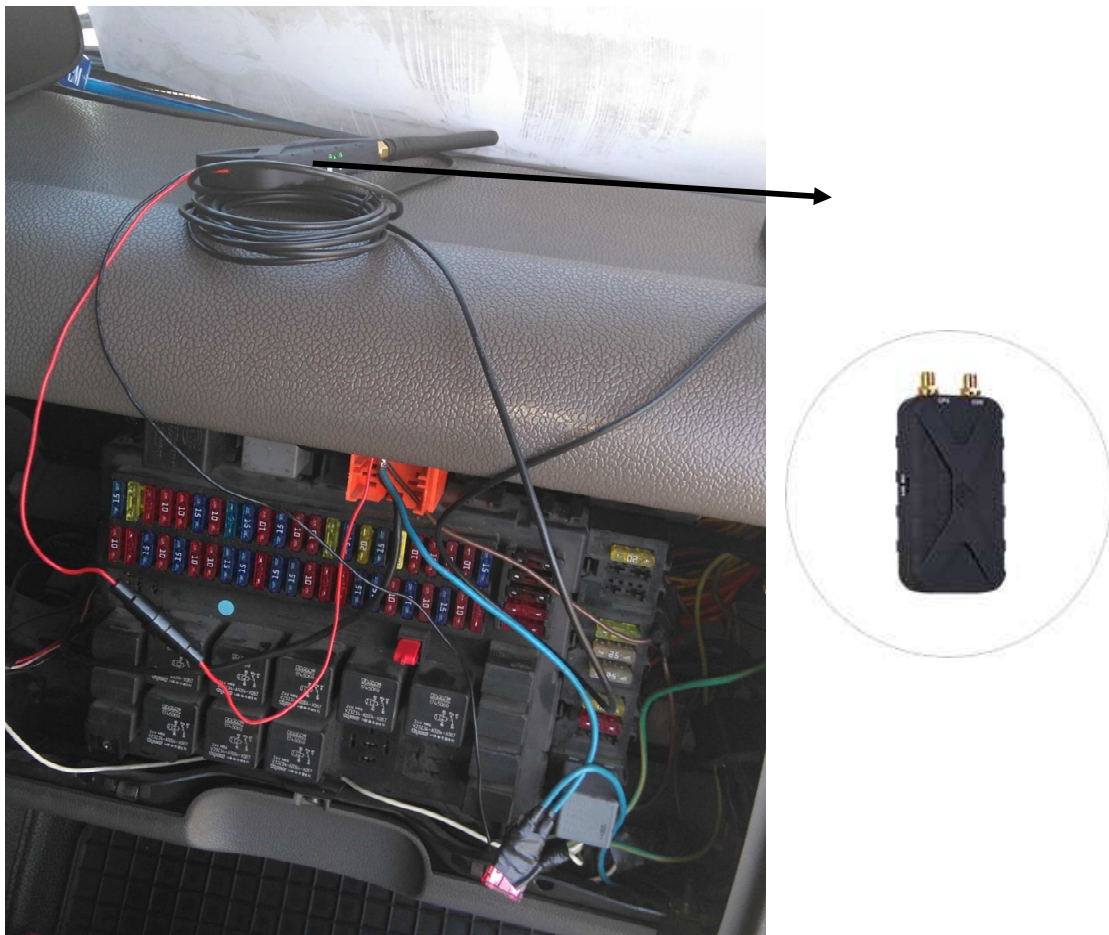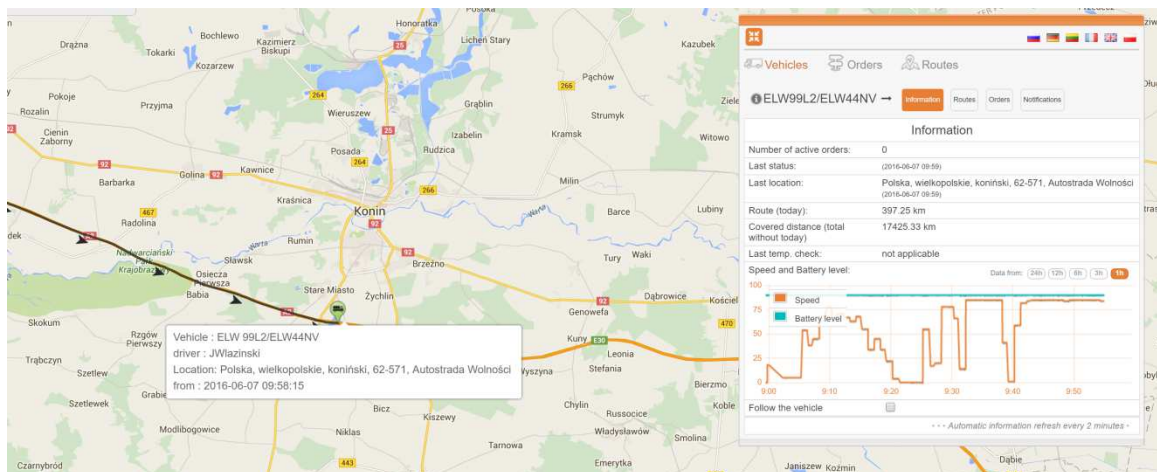

Source: own

Fig. 3. GPS device allowing track&trace of the vehicle
Rys. 3. Nadajnik GPS pozwalający na monitorowanie pojazdu
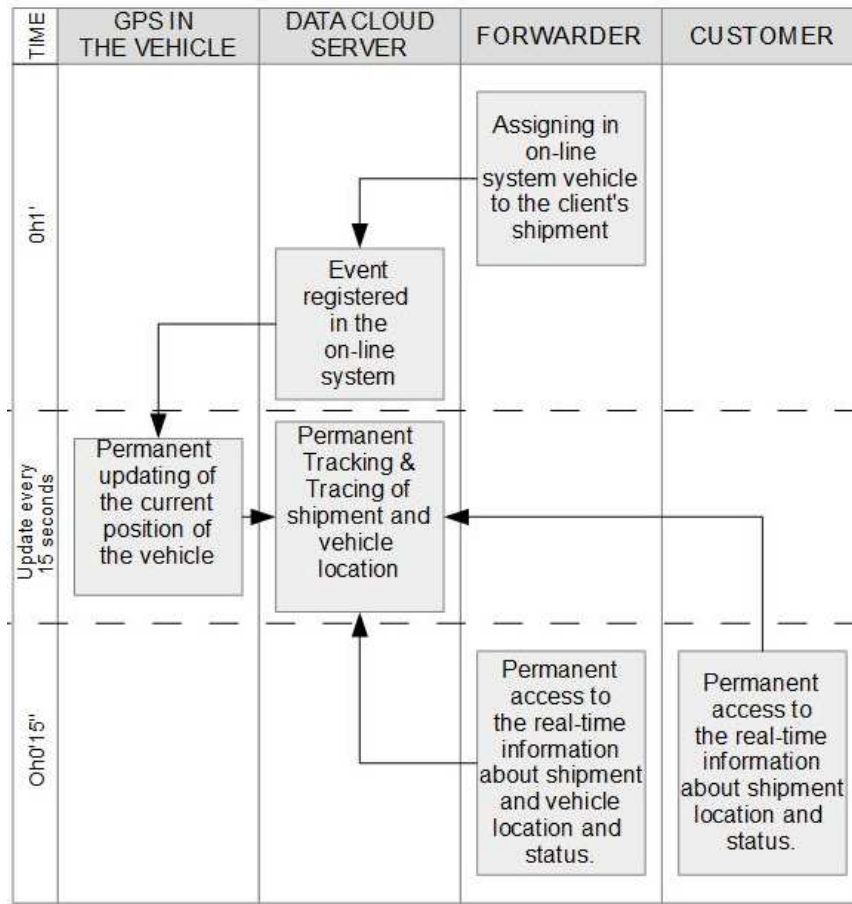
Source: own

Fig. 4. TO-BE process allowing monitoring of shipment execution (visibility) with M2M technology
Rys. 4. Docelowy proces identyfikacji stopnia realizacji przewozu z wykorzystaniem technologii M2M
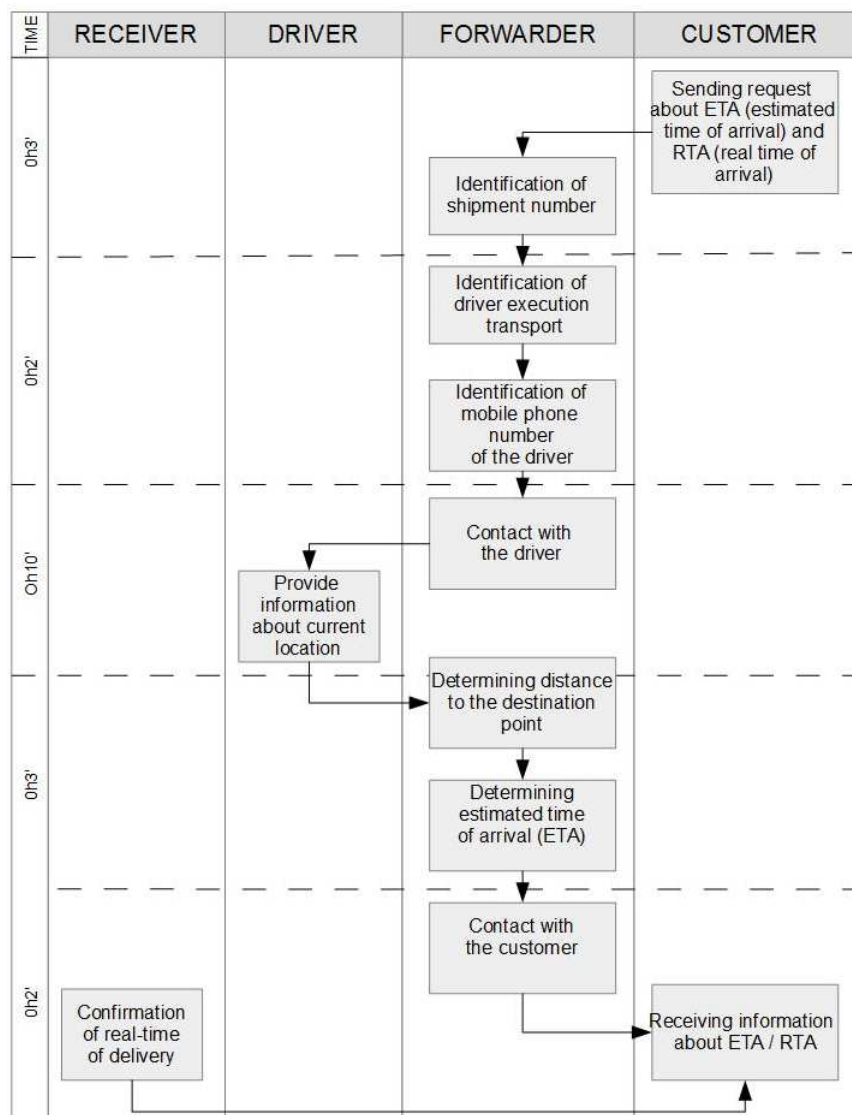

Source: own

Fig. 5. Visualisation of data received from GPS device in the on-line TMS system T-Traco
Rys. 5. Prezentacja danych otrzymanych z urządzeń GPS w systemie T-Traco dostępnym on-line

TIME-SLOTS MANAGEMENT

Many customers expect their shipments to be delivered at a specific hour or in a specific time slot (e.g. 13:00 - 13:00). It is essential to manage time-slots and generate timely delivery reports. Moreover, offering customers proof of delivery at specific time-slots is an emerging business strategy in transport and logistics services because it has the potential to improve the service level [Chen, 2016].

Figure 6 presents the AS-IS process of time-slot management. Figure 7 presents the TO-BE process of time-slot management with M2M technology. Finally, figure 8 presents a visualised report automatically generated by the on-line system based on the data received from GPS trackers.

Source: own

Fig. 6. AS-IS process allowing time-slots management
Rys. 6. Bieżący proces zarządzania oknami czasowymi dostaw
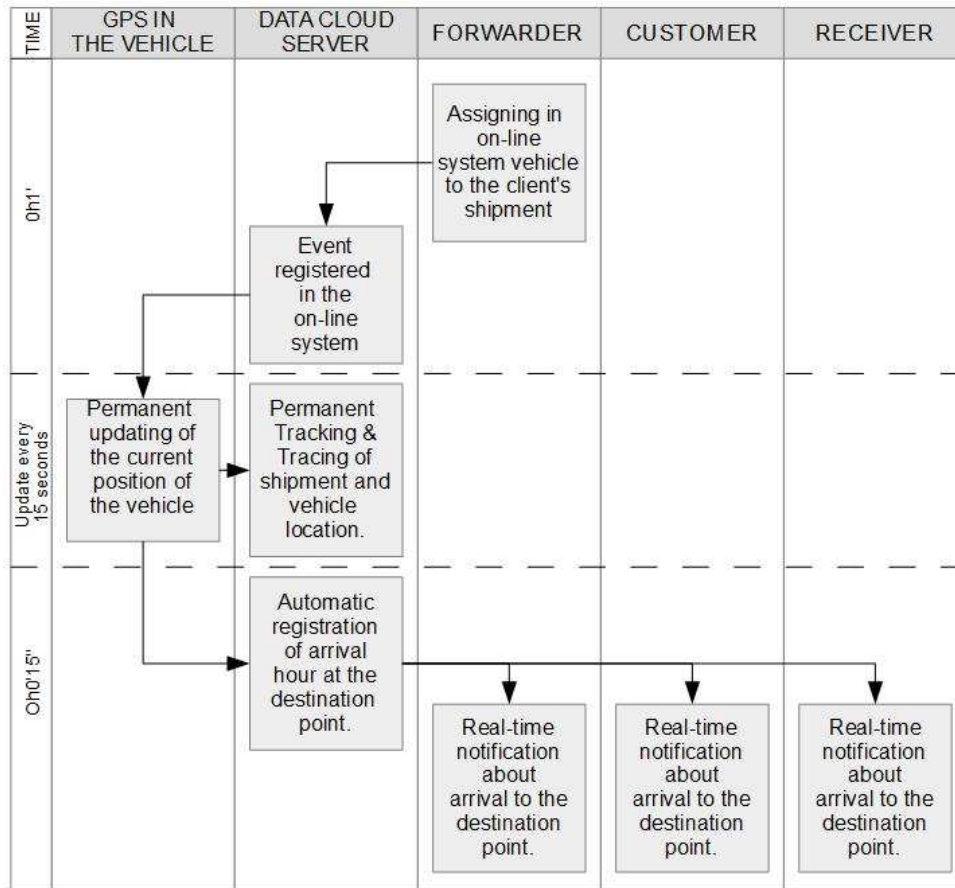
Source: own

Fig. 7. TO-BE process allowing time-slots management based on the M2M technology
Rys. 7. Docelowy proces zarządzania oknami czasowymi dostaw bazujący na technologii M2M

Source: own

Fig. 8. Visualisation of time-slots data received from GPS device in the on-line TMS system T-Traco
Rys. 8. Prezentacja danych dotyczących okien czasowych dostaw w systemie T-Traco

AUTOMATIC ACCOUNTING OF TRANSPORT COSTS

Once the shipment is executed, payment should also be settled as soon as possible in order to ensure the proper cash flow in the company. In order to settle shipment and transport costs, it is necessary to receive a copy or original of proof of delivery signed by a receiver. In most cases proof of delivery is the receiver's transportation letter (CMR). Figure 9 presents the AS-IS process

of shipment settlement. Figure 10 presents the TO-BE process of shipment settlement with the support of M2M technology.
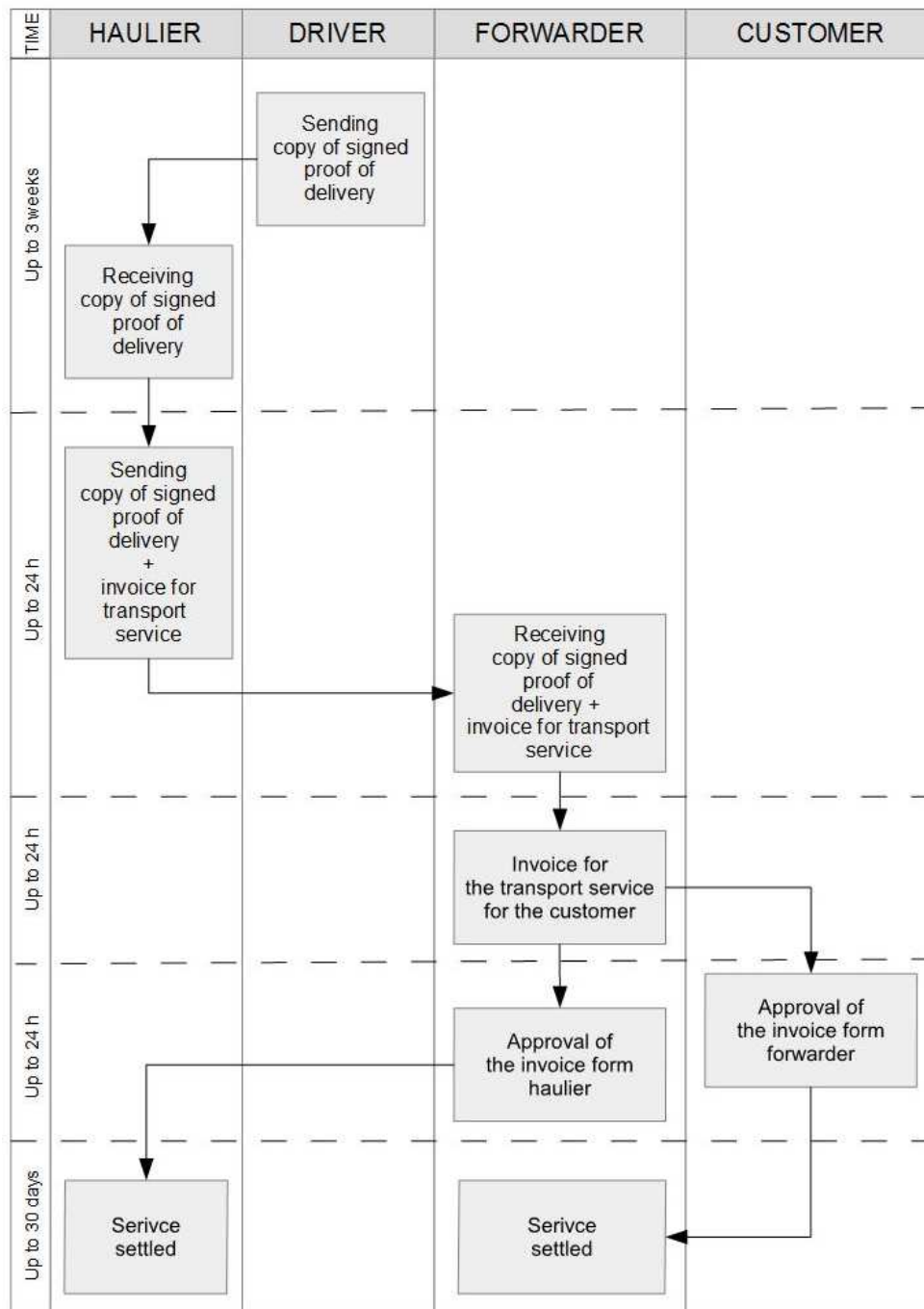
Source: own

Fig. 9. AS-IS process allowing accounting of transport costs
Rys. 9. Bieżący proces rozliczania usług transportowych
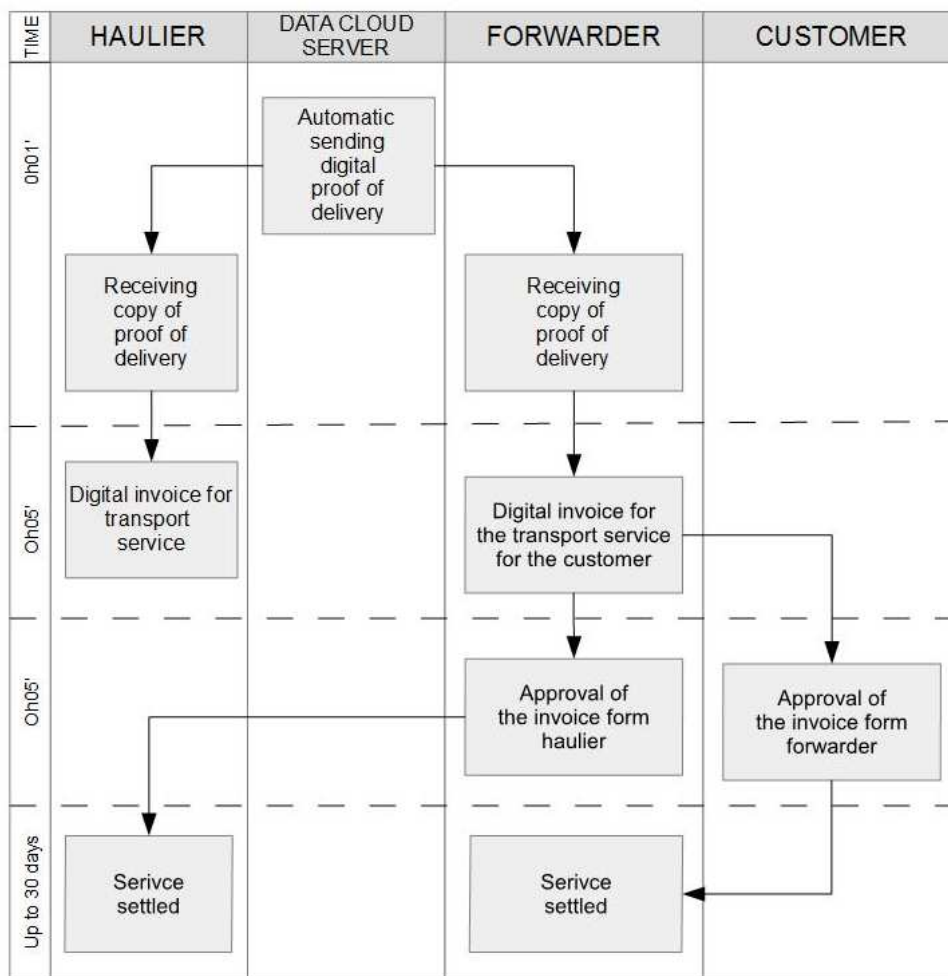
Source: own

Fig. 10. TO-BE process allowing accounting of transport costs
Rys. 10. Docelowy proces rozliczania usług transportowych

CONCLUSIONS

According to ALICE - European Logistics Technology Platform, freight transport and logistics is the link between different processes in the value chain of goods from raw materials to finalized products and end-of-life management. In that sense, transport needs to be seen from a systemic perspective, allowing end-to-end solutions addressing first mile, long distance transport and last mile in the context of cities, regions, countries European and global transport. Therefore, the transport and logistics market is in a need of a lean, secure and reliable solution for seamless communication within the supply chains. One of the crucial issues in data sharing is to know what type of information is relevant for the companies in the freight management for all transport modes. The crucial expectation from the market is to get an IT solution with the following features: real-time visibility of the whole supply chain for all transport modes, service as software, inexpensive, reliable, global coverage of tracking logistics assets, geofencing and mobility, real-time ETA, ATA, ETD, ATD. In order to achieve the expected results, there is a need to implement automatization (through M2M communication) to data exchange during the execution of transport.

Finally, based on the studies carried out at Speedbergx, the following results, presented in table 1, were obtained.

Table 1. Results of the study on the efficiency of the implementation M2M technology for communication in supply chains

Tabela 1. Rezultaty badań skuteczności i efektywności sposobu komunikacji wykorzystującego technologię M2M w łańcuchach dostaw

Process	Total time needed to execute all tasks in the process	
	AS-IS (traditional way of communiation)	TO-BE (using M2M technology for communication)
Real-time visibility of transport processes	0h20'	0h01'15"
Time-slots management	0h20'	0h01'15"
Accounting of transport costs	Up to 24 days + up to 30 days of payment terms	0h11' + up to 30 days of payment terms

Based on our findings, it can be clearly stated that implementing M2M technology allows seamless communication in supply chains. It saves time needed to collect all the necessary information. Moreover, through the automatization of data collection, drivers and forwarders can focus on their primary tasks. This leads to improved effectiveness and efficiency in the whole company.

Finally, wider implementation of M2M technologies is also a step towards a truly integrated transport system for sustainable and efficient logistics. This is a future concept, which is currently being developed by the ALICE technology platform. A truly integrated transport system is based on an open and global system of transport and logistics assets, hubs, resources and services operated by individual companies. They are fully visible and accessible to market players, hence creating a network of logistics networks. The coordination of logistics, transport, infrastructure and supply networks aims to move, store, supply and use physical objects throughout the world in a manner that is economically, environmentally and socially efficient, secure and sustainable. The system will be based on physical, digital, and operational interconnectivity, enabled through modularization as well as standardisation interfaces and protocols.

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BEZPROBLEMOWA KOMUNIKACJA W ŁAŃCUCHACH DOSTAW DZIĘKI WYKORZYSTANIU TECHNOLOGII M2M

STRESZCZENIE. **Wstęp:** Dostęp do informacji jest kluczowym elementem skutecznej i efektywnej organizacji transportu i procesów logistycznych. Znaczenie dostępu do informacji w czasie rzeczywistym potwierdzają przeprowadzone badania panelowe. Do realizacji badań wykorzystano metodę design thinking. W dalszej części pracy omówione zostały dwa sposoby pozyskiwania niezbędnych informacji w trakcie przewozu - manualny, gdy zachodzi konieczność pracy ludzkiej oraz w pełni zautomatyzowany, przy zastosowaniu technologii M2M. Wdrożenie technologii M2M poprawia bezproblemową komunikację podczas realizacji przewozu i umożliwia dostęp w czasie rzeczywistym do potrzebnych informacji. Celem pracy było ustalenie wpływu wykorzystania wybranych technologii M2M oraz tradycyjnego sposobu komunikacji na zapewnienie niezawodnej komunikacji w łańcuchu dostaw.
Metody: W pracy wykorzystano badania panelowe, metodę design-thinking, przegląd literatury jak i rezultaty z praktycznego wdrożenia systemu TMS w firmie Speedbergx
Wyniki i wnioski: Bezproblemowa wymiana informacji w czasie rzeczywistym w ramach globalnych łańcuchów dostaw (włączając w to komunikację ze środkami transportu oraz jednostkami ładunkowymi) jest podstawą realizacji wiarygodnych i wydajnych procesów w ramach cyfrowych łańcuchów dostaw.

Słowa kluczowe: cyfrowe łańcuchy dostaw, bezproblemowa komunikacja, M2M, zarządzanie oknami czasowymi dostaw, rozliczanie kosztów transportu

PROBLEMLOSE KOMMUNIKATION IN LIEFERKETTEN DURCH DIE ANWENDUNG DER M2M-TECHNOLOGIE

ZUSAMMENFASSUNG. Einleitung: Der Zugriff auf die Informationen ist das Schlüsselelement einer leistungsfähigen und effizienten Organisation von Transport- und Logistikprozessen. Die Bedeutung des Zugriffs auf die Informationen in der Ist-Zeit bestätigen die durchgeführten Panelforschungen. Für die Ausführung der Forschungen wurde die Methode von Design Thinking in Anspruch genommen. Im weiteren Teil der Arbeit wurden zwei Vorgehensweisen bei der Gewinnung von unentbehrlichen Informationen während der Beförderung erläutert, und zwar die manuelle, wenn die Notwendigkeit der menschlichen Beteiligung am Prozess besteht und die vollautomatisierte Vorgehensweise unter Anwendung der M2M-Technologie. Die Einführung der M2M-Technologie verbessert die problemlose Kommunikation während der Durchführung einer Beförderung und ermöglicht den Zugriff in der Ist-Zeit auf die unentbehrlichen Informationen. Das Ziel der Arbeit war es, den Einfluss der Anwendung der ausgewählten M2M-Technolgien und der herkömmlichen Art der Kommunikation auf die Gewährleistung einer zuverlässigen Kommunikationsweise innerhalb einer Lieferkette festzulegen.

Methoden: In der Arbeit wurden Panelforschungen, die Design-Thinking-Methode, die Fachliteratur-Übersicht sowie die Ergebnisse einer praktischen Einführung des TMS-Systems bei der Firma Speedbergx in Anspruch genommen.
Ergebnisse und Fazit: Der reibungslose Austausch von Informationen in der Ist-Zeit innerhalb der globalen Lieferketten (einschließlich der Kommunikation mit den betreffenden Transportmitteln und Ladungseinheiten) schafft die Grundlage für die Durchführung von glaubwürdigen und leistungsfähigen Prozessen innerhalb der digitalen Lieferketten.

Codewörter: digitale Lieferketten, problemlose Kommunikation, M2M-Technologie, Management von Lieferungs-Zeitfenstern, Abrechnung von Transportkosten

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SUPPLY CHAIN AND INNOVATION ACTIVITY IN TRANSPORT RELATED ENTERPRISES IN EASTERN POLAND

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ABSTRACT. **Background:** One of the development strategies uses R&D activity as the main source of innovation, which is often carried out in cooperation with other units, but in particular in the supply chain, and therefore applies to cooperation between enterprises and their customers and suppliers.

The aim of the study was to identify the variable determinants of the impact of the character of relationships among enterprises and their suppliers and customers on their innovative performance, within regional industrial systems and to define the constraints for a model regional structure of innovation network tailored to the needs of Poland and its regions.

Methods: 167 enterprises belonging to the transport sector and operating in the area of Eastern Poland took part. In order to determine the impact of relationships with suppliers and customers on innovation activity, models based on probability analysis - probit models - were used.

Results: It can be clearly stated that the cooperation of industrial enterprises in the transport sector with customers and suppliers activates innovation activity and its specified attributes. However, the probability varies depending on the test variable adopted.

Conclusions: The cooperation with suppliers and customers is the cognitive aspect in the development of innovation activity in industrial enterprises representing the transport-related sector. Such cooperation has a stimulating effect on expenditures on innovation activity and on the implementation of innovative solutions in the field of technological innovation (products and processes).

Key words: logistics, innovation, supply chain, industry, transport, region.

INTRODUCTION

The Eastern Poland macroregion is a compact area with the lowest level of economic development in poland and one of the weakest in the European Union. The nature of the problems adversely affects the socio-economic situation and development prospects of the area largely in the structural dimension, which is a result of historical circumstances. There are also amplified negative effects of its peripheral location of this macroregion on the external border of the european union, similar to other areas still lagging behind.

The Eastern Poland region has a much lower level of development in comparison with both the average level for all other provinces in the country and the Poland's western provinces [Fiedorowicz, Duda 2007]. The level of development of the Eastern Poland provinces is 37% of the average level of EU development [Fiedorowicz, Duda 2008].

The development strategy for Eastern Poland identifying the key development

challenges facing the macroregion and how they are addressed should form part of the most important national and European determinants of development, so that it can serve as a basis for planning effective action of an operational nature.

One of these challenges is to increase the innovativeness of the region, which will contribute to the elimination of its technological backwardness in relation to other regions of the country and across the EU. This specific macroregion is in this regard subject to special, dedicated supra-regional support in the form of a number of operational and strategic programs of regional development.

Considering the above facts, the authors decided to find out whichdeterminants stimulate innovation activity in Eastern Poland in terms of cooperation between transport-related industrial enterprises and their suppliers and customers. In general, the major objective of the research was to attempt to find the variable determinants of how the character of relationships between enterprises and their suppliers and customers impacts on their innovative performance within regional industrial systems and hence to define the constraints for a model regional structure of innovation network tailored to the needs of Poland and its regions. The results presented in this study represent only one finding. From the viewpoint of sampling, the authors decided to analyze the case of one region with low-weak industrial development. Such a solution allowed a more in-depth analysis of the features characteristic of regional industrial systems in the transport-related sector in Eastern Poland. The main hypothesis of this research is that innovative activity of economic entities is influenced by a number of determinants, and cooperation with suppliers and customers have the impact on innovation activity in a multidirectional way.

In the survey on the impact of relationships with suppliers and customers on innovation activity in industrial enterprises in the transport sector in Eastern Poland, 167 enterprises belonging to this sector and operating in the area took part. These included the following regions: Warmia-Mazury, Podlasie, Lublin, Świętokrzyskie and Podkarpackie

voivodeships. The transport-related industrial enterprises analysed come from the following represents sectors: locomotive, rolling stock and tram production, the production of motorcycles and bicycles, and transport equipment not elsewhere classified, manufacture of motor vehicles, trailers and semi-trailers, manufacture and repair of ships and boats.

Similar studies on factors determining of the regional development of areas which are less technologically advanced were conducted in similar regions such as Italy - Province of Messina (Sicily) [Ioppolo et al. 2016, Ioppolo et al. 2012]. Therefore, the decision was taken to analyze the determinants of innovative activity in the region.

SUPPLY CHAIN IN NETWORKS OF INNOVATION- THEORETICAL APPROACH

One of the significant elements influencing how of a company functions properly is a well-organized logistics network. It should ensure the smooth operation of the distribution system, thanks to the best possible coordination of the movement of products in specific places to the criterion of time. The logistics network infrastructure considers the flow of materials, semi-finished and finished products, consisting of point objects and the roads connecting them by any mode of transport. Point objects include storage areas, manufacturing, distribution centers, and retail space. Setting up a logistics network is currently a necessary action in logistics companies. It should take into account above all markets, the cost of transportation of raw materials and finished products and storage costs. It should be noted here that the complexity of decision-making problems increases with product differentiation and a wide product range and geographical coverage, and also the number of customer segments. Diverse segments require the inclusion of additional nodes in the logistics system. The system consists of multiple cooperating nodes and creates a network [Kramarz 2009].

Nowadays, in relation to the ongoing process of internationalisation and globalisation, the majority of industrial enterprises, and mainly those involved in production, are elements of a more or less formalised networks of innovation [Świadek, Szopik-Depczyńska 2015]. In such relations vertical industrial cooperation prevails, that is cooperation with the suppliers and customers [Hakansson 1987] (this is confirmed in other studies by the authors). Such relations are not typically of a market nature. However, they are more durable and, so to speak, interactive (network type). Such relations are more stable, because they are based on common trust and allow implementation of the learning process [Asheim 1996]. Moreover, for this reason it is believed that this network activity (intra- and interregional), is currently the main success factor in the of innovation activity [Saxenian 1994]. The way the network of innovations functions on the local level may lead to the creation of opportunities for less developed regions. They allow small and medium-sized businesses to access global resources (including the resources of knowledge and technology), while on the other hand, they provide the possibility to produce products and offer them on the international market [Huggins 1995].

The supply chain strategy is shaped by supply and demand and 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 take into account the use of control measures and power by the supply chain leader. Reflections on participants' behavior are part of the analysis of supply chain strategies described in pertinent literature and are treated as one of the determinants of their formation [Konecka, Matulewski 2014].

Business practice, in turn, is usually much more complicated. Companies - suppliers of products to customers - have their own suppliers and subsuppliers, and often also have intermediaries in the field of distribution. This means that they participate in supply chains, i.e. they are not independent creators of quality in the end-customer service. The reason is that there are also other supply chain participants which take part in this service. A production company sometimes provides services only to ntermediaries in distribution channels. Hence, the quality of customer service is affected by the whole supply chain, i.e. the manner of logistics cooperation among all of its participants, including suppliers of logistics services. If this cooperation is to be successful for the end customer, it may not be reduced to operative activities of transferring specific goods, but must be of a strategic nature [Długosz 2010].

COOPERATION WITH SUPPLIERS AND CUSTOMERS IN TERMS OF INNOVATION ACTIVITY

Collaboration with suppliers offers only limited new knowledge, because these often operate in the same market as the firm. Information from the supplier and buyer might therefore be the same, or at least similar. Nevertheless, the supplier's knowledge is something very important for the firm, and as the supplier has another set of skills, this might be a resource for the firm to use. Furthermore, even if suppliers' knowledge is limited, it is easier to access this knowledge than that of other actors in the supply chain. The supplier also supports innovations more than other actors, due to the combination of common goals and complementary capabilities between the supplier and the firm [Un et al. 2010]. Wynstra et al. [2001] state that integrating suppliers leads to lower risk, as the risk is shared between the two firms (supplier and buyer), the firm can move faster into new markets, and also gain new resources. Hagedoorn [1993] states that if the information and knowledge are shared to a greater extent between firms, the quality of the product will be higher than if the information and knowledge exchange were to be poor [Hagedoorn 1993]. Lau et al. [2010] conclude in their research that suppliers might not want to reveal their knowledge and resources and thus not be willing to share all valuable information. By only delivering the required information, the innovation process might be disturbed, which will probably lead to less innovative products and lower performance [Lau et al. 2010].

When it comes to relations with customers, the information and knowledge they offer is extremely valuable for a firm's ability to innovate. Customer innovation is an important source of innovation for firms [Johansson, Möllefors 2013]. A study by Cohen et al. [2002] showed that 90% of the firms surveyed had used knowledge from the customers as an initiator for new innovation projects. To collaborate with customers in the innovation process, needs information must be converted to explicit information, which is very difficult [Nonaka 1994]. Another problem of using the information and knowledge from customers is that they do not have the same incentives and mindset as the employees in the firm. This makes it even harder to transfer useful and valuable information and knowledge from the customer to the firm [Szulański 1996]. Moreover, the average customer can only help the firm to innovate existing products and do so incrementally, because (s)he does not have the ability to identify the latent needs of the market andhow it may be served [Füller, Matzler 2007].

In general, awareness of benefits that may be obtained by improving supply chain and logistics management is still in the initial phase in Poland, and this is on too low a level. What is needed is courage to trust your partners; strength, to break the stereotypes and fears in your own company; and charisma to make others follow you. That is why it is worth taking up the challenge. Those who succeed will be one step ahead of the competition [Stajniak 2010].

METHODOLOGICAL CONDITIONS OF THE CONDUCTED RESEARCH

The methodological part of the analyses is based on probability calculus. When a dependent variable takes dichotomous values, the possibilities of using popular multiple regression, widely used for quantitative phenomena, are limited. The problem can be solved by an alternative solution - logistic regression [Frenkel 2000]. Its advantage is that analysis and interpretation of results are similar to the classical regression method, hence the methods for selecting variables and testing the hypotheses have

a similar pattern. There are, however, also differences, which include more complex and time-consuming calculations and producing residual plots which usually do not contribute significantly to the model [Stanisz 2007].

Generally, logistic regression is a mathematical model which can be employed to explain the impact of several variables X_1, X_2, ... , X_k on a dichotomous variable Y. If all the independent variables are qualitative, the logistic regression model is equivalent to a log-linear model. To describe such a phenomenon, one could also employ probit regression [Świadek 2011].

Discrepancies between the probit and logit models focus on the specifications in the equation of random factor distribution. The logit model exists when F is the distribution function of logistic distribution, and the probit model is obtained when random factors have normal distribution [Maddala 2006]. The correlation between the Logit and Probit values is illustrated by the following equation:

$$\frac{Logit}{Probit} = \frac{\pi}{\sqrt{3}} = 1,8$$

With the methods of a dichotomous variable, the assessment of parameters is carried out using the method of the maximum likelihood (MNW). This method requires finding the vector of variables to guarantee the highest probability of the occurrence of values observed in the sample. This method applied in the case of small communities is often more advantageous in comparison with the competing estimators [Welfe 1988].

On the side of dependent variables attributes of innovation were highlighted in accordance with the international standards set by the OECD countries and Eurostat. These variables included [Oslo Manual 2008]:
- expenditures on innovation activity in relation to their structure,
- implementation of new products and technological processes.

Considering the fact that the variables are binary (i.e. they take two values - 0 or 1), the majority of the results will be presented at the level of the structural form of the model.

A "plus" sign preceding a parameter denotes that the probability of an innovative phenomenon in the selected group of entities is higher than for the rest of the population. Probit modelling is an efficient research tool in the case of big yet static samples where the dependent variable is qualitative. Each questionnaire was entered into an Excel spreadsheet for initial processing based on formal logic. The actual calculations were made with Statistica software.

RELATIONSHIPS WITH SUPPLIERS AND CUSTOMERS IN THE SUPPLY CHAIN - RESEARCH RESULTS

The research about the determinants of innovation activity in Eastern Poland was conducted with 1067 industrial enterprises. 167 of them were transport-related enterprises: manufacturers of motor vehicles, trailers and semi-trailers, manufacturers and repair industry of ships and boats and manufacturers of locomotives and rolling stock and tram, the production of motorcycles and bicycles and transport equipment not elsewhere classified.

In the group of 167 industrial enterprises in Eastern Poland, 112 of them cooperated with customers on innovative projects (products or/and processes). The graph illustrating the distribution of answers in terms of the main customer for industrial enterprises which are cooperating in innovative projects is shown below.
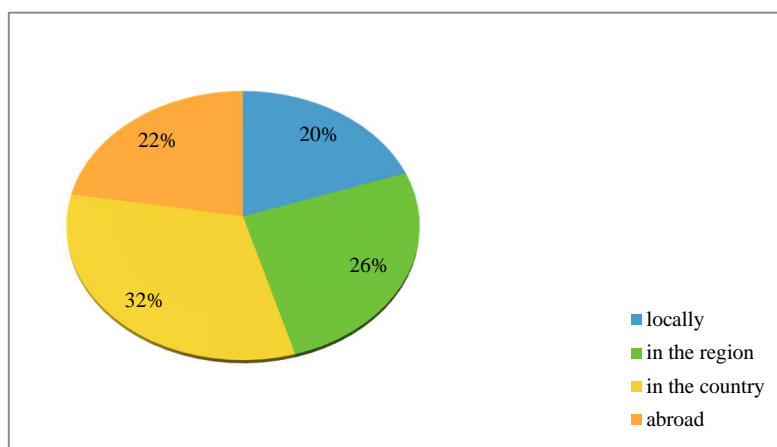

Fig. 1. Main customer of transport related industrial enterprises in Eastern Poland - by location
Rys. 1. Główny klient przedsiębiorstw przemysłowych w Polsce Wschodniej związanych z transportem - według lokalizacji

In the graph above showing the distribution of declared answers on the location of the main customer, enterprises which operate in Eastern Poland identified the target marker as being located within the country (32%). The second target market is ranked as operating in the region (26%). The third target market is an international market (22%). The last target market where industrial companies offer their products are the customers which operate locally (20%). The fact that companies mainly sell their products within regional and national markets shows that domestic products are still not very competitive on the world market. This may be a result of both product quality and price of the final product.

When it comes to the main supplier of transport-related industrial enterprises in Eastern Poland, in the group of 167 industrial enterprises in Eastern Poland 134 cooperated with suppliers on innovative projects. The graph illustrating the distribution of answers in terms of the main supplier for industrial enterprises which are cooperating on innovative projects is shown below.
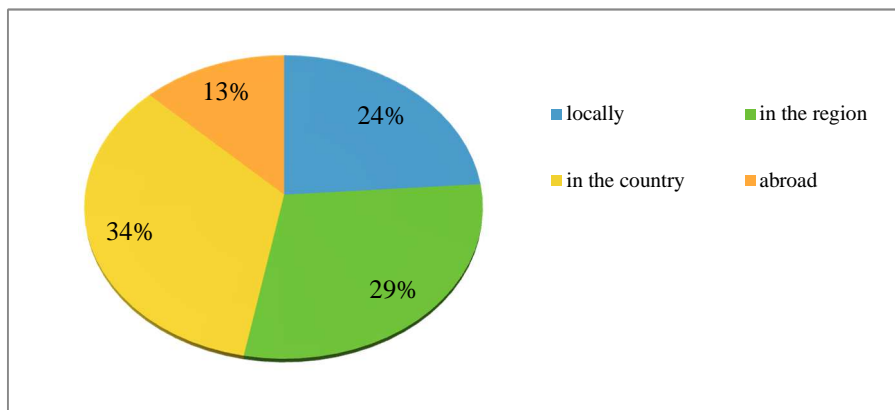
Fig. 2. Main supplier of transport related industrial enterprises in Eastern Poland - by location
Rys. 2. Głównym dostawca przedsiębiorstw przemysłowych w Polsce Wschodniej związanych z transportem - według lokalizacji

As shown in the figure above, which presents the structure of declared answers on the location of the main supplier, it turned out that transport related industrial companies operating in Eastern Poland cooperate mainly with suppliers domestically (34%). The next main supplier selecetd was located locally (24%). The third position of suppliers located locally may be due to the fact that suppliers located so close are not able to offer the latest technology, which could allow the competion on broader markets than just the local one. The last group is suppliers located abroad (13%). This low number is not very surprising, since due to their since due to disproportionately low level of technology, Polish enterprises are still seeking competitive advance within country of residence but don't have a high enough budget to finance projects with foreign partners.

THE IMPACT OF RELATIONSHIPS WITH SUPPLIERS AND CUSTOMERS IN THE SUPPLY CHAIN ON INNOVATION ACTIVITY - PROBIT MODELING

The table below presents the results of probit modeling defining the impact of cooperation with customers on the innovation activity. Modeling was performed on a group of 112 enterprises declaring cooperation with customers in the area of new/improved products and processes.

Table 1. The value of the parameter with the independent variable "cooperation with customers" in probit models describing innovation activity in transport related industrial enterprises in Eastern Poland
Tabela 1. Wartość parametru przy zmiennej niezależnej "współpraca z klientami" w modelach probitowych opisujących działalność innowacyjną przedsiębiorstw przemysłowych w Polsce Wschodniej związanych z transportem

Innovation attribute	Parameter	Standard error	Statistics of *t-student*	p_1	p_2
Investments in R&D	+,813	0,147	3,924	0,82	0,43
Investments in machinery and technical equipment	+,589	0,301	2,273	0,56	0,30
Introduction of new products	+,602	0,309	2,342	0,79	0,51
Implementation of new technological processes (including):					
a) methods of manufacturing	+,478	0,179	2,023	0,69	0,42
b) production related systems	+,678	0,299	2,011	0,26	0,15
c) supporting systems	+,691	0,368	2,352	0,81	0,76

p_1 - the probability of occurrence in the study group
p_2 - the probability of occurrence in remaining group

The results of the research among transport-related industrial companies in Eastern Poland which cooperated with customers showed that opportunities for investing in R&D activity, in the case of cooperation with customers, was growing by as much as 90%. The likelihood of investment in machinery and technical equipment has increased by 87%. New products are introduced more frequently - almost by 55%, manufacturing processes by 64%, production-related systems by 73% and support systems (e.g. computer programs for accounting) not so much - 6.6%.It can be concluded that cooperation with customers has a positive effect on the implementation of innovation processes in transport-related industrial enterprises in Eastern Europe, as evidenced by a positive sign in each of the parameters in the models statistically significant.

The table below presents the results of probit modeling defining the impact of cooperation with suppliers to the innovation activity attributes. Modeling was performed on a group of 134 enterprises declaring cooperation with customers in the area of new/improved products and processes.

Table 2. The value of the parameter with the independent variable "cooperation with suppliers" in probit models describing innovation activity in transport related industrial enterprises in Eastern Poland
Tabela 2. Wartość parametru ze zmiennej niezależnej "współpraca z dostawcami " w modelach probitowych opisujących działalność innowacyjną przedsiębiorstw przemysłowych w Polsce Wschodniej związanych z transportem.

Innovation attribute	Parameter	Standard error	Statistics of *t-student*	p_1	p_2
Investments in R&D	+,526	0,167	3,516	0,72	0,36
Investments in machinery and technical equipment	+,525	0,278	2,689	0,49	0,19
Introduction of new products	+,690	0,217	2,217	0,79	0,53
Implementation of new technological processes (including):					
a) methods of manufacturing	+,401	0,167	2,178	0,67	0,51
b) production related systems	+,679	0,367	2,128	0,42	0,29
c) supporting systems	+,409	0,270	2,166	0,83	0,67

p_1 - probability of occurrence in the study group
p_2 - probability of occurrence in remaining group

The results of research conducted among transport-related industrial enterprises in Eastern Poland which cooperated with suppliers has shown that opportunities for investing in R&D activity, in the case of cooperation with suppliers, increased by exactly 100%. The likelihood of investment in machinery and technical equipment increased by 158%. The probability of implementing new products increased by 49% and when it comes to the implementation of new or improved technological processes, such as manufacturing processes, the probability increased by 31%, production-related systems by and support systems by 45%.

The general conclusion is that cooperation with suppliers also has a positive effect on the innovation activity in transport-related industrial enterprises in Eastern Europe, as evidenced by a positive sign at each of the parameters in the models which were statistically significant.

CONCLUSIONS

Innovations in industrial systems are determined by the nature of relationships between enterprises and other units. This also includes cooperation with suppliers and customers, their location and the nature of the cooperation between them. Such factors affect the shape of industrial systems. Therefore, knowledge of the possible effects of cooperation in terms of innovation activity in the industry chain should be taken into consideration while developing innovation strategies in enterprises. The key to the development of the Eastern Poland region is

the implementation of innovations in enterprises, especially technological innovations in industrial enterprises.

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ŁAŃCUCH DOSTAW I INNOWACYJNOŚĆ PRZEDSIĘBIORSTW SEKTORA TRANSPORTOWEGO W POLSCE WSCHODNIEJ

STRESZCZENIE. **Wstęp:** Jedna ze strategii rozwoju wykorzystuje działalność B+R, jako główne źródło innowacji, która często realizowana jest we współpracy z innymi jednostkami, w szczególności jednak w łańcuchach dostaw, a zatem dotyczy współpracy przedsiębiorstw z ich odbiorcami i dostawcami.
Głównym celem pracy było określeniu wpływu kooperacji o charakterze innowacyjnym na aktywność innowacyjną przedsiębiorstw przemysłowych sektora transportowego w Polsce Wschodniej.
Metody: Przeprowadzono badanie ankietowe dotyczącym wpływu powiązań z dostawcami i odbiorcami na innowacyjność przedsiębiorstw przemysłowych sektora transportowego w Polsce Wschodniej wśród 167 jednostek należących do tego sektora, funkcjonujących na obszarze Polski Wschodniej. W celu określenia oddziaływania wpływu powiązań z dostawcami i odbiorcami na aktywność innowacyjną innowacyjną przedsiębiorstw posłużono się modelami opartymi na analizie prawdopodobieństwa - modelami probitowymi.
Wyniki: Na podstawie przeprowadzonego badania można jednoznacznie stwierdzić, iż kooperacja przedsiębiorstw przemysłowych sektora transportowego z odbiorcami i dostawcami ma aktywizujący wpływ na wyszczególnione atrybuty innowacyjności przedsiębiorstw. Prawdopodobieństwo jednak waha się w zależności od przyjętej do badania zmiennej.
Wnioski: Kooperacja z dostawcami i odbiorcami jest istotna w kształtowaniu aktywności procesów innowacyjnych w przedsiębiorstwach przemysłowych sektora transportowego oraz ma charakter stymulujący na ponoszenie nakładów na działalność innowacyjną w różnych aspektach oraz implementację innowacyjnych rozwiązań z zakresu innowacji technologicznych (produktowych i procesowych).

Słowa kluczowe: logistyka, innowacyjność, łańcuch dostaw, przemysł, transport, region

DIE LIEFERKETTE UND INNOVATION BEI TRANSPORT-UNTERNEHMEN IN OSTPOLEN

ZUSAMMENFASSUNG. Einleitung: Eine der heutzutage angewendeten Entwicklungsstrategien benutzt die Betätigung von B+R als die Hauptquelle von Innovationen, die in Zusammenarbeit mit anderen Wirtschaftseinheiten realisiert werden. Dies kommt jedoch besonders innerhalb von Lieferketten zustande, so betrifft diese Regel die Zusammenarbeit der Unternehmen mit ihren Empfängern und Lieferanten an. Das Hauptziel der Arbeit war es, den Einfluss einer innovativen Kooperation auf die innovativen Aktivitäten bei den im Transportbereich wirkenden und in Ostpolen befindlichen Industrieunternehmen zu bestimmen.

Methoden: Es wurde unter 167 in Ostpolen betätigten Unternehmen eine Umfrage hinsichtlich des Einflusses von Zusammenhängen zwischen den Lieferanten und Empfänger auf die Innovation der im Transportbereich wirkenden Industrieunternehmen durchgeführt. Zwecks der Bestimmung von Auswirkungen des Einflusses solcher Zusammenhänge zwischen den Lieferanten und Empfängern auf die innovative Aktivität der betreffenden Unternehmen hat man die auf Wahrscheinlichkeitsanalyse gestützten Modelle, d.h. die Probitmodelle in Anspruch genommen.

Ergebnisse: Aufgrund der durchgeführten Forschungen kann man eindeutig festlegen, dass die Kooperation der im Transportbereich tätigen Industrieunternehmen mit den Empfängern und Lieferanten einen aktivierenden Einfluss auf die ausgewählten Innovationsattribute der betreffenden Unternehmen ausüben kann. Die Wahrscheinlichkeitsquote oszilliert in Abhängigkeit von der für die Untersuchung in Anspruch genommenen Variable.

Fazit: Die Kooperation mit den einzelnen Lieferanten und Empfängern begünstigt wesentlich die Ausgestaltung von aktivierenden Innovationsprozessen in den im Transportbereich tätigen Industrieunternehmen und besitzt einen stimulierenden Charakter hinsichtlich der Erhöhung von Aufwendungen für die Förderung der Innovationsaktivität in unterschiedlichen Aspekten sowie für die Einführung konkreter Innovationslösungen im Bereich technologischer (produkt- und prozessgemäßer) Innovationen.

Codewörter: Logistik, Innovation, Lieferkette, Industrie, Transport, Region

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COMPARISON OF MULTIPLE-CRITERIA DECISION-MAKING METHODS - RESULTS OF A SIMULATION STUDY

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ABSTRACT. **Background:** Today, both researchers and practitioners have many methods for supporting the decision-making process. Due to the conditions in which supply chains function, the most interesting are multi-criteria methods. The use of sophisticated methods for supporting decisions requires the parameterization and execution of calculations that are often complex.
So is it efficient to use sophisticated methods?
Methods: The authors of the publication compared two popular multi-criteria decision-making methods: the Weighted Sum Model (WSM) and the Analytic Hierarchy Process (AHP). A simulation study reflects these two decision-making methods. Input data for this study was a set of criteria weights and the value of each in terms of each criterion.
Results: The iGrafx Process for Six Sigma simulation software recreated how both multiple-criteria decision-making methods (WSM and AHP) function. The result of the simulation was a numerical value defining the preference of each of the alternatives according to the WSM and AHP methods. The alternative producing a result of higher numerical value was considered preferred, according to the selected method. In the analysis of the results, the relationship between the values of the parameters and the difference in the results presented by both methods was investigated. Statistical methods, including hypothesis testing, were used for this purpose.
Conclusions: The simulation study findings prove that the results obtained with the use of two multiple-criteria decision-making methods are very similar. Differences occurred more frequently in lower-value parameters from the "value of each alternative" group and higher-value parameters from the "weight of criteria" group.

Key words: weighted sum model, analytic hierarchy process, multiple-criteria decision-making, simulation study.

INTRODUCTION

In the conditions in which contemporary supply chains function, multiple-criteria decision-making methods are of great interest to both theoreticians and practitioners. They allow analyses to be conducted in complex environments and under a variety of criteria. It makes it possible to make an optimal choice for a selected criterion or a set of criteria, which is a particularly important feature from a scientific point of view. However, the opinions of practitioners on the process of decision-making are often different. Seeking an optimal solution from the point of view of

a specific criterion or a set of criteria certainly is a desired goal, nonetheless the efficiency of the decision-making process is frequently of greater significance. Productivity is understood as the sum of effectiveness of an action in order to achieve a goal - making the right decision and putting it into effect efficiently, i.e. executing the decisive process at the lowest possible cost.

Literature on the subject describes many multiple-criteria decision-making methods. They may be divided on the basis of various criteria. One of them is the complexity of a method, and, consequently, cost of its application in the decision-making process.

Complex methods frequently require complicated parametrisation and numerous calculations. This, in turn, prolongs the time of executing the decision-making process and may lower its productivity. Thus, a particularly significant criterion for selecting the method which supports decision-making is not only the results of the method, but also its practicability. This is particularly important to practitioners working within contemporary supply chains. Intensive competition, a multitude of opportunities and the threats typical for this environment require effective and efficient decision-making.

The research presented in the article compares the results of employing two multiple-criteria decision-making methods: the weighted sum model (WSM) and the analytic hierarchy process (AHP). The first one has been described as a simple method, which does not require excessive costs in the decision-making process. The second one has been described as complex. The purpose of the research was to choose the method of assessing variants of material flow in supply chains, in order to determine economic lot size.

2 MULTIPLE-CRITERIA DECISION-MAKING METHODS

Review of multiple-criteria methods

Problems analysed today are usually very complex, which is why decision-makers often have difficulties making the right decision. In the light of this, increased interest in multiple-criteria decision-making methods has been observed in recent years. Currently, many solutions which allow analysis to be conducted using a model of a decision-making situation, with the use of a number of criteria, have been developed. Multiple-criteria methods may be applied to decision-making in potentially every area of human activity.

The list below presents selected multiple-criteria methods which support decision-making (with original spelling):
- elementary methods:
  - WSM (Weighted Sum Method) [Wang, Jing, Zhang, Zhao, 2009],
  - WPM (Weighted Product Method) [Wang, Jing, Zhang, Zhao, 2009];
- additive methods:
  - SAW (Simple Additive Weighting Method) [Churchman, Ackoff, 1954],
  - F-SAW (Fuzzy Simple Additive Weighing Method) [Tzeng, Huang, 2011],
  - SMART (Simple Multi-Attribute Ranking Technique) [Edwards, 1971],
  - SMARTER (Simple Multi-Attribute Ranking Technique Exploiting Ranks) [Edwards, 1994];
- analytical hierarchy method and related methods:
  - AHP (Analytical Hierarchy Process) [Saaty, 1980],
  - REMBRANDT (Ratio Estimation in Magnitudes or deciBells to Rate Alternatives which are Non-DominaTed) [Lootsma, 1992],
  - F-AHP (Fuzzy Analytic Hierarchy Process) [Mikhailov, Tzvetinov, 2004],
  - ANP (Analytic Network Process) [Saaty, 1996],
  - F-ANP (Fuzzy Analytic Network Process) [Tzeng, Huang, 2011],
  - MACBETH (Measuring Attractiveness by a Categorical Based Evaluation TecHnique) [Bana e Costa, Vansnick, 1999];
  - ZAPROS methods ЗАмкнутые ПРоцедуры у Опорных Ситуаций):
  - ZAPROS I [Larichev, Moskovich, 1995],
  - ZAPROS III [Larichev, 2001];
- ELECTRE methods (ELimination Et Choix Traduisant la REalia):
  - ELECTRE I [Roy, Bouyssou, 1993],
  - ELECTRE Iv [Roy, Bouyssou, 1993],
  - ELECTRE Is [Roy, Bouyssou, 1993],
  - ELECTRE III [Roy, Bouyssou, 1993],
  - ELECTRE TRI [Roy, Bouyssou, 1993],
  - ELECTRE I + SD [Zaraś, Martel, 1994],
  - ELECTRE III + SD [Nowak, 2004];
- PROMETHEE methods (Preference Ranking Organisation METHod for Enrichment Evaluations):
  - PROMETHEE I [Brans, 1982],
  - PROMETHEE II [Brans, 1982],
  - PROMETHEE II + veto [Górecka, Muszyńska, 2011],

- EXPROM (EXtension of the PROMethee method) [Diakoulaki, Koumoutsos, 1991],
- EXPROM II + veto [Górecka, Szałucka, 2013],
- PROMETHEE II + veto + SD [Nowak, 2005],
- EXPROM II + veto + SD [Górecka, 2010];
- using points of reference:
  - TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) [Hwang, Yoon, 1981],
  - F-TOPSIS (Fuzzy Technique for Order Preference by Similarity to Ideal Solution) [Jahanshahloo, Hosseinzadeh Lotfi, Izadikhah, 2006],
  - VIKOR (VIsekrzterijumska Optimizacija i Kompromisno Resenje) [Opricovic, 1998],
  - DEMATEL (DEcision Making Trial and Evaluation Laboratory) + ANP + VIKOR [Tzeng, Huang, 2011],
  - BIPOLAR [Konarzewska-Gubała, 2009],
  - BIPOLAR zmodyfikowany [Trzaskalik, Sitarz, Dominiak, 2013],
  - BIPOLAR + SD [Górecka, 2009];
- interactive methods:
  - STEM-DPR (STEp Method for Discrete Decision Making Problems under Risk) [Nowak, 2008],
  - INSDECM (INteractive Stochastic DECision Making Procedure) [Nowak, 2006],
  - ATO-DPR (Analysis of Trade-Offs for Discrete Decision Making Problems under Risk) [Nowak, 2010].

Each of the methods has been briefly summarised in a research paper [Trzaskalik, 2014]. Point 2.2. describes in more detail only the methods which form a direct basis for the article.

A short summary of selected methods - AHP and WSM

The hierarchical structure of the AHP method (analytical hierarchy process) means that the general goal lies on the highest level of the hierarchy. It is broken down into independent assessment criteria determined by the decision maker's preferences. They are located on the next level of the hierarchy. This hierarchy may be composed of many levels, which means that the criteria considered may be divided into subcriteria, which in turn may be subject to yet another division. Decisive variants under consideration are on the lowest level of hierarchy. A nine-degree grading scale, called Saaty's scale [Saaty 1980)] is used for comparisons. The AHP method requires a decision-maker to [Bozarth, Handfield 2007]:

- identify a set of the most important criteria and define their mutual relations involving domination (determining the hierarchy of criteria),
- define domination-related relations between available options in reference to individual criteria (determining the hierarchy of options),
- use the information to calculate absolute indicators of preference for individual options, where the higher the indicator, the higher the preference of a specific variant.

The WSM method (weighted sum method) is presently the most popular and the most common multiple-criteria decision-making method. Its distinctive feature is the intuitive nature of the algorithm of conduct. In the WSM method, instead of comparing pairs of criteria to determine priorities and assess preferences, a decision-maker assigns weight to individual criteria and assesses options with reference to all criteria [Bozarth, Handfield 2007].

Both methods are commonly applied to scientific theory and business practice. Therefore, they will not be further summarised here. Interested parties will find detailed examples of calculations (method execution procedure) in this paper [Bozarth, Handfield 2007]: AHP, WSM.

When comparing both multiple-criteria methods supporting the decision-making process, it should be stated that the AHP (advanced) method is more complicated in execution than the WSM (simple) method, i.e. it is more time-consuming and labour-intensive. The question posed by the authors of the article is under what conditions (set of parameters) both methods (WSM and AHP) will point to the same alternatives, and under

what conditions they will indicate different ones (with seeking an answer to the second part of the question considered most meaningful).

EFFICIENCY OF A DECISION-MAKING PROCESS

The decision-making process is the key element of one of the fundamental management functions, i.e. planning. According to Kisielnicki, planning is in fact a decision-making process. As he puts it, "[it is]... a decision-making process whose task is to achieve set goals" [Kisielnicki 2008]. When interpreting planning as a process, its stages should be specified. Klasik [Klasik (ed.), 1993] distinguishes the following stages: setting goals, identifying problems, seeking alternative solutions, assessing consequences, making a choice, implementing a plan, monitoring the execution. Klasik's first five tasks of planning are related to decision-making. Kisielnicki and Turyna share his view on the relationship between planning and decision-making. In their opinion, planning is a decision-making process which has the form of a sequence of deliberate actions, such as intellectual analyses or judgments, which lead to the selection of the best solution according to a specific criterion [Kisielnicki, Turyna 2012].

These ideas indicate that an efficient decision-making process and efficient planning are similar processes. Reference books describe two approaches to the description of efficiency: a purposive and a systemic approach. The purposive approach was presented, among others, by Frankowska and Jedliński [Frankowska, Jedliński 2011]. They attribute its name to the triad of "purposes-effects-outlays", according to which an organisation is established to achieve specific goals with the help of incurred costs. M. Bielski [Bielski, 1992] claims, on the other hand, that the systemic approach prefers the assessment of opportunities and possibilities of future development to the organisation's achievement of assumed goals. I. Pisz and I. Łapuńska presented the criteria of logistics project efficiency. They divided this phenomenon into four dimensions: financial,

stakeholders, process learning and growth [Pisz, Łapuńska, 2016].

In view of the above considerations, the efficiency of a decision-making process will in this article be interpreted as purposive efficiency accordant with the approach presented by M. Frankowska and M. Jedliński [Frankowska, Jedliński 2011] as the sum of two factors:
− effectiveness of action - ability to achieve set goals;
− efficiency of action - an optimal use of owned resources (may be related to the rationality of management, economy or profitability).

A method will be considered effective when its results are the same as for a different method. In terms of efficiency, the lower the costs incurred in order to perform the multiple-criteria decision-making method, the more efficient it is considered. It is not possible to actually determine which of the alternatives is better, since the analysis covers the way the method works and not the entire process of planning and carrying out tasks.

RESULTS OF A SIMULATION STUDY

Description of a simulation model

The iGrafx Process for Six Sigma simulation software recreated both multiple-criteria decision-making methods: WSM and AHP. The simulation model analysed making decisions on the basis of two alternative variants (A1, A2) based on three criteria (C1, S2, C3). The input data used to carry out the simulations were the values of nine parameters divided into two groups:
− value of each alternative (A1_C1, A2_C1, A1_C2, A2_C2, A1_C3, A2_C3) - assessment of each alternative according to each of the criteria - 6 parameters;
− weight of criteria (C1, C2, C3) - defining the significance of each of the criteria – 3 parameters.

Each of the parameters could assume a value from 1 to 10. At first, the parameters

were used to determine the preference index for each alternative with the use of the WSM method. Further on, values of these parameters were transformed into preference indices in accordance to Saaty's scale used in the AHP method. The quotient method was applied to the transformation. Assuming that the value of parameter A was higher than the value of parameter B (if not, the formula assumed the reciprocal value 1/SaatyAB), the quotient formula is as follows:

$$Saaty_{AB} = Ceiling\left(\frac{Param.A}{Param.B}\right) \qquad (1)$$

Due to the number of possible combinations of states of parameters (109), a full-factor experiment was not conducted. In a limited plan for each of the parameters, three states were distinguished. They were assigned proper numerical values:

- low - value of parameter 2;
- mean - value of parameter 5;
- high - value of parameter 8;

In an experiment so planned, the number of simulations, assuming one iteration (based on the lack of random elements), was 39=19 683.

The result of the simulation was a numerical value defining the preference of each of the alternatives according to the WSM and AHP methods. The alternative producing a result with a higher numerical value was considered preferred according to the selected method.

Analysis of results

The analysis of simulation results verified in how many cases both analysed methods pointed to the same alternative. The results have been presented in Figure 1.
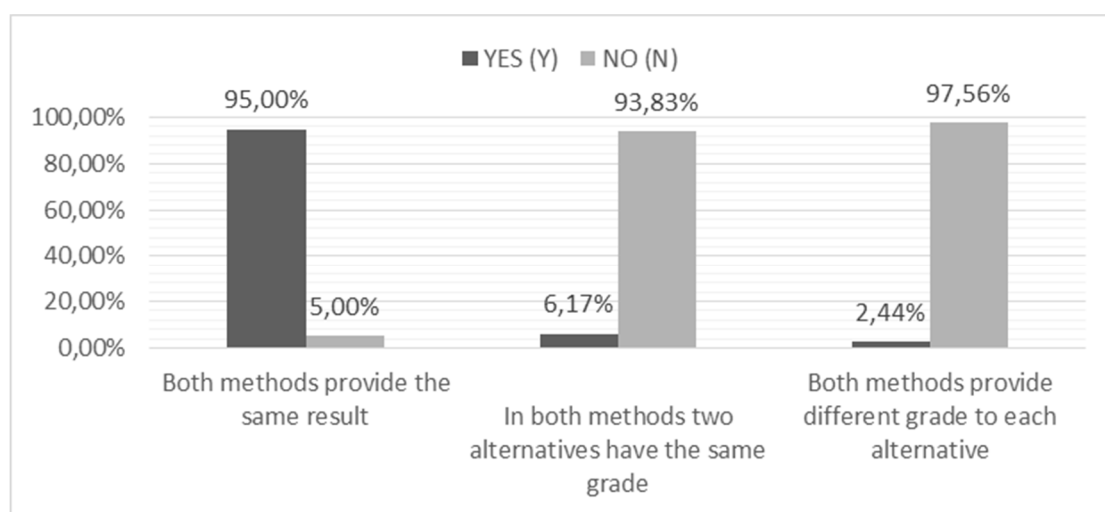
Source: Own study

Fig. 1. Comparison of results of WSM and AHP methods
Rys. 1. Porównanie wyników metod WSM i AHP

Both methods indicated the same results in 95% of cases. In some of the results (6.17% of total results), both methods did not clearly indicate any preferred variant (both alternatives obtained the same preference index). From the perspective of analysing the effectiveness of both methods, the cases in which both methods clearly indicated the other alternative were of particular interest. Such cases represented 2.44% of total results. Having identified specific conditions in which disparities occurred, the authors measured mean parameter values for equal and different results. Table 1 presents results of the analysis.

Table 1. Mean value of parameters in the same and different results
Tabela 1. Średnie wartości parametrów dla wariantów tych samych i różnych wyników

	Both methods provide the same result	In both methods two alternatives have the same grade	Both methods provide different grade to each alternative
	Mean value of each alternative		
YES (Y)	5,005	5,000	4,825
NO (N)	4,912	5,000	5,004
	Mean weight of criteria		
YES (Y)	4,988	5,000	5,463
NO (N)	5,232	5,000	4,988

Source: Own study

Results presented in column 3 are particularly important for further analysis. They depict mean parameter values in a situation where both methods gave different results for both alternatives. From a scientific point of view, it is important to indicate the statistical significance of differences between mean parameter values in conditions in which the methods clearly pointed to different outcomes. The analysis was based on two statistical tests (for each parameter group).

− A pair of statistical hypotheses for parameters indicating the value of each alternative:
  H0: All means are equal.
  H1: Means of data representing different results are lower.
− A pair of statistical hypotheses for parameters indicating the weight of criteria:
  H0: All means are equal.
  H1: Means of data representing different results are greater.

The test of statistical hypotheses was conducted for significance level $\alpha = 0,05$. P value for both pairs was below 0.001, which means that zero hypotheses may be rejected in favour of alternative hypotheses. Thus, there is a dependency between the parameter values of each group and results preferred by either of the methods. It has been statistically proven that results more frequently differ in lower-value parameters from the "value of each alternative" group and higher values of parameters from the "weight of criteria" group.

CONCLUSIONS

The results of simulation studies prove that findings obtained with the use of two multiple-criteria decision-making methods are very similar. The results of both methods analysed, WSM and AHP, differed in 5% of cases. Excluding the ones in which one of the methods did not clearly indicate a preferred option, the results differed only in 2.44% of cases. The differences occurred more frequently in lower-value parameters from the "value of each alternative" group and higher-value parameters from the "weight of criteria" group.

A statement on the absence of significant differences in results of both multiple-criteria decision-making methods was based on an assumption that the alternative chosen by both methods was better (both presented the same option as the preferred choice). The authors claim that the connection between the multiple-criteria decision-making method and the results of a decision made in an actual supply chain is an issue which is much more strongly correlated to the determination of the value of each alternative, not the logic of the method itself.

With reference to the efficiency of multiple-criteria decision-making methods, it should be ascertained that the WSM method is more efficient. WSM method is simple and does not require any complex parametrisation. Its application therefore requires smaller outlays in the decision-making process. Thus, the efficiency of this method is greater than in the

case of the AHP method. In an event when results of both methods do not differ significantly it may be stated that their effectiveness is similar. Using the commonly applied definition of efficiency (as a combination of effectiveness of action and efficiency of action), if the two methods are characterised by similar effectiveness, the one with greater efficiency is more efficient. Considering the results of the study, the WSM method should be considered as such.

Due to the suggested size of the article and the introductory nature of its content, the authors have only presented an initial analysis of the results. In the future, the authors see the possibility to extend the study on two levels. The first one is the detailing level. The analysis of the study on this level will focus on analysing single cases in which results of both methods differ. Such an analysis requires employing different research apparatus, and its purpose will be to determine the influence of dependencies between the weight of criteria and value of each alternative and lack of comparability of results between WSM and AHP. The second level extends the study to include other methods for transforming the parameters that steer the analysed multiple-criteria decision-making methods. The article focuses on the quotient method. Studying and comparing results for the differential method and the expert method seems interesting.

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PORÓWNANIE WIELOKRYTERIALNYCH METOD WSPOMAGAJĄCYH PODEJMOWANIE DECZYJI - WYNIKI BADAŃ SYMULACYJNYCH

STRESZCZENIE. **Wstęp:** Obecnie teoretycy i praktycy dysponują wieloma metodami wspomagającymi proces podejmowania decyzji. Z uwagi na warunki, w jakich funkcjonują współczesne łańcuchy dostaw najbardziej interesujące wydają się metody wielokryterialne. Wykorzystanie skomplikowanych metod wymaga jednak wieloetapowej parametryzacji i przeprowadzenia rozbudowanych obliczeń.
Czy zatem efektywne jest stosowanie skomplikowanych metod?
Metody: Autorzy publikacji porównali dwie popularne wielokryterialne metody wspomagające proces podejmowani decyzji: metodę punktową ważoną (WSM) oraz metodę hierarchiczną (AHP). W modelu symulacyjnym odzwierciedlono funkcjonowanie obu tych metod. Dane wejściowe do symulacji stanowiły wartości parametrów: ocena alternatywy oraz waga kryterium.
Wyniki: Model symulacyjny opracowano w oprogramowaniu iGrafx Process for Six Sigma. Odzwierciedlono w nim funkcjonowanie dwóch wielokryterialnych metod wspomagania procesu decyzyjnego: WSM oraz AHP. Wynikami symulacji były wartości liczbowe odzwierciedlające preferencję każdej z alternatyw według każdej z metod. Za wybraną przez daną metodę alternatywę uznawano tą, której wartość wskaźnika preferencji była wyższa. W analizie wyników poszukiwano zależności pomiędzy wartościami parametrów oraz różnicą wyników przedstawioną przez obie metody. Wykorzystano w tym celu metody statystyczne w tym testowanie hipotez.
Wnioski: Przedstawione rezultaty badań symulacyjnych wskazują, że wyniki uzyskane dwiema wielokryterialnymi metodami wspomagania decyzji są do siebie bardzo zbliżone. Różnice wyników pomiędzy nimi miały miejsce częściej w warunkach niższych wartości parametru ocena alternatywy oraz w wyższych wartości parametru waga kryterium.

Słowa kluczowe: metoda ważona, metoda AHP, wielokryterialne metody wspomagania decyzji, badania symulacyjne

EINE VERGLEICHSSTUDIE VON MEHRKRITERIEN-METHODEN FÜR DIE UNTERSTÜTZUNG VON ENTSCHEIDUNGSTREFFEN - ERGEBNISSE VON SIMULATIONSUNTERSUCHUNGEN

ZUSAMMENFASSUNG. Einleitung: Heutzutage verfügen die Theoretiker und Praktiker über viele den Entscheidungsprozess unterstützende Methoden. In Hinsicht auf die Gegebenheiten, in denen die gegenwärtigen Lieferketten in Funktion treten, scheinen die Mehrkriterien-Methoden am meisten interessant zu sein. Die Inanspruchnahme der komplizierten Methoden macht aber eine Mehretappen-Parametrisierung und Durchführung von ausgebauten Berechnungen erforderlich. Ist die Anwendung der komplizierten Methoden denn effektiv?

Methoden: Die Autoren der Veröffentlichung haben sich eine Vergleichsstudie vorgenommen und zwei populäre, den Entscheidungsprozess unterstützende Mehrkriterien-Methoden miteinander konfrontiert, und zwar: die gewichtete Punkt-Methode (WSM) und die hierarchische Methode (AHP). Im Rahmen eines Simulationsmodells wurde die Funktionsausübung der beiden Methoden projiziert. Die Eingangsdaten zur Simulation machten die zwei folgenden Parameterwerte: die Bewertung der Alternative und das Gewicht des Kriteriums aus.

Ergebnisse: Das Simulationsmodell wurde im Programm von iGrafx Process for Six Sigma ausgearbeitet. In diesem Programm widerspiegelte man die Funktionsausübung der beiden Mehrkriterien-Methoden für die Unterstützung des Entscheidungsprozesses: die WSM und die AHP. Die Ergebnisse der Simulation stellten die Zahlenwerte, die jeweils die Präferenz einer jeder Alternative gemäß jeder der beiden Methoden aufzeigen, dar. Für die durch die jeweilige Methode ausgewählte Methode wurde die als relevant anerkannt, deren Wert der Präferenz-Kennziffer höher war. Im Rahmen der Ergebnisanalyse wurde es nach der Abhängigkeit zwischen den Parameterwerten und der durch die beiden Methoden dargestellten Ergebnisdifferenz gesucht. Dabei hat man zu diesem Zweck statistische Methoden, darunter die Methode für Testen von Hypothesen in Anspruch genommen.

Fazit: Die erzielten und projizierten Ergebnisse der Simulationsuntersuchungen zeigen darauf hin, dass die mithilfe der Mehrkriterien-Methoden für die Unterstützung des Entscheidungsprozesses gewonnenen Resultate nicht allzu sehr differenziert sind. Die Ergebnisdifferenzen kamen öfter beim Vorhandensein der niedrigeren Werte des Parameters der Bewertung der Alternative und bei höheren Werten des Parameters des Kriteriumsgewichtes vor.

Codewörter: gewichtete Methode, AHP-Methode, Mehrkriterien-Methoden für Unterstützung des Entscheidungsprozesses, Simulationsforschungen

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SELECTED ASPECTS OF THE LOGISTICS NETWORK OF PUBLIC HOSPITALS IN THE COMPETITIVE MARKET OF HEALTH SERVICES

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ABSTRACT. **Background:** The below considerations provide an overview of the issues of sustainable development, logistics, to financial engineering instruments and the role of intellectual capital in the process of transformation of public hospitals. The aim of this research was to assess the competitiveness of the network of public hospitals in the market of health services based on literature studies, as well as empirical research.

Methods: Empirical study using a questionnaire survey was conducted in the period from January 2007 to December 2011, in the area of Warmia and Mazury, Pomerania and Wielkopolska.

The goal of this questionnaire survey was to know the medical staff reviews issues related to adaptation to the nature of the network of public hospitals methods and logistics tools, sustainable development, corporate social responsibility - CSR. The study was carried out in 104 public hospitals, on a sample of 8975 respondents.

Results and conclusions: Analysis of the completed study showed that the logistic processes and their improvement in the health sector play a significant role.

The surveyed entities explicitly draw attention to the need for information systems, pro-environment activities, access to information, or the use of GS1 global standards.

These tools allow you to increase the efficiency of supply chains, ensuring not only tracking and tracing of products from the manufacturer to the patient, but also enabling better protection against making a mistake or counterfeit products.

Key words: logistics, network of hospitals, CSR, logistics, competitive market, sustainable development.

INTRODUCTION

Today public hospitals that address the challenges of the twenty-first century need a strategy which would enable them to become more distinguishable from the competition. The increasing globalization of the economy causes decrease in quality, technology and price differences between offered health services. Cooperation and building partnerships is essential for sustainable development of the network organization, by obtaining a balance between the development of economic activities and human development in the following areas:

− economic - concerning effective financial management implemented through the introduction of innovative diagnostic and therapeutic technologies for managing the process of providing comprehensive health services affecting directly and indirectly the increase in the quality of life,

− natural - determining the development of the network of public hospitals through investments that have a positive impact on

the environment, compliance with standards and regulations relating to environmental protection, rationalization of water and electricity consumption, prevention of water soil and air pollution, using the technology of effective waste management and recycling,

– social - which creates the possibility of dialogue with all stakeholders, which results in the analysis of the needs of health care (prevention), assuming from the beginning that the benefits must be balanced on both sides: the network of public hospitals and social groups (an increase in quality of life).

The changes caused by the emergence of "risk society", individualization, detraditiona-lization and cultural processes of globalization, impose taking action to increase the quality of human life while preserving natural and cultural values. Outphasing activities in the above-mentioned dimensions can only help to solve the current problems, rather than building a long-term strategy that would enable the efficient development of the network of public hospitals.

For years, the health sector has successfully adapted methods and tools to improve quality in the industry [Fiałkowska, Zymonik 2012]. The challenges of economic, social and organizational strongly are also influenced by the demographic change - aging populations.

The determinant of the implementation of methods and tools related to logistics sustainable development, corporate social responsibility - CSR is to adapt them to the nature of the network of public hospitals - health services and their nature. In characterizing the contemporary society and health requirements, you should also emphasize the phenomena and manifestations which determine the implementation of these solutions into a network of public hospitals by:
– escalating population movements,
– emphasis on the protection of nature,
– increase in the importance of quality,
– frequent changes in health systems, education,
– technical and technological progress,

– development of the theory of entropy (Entropy is a measure of the degree of disorder of the system (system), from the physical point of view each economic process is an one-way entropy increase ("degradation"); the term was coined by German physicist),
– more and more significant "minorities", not "majorities" [Toffler 2006].

It is a positive fact, however, that there is a growing awareness of hospital personnel - if the network organization is to survive, it must actively seek ways to communicate and interact with local communities. Having better access to information modern prosumers require that health services provided should meet higher and higher demands in terms of availability and quality.

LOGISTICS IN THE MODERN MANAGEMENT OF THE NETWORK OF PUBLIC ENTITIES

In medical care logistics is a field that is not visible to the patient, but directly affects the quality of the management processes of health services in the network organization, which is an important area of interest. Since this process is a non-medical one, the main actors will be those managing entities which are included in the areas of economy, administration, technology, but also law. It depends on the respective competences of these people whether the implementation process of health services will be at a satisfactory level for prosumers.

Supply chain management must take place in consultation and cooperation with medical professionals since they are responsible for appropriate diagnostic and therapeutic processes, and their recommendations determine the consolidation of orders.

The size and structure of the logistics center network of public hospitals should be tailored to the specific tasks that are a function of the number and nature of needs because the traditional hospital storage are being replaced by cross-docking terminals. The components of hospital services are received from

suppliers. Then they are deconsolidated in the terminals and consolidated again for load units in accordance with the order of a specific entity. The product stream flowing through the terminal remains uninterrupted, regardless of the number of providers, the type of products and their distribution. Logistics Flow helps meet the growing demands of the network of public hospitals in the supply and distribution of products. Implementation of the principles of outsourcing of logistics services is to allow logistics centers or logistics operators to perform some or all of the logistical operations for the network of public hospitals. This allows to focus on the core business which is comprehensive management of hospital services. Infrastructure and environmental constraints determine the development of interest in multimodal transport (under one contract at least two means of transport are used). Creative logistics management is becoming increasingly important. There are many starting points for operations which can rationalize the course diagnostic subprocesses aimed at reducing costs, sustaining high quality, and increasing the added value of comprehensive hospital services. Implementation of new management concepts (ISO, TQM philosophy and many others) creates further opportunities for process optimization (IT development, computerization, etc.). Moreover, in the process of solving problems which arise when implementing these concepts, what might be helpful is the philosophy of Kaizen consisting of simple improvement tools. Imai [2007] assumes that: our way of life (regardless of whether it is a job, social or personal life) should be continuously improved. In contrast, increasing the participation of administrators of public entities in activities that shape Kaizen is possible, inter alia, through active participation in all processes related to the improvement, including personally assisting employees in the process of solving problems [Staszewski, Kautsch 2010].

In the process of identification and characterization of processes (systems) what plays a critical role is logistics comprehensive analysis of their functional, instrumental and structural characteristics and effects of their interaction. Based on this, the logistic system can be described as a collection of elements where the relationships between them are concretized through appropriate processes of transformation. These elements, having specific properties, also interact with each other closely in terms of organizational relationships. This means that the structure of the logistics system is created by only those processes that are assigned in a systemic manner to appropriate organizational and functional solutions of a network organization. In practice, this means moving from an operational approach geared to control logistics operations, towards the systemic concept of logistically oriented management.

The problem of choosing a logistics operator for the management and implementation of certain logistics functions belongs to the strategic issues of comprehensive management of a network organization. Decisions of this type are decisions such as: leave it at home, or acquire it from outside". This applies to all situations, which play a decisive role in the reduction of the operating costs of entities, taking into account both quantitative and qualitative factors [Hella, de Leeuw, Klumpp].

One of the methods for the comparison of qualitative factors in the decision process "make or buy" is the method of "scoring". The final result is a solution that can be an element of support in the decision making process. The process approach and flow concurrency are a requisite for the reduction in the time of processes (hospital services). The logistics operator participating in the value chain monitors the completion of deliveries from sub-supplier; their processes - deliveries to the main link, which is the network of public hospitals. Turbulences in the environment enforce the need to continuously adapt to new conditions and to be flexible in the comprehensive management of the process of provision of hospital services. On the one hand they must be solutions for relatively rapid and significant improvement in quality, reduction in the decision-making risk, involving adequate measures. On the other hand, what should also be considered is the effectiveness of implemented diagnostic and therapeutic innovation and the ability to use them for a longer period of time. According to the authors, the term "do it once and for all"

carries a new message for a network organization, determining, on the one hand, the costs of providing services and the increase in health satisfaction and reduce the risk of decision-making on the other hand. Economic reality forces the network of public hospitals operating in turbulent conditions to subordinate to the concept of modern supply chain [Wolffgram, Rutkowski 2001], which is characterized by:
- rapid response capability, the ability to satisfy the rapidly changing demand,
- flexibility, ability to adapt to the optimum: "cost of hospital service - patient care level",
- ability to make optimal use of a hospital /a ward resources,
- the ability to make full use of all available information.

This is what makes the logistics network of public hospitals an interdisciplinary area, involving all the staff employed (regardless of the form of employment). In managing the process of health services costs play an important, but not dominant role. Through this approach, properly implemented logistics processes in the network of public hospitals, can directly affect the quality of health services, reduce the risk of decision-making and increase satisfaction of health prosumers.

In the era of knowledge-based economy what is required is a new look at the functioning of the network of public hospitals. [Matczewski 2001] asserts that contemporary management is necessarily includes fraction of different approaches, combining the results of research of many fields, even breaking down barriers of disciplinary, because management needs the interdisciplinary approach. The synergistic merging and the use of different expertise, can allow organizations to obtain network capacity to cope with environmental turbulence. Query literature indicates the growing needs and a growing number of manifestations of systemic treatment, shaping functions and logistics processes in integration and strategic aspects. The proper selection of components makes it possible to obtain an advantage over competitors, and this, in turn, allows to achieve long-term goals. In this context, the search for solutions in the field of logistics management refers to those that can

be used in sustainable logistics chains. These are complex operations, requiring of public bodies close partnership and flexibility, so that the end result of their actions will satisfy the expectations of stakeholders.

In the literature sustainable logistics chains are referred to as feedback chains or waste chains. There are seen as processes where resources used environmentally friendly, and whatever is produced as a result is subject to disposal. This creates a balance in the chain, providing the opportunity to dispose of the product obtained and, consequently prolonging its life cycle [Brdulak, Michniewska, 2009]. The offer of logistics services available in the market is rapidly expanding to meet the expectations of the organization of the network. For the market offer to be suitable to meet the specific requirements of public entities it includes:
- comprehensive service by offering an integrated set of logistics services in accordance with the concept of "buy everything in one place", what enables the organization to make significant savings in terms of costs, but also time,
- excellence of orders (relevant to the diagnostic and therapeutic processes) in accordance with the major principles of logistics:
  - the right shipping (elimination of mistakes and errors in terms of objects transported),
  - at the right time (punctuality),
  - the right place (elimination of mistakes and errors to targets),
  - the right condition (increasing importance of transport security).

(Re)defining its business model the organization (network) must define its strategic dimensions of functioning by [Slywotzky, Morrison, Andelman, 2000]:
- choice of target groups of patients,
- capturing value,
- strategic controlling,
- the scope of activities.

Implementation of solutions for sustainable logistics network of public hospitals should consider:

- Transfer of the industry-specific know-how, as well as temporarily delayed return-on-investment,
- clearly defined competencies in data processing (compatible databases),
- readiness to deal with the legal conditions of health,
- readiness to take design responsibility for the basic functions that go far beyond the normal flow of materials.

The term "supply chain" is one of the most dynamically developing concepts [Świerczek 2004]. Coordination of activities within the framework of a comprehensive management of hospital services - a network of public hospitals - is associated with the need to solve complex, multi-criteria decision problems, the choice of "something for something" - trade off. Particular areas of strategic behavior subsidize each other: the cost for time, the time for the service level (quality), quality for the cost, etc. [Chaberek 2001].

Porter [2001] believes that the value chain is: Performing similar activities better than the rivals do, where every company (including public hospitals) is not only a link in the value chain of the broader economy, but also creates the same internal value chain [Giereszewska, Romanowska 1999] – a balanced budget. The concept of the value chain is the basis of a comprehensive process approach to managing the process of providing hospital services [Pinna, Carrus, Marras 2015]. It is subject to verification in terms of value for the customer (patient) and the reference to performance indicators achieved by the organizations (the network of public hospitals) in relation to the competitive environment [Lisiecka 2003]. It is also the structure of cooperating with each other entities [Fung, Fung and Wind 2008], while the network is the entire population of suppliers, from which, for a specific order, one can extract the best set of suppliers - the supply chain. Modern supply chains should be "demand controlled chains" - or controlled by the needs of the consumer. This means the ability to respond rapidly to changing demand, i.e. in the so-called reaction in real time.

Rising medical costs arising from the use of more advanced technologies and a growing number of patients are contributing to the search for solutions to improve the supply chain and improve the safety of the patient. The basic criterion for a comprehensive policy analysis of supply chain management in the network organization are the costs generated by logistics operations, while the process approach indicates the need for consideration of the costs relating to activities carried out within the framework of individual processes. The concept of cost accounting taking into account processes in logistics is ABC - Activity Based Costing [Bober 2012]. Its wide range of applications gives it huge potential opportunities for both strategic and operational management of the network organization costs. The integrated supply chain is the optimal approach to the market of health services, where the network of public hospitals operates. Depending on the pro-quality needs, the supply chain must provide a suitable compromise between reaction rate and efficiency. In addition to the above tasks, processes of order management must also provide the so-called exception handling, such as for example, road crashes. The desire to organize and enrich the knowledge of logistics in unusual applications has been the inspiration for this work.

IT SYSTEMS SUPPORTING THE PROCESS OF CHANGE IN THE NETWORK OF PUBLIC HOSPITALS

The implementation of procedures and systems tailored to the organizational and functional requirements of a network of public hospitals, the market and the law, enables the identification of the components of hospital services at each stage of the supply chain. Additionally, one can also reduce the risks associated with the management of the provision of services, thus determining reproducible quality. Data, information and knowledge are assets necessary in the process of implementing the principles of sustainable development of the network of public hospitals, supply chain management - SCM.

They are the basis for the operation of e-medicine and management control of the flow

of goods and information, and their distribution among the supply chain participants. IT systems are used in particular in [Waters 2007]:

– acquisition and data collection about services for specific logistics operations in real time,
– storage of information in databases in pre-defined categories and formats,
– analyzing the stored data to generate information for decision-making in terms of cost reduction,
– cooperation and communication with the participants of the chain,
– formulation of a coherent system of coding to automate communication between participants in the process of exchange based on the standard UCC - European Article Number Association-Uniform Code Couneil (transformed into a global standard GS1 - Global Standard),
– standardizing logistics operations and procedures for data acquisition, regulatory and control measures.

In contrast, intelligent transport systems - ITS, provide a wide collection of various telecommunication and information technologies as well as management techniques used in medical transport, in order to increase the efficiency of the transport system safety and protection of natural resources. The implementation of the concept of the so-called. Quick Response - QR allows to identify and meet the real demand for health services. The integration with electronic commerce tools is used to make decisions and actions helping time compression in the duration of the process of distribution. [Rutkowski, 2005].

IT solutions for the possibility of links between the patient and the supply chain will allow not only the identification of the drug, but above all in the case of adverse reaction of non-patient, an immediate intervention. The evolution of technology provides tools and systems to facilitate, to meet the demand for processing, transmission of data and information. It also provides innovative technologies, such as wireless technologies and systems for flow control based on RFID - Radio Frequency Identification. AIDC

Technology - Automatic Identification and Data Communication is used for automatic identification and data collection, recording the maximum number of components in the system of health services using e.g. barcodes, magnetic stripes. It also allows to perform the following operations in the hospital supply chain:

– store relevant information to enable product traceability,
– solve the problem at the source - the general improvement of quality,
– decline in demand for labor,
– inventory control, quality assurance,
– elimination of errors related to the human factor,
– locating components of services - enabling delivery on time,
– control of transport conditions - reduction of damage.

Technologies based on barcodes or RFID tags are increasingly applicable in the implementation of the logistics activities in hospitals [Roper, Sedehi and Ashuri 2015; Long, Dung, Xuan, Qiang, Enmin 2015]. Tracking the movement of goods in the supply chain improves inventory management undoubtedly, while guaranteeing an appropriate medication, in the right place and time.

Gaining quick access to comprehensive information, improving patient safety in the process of hospital treatment is extremely important. Such actions raise the efficiency of logistics hospital, allowing at the same time, reduce administrative costs. Optimizing the conduct of health and medical organizations sausages translates to minimize errors, increase employee effectiveness and efficiency of processes. It should be pointed out that in hospitals dealing with the identification of multiple streams of natural resources, among which indicate [Nowakowski, 2011]:

– Medicinal products (e.g. Vaccines, prescription drugs, blood, etc.),
– Medical devices (e.g. Laboratory and diagnostic equipment, containers, etc.),
– Organ to transplant,
– Personal protective equipment (e.g. Protective clothing and footwear, etc.),
– Articles hotel (e.g. Sheets, chairs, cosmetics, etc.),

- Foodstuffs,
- Articles and office equipment and renovation,
- Medical waste.

This classification shows the enormity of the problem with which the hospitals are struggling to effectively manage, plan, hospital supplies, or spend all sorts of products. Due to the nature of assortments should take into account a number of important issues such as low predictability of supply of medicinal products, the need to ensure inventories, high capital intensity, or provision of special physicochemical conditions during transport and storage. It is also necessary to continuously monitor the use-by dates, as well as keeping track of individual production batches of medicines and changes in this regard. Therefore, each of the product groups has to do with logistics functions, such as: development and implementation of the order, warehousing, packaging, transport and waste management. Some functions require a number of significant decisions.

The multidimensional nature of the decisions made in the diagnostic and therapeutic process means that the effectiveness and success is often determined by the ability to work in an interdisciplinary medical team. An important task in the provision of health services is to coordinate and control the movement of people (co-workers and patients) and information about them.

Through decision support systems - SWD [Bober 2013] contemporary IT proposes solutions for vague environments, incomplete data, minimizing errors arising from misinterpretation of medical records. On the one hand the system ensures the correct identification of the patient, controls the diagnostic and therapeutic process and responds to the patient's changing vital signs, makes the medical staff focus more on the patient and less on writing referrals, prescriptions, etc. On the other hand, medical managers can optimally control the revenues and costs, manage medications and inventory more efficiently and safely, etc. Another important aspect is the optimization of medical orders by identifying the hospital units producing unjustified costs.

IMPLEMENTATION OF THE PRINCIPLES OF SUSTAINABLE DEVELOPMENT AS THE BASIS FOR DEVELOPMENT OF A NETWORK OF PUBLIC HOSPITALS

The 1989 reform changed the rules of public hospitals. Although the hospitals are not viewed as acting according to the principles of sustainable development, they have a relatively rich record of responsible business conduct. These actions result from their policies which include quality standards determining all aspects of a network of public entities. The concept of sustainable development was formulated at the Second Session of the Executive of the United Nations Environment Programme in 1975 (The concept of sustainable development comes from the German forestry and was introduced by H. von Carlowitz in 1713, and meant such a way of managing the forest that such a number of trees was cut only that could be restored at the same location) [Witte 2011]. It assumes: such a course of inevitable and desirable economic development, which would not irreversibly affect the human environment and would not lead to the degradation of the biosphere, which would not undermine the laws of nature, economy and culture [Dick, 2006]. In Poland, it was considered a problem so weighty that it was entered into the 5 article of the Polish Constitution that: the Constitution safeguards the national heritage and protects the natural environment, based on the principle of sustainable development [1997 Constitution]. In addition, it creates a common basis for analysis and practical solving of social, economic and ecological problems of a network organization. It involves shaping development policies in such a way that apart from the purely economic elements also social and environmental goals would be taken into account. The condition for the achievement of the strategic objectives of sustainable

development in the regional ecosystem is endogenous ability to create innovation and, in particular, eco-innovation understood as ecological novelty - in technology, organization, management, promotion, environmental education, planning, marketing, which reduce or prevent the negative effects of regional entities on the environment [Strahl 2010].

Innovation is defined in many ways, but using the most general terms we can say that these are all facts, processes, phenomena of a technical, organizational, social, psychological, scientific, financial or commercial nature, aimed at the development and implementation of new or significantly improved products and processes [Kurpanek 2006]. Defining innovation Schumpeter [Pomykalski 2001] has focused his attention on the introduction of new processes or improving existing ones, introducing new or improving existing products, the use of a new method of sales or purchases, opening a new market, the use of new raw materials or semi-finished products and the introduction of a new organization of production. However, according to the OECD definition, innovation is when a new or significantly improved solution is introduced in the company, with regard to the product, process, marketing or organization [European Commission 2003, 2004]. Innovation can be both a product and a whole range of different products, which constitute an integrated entity. The use of new technology is not only more economical but also more efficient than the search for different ways to reduce pollution, which arose as a result of the use of outdated technologies [Janasz 2007]. The life cycle of products and services is becoming shorter and innovative products, positively verified by the market, play an increasingly important role in achieving the success of many companies [Majchrzak-Lepczyk 2012]. Innovation, therefore, determines the development of logistics, thus leading to increased competitiveness and development of the organization. In contrast, logistics competences, as factors affecting the changes in the comprehensive management, enable more effective implementation of the planned economic effects of a market [Bujak 2011]. In addition, logistics facilitates the formation of

social, ecological and spatial order. In the environmentally oriented logistics system environmental objectives are treated as equivalent to economic objectives [Messiah-Lech 2012]. A special type of innovation is eco-innovation, which is seen as an essential tool in the quest for efficient use of environmental resources, competitiveness and job creation resulting from the social interaction, technical discoveries and applications of new knowledge. As a result of interaction they create new products and processes with reduced negative impact on the environment [Wozniak, Ziolkowski 2006].

The network of public hospitals meet many criteria for the applied ecological, economic, and social solutions. The creation of the report GRI - Global Reporting Initiative would be a confirmation of the achievements of the network organization in meeting these standards. It is a tool to monitor the achievements in the implementation of sustainable development strategies. It also allows the identification of the places where it is possible to introduce modifications. The effectively conducted policy of sustainable development is a major step in order to influence the image of public entities. Moreover, emphasizing the achievements in the environmental and social fields can be a great tool for Public Relations in the network of public hospitals.

SUSTAINABLE TRANSPORT AS A RESPONSE TO ENVIRONMENTAL REQUIREMENTS

Ongoing economic volatility causes changes in the business of public hospital network. The network exists in the booming environment and is constantly forced to seek new and effective business models that provide enhanced competitiveness. The concept of sustainable development is a proposal for a qualitatively new form of conscious, responsible individual and social conduct, enabling the further development of civilization with respect for the laws of nature and socio-economic aspirations of mankind [Skowronski 2006].

In the context of a general reflection on the sustainable development of the network organization what should be noted is the increased interest in the phenomenon of sustainability in different areas of human activity. In numerous publications relating to sustainable transport one can encounter two similar concepts: Sustainable Development of Transport and Sustainable Transportation. Sustainable transport development is a process of changes in the transport sector, showing characteristics of growing sustainability (mobility, accessibility), reflecting a steady disparate economic, social and environmental objectives. In contrast, sustainable transport is referred to interchangeably as environmentally sustainable transport and or a environmentally sustainable system (these terms are treated as synonyms).

Within the framework of the White Paper the European Union has developed its own definition of a sustainable transport system, according to which it:
− ensures the availability of the communication objectives in a safe manner, without jeopardizing human health and the environment, in a manner equal to the current and next generations,
− can function effectively, offer a choice of means of transport and sustain the economy and regional development,
− limits emissions and waste within the limits of the soil absorption properties, uses renewable resources in the amounts possible to restore them, consumes non-renewable resources in the amounts possible to replace them by renewable substitutes, while minimizing land take and noise [White Paper 2010].

Man not only uses natural resources satisfying their needs, but also protects them from degradation and transforms them according to their needs [Deszczka, Wąsowicz 2013]. However, according to the definition (The definition of a sustainable transport system, adopted in 2004 by the European Conference of Ministers of Transportation of the OECD and the Centre for Sustainable Transportation in Toronto in 2005.), a sustainable transport system should take into account accessibility criteria for transport services in line with the requirement of health

and environmental safety (impacts on ecosystems) including:
− the principle of intergenerational justice,
− the criterion of economic efficiency,
− the criterion limiting the impact on the environment (negative external factors),
− the use of space (land).

Transport is the sphere of management which has a multidimensional character of relationships and dependencies of the economy, society and the natural environment [Crew 2013]. Despite its complex nature, being the "bloodstream" of the economy, transport should be balanced, and the balance should go along the following axes: economic, social, environmental and spatial ones [Pawłowska 2011].

CSR - AN EFFECTIVE AND RESPONSIBLE PUBLIC HOSPITAL

The art of management responds quickly to the changing reality and the drive for change in the network of public hospitals are new practical experiences. The economic, social and natural challenges inspire the creation of new concepts, methods, systems and management techniques [Poskrobko 2008]. These challenges led to the development of the concept of corporate social responsibility - CSR. The concept of corporate social responsibility has many counterparts, used interchangeably. In the literature and business practice the most frequently used terms are: Corporate Sustainability Management, Business Responsibility, Corporate Citizenship, Global Business Citizenship, Corporate Social Performance, Corporate Social Responsiveness, Social Responsibility, Corporate Responsibility, Community Relations [Roszkowska 2011]. The multiplicity of interpretations of the term CSR, as well as ambiguity in its conveyed meaning is shows that the idea is still being developing, but if it is still taking shape, it is not so easy to capture its essence, and hence, not so easy to implement it in life [Filek 2008].

A precise definition of corporate social responsibility was reflected in ISO 26000, which requires entities: to include

environmental and social aspects in the decision making process and take responsibility for the impact of decisions and activities on society and the environment [Ministry of the Economy 2011]. They contribute to sustainable development, including health and the welfare of the society and:
- involve expectations of stakeholders,
- comply with the applicable rules of law and being consistent with international norms of behavior,
- implemented throughout the organization they are practiced in its activities within its sphere of influence [ISO 2010].

The basic premise of CSR is therefore responsible and ethical conduct of business in relation to social groups, which it interacts with as well as the greatest possible respect for the natural environment.

In addition, Kuraszko [2010] recognized the following as the characteristics of socially responsible actions:
- the introduction of ethical values in core business,
- fair fulfillment of commitments,
- the use of transparent business practices based on respect for employees and the community,
- use of dialogue in the process of streamlining the development strategy of the organization,
- building a strategy of competitive advantage in the market, which is based on providing a lasting value.

In the above mentioned definitions, the emphasis is on the conscious and voluntary commitments adopted by entities towards various stakeholder groups: society as a whole, and its separate groups, in particular: customers, consumers, employees, business partners and the environment [Nowak-Lewandowska, 2010].

Social responsibility in the relation: hospital network towards the patient is quite diverse in the way it is expressed, measured and considered. This is due to the fact that it is a diverse subject matter and the nature of services of these entities is diverse, too.

However, there are some general rules - the CSR imponderables, which gather most attention when prosumer-hospital relations are examined:
- compliance with the acceptable forms of advertising and promotion,
- analyzing the level of patient satisfaction with the quality of hospital services and following certain principles related to response to their feedback,
- clear definition of the obligations of public entities providing services and presenting accurate, relevant information.

In these areas, there are rules of conduct under the law as well as principles (codes) voluntarily accepted by the network of public hospitals. Reputation, as one of the intangible resources, becomes a particularly valuable resource in developing and achieving competitive advantage in the market for health services. Gaining a good reputation takes many years, and minimizing the risk of its loss means taking measures to create value for stakeholders. Public entities within the network, implementing the concept of corporate social responsibility are becoming more transparent. In this regard Corporate Social Responsibility reporting plays an important role. It can be defined as a voluntary initiative for the presentation of the overall strategy of the organization to everybody concerned. Reporting social activities is a key communication tool for an organization with different groups of stakeholders [Golob, Bartlett 2007].

The implementation of CSR principles into practice network of public hospitals is hindered by a number of significant barriers: poor quality of leadership, inappropriate relationships between roles of authority and ownership as well as imperfect law and fairly high social approval of unethical business behavior. To change the attitude of the society to the environment and sustainable development Howaniec [2010] suggests starting with the proper presentation of the same concept, both in informal and formal education (ranging from senior grades of primary school).

In addition, it is advisable to develop and implement a conscious policy of ethics, which

requires the inclusion of ethical principles in the mission of the network organization and their transfer to all staff, regardless of the form of employment.

THE CHALLENGE OF MODERNITY - TELEMEDICINE

The following piece of work has been devoted to one of the most important elements falling within the scope of sustainable development, namely the health of present and future generations. The authors showed that, thanks to modern communications technologies, digitization and computerization of medicine the quality and standard of public health can be improved. With e-medicine medical staff network of public hospitals will be able to reach a larger number of patients, ensure safety and permanent professional help, and by means of telecommunications quickly and efficiently give immediate guidance on dealing with specific ailments [Mendoza, 2014].

Telemedicine is also an advancing cooperation between hospital institutions and interdisciplinary diagnostic and therapeutic teams. In contrast, the creation of databases of medical cases, descriptions of rare diseases are just some of the elements that determine the process of increasing the knowledge of medical staff at any place and time. In addition to benefits of equal opportunities and the possibility of improving health, it is also designed to significantly reduce the process costs of hospital services rendered. Improving the quality of health with the help of e-medicine contributes to the objectives of sustainable development such as: green development, security, acting in accordance with democracy, and last but not least – a decent life. In addition, the process of their implementation can be a source of knowledge affecting the rationalization of activities undertaken in the network of public hospitals, improving relationships with patients, strengthening cooperation with partners and creating network connections. As the P.F. Drucker [2010], management philosophy should allow, among other things: full development of the individual human forces and responsibility; give a common direction to

the sense of perspective and efforts, as well as provide work collectivity, harmonizing the objectives of the individual with the common good. The need for a rapid and flourish is justified by both ethical and economic reasons. They allow the reduction of health care costs, and help to create equal opportunities for all patients.

THE ESSENCE OF INTELLECTUAL CAPITAL IN SOCIALLY RESPONSIBLE HOSPITAL NETWORKS

Corporate social responsibility is a relatively new and still evolving concept, which speaks of the need to care for the natural environment and concern for the satisfaction of social needs. It should be emphasized that the skillful implementation of the concept of corporate social responsibility is determined not only by the available resources of financial capital, but also intellectual capital, which a network organization has. According to the authors whether the presented solutions will prove effective in their implementation depends on the availability of human capital with adequate quality and effective management.

Knowledge, skills, perception, attitudes, values employees, openness to change, and everything that falls under the concept of human capital is a factor in determining the degree of competitiveness and innovation of a network of public hospitals. A major support is also important structural capital associated with technical, organizational and IT infrastructure.

Accumulation of knowledge at the level of individual entities within the network, allows to increase the skills and knowledge of staff, adapting health services to pro-quality requirements of patients and environmental requirements It also contributes to a more effective knowledge acquisition from the outside, as well as shape the correct relationships with various groups of stakeholders. From the perspective of CSR, structural capital is therefore very important, because it has a positive effect on the

improvement of core competencies, supports the process of organizational learning, serves to create innovative solutions to build up relationships of individual entities with the environment. In this context, the organizational culture plays a special role, which constitutes an integral part of structural capital.

Environmental education is, among others, environmental education and upbringing, which is the transfer of knowledge about the natural environment, about the processes taking place within it, as well as its problems and the formation of environmentally friendly system of values (ethics, sensitivity) and raising the society's activity in order to protect the natural world [Kiełczewski 2001]. In contrast, education for sustainable development is a broader concept than environmental education. This is mainly due to the fact that the concept of sustainable development is a complex notion, whose features make it difficult to translate it into practical effect, including also the sphere of education. The complexity of the concept results from the fact that it applies to all aspects of human life and requires a multidisciplinary, systemic and holistic approach. Meanwhile, sustainable development is about cultural identity, social equality, access to environmental resources, the relationship: society- nature and conflicts between values. [Dobrzański 2006]. A network organization initiating activities aimed at their staff is now making efforts to implement integrated systems of health and safety management - Environmental, Health and Safety Management System - EHS. In this way it is possible to manage the strategic planning process, linking environmental and health and safety issues, together with development plans. Undoubtedly, the key element in the creation of a network of public hospitals appears to be human capital.

PUBLIC SUPPORT AS A TOOL TO STIMULATE THE SUSTAINABLE DEVELOPMENT OF THE NETWORK OF PUBLIC HOSPITALS

The main objective of sustainable development is to ensure economic prosperity

while maintaining a high level of protection of the natural environment and social justice. Among the instruments for the implementation of the policy are legal and economic factors, financial factors. The latter play an important role; these are subsidies to support investment activities in public hospitals. It is worth mentioning that due to the scope, donors and forms which they take subsidies are a broader concept than aid [Stiglitz 2004]. A characteristic feature of public aid is its selective nature, that is, the focus on the selected instances: public hospitals (health care).

State aid is a form of state intervention in economic activity and the social public entities. Appearing in various forms, it plays an important role in the intensification of efforts at improving the quality of life of society and the protection of the natural environment. The managerial staff of public hospitals must be aware that: financial intelligence is a gift and a skill for proper handling of money [Fesnak 2011] – a collection of psychological and financial skills required for effective management of public resources, and the goal of efficient financial management of public finances is balanced budget. In addition: management habit is more important than the amount of money [Ecker 2007].

One cannot distinguish any health care system that would systematically work better than others in terms of cost-effectiveness. It turns out that this is not the type of system, but how to manage it is what determines the cost-effectiveness. Both systems - these focused on the market and these centralized - have advantages and disadvantages.

THE RESEARCH MATERIAL AND RESEARCH METHODOLOGY

The empirical study was conducted in the period from January 2007 to December 2011 (on an annual basis), the area of the Warmia and Mazury, Pomerania and Wielkopolska, marked for the further consideration, respectively, as A, B, C (18.75% of all the provinces). The aim was to know the opinion of medical staff on issues relating to the

adaptation to the nature of the network of public hospitals in terms of methods and tools in the field of logistics, sustainable development, corporate social responsibility - CSR. The author's questionnaire consisted of mostly closed questions (with the matching list of answers based on the study of literature) of single - and multiple choice types. Anonymous questionnaires were sent to 104 public hospitals (20.43% of the total), the region A, B and C in the period from January 2007 to December 2011. The representatives of management issued a letter to the coordinators of hospital wards, as well as financial directors, due to some valuable financial data on the costs at the end of five years studied (data from the years 2007-2011). For further analysis 203 correctly completed questionnaires 81.20% (250) were allowed.

The study was conducted on a sample of 8975 respondents (7.33% of all physicians), representing the medical staff of public hospitals, regardless of the form of employment. The share of respondents in each of the five hospital branches (The criterion for selection of wards: internal, gynecology and obstetrics, neurology, orthopedics and cardiology was data on the number of complaints lodged with the Ombudsman (Act of 15 July 1987. on the Ombudsman (Journal. Laws of 2001. No. 14, item. 147 later. amended.), the Patient Ombudsman (Commissioner for Patients' Rights was

established by the Act of March 31, 2009., Journal. Laws of 2009. No. 52, item. 417), the Ministry of Health, the Principal Court whose composition, , according to art. 38 of the Act of 2 December 2009 (about medical chambers) is decided by the National Assembly of medical doctors) is - in line with the test procedures - similar, although there was little difference in the number of public hospitals being the result of changes in health care. In order to know personal data, the research questionnaire contained "the respondent's imprint ". The sample was selected in a random-stratified manner. The strata were public hospitals (small, medium, large).

In the registry REGON (As of 31.12.2006., Poland had 425 registered public hospitals in 16 provinces (excluding hospitals of Defense and Ministry of Interior)) 104 public hospitals were registered in the analyzed regions (which increases the reliability and representativeness of the results). The sampling took place with the stratification criteria:
− regional differences - the division into provinces (voivodships),
− the size of the public hospital.

The selection of the research sample was purposive (medical staff of public hospitals), which allowed the selection of respondents with specific characteristics (job seniority, education, position / department).

Table 1. The detailed structure of the surveyed population - medical staff of public hospitals
Tabela 1. Szczegółowa struktura badanej zbiorowości - kadry medycznej szpitali publicznych

| L.s	Branches	Seniority in wards					Education					Sex	
		do 5	6-10	11-15	16-20	above 20	no-specialist	I^0	II^0	dr	prof	W	M
1.	Internal Medicine	2051	174	294	429	318	2051	397	686	657	74	2555	973
2.	Gynecology and obstetrics	421	139	245	385	213	421	113	134	153	26	1058	331
3.	Neurology	249	198	209	184	167	249	299	354	398	56	1020	503
4.	Orthopedics	583	193	229	294	174	583	322	374	429	31	199	767
5.	Cardiology	271	231	299	309	216	271	250	264	342	41	1076	493
	Total	**3575**	3575	935	1276	1601	1588	3575	1381	1812	1979	228	5908

Source: Compiled on the basis of own studies in the period from January 2007 to December 2011

In this research, in addition to professional categorization, another kind of stratification was introduced. It took into account, among other things, work experience, education, gender (Table 1).

Taking into account the criterion of length of service, the largest group is people up to 5 years, 39.84% (3575). Subsequently, there are people with experience between 6-10, 10.42%

(935) of respondents, followed by 11-15, 14.22% (1276), 16-20, 17.82% (1601) (figure 1). People over 20 years of seniority and more represent 17.70% (1588) of the subjects of the study. Another division
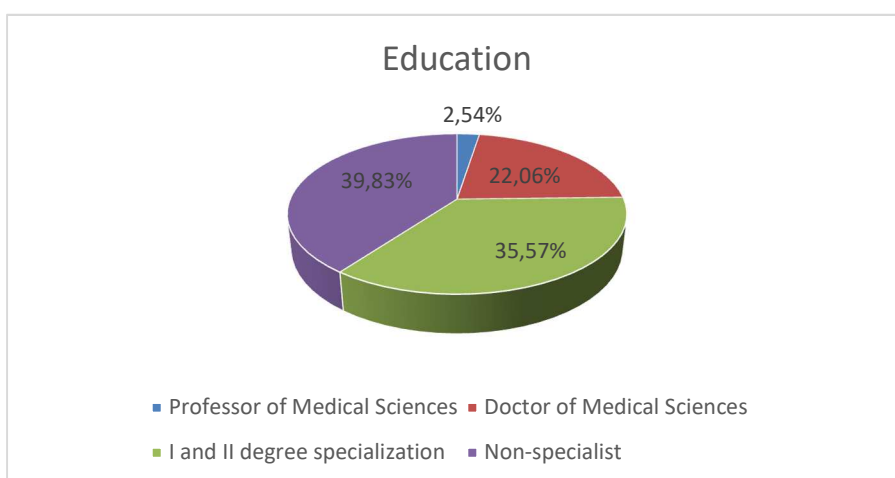
criterion included in the sampling is gender test.
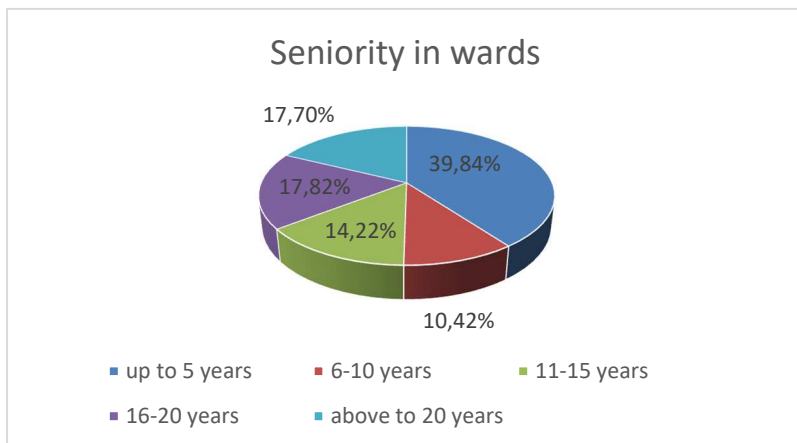
Source: Compiled on the basis of own studies in the period from January 2007 to December 2011

Fig. 1. Seniority in wards of the surveyed population
Rys. 1. Staż pracy badanej populacji

Public hospitals are mostly entities dominated by women, which was confirmed also in this case. In the surveyed enterprises the female share in the medical staff is 65.83% (5907), M - 34.17% (3067). Studies have shown that 39.83% of respondents are characterized by a lack of sufficient experience (1-5 years work experience). 35.57% (3193) hold the 1st and 2nd degree specialization, Doctor of Medical Sciences is the title possessed by 22.06% (1979) of respondents.

The degree of professor of medical science is in the hands of 2.54% (228) (figure 2).

Moreover, information from various sources was used in the research, both primary and secondary. Primary information was obtained directly from the analyzed public entities, while secondary information was derived from statistical studies, reports, records of government institutions.

Source: Compiled on the basis of own studies in the period from January 2007 to December 2011

Fig. 2. Education in wards of the surveyed population

Rys. 2. Wykształcenie wśród badanej populacji

The verification process was based on the results of the query literature and analyses made by the researchers of scientific centers, existing legislation, statistical data of the Central Statistical Office, Marshal Offices and Provincial Environmental Protection Inspectorates.

Table 2. Structural Capital in analyzed public hospitals
Tabela 2. Kapitał strukturalny w analizowanych szpitalach publicznych

L.p.	Province		population	Number of hospitalized patients	gamma camera	linear accelera-tor	X-ray camera with video	CT scanner	magnetic resonance imaging
1.	Warmia and Mazury	2007	1426883	265059	2 /0,1	0/0,0	35/2,5	4/0,3	0/0,0
		2008	1426155	263607	1/0,1	0/0,0	38/2,7	4/0,3	0/0,0
		2009	1427073	285201	2/0,1	0/0,0	33/2,3	4/0,3	0/0,0
		2010	1427118	270100	2/0,1	0/0,0	30/2,1	6/0,4	0/0,0
		2011	1427241	265 975	3/0,2	0/0,0	33/2,3	6/0,4	0/0,0
2.	Pomerania	2007	2203595	359646	5/02	7/0,3	53/2,4	18/0,8	3/0,1
		2008	2210920	340109	5/0,2	7/0,3	51/2,3	19/0,9	3/0,1
		2009	2219512	399360	5/0,2	7/0,3	56/2,5	17/0,8	4/0,2
		2010	2230099	416795	4/0,2	7/0,3	60/2,7	19/0,9	6/0,3
		2011	2240319	406 568	7/0,3	8/0,4	46/2,1	19/0,9	6/0,3
3.	Wielkopolskie	2007	3378502	691356	6/0,2	5/0,1	84/2,5	20/0,6	3/0,1
		2008	3386882	705756	6/0,2	5/0,1	82/2,4	23/0,7	2/0,1
		2009	3397617	765273	5/0,1	7/0,2	82/2,4	27/0,8	2/0,1
		2010	3408281	781568	5/0,1	7/0,2	73/2,1	31/0,9	3/0,1
		2011	3419426	786 807	5/0,1	7/0,2	81/2,4	34/0,1	6/0,2

Indicator: 100 thousand people
Source: Compiled on the basis of own studies in the period from January 2007 to December 2011

The work also uses materials derived from post-conference publications, which reflect the most current developments and perceptions of the representatives of sciences. The analysis of structural capital deployment carried out in the period from January 2007 to December 2011, regions A, B and C allowed to assess the extent of the problem of access to modern diagnostic equipment (table 2). In the region A there is, among other elements, the lack of a linear accelerator and magnetic resonance imaging. This represents, on the one hand, a significant threat to the regularity (continuity) of the diagnostic process, and on the other it means an increase in the cost of providing hospital services. Significant differences also exist in access to a CT scanner in A province in relation to the regions B and C.

THE RESULTS OF THE STUDY

As a result of empirical research it has been found that 83% of employees in the analyzed public entities understand the concept of social responsibility. What is interesting is how CSR is understood by subjects: ethical action 56%, in accordance with the law 52%, environmental protection 37%, transparency measures 36% (figure 3) (Statements do not add up to 100 because respondents could choose more than one answer.).

78.69% of respondents opted for the separation of logistic processes to a specialized operator. Regarding the use of IT systems functioning in the analyzed public entities, 64% of statements indicated that access to the database has a positive impact on the decision-making processes. In contrast, 56%

of respondents indicated the importance of compactness, transparency, credibility of the information available.

Non-economic benefits arising from the implementation of the presented tools include: development of manuals and operating procedures included in the network organization, increasing the monitoring and control of environmental impact, increasing the loyalty of contractors, subcontractors and associates - this was stated by 69.77% of respondents. The study also showed that 72.21% believe activities in the field of

environmental protection are cheaper than corrective action, and more than 51.16% have knowledge of the pollution reduction. Moreover, they are also aware of its importance in building of the image - 67.44% of respondents. 78.49% of respondents mentioned subsidies as an instrument for the development of infrastructure, yet, the motto of H. Ecker should be a guidance in the distribution of aid funds: as long as you show that you get by with what you have, you will not get anything more.
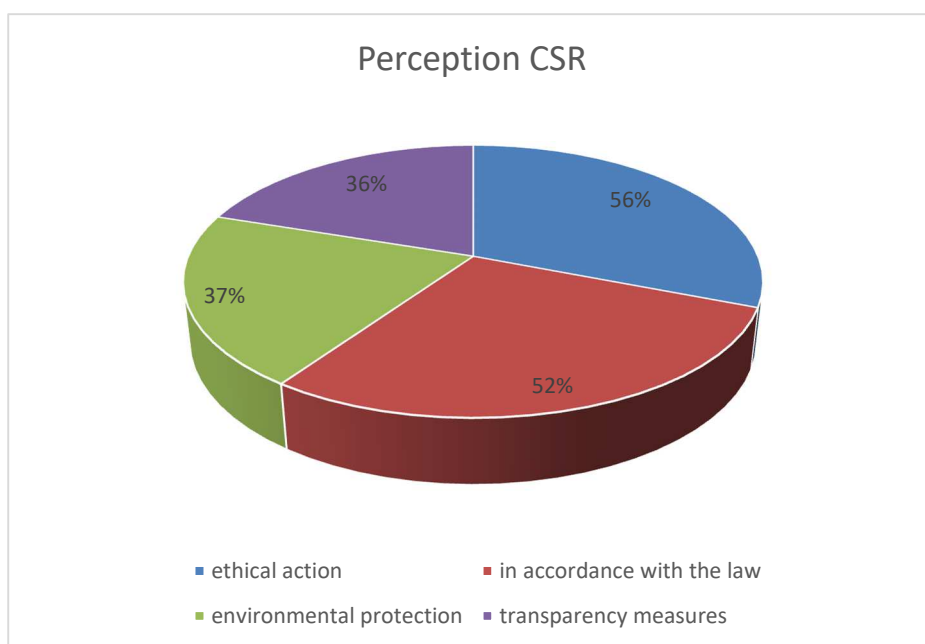
Source: Compiled on the basis of own studies in the period from January 2007 to December 2011

Fig. 3. Perception CRS in analyzed public hospitals
Rys. 3. Postrzeganie CSR w analizowanych szpitalach publicznych

The analysis of the questionnaire survey shows that in the studied public entities there is an effective communication system, affecting the quality of provision of hospital services - 69% of the respondents' answers. Also, interpersonal relationships between the participants of the interdisciplinary team are rated as good - 41%. It is therefore a confirmation of the fact that the information supplied by collaborators affects the efficiency of work, as well as confidence among medical staff, which is so important. This is the basis to develop appropriate practices, standards and procedures in the diagnostic and therapeutic processes. The analyzed public entities

perceive the patient as a buyer, indicating in some cases that the patient is the source of their recommendations. In one case, it was even expressed clearer: that the patient is the most important asset and a major stakeholder. The information from the survey also shows consideration for patients' observations: A complaint is the basis of a careful analysis of its causes and corrective actions, if confirmed is its merits. Yet, it should be noted that the reported observations are often emotional, and are not directly related to the assessment process in the provision of hospital services. Therefore, it can be concluded that the studies seem to confirm this work's idea that

the implemented tools determine the advantage of the network organization in a competitive health services market. It is therefore necessary to build and strengthen a sense of responsibility for a comprehensive process management among the personnel. The surveys were a valuable source of information, they enriched knowledge of the issues raised in this publication, and their results complement the theoretical considerations.

The economic progress increases the range of choices available to an individual recipient of services, but the increase in the number of the available choices is not synonymous with the growth of wealth of individual recipients and improving the quality of life. The implementation of tools in the field of logistics, sustainable development, CSR is the basis for development of a network of those public hospitals which (in the era of globalization) intend to stay in business and want to be seen as socially responsible. According to the authors an effective way in the process of implementing characterized tools seems the idea to promote the mixed concepts. Such concepts contain both ethical demands and elements defining the strategy of the network organization, as well as codes of defining the standards of good medical practice. A major mistake is, therefore, defining a strategy without any influence on its implementation. Another mistake is to regard CSR as a set of rules of conduct of public bodies and the outsourcing of logistics services as the remedy to reduce costs in managing the process of provision of health services. A mistake is also forgetting that the process of accumulation of knowledge determines the adjustment of health services to pro-quality requirements of patients and environmental requirements, while also contributing to a more effective knowledge acquisition from outside.

Presented topics should not be exposed to frequently in the literature, which is why it is worth further research, the results of which from a practical point of view can help public hospitals operate efficiently and effectively.

SUMMARY

This publication is an introduction both into the subject as a whole, as well as into these tools, which the authors of this paper refer to. It does not exhaust the whole subject, but provides a list of supplementary literature. Competition and prosumers, as essential elements of the external environment network of public hospitals determine the operational realities. In contrast, the rate and nature of these factors is characterized by variability of the comprehensive process of managing hospital services. This requires the implementation of such organizational models as well as diagnostic and therapeutic processes, which will allow sufficiently flexible responses, or even forward phenomena (pro-health prevention). More and more public hospitals (and medical management) understand the need for the introduction of modern, but proven organizational solutions, but the importance of problems arising during implementation is not always appreciated. The problems are:
- insufficient preparation of public entities to make changes which would require re-implementation of certain activities,
- frequent implementation of technical changes without prior preparation of other elements of the hospital (e.g. taking into account the potential needs of prosumers),
- concerns in the implementation of changes that may not properly adjust the pace of their introduction to the pace and nature of changes in the environment.

The above-mentioned determinants are of particular importance in the context of the implementation to the specific nature of public hospitals (another dimension here are technical elements, another dimension are organizational ones). The adaptation of these solutions to the scale of the needs of those entities is indeed quite difficult, but necessary - increase in quality of life. The success of public hospitals is the result of the degree of adaptation and accepting the economic, social, legal and technological changes, which are recognized as the result of turbulent economic changes.

It is the commitment of public hospitals to act in accordance with applicable law.

Any activities that go beyond the minimum and activities related to the care for the common good are a voluntary decision. They, however, cannot be really blamed for this state, and for the choice of these and not the other solutions. Public hospitals, or rather a system in which they function - makes it impossible or extremely difficult to carry out the action presented here. Each of them requires a commitment of certain funds to perform a technological change and, in the short term, may also reduce the demand for certain health services. For this reason it is difficult to expect that in the current socio-economic system the characterized tools will be much more than a detail which slightly improves the indicators, but does not change the overall picture.

From all these considerations, what can be observed is the alteration in the development of these concepts as well as their multiple aspect nature, problems arising in the course of its implementation, conditions and challenges posed by the changing reality. The application of global GS1 standards gives you doubtless the ability to create an efficient supply chain to guarantee tracking and origin of products from the manufacturer to the patient. This situation ensures better protection against making a mistake or counterfeit product, which is the biggest problem of modern medicine. Therefore, in the above synthesis specific tools in the functioning of the network of public hospitals are exposed, which - as the authors say - deserve to be presented in order to be popularized.

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WYBRANE ASPEKTY LOGISTYCZNE SIECI SZPITALI PUBLICZNYCH NA KONKURENCYJNYM RYNKU USŁUG ZDROWOTNYCH

STRESZCZENIE. **Wstęp:** Poniższe rozważania stanowią przegląd zagadnień zrównoważonego rozwoju, logistyki, do instrumentów inżynierii finansowej oraz roli kapitału intelektualnego w procesie przekształceń szpitali publicznych. Celem pracy była ocena konkurencyjności sieci szpitali publicznych na rynku usług zdrowotnych na podstawie badań literaturowych, jak również badań empirycznych.
Metody: Badanie empiryczne przy wykorzystaniu kwestionariusza ankiety zostało przeprowadzone w okresie od stycznia 2007 do grudnia 2011 roku, na obszarze województw: warmińsko-mazurskiego, pomorskiego oraz wielkopolskiego.
Celem ankiety było przeanalizowanie opinii kadry medycznej w zakresie zagadnień związanych z dostosowaniem do charakteru sieci szpitali publicznych metod oraz narzędzi z zakresu logistyki, zrównoważonego rozwoju, społecznej odpowiedzialności przedsiębiorstw - CSR. Badania zrealizowano w 104 szpitalach publicznych, na próbie 8975 respondentów.

Wyniki i wnioski: Analiza zrealizowanych badań wykazała, iż procesy logistyczne i ich poprawa w służbie zdrowia mają istotną rolę. Badane podmioty w sposób jednoznaczny zwracają uwagę na potrzebę stosowania systemów informatycznych, działań pro-środowiskowych, dostęp do informacji, czy stosowanie globalnych standardów GS1. Narzędzia te pozwalają zwiększyć efektywność łańcuchów dostaw, gwarantując śledzenie nie tylko ruchu i pochodzenia wyrobów od producenta do pacjenta, ale również umożliwiając lepsze zabezpieczenie przed popełnieniem błędu czy sfałszowaniem produktu.

Słowa kluczowe: sieć szpitali, usługi, CSR, logistyka, konkurencyjny rynek, zrównoważony rozwój.

AUSGEWÄHLTE ASPEKTE DES LOGISTIKNETZWERKES VON ÖFFENTLICHEN KRANKENHÄUSERN AUF DEM WETTBE-WERBSMARKT VON GESUNDHEITSDIENSTLEISTUNGEN

ZUSAMMENFASSUNG. Einleitung: Die nachfolgende Diskussion liefert einen Überblick über die Fragen der nachhaltigen Entwicklung, der Logistik und der Finanzinstrumente sowie und über die Rolle des intellektuellen Kapitals im Prozess der effektiven Transformation der öffentlichen Krankenhäuser. Der Artikel bewertet die Wettbewerbsfähigkeit des Netzes der öffentlichen Krankenhäuser innerhalb des Gesundheitsmarktes aufgrund der Forschungsliteratur sowie empirischer Forschungen.
Methoden: Die empirische Erforschung dieser Fragen wurde anhand von Fragebögen in der Zeit vom Januar 2007 bis zum Dezember 2011 auf den Gebieten von Ermland, Masuren, Pommern und Großpolen durchgeführt. Ihr Ziel war es, das Meinungsgut des medizinischen Kaders in Bezug auf die mögliche Anpassung von logistischen Tools und Methoden, ferner von Prinzipien der nachhaltigen Entwicklung und der CSR-Unternehmensführungsphilosophien an die Beschaffenheit des jeweiligen Netzwerkes der öffentlichen Krankenhäuser zu analysieren. Die Studie wurde in 104 öffentlichen Krankenhäusern durchgeführt und auf eine Stichprobe von 8975 Befragten gestützt.
Ergebnisse und Fazit: Die Analyse der abgeschlossenen Studie zeigte, dass die logistischen Prozesse im Gesundheitssektor eine bedeutende Rolle spielen. Die befragten Organisationen weisen ausdrücklich auf die Notwendigkeit der Anwendung von Informationssystemen, auf die Inangriffnahme von Umweltschutz-Aktivitäten, auf den Zugang zu Informationen bzw. auf die Inanspruchnahme von globalen GS1-Standards hin. Diese Tools ermöglichen es, die Effizienz von Lieferketten zu erhöhen, wobei sie die Verfolgung der Herkunft und Bewegung von Produkten vom Hersteller bis zum Patienten, sowie einen besseren Schutz vor Fehlern oder gefälschten Produkten gewährleisten.

Codewörter: Netzwerk von Krankenhäusern, Dienstleistungen, CSR-Unternehmensführungsphilosophie, Logistik, wettbewerbsorientierter Markt, die nachhaltige Entwicklung.

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SERVICE QUALITY AS A PREDICTOR OF CUSTOMER SATISFACTION AND CUSTOMER LOYALTY

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ABSTRACT. **Background:** Service quality, customer satisfaction and customer loyalty have received a special attention in the recent health sector literature. The aim of this study was to examine the correlation between service quality and customer satisfaction as well as the correlation between service quality and customer loyalty.
Methods: The self-report questionnaires gathered from patients at army medical centres in West Malaysia were used for this purpose.
Results: The outcomes of SmartPLS path model analysis showed that service quality dimensions, namely tangible, reliability, responsiveness, assurance and empathy were significantly correlated with customer satisfaction and customer loyalty.
Conclusions: This finding confirms that the capability of service providers to appropriately implement the quality dimensions in providing medical services has enhanced customer satisfaction and customer loyalty in the organizational sample.

Key words: logistics, service quality, customer satisfaction, customer loyalty, army medical centers, SmartPLS.

INTRODUCTION

Service quality has widely been discussed since 20th century and its idea is still relevant to help today organizations in creating differentiation and gaining competitive advantage in an era of borderless world and globalization [Ali et al. 2016, Fotaki 2015, (Karatepe 2016]. In a quality management literature, service quality is often seen as a multi-dimensional construct. For example, Nordic school of thought suggests that effective service quality should have two important dimensions, namely technical quality (i.e., what customers' received from services provided by an organization) and functional quality (i.e., how an organization delivers services to customers) [Brady & Cronin 2001, Gronroos 1994]. Later, the service quality construct has been modified

and simplified by US school of thought where it proposes that effective service quality should have five specific dimensions, namely tangible (physical facilities, equipment, and appearance of workers), reliability (ability to perform the promised service dependably and accurately), responsiveness (willingness to help customer and provide prompt service), assurance (knowledge and courtesy of workers and their abilities to inspire trust and confidence), and empathy (caring, individualized attention the organization provides its customers) [Ismail, Rose & Foboy, 2016, Baldwin & Sohal 2003, Parasuraman, Berry & Zeithaml 1991, 1994, Wan Edura & Jusoff 2009].

However, these quality school of thoughts have different perspectives, the source of their ideas are developed based on individual attitudes and perceptions [Sriram, Chintagunta & Machanda 2015, Yuen & Thai 2015].

This view believes that service quality is an important outcome of comparison between customer expectations before and after their experience of the service [Gronroos 2007]. If customers view that their expectations for service performance conform their perceptions of the service, this situation may lead to induce the notion of service quality [Gronroos 2007, Kitapci, Akdogan & Dortyol 2014, Zeithaml 1988].

A review of the recent literature pertaining to workplace quality published in the 21st century highlights that tangible, reliability, responsiveness, assurance and empathy are generic service quality components that are applicable to be used by researchers and practitioners to assess the effectiveness of service quality in various types of service sector such as banking [Kranias & Bourlessa 2013, Sangeetha, Mahalingam 2011], retailing [Ahmad, Ihtiyar, Omar 2014, Vera, Trujillo 2013], supply chain and logistics [Yeo, Thai, Roh 2015, Yuen, Thai 2015], telecommunication [Segoro 2013, Yen, Lu 2008]; hotel [Akbar et al. 2010, Raza et al. 2012], aviation [Gemmel 2007, Hussain Al Nasser, Hussain 2015]; defense and security [Ismail et al. 2014, Ridzuan et al. 2013] health [Ismail, Zaki, Rose 2016, Wan Edura, Jusoff 2009].

Unexpectedly, a thorough investigation of successful service based organization reveals that the ability of service providers to appropriately implement tangible, reliability, responsiveness, assurance and empathy in executing daily job may have a significant impact on positive customer outcomes especially customer satisfaction [Azman et al. 2016, Hussain et al. 2015, Rao Kondasani, Panda 2015] and customer loyalty [Akbar et al. 2010, Kitapci et al. 2014, Yeo et al. 2015].

Customer satisfaction is broadly defined as a difference between customers' expectations and experience performance after using a service and/or product at a certain period [Azman, Ilyani Ranlan et al. 2016, Mosahab, Mahamad & Ramayah 2010].

While, customer loyalty is often related to as the willingness of customers to repeatedly purchase a good or service that is accompanied by psychological bond and hold favorable attitudes toward a good or toward the organization supplying the goods or services [Deng et al. 2010, Gede Mahatma Yuda Bakti & Sumaedi 2013, Yeo et al. 2015]

Within a workplace service quality model, many researchers concur that service quality, customer satisfaction and customer loyalty are distinct, but strongly interrelated constructs. For example, the ability of service providers to appropriately implement service quality in executing daily job may lead to greater customer satisfaction [Azman, Hafizah et al. 2016, Hussain et al. 2015] and customer loyalty [Bardauskaite 2014, Lee & Lambert 2008].

Although this relationship has widely been investigated, the predicting variable of service quality is little explained in the service quality model of service based organization. Many researchers argue that this condition may be caused by several reasons: first, previous studies have much conceptually discussed the definitions, purposes and disconfirmation paradigms of effective service quality dimensions in service organizations [Azman, Hafizah et al. 2016, Wan Edura&Jusoff 2009].

Second, previous studies mostly use a simple analysis methods and gap analysis method to describe customer attitudes toward technical and functional aspect and make comparison between after and before service and/or product deliveries [Donnelly et al. 2006, Mohsin & Cyril De Run 2010, Naik & Byram 2016, Wisniewski 2001]. Consequently, these studies have produced general recommendations and this may not adequate to be used as important guidelines by practitioners to understand the complexity of service quality nature and formulate strategic action plans to enhance the effectiveness of service quality in various types of service based organization [Azman, Hafizah & Ilyani 2016, Kondasani & Panda 2015, Kitapcia, Akdogan, Dortyol 2014, Yeo, Thai & Roh 2015]. Hence, this situation motivates the researchers to fill in the gap of literature by quantifying the effect of service quality on customer outcomes.

This study has twofold objectives: first, to examine the correlation between service quality and customer satisfaction. Second, to examine the correlation between service quality and customer loyalty.

LITERATURE REVIEW

Service Quality

Parasuraman et al.'s, [1988] develop a gap analysis model to measure the influence of service quality based on the integrated view of consumer-company relationship. This model provides five generic dimensions of service quality, namely tangible, reliability, responsiveness, assurance and empathy. For example, if customers view that the implementation of quality dimensions in executing daily job will strongly fulfill their needs and expectations, this situation may lead to induced positive customer behavior. The spirit of this theory gained strong support from the service quality research literature.

Several recent studies were conducted using a direct effects model to examine service quality in different service based organization such as 357 patients at dental care in Australia [Baldwin & Soha, 2003], 1,261 customers at a large chain department store in Victoria, Australia [Wong & Sohal 2003], 183 customers at the Marmara University Hospital in Turkey [Ozturkcan et al. 2009], 105 hotel guests in Penang [Akbar et al. 2010], 749 patients at public and private hospitals in Saudi Arabia [Al-Borie & Damanhouri, 2013], 377 customers at telecommunication firms in Jordan [Muhammed et al. 2014], 369 patients facing a range of services at hospital polyclinics in Turkey [Kitapci et al. 2014], 253 passenger Dubai International Airport Terminal 3 [Hussain et al. 2015], 313 members of the Korean Port Logistics Association [Yeo et al. 2015], 475 patients at five Indian private hospitals [Rao Kondasani & Panda 2015], 100 customers at armed forces health organizations in Peninsular Malaysia [Azman, Hafizah et al. 2016]. These surveys reported that the capability of service providers to appropriately practice tangible, responsive, reliable, assured and emphatic in performing daily job had enhanced positive customer outcomes, especially customers' satisfaction [Al-Borie & Damanhouri 2013, Ozturkcan et al. 2009, Ismail, Zaki & Rose 2016, Baldwin & Sohal, 2003, Hussain et al. 2015, Rao Kondasani & Panda 2015] and customer loyalty [Akbar et al. 2010, Kitapci et al. 2014].

Customer Loyalty

Customer loyalty is often related to as the willingness of customers to repeatedly purchase a good or service that is accompanied by psychological bond and hold favorable attitudes toward a good or toward the organization supplying the goods or services [Deng et al. 2010, Wong & Sohal 2003, Gede Mahatma Yuda Bakti & Sumaedi, 2013, Prakash, 2011; Yeo et al. 2015].

The quality of service can bring customer intention to use the service again. These will bring the loyalty of the customer to the business. Service quality came as a superior quality to customer and brings the customer loyalty [Zeithaml, Berry & Pasuraman 1996] and there are strong relationships between service quality and customer loyalty [Kuo, Wu & Deng 2009, Saura et al. 2008].

The good quality of service will convincingly client to repeat the demand of service. It show customer behavioural towards service provider. The quality of service that fulfills customer expectation will gain the customer loyalty. This intention will make customers' favorable inclination a service relative to other firms offering the same service [Kaura, Prasad & Sharma 2015].

Further studies show that customers' loyalty as an important outcome of the relationship between service quality and customers' satisfaction. The effect of customers' satisfaction in relationships is often measured using an indirect effects model based on various samples such as perceptions of 542 shoppers at the retail department store context [Sivadas & Baker-Prewitt 2000], 500 respondents at the Chinese Petroleum Corporation [Bei & Chiao 2006], 505 supermarket customers in Turkey [Kitapci et al. 2013] and 300 Islamic banking customers located in the city of Kuching, Malaysia [Muahmmad et al. 2015].

Findings from these surveys showed that the ability of service providers to appropriately implement tangible, responsiveness, reliability, assurance and empathy in performing daily work had strongly invoked customer satisfaction. Consequently, it could lead to an enhanced customers' loyalty [Bei & Chiao 2006, Muahmmad et al., 2015, Kitapci et al. 2013, Sivadas & Baker-Prewitt 2000].

Customer Satisfaction

In a quality management and marketing literature, customer satisfaction is often viewed as a function of transaction-specific satisfaction and multiple transaction-specific satisfactions [Fornel 1992, Rust&Oliver 1994]. Under this view point, for example, customer satisfaction is defined based on several perspectives such as a decision made by customers about the service quality, product quality and price [Parasuraman et al. 1991, Zeithaml et al. 1996], an inner view resulted from customer's own experience from the service, an output of customers' comparison between expected performance and actual performance [Churchill & Surprenant 1982, Rosen, Surprenant & Rosen 1998], a series of customer post experience decisions with a product or service over time [Clemes, Gan & Ren 2011, Fournier & Mick 1999] and a difference between customers' expectations and experience performance after using the particular services [Kotler & Clarke 1985, Ramayah, Osman & Rahbar 2010]. The discussion shows that customer satisfaction is achieved if a customer feels that services delivered by a service provider may fulfill his/her needs, expectations and/or goals.

Several studies has been done to test the relationship between service quality and customer satisfaction such as Thai [2015] with 175 respondent from Singapore Shipping Association and Singapore Logistics Association, Bellingkrodt & Wallenburg [2015] with 778 respondents from IT service provider company and Herman [2014] 200 students involved.

The literature has been used as foundation of establishing a theoretical framework for this study as exhibited in Figure 1.
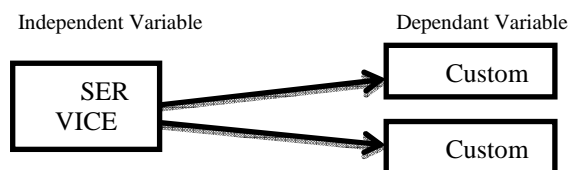

Fig. 1. The theoretical framework for this study
Rys. 1. Teoretyczny schemat badań

Based on the framework, it can be hypothesized that:

H1: There is a positive relationship between service quality (i.e., tangible, reliability, Responsiveness, assurance and empathy) and customer satisfaction.

H2: There is a positive relationship between service quality (i.e., tangible, reliability, Responsiveness, assurance and empathy) and customer loyalty.

METHOD

Sample and procedure

The research utilized a cross-sectional technique because it allowed the researchers to blend library study and survey questionnaire as the main procedure of collecting data for this study. The main advantage of using this procedure may help the researchers to gather accurate, less bias and high quality data at the studied organizations [Creswell 2003, Sekaran 2000].

The target population of this study was patients who are receiving medical treatment service at Malaysia army medical center. This organization is managed by Department of Health Service of the Ministry of Defense, Malaysia. The personnel came from army staff that is well-trained as health practitioners such as doctors and staff nurses. At the beginning of this study, a survey questionnaire was drafted based on service quality literature. Further, a back translation technique was employed to translate the survey questionnaires in English and Malay versions in order to enhance

the validity and reliability of the research findings [John W Creswell 1998, Sekaran & Bougie 2010]

A purposive sampling was utilized to distribute 400 survey questionnaires to patients who received treatments at the organizations. This sampling technique was chosen because the head of organization had not provided the list of patients who received treatments and this situation did not allow the researchers to select patients using a random technique. Of the total number, 128 respondents sent the survey questionnaires to the researchers, yielding 32 percent response rate. They answered the survey questionnaires based on their consents and a voluntarily basis.

Measures

The survey questionnaire consists of three sections: first, service quality features, namely tangible had 3 items, reliability had 7 items, responsiveness had 10 items, assurance had 5 items and empathy had 4 items that were adapted from service quality literature [Al-Borie & Damanhouri 2013; Azman, Hafizah et al. 2016, Parasuraman, Zeithaml & Berry 1985, Wong & Sohal 2003]. The dimensions used to measure tangible were adequate equipment, suitable equipment, suitable location and communication network. The dimensions used to measure reliability were solving, good service, schedule and performance. The dimensions used to measure responsiveness were feedback, priority, take care and urgent action. The dimensions used to measure assurance were comfortable, polite, confident, no complaint and believe. The dimensions used to measure empathy were cooperation, understanding and delivery. Second, customer satisfaction had 7 items which were adapted from the quality related customer satisfaction literature [Azman & Norashyikin 2009, Hussain et al. 2015, Izogo & Ogba 2015, Rao Kondasani & Panda 2015]. The dimensions used to measure customer satisfaction were treatment, communication and expectation. Third customer loyalty also had 7 items that were adapted from service quality related customer loyalty [Akbar et al. 2010, Kitapci et al. 2014, Muhammed et al. 2014]. The dimensions used to measure customer loyalty repurchase a good or service

and favorable attitudes toward a good or service. Demographic variables were only used as controlling variables because this study focused on customer attitudes

Data Analysis

The study used SmartPLS 2.0 to analyze the survey questionnaire data because it may deliver latent variable scores, avoid small sample size problems, estimate every complex models with many latent and manifest variables, hassle stringent assumptions about the distribution of variables and error terms and handle both reflective and formative measurement models [Henseler, Ringle & Sinkovics 2009] This technique analyzed the data using the following steps: first, determine construct and item validities using convergent and discriminate validity analyses. Second, evaluate construct reliability using a composite reliability analysis. Third, construct the structural model by examining the path coefficients using standardized betas (β) and t statistics (t >1.96). Finally, calculate the value of R^2 as an indicator of the overall predictive strength of the model (i.e., 0.19 (weak), 0.33 (moderate) and 0.67 (substantial) [Chin 2010, Henseler et al. 2009]. Fifth, measure the value of Q^2 as a criterion to assess the model's predictive relevance (i.e., 0.02 (weak), 0.15 (medium) and 0.35 (large) [Hair et al. 2014].

RESULT

The table 1 shows that the majority respondent characteristics were male (59%), ages between 21 to 30 years old (38%), non-married employees (83%), army patients (98%), patients who received ordinary treatments (94%), patients who received one time treatment in a month (77%).

Table 2 show that the factor loadings and cross loadings from different constructs, and composite reliability for different constructs. The variables weighted down more strongly on their own constructs in the model and if the result is greater than 0.70 then the items were considered adequate. Besides, the correlation between items and factors had higher loadings than other items in the different constructs

[Chin 2010, Fornell & Larcker 1981, Gefen & Straub 2005], meaning that all items have met the acceptable standard of discriminant validity. Furthermore, the composite reliability showed values greater than 0.8, indicating that all the measurement scale used in this study had high internal consistency [Nunally & Bernstein 1994]. In this sense, these results confirm that the instrument used in this study has achieved the acceptable standards of validity and reliability analyses.

Table 1. Profile of respondents (n =128)
Tabela 1. Profil respondentów (n =128)

Respondent Characteristics	Sub-Profile	Percentage (%)
Gender	Male	64.1
	Female	35.9
Age	Less than 20 years	44.5
	21-30 years	45.3
	31-40 years	8.6
	More than 41 years	1.6
Marital status	Single	83.6
	Married	16.4
Patient	Army	97.7
	Army family	1.6
	Ministry Public Staff	0.8
Type of treatment	Ordinary/acute	93.8
	Chronic	0.8
	Dental	5.5
Frequency of treatment	1 time	75.8
in a month	2 to 4 times	20.3
	More than 5 times	3.9

Table 2. Factor loading and cross loading for the constructs and composite reliability
Tabela 2. Współczynnik wagowy i krzyżowy współczynnik wagowy według czynników oraz niezawodność

Construct/Items	No. Of Item	Factor Loading	Composite Reliability
Tangible	6	0.796 to 0.878	0.874
Reliability	8	0.781 to 0.900	0.944
Responsiveness	10	0.812 to 0.909	0.967
Assurance	5	0.794 to 0.939	0.931
Empathy	4	0.774 to 0.881	0.907
Customer Satisfaction	7	0.827 to 0.921	0.96
Customer Loyalty	7	0.730 to 0925	0.952

Table 3 display the outcomes of convergent and discriminant validity analyses. All constructs had the values of average variance extracted (AVE) larger than 0.5 indicating that they meet the acceptable standard of convergent validity [Barclay, Higgins, Thompson 1995, Fornell, Larcker 1981, Henseler, Ringle, Sinkovics 2009]. Besides, the significance of the results with standard of convergent validity, all constructs had the values of AVE square root in diagonal greater than the squared correlation with other constructs in off diagonal, confirming that all constructs met the acceptable standard of discriminant validity [Henseler et al. 2009].

Table 4 shows the results of variance inflation factor and descriptive statistics. The means for the variables assortment range between 5.27 and 5.69, showing that the levels of tangible, reliability, responsiveness, assurance, empathy, customer satisfaction and customer loyalty are in the range of high (4) and highest (5) levels. The values of variance inflation factor for the relationships: (a) between the independent variable (i.e., tangible, reliability, responsiveness, assurance

and empathy) and dependent variable (i.e., customer satisfaction and customer loyalty) were lower than 5.0, signifying that the data were not affected by serious multicollinearity

problem [Hair et al. 2014]. Thus, this measurement model fulfilled the validity criteria.

Table 3. Fornell-Larcker criterion test
Tabela 3. Test kryteriów Fornell-Larcker'a

Construct/Items	AVE	1	2	3	4	5	6	7
Tangible	0.698	**0.836**						
Reliability	0.679	0.615	**0.824**					
Resposiveness	0.745	0.599	0.700	**0.863**				
Assurance	0.731	0.404	0.57	0.554	**0.855**			
Empathy	0.709	0.533	0.517	0.618	0.371	**0.0842**		
Customer Satisfaction	0.773	0.315	0.671	0.404	0.586	0.368	**0.87**	
Customer Loyalty	0.742	0.218	0.628	0.377	0.477	0.480	0.71	**0.862**

Table 4. Variance Inflation Factor and descriptive statistics
Tabela 4. Współczynnik wariancji inflacji oraz statystyka opisowa

Variable	Mean	Standard Deviation	Variance Inflation Factor						
			1	2	3	4	5	6	7
1. Tangible	5.61	0.63						1.857	1.857
2. Reliability	5.58	0.73						2.435	2.435
3. Responsiveness	5.69	0.67						2.617	2.617
4. Assurance	5.31	0.80						1.592	1.592
5. Empathy	5.56	0.63						1.741	1.741
6. Customer Satisfaction	5.27	0.85							
7. Customer Loyalty	5.33	0.85							

Significant at **p<0.01

Table 5 shows that the inclusion of service quality components (i.e., tangible, reliability, responsiveness, assurance and empathy) in the analysis explained contribution at 55 percent of the variance in customer satisfaction. In terms of explanatory power of this model, it provides a moderate support for the overall model [Hair et al. 2014]. Further, the outcomes of testing the research hypotheses showed five important findings: first, tangible was not significantly correlated with customers' satisfaction (B=0.159; t=1.823), therefore H1a was not supported. Second, reliability was significantly correlated with customers' satisfaction (B=0.675; t=5.344), therefore H1b was

supported. Third, responsiveness was significantly correlated with customer satisfaction (B=0.248; t=2.368), therefore H1c was supported. Fourth, assurance was significantly correlated with customers' satisfaction (B=0.346; t=4.176), therefore H4 was supported. Fifth, empathy was not significantly correlated with customers' satisfaction (B=0.353; t=4.076), therefore H5 was supported. In sum, this result demonstrates that tangible and empathy are not important predictors of customer satisfaction. Conversely, reliability, responsiveness and assurance are important predictors of customers' satisfaction.

Table 5. The Outcomes of Testing H1
Tabela 5. Wyniki testowania H1

Structural Path	Path Coefficient	R^2
H1a: Tangible à Customer Satisfaction	β=0.159 (*t*=1.823)	
H1b: Reliability à Customer Satisfaction	β=0.675 (*t*=5.344)*	
H1c: Responsiveness à Customer Satisfaction	β=0.248 (*t*=2.368)*	0.551
H1d: Assurance à Customer Satisfaction	β=0.353 (*t*=4.076)*	
H1e: Empathy à Customer Satisfaction	β=0.125 (*t*=1.423)	

Significant at *>1.96

Table 6. The Outcomes of Testing H2
Tabela 6. Wyniki testowania H2

Structural Path	Path Coefficient	R^2
H2a: Tangible à Customer Loyalty	β=0.349 (*t*=3.646)*	
H2b: Reliability à Customer Loyalty	β=0.697 (*t*=7.242)*	
H2c: Responsiveness à Customer Loyalty	β=0.272 (*t*=2.271)*	0.572
H2d: Assurance à Customer Loyalty	β=0.246 (*t*=3.578)*	
H2e: Empathy à Customer Loyalty	β=0.388 (*t*=3.041)*	

Significant at *>1.96

As an extension of testing the research hypotheses, a test of predictive relevance for the reflective endogenous latent variable was further conducted based on Stone-Geisser's formula: q2= Q2included-Q2excluded/1-Q2 included=0.417. The result was greater than zero (0) for the reflective endogenous latent variable, indicating that it has predictive relevance [Hair et al. 2014].

Table 6 shows that the relationship of service quality components (i.e., tangible, reliability, responsiveness, assurance and empathy) in the analysis explained contribution at 57 percent of the variance in customer satisfaction. In terms of explanatory power of this model, it provides a moderate support for the overall model (Hair et al. 2014). Further, the outcomes of testing the research hypotheses showed five important findings: first, tangible was significantly correlated with customers' satisfaction (B=0.349; t=3.646), therefore H2a was supported. Second, reliability was significantly correlated with customers' satisfaction (B=0.697; t=7.242), therefore H2b was supported. Third, responsiveness was significantly correlated with customer satisfaction (B=0.272; t=2.271), therefore H2c

was supported. Fourth, assurance was significantly correlated with customers' satisfaction (B=0.246; t=3.578), therefore H2d was supported. Fifth, empathy was significantly correlated with customers' satisfaction (B=0.388; t=3.041), therefore H2e was supported. In sum, this result demonstrates that tangible, reliability, responsiveness, empathy and assurance are important predictors of customers' satisfaction.

As an extension of testing the research hypotheses, a test of predictive relevance for the reflective endogenous latent variable was further conducted based on Stone-Geisser's formula: q2= Q2included-Q2excluded/1-Q2 included=0.411. The result was greater than zero (0) for the reflective endogenous latent variable, indicating that it has predictive relevance [Hair et al. 2014].

DISCUSSION

The findings of this study show that service quality does act as an important predictor of customer satisfaction and customer loyalty. In the context of this study, management has taken proactive actions to plan, maintain,

and monitor their services to customers based on the broad policies and procedures established by their stakeholders. The majority respondents view that the levels of service quality (i.e., tangible, reliability, responsiveness, assurance, and empathy), customer satisfaction and customer loyalty are high. This situation describes that the capability of service providers to appropriately implement tangible, reliability, responsiveness, assurance, and empathy in performing daily job may lead to greater customer satisfaction and customer loyalty in the organizations.

This study provides three major implications: theoretical contribution, robustness of research methodology, and practical contribution. With respect to theoretical contribution, the findings of this study showed two important findings: first, service quality does act as an important predictor of customer satisfaction. This finding also has supported and broadened studies done by (Baldwin, Sohal 2003, Ozturkcan et al. 2009, Al-Borie & Damanhouri 2013, Hussain et al. 2015, Kondasani & Panda, 2015, Ismail et al. 2016]. Second, service quality does act as an important predictor of customer loyalty. This finding also has supported and extended studies by [Wong & Sohal 2003, Akbar et al. 2010, Kitapci et al. 2013, Muhammed et al. 2014]

The credibility of research methodology is maintained by ensuring that the survey questionnaire used in this study satisfactorily met the acceptable standards of validity and reliability analyses. This condition may lead to produced accurate and reliable findings. Further, in terms of practical contribution, the findings of this study can be used as important guidelines by management to improve the implementation of service quality in Malaysian army health centers. In order to support this aim, management should give more focus on the following aspects: first, leaders' coach should be promoted between senior management and middle management, middle management and low management levels, and low management and supporting employees in order to upgrade their soft skills and confident levels in dealing with different customer backgrounds. Second, employees who have high commitment with quality service and able

to satisfy their customer needs should be provided extra monetary and non-monetary rewards in order to retain and motivate them to support their stakeholder's needs and expectations. Third, recruitment policy and career path strategy should be properly set up in order to select competent and experienced employees to fill senior management positions. Their capabilities may be used to mentor, coach and counsel juniors managers in appropriately practicing service quality based on international quality health management standards. Fourth, knowledge management strategy must be stimulated in order to motivate employees learn new knowledge, up to date skills, latest abilities and positive attitudes, and encourage them to apply what they have learned to improve delivery of service quality to customers. Finally, communication openness between organization and customers should be promoted through disseminating and sharing service quality policies and procedures via printed materials, online and face to face interaction. This communication style may decrease misconceptions, prejudices and increase good rapports between customers and service providers. If these suggestions are given more attention this may lead to maintain and support the organizational strategy and goals.

CONCLUSION

This research tested a conceptual schema developed based on relevant service quality research literature. The measurement scale used in this study met the acceptable standards of the validity and reliability analyses. The outcomes of SmartPLS path model analysis confirmed that service quality was significantly correlated with customer satisfaction and customer loyalty, therefore H1 and H2 were supported. This finding explains that the capability of service providers to appropriately implement the service quality dimensions, namely tangible, reliability, responsiveness, assurance and empathy may enhance customer satisfaction and customer loyalty in the organizations. This result also has supported and enriched service quality studies mostly published in developed countries. Therefore, current study and practice within organizational quality models need to

incorporate tangible, reliability, responsive-ness, assurance and empathy as key dimensions of the service quality domain. This study further suggests that the capability of service providers to plan and apply the service quality dimensions in executing daily job will strongly enhance subsequent positive customer outcomes (e.g., behavioural intentions and trust). These positive behaviour may lead to maintained and enhanced the organizational performance in an era of global economy and borderless world.

This study has several limitations in terms of methodological and conceptual framework. First, a cross-sectional research design used in this study may not capture causal connections between the variables of interest. Second, the sample for this research was only taken from armies and their families who received treatments at Malaysian army medical centers. Finally, the results of SmartPLS path model analysis have not assessed the relationship between specific components for the independent variable and dependent variable. Due to these limitations, it may decrease the ability of this study to generalize of its results to other organizational settings

In order to strengthen a future research in this area, certain aspects of this study need to be improved. First, several customer service and personal characteristics should be further discovered, where this may show meaningful perspectives in understanding how the similarities and differences among customers affect the implementation of service quality by organizations. Second, a longitudinal study is another research design type should be utilized to collect data because it may clearly describe the forms of change and the direction and magnitude of causal relationships amongst variables of interest. Third, to fully understand the effect of service quality on customer outcomes, varied organizations need to be involved. Fourth, the number of sample size should be increased in order to represent the studied population and this may lead to lower response bias in survey method. Fifth, other specific theoretical constructs of service quality such as technical and functional qualities need to be considered because they have widely been acknowledged as an important link between service quality and

many aspects of customer outcomes [Gronroos 2007, Hussain et al. 2015, Rao Kondasani & Panda 2015].

Finally, other specific dimensions of customer outcomes such as readiness to recommend, retention and word of mouth need to be given attention because they are widely recognized as critical customer outcomes in many service quality research literature [Azman, Hafizah et al. 2016, Yeo et al. 2015].Thus, the significance of these issues needs to be explored in future research.

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POZIOM OBSŁUGI KLIENTA JAKO WZKAŹNIK POZIOMU ZADOWOLENIA KLIENTA ORAZ LOJALNOŚCI KLIENTA

STRESZCZENIE. **Wstęp:** Poziom obsługi klienta, zadowolenia klienta jak i lojalność klienta to zagadnienia, którym ostatnio poświęca się sporo uwagi w fachowej literaturze dotyczącej ochrony zdrowia. Celem tej pracy było zbadanie występowania zależności pomiędzy jakością obsługi i zadowoleniem klienta jak również zależnością pomiędzy jakością obsługi i lojalnością klienta.

Metody Badania zostały przeprowadzone przy użyciu ankiety wśród pacjentów wojskowych centrów medycznych na terenie Zachodniej Malezji**.**

Wyniki: Wyniki uzyskane przy zastosowaniu analizy SmartPLS wskazują, że takie składowe jakości obsługi jak: konkretność, niezawodność, odpowiedzialność, bezpieczeństwa i empatia są istotnie skorelowane z zadowoleniem klienta oraz lojalnością klienta.

Wnioski: Otrzymane wyniki potwierdzają możliwość dostawcy usług na takie kształtowanie oferowanych usług medycznych, aby zwiększyć poziom zadowolenia klienta oraz jego lojalności.

Słowa kluczowe: jakość obsługi, zadowolenia klienta, lojalność klienta, wojskowe centra medyczne, SmartPLS

KUNDENSERVICE ALS INDIKATOR DES NIVEAUS DER KUNDENZUFRIEDENHEIT UND -LOYALITÄT

ZUSAMMENFASSUNG. Einleitung: Das Niveau des Kundenservices, der Kundenzufriedenheit und der Kundenloyalität stellen die Fragen dar, denen in der letzten Zeit viel Aufmerksamkeit in der die Gesundheitspflege anbetreffenden Fachliteratur gewidmet wird. Das Ziel der Arbeit war es, das Auftreten von Abhängigkeiten zwischen der Qualität der Kundenbetreuung und der Kundenzufriedenheit sowie der Abhängigkeit der Kundenservice-Qualität und der Kundenloyalität zu ermitteln und zu erforschen.

Methoden: Die betreffenden Forschungen wurden bei der Inanspruchnahme von Fragebögen unter den Patienten medizinischer Militärzentren auf dem Gebiet des westlichen Malesiens durchgeführt.

Ergebnisse: Die dank der Anwendung der SmartPLS-Analyse ermittelten Ergebnisse weisen darauf hin, dass solche Bestandteile der Qualität des Kundenservices wie: Greifbarkeit, Zuverlässigkeit, Verantwortlichkeit, Sicherheit und Empathie im direkten Zusammenhang mit der Kundenzufriedenheit und -loyalität stehen.

Fazit: Die gewonnen Resultate bestätigen die Möglichkeit einer solchen Ausgestaltung der durch den Dienstleister angebotenen medizinischen Dienstleistungen, die das Niveau der Kundenzufriedenheit und -loyalität zu erhöhen vermögen.

Codewörter: Kundenservice-Qualität, Kundenzufriedenheit, Kundenloyalität medizinische Militärzentren, SmartPLS-Analyse

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THE FUTURE OF LOGISTICAL EDUCATION IN POLAND AND UKRAINE: COMPARATIVE ANALYSIS OF STUDENTS' OPINIONS

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ABSTRACT. **Background:** A professional future is the next logical step after a student completes their chosen degree course. More frequently, even during their studies, young people seek opportunities to participate in various conferences, training courses, internships, work placements, and to travel abroad, etc. All of this has one main goal - to increase the student's attractiveness as a potential employee on the labour market. Thus, it becomes very important to ask relevant and timely questions to students about the knowledge they gain during their studies, the skills they possess and how they perceive their future work.

Methods: This paper presents the views of students of logistics and related disciplines regarding their future careers. The aim of this study was to investigate the expectations, skills and visions of the future of the young generation who stand at the threshold of their careers, in two countries - Poland and Ukraine. The test method used for collecting opinions was a questionnaire.

Results: This paper recognises key elements of young people's perception of the labour market. They present a brief theoretical discussion on the issue in question. The authors present the results of the comparison of attitudes of students from two universities in Poland and in Ukraine, in four areas: Participant's Profiles; Professional Attractiveness; Obtained Knowledge and Skills; Employment.

Conclusions: Contemporary logistics requires professionals of the highest calibre, which is confirmed by many respected authorities. The research results show a preview of the preferences of students of logistics and related disciplines in terms of future work, and give information about the knowledge they gained during their studies. Comparison of the two groups of participants from different countries gives the opportunity to observe the aspirations and visions of each , as well as propose recommendations aimed at signalling the possibility of improving the situation of graduates in relation to their future employment.

Key words: students' professional future, logistics, labour market, employment, job.

INTRODUCTION

The dynamically changing situation of the modern economy constantly presents new challenges to young people preparing for their future. The modern era is referred to as an era of rapid change, part of which is unfavourable for individuals, because changes in the nature of employment have led to instability and a reduced sense of security, or require more dynamism than the average person possesses

[Bauman 2013]. Many young people are trying their hand at various activities even while at university, in order to test the waters in different areas, and therefore learn to adapt to different social roles. They must then adjust their goals and actions to specific life situations, learn to overcome difficulties and solve the range of problems that they encounter. For this reason, the problem of defining plans and life goals related to future professional work is unusually important.

Higher education is seen as admission to a better world of work and treated as an investment, ensuring financial success and protection against unemployment. The demands of the labour market for people with higher education is indisputable, to which a CEDEFOP report testifies [Future skills ..., 2012]. It predicts an increase in the level of competition in areas that require knowledge and skills – from 29% in 2010 to 35% in 2020. At the same time it indicates that the majority of jobs available will be for skilled workers. The recommendations put forward in the CEDEFOP report concern investment in highly productive and skilled workers, as well as support counselling for the appropriate targeting of decision-makers in relation to their future education and training.

However, acquiring a university degree is no guarantee of employment. Research carried out by SW Research Agency Market Research and Opinion shows that almost half of future graduates fear not being able to find a job after graduation (49%), and are afraid that they will not meet the expectations of future employers (41%) [Młodzi na rynku pracy, 2016]. Student attitudes such as these are a cause for reflection about the quality of higher education.

University authorities in Europe and around the world have long understood the need to properly prepare students for the labour market, not only by providing the highest quality of knowledge and skills related to the field of study, but also by educating them in universal competences and providing technical assistance and access to information about the reality of the economy and labour market to help students start proactively planning their career [Domańska, 2013]. Preparing young people for a future profession is a serious challenge for the Polish education and training system. This issue is part of the ongoing debate about the extent to which university education programmes should pragmatically meet the current needs of the labour market, as opposed to focusing on a traditional academic education. [Pierwsze kroki na rynku pracy, 2015].Young people, concerned about their future careers, tend to follow the trends of market economy, use changes, and freely choose a course of study that will provide them with a safe start to their careers. One of these

areas is logistics. According to the Bureau of Labour Statistics (BLS), the number of jobs in the sphere of logistics is expected to increase by 22% by 2022 [7 things ..., 2015]. In the economy and business, modern logistics plays, and will continue to play, a significant role. This is an industry that, in a globalised world, is increasingly gaining in importance [Long 2003, Крикавський, Чухрай 2001, Сергеев 2001, Ciesielski, 2001, Gołembska 2005, Kozlowski 2009]. Due to its specificity, it is still evolving to meet the needs of modern business and adapt to dynamic changes in the economic environment, hence the increasing demand for specialists in logistics from year to year [Kurasiński 2014,]. Additionally, more and more companies are becoming more aware of the strategic importance of logistics, primarily due to the significant potential savings [Васильців, 2010]. As a result, the top places on their list of priorities are taken by the necessity of find young people with great potential for the future, who have not only adequate expertise but also leadership abilities, which in the future will allow them to take up leading positions in the organisation.

We can reference a number of papers published in recent years which deal with various aspects of research plans and priorities in students' lives [Pawłyszyn et al., 2016]. Among their priorities is research into identifying the dynamics of professional self-determination for students [Дідковська 2001]. Similarly, Moskalenko undertook research on the professional development of young people, as well on the formation of their professional awareness [Москаленко, 2004]. Titarenko proves that ambition has a decisive impact on success and life satisfaction [Титаренко, 2004]. Oczachowski's research is focused on the expectations of students in Koszalin about the future labour market [Oczachowska, 2013]. Also, studies were carried out on the plans for professional activity of Silesian students [Zak work ..., 2013] or students from Warmia and Mazury [Bačík et al., 2010]. These studies mainly concern selected universities in Poland. It was therefore decided to conduct an in-depth study, aimed at understanding the vision and perception of the future by students of universities that offer Logistics or related disciplines as a full degree subject,

and to expand them geographically, covering two countries – Poland and Ukraine.

Thus, the objective of this research is the elimination of the information gap in the sphere of analysis of the condition of modern logistical education, as well as a comparison of the quality of educational services offered with the expectations and experiences of students as future participants in the European labour market.

In order to achieve this purpose, the following tasks needed to be carried out:
− development of a questionnaire, which allows the above-mentioned questions to be evaluated by students of Logistics. In the development process, it is necessary to consider the specificity of the modern economic situation and the state of education in the two European countries in question – Poland and Ukraine;
− conduction of a survey among students at the Polish and Ukrainian universities and statistical processing of the results;
− conduction of a comparative analysis of the obtained results and definition of the main differences/similarities of opinions of students from the two countries;
− formulation of conclusions and recommendations, based on the results of the conducted analysis.

STUDENT'S VISION OF THEIR FUTURE IN THE LABOUR MARKET

The research was conducted in 2015-2016. Students from two European countries, Poland and Ukraine, took part. As a research environment the authors selected universities which offer Logistics as a full degree subject. Students from the following departments took part in the survey:
− Department of Engineering Management of the Poznan Technical University (52.5%);
− Department of Commodity Research and Commercial Entrepreneurship of Alfred Nobel University, Dnipro (47.5%)

The research was conducted with the application of the method of diagnostic examination, with the usage of the authors'

questionnaire. Participation by students was voluntary and anonymous. Students were selected purposefully; the required condition of participation was students' agreement to participate in scientific research. Agreement to participate was given by returning a completed copy of the questionnaire.

The survey contained 23 questions and was divided into 4 parts: Participant's Profile; Professional attractiveness; Obtained knowledge and skills; Employment. The questionnaire consisted of closed questions and single- and multiple-choice questions, as well as questions with 7-level scale weights, where 1 means "strongly disagree / least attractive" and 7 means "strongly agree / the most attractive". The questionnaires were handed out to students in person.

The results were both qualitative and quantitative and were analysed statistically. The results include only those participants who gave answers to all questions in the questionnaire. Statistical research was conducted with the help of Pearson's test of independence. The following statistical rules were applied:
$p > 0,05$ – no statistical significance,
$p < 0,05$ – significant statistical connection,
$p < 0,01$ – very significant statistical connection,
$p < 0,001$ – very high statistical significance.

Participant's Profile

As stated above – the number of students who took part in the survey is 686 (360 Polish and 326 Ukrainian). An overview of the participants is presented in the following table.

Table 1. Overview of participants
Tabela 1. Profil respondentów

	Ukraine		Poland	
Age	Women	Men	Women	Men
<=20	145	65	69	65
21-22	34	14	91	66
23-24	7	1	37	24
>24	52	8	6	2
Total	238	88	203	157

The research was conducted among students studying for their first and second

degrees. Therefore, the age of the participants ranged from 17 to 30. Most of the participants were between the ages of 20 and 25.

Distribution of students enrolled in the different years of study is presented in Figure 1.
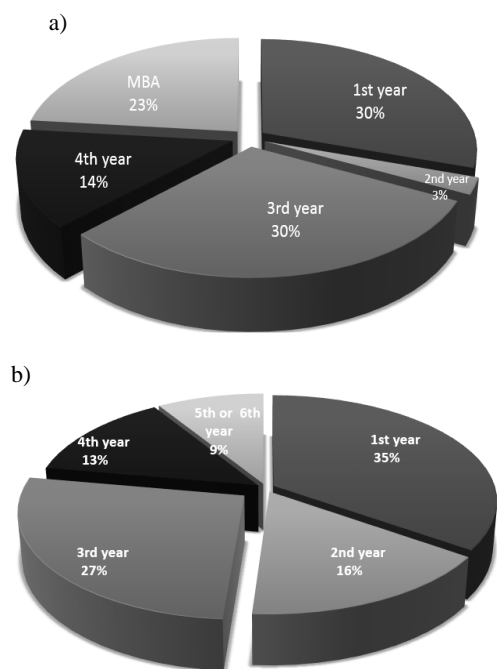

Fig. 1. Number of participants by year of study:
a) Ukraine; b) Poland
Rys. 1. Liczba respondentów według określonych lat studiów: a) Ukraina; b) Polska

As shown in figure 1, most students who took part in the survey were in their 1st-3rd year of study (86% and 63% of participants in Poland and Ukraine respectively). In Poland, students in their 4th year constitute only 22% of the study, while the participation of more older students in Ukraine allows to us analyse a higher percentage of MBA students.

The profile of the selection of students examined is of particular interest for the authors, because, from the authors' point of view, the major differences between Polish and Ukrainian educational systems are:
− in Ukraine the 1st year students are mostly young people aged 17. Polish students in their 1st year are 19 years old or more;
− Polish students do not always start their Master's programme (4th-6th years of study) right after finishing their Bachelor's

degree; they make decision to continue their education after obtaining professional experience. In Ukraine, a Bachelor's degree is generally not accepted as higher education, so most students do their Master's degrees right after their Bachelor's. MBA programs are usually taken by more mature students, who choose their degree subject more consciously, understanding that additional knowledge and skills are required for their future professional career.

The conclusions drawn from the first question of the survey, about students' professional experience before entering university, are of great interest. As the statistics presented in table 2 show, despite the fact that Ukrainian students are younger than their Polish counterparts, participants from both countries and of the same age already have work experience (Table 2). This result suggests that young people seriously think about their future careers, and even undertake the first steps towards obtaining practical skills before starting their university education. We believe that this is due primarily to awareness of the reality of market competition, which requires potential employees to possess specialised knowledge and experience.

Table 2. Percentage of students who have already undertaken work experience before starting their degree
Tabela 2. Procent osób posiadających doświadczenie przed podjęciem studiów

Age	<=20	21-22	23-24	>24
Ukraine	26	38	48	52
Poland	26	42	41	38
p – for Pearson's test		p>0.05		

However, if we examine the trend, we notice that students in higher years, and especially on the MBA program in Ukraine, form a specific category of participants, whose decisions about education are mostly supported by professional experience (52%), in comparison with the students of the 4th-6th years in Poland (38%). This is testament to the difficult economic situation in Ukraine; now students in their 2nd and 3rd years of study need to obtain practical experience while still studying (before starting their Master's programme or MBA) with the aim to increase

their attractiveness as potential employees (collecting an employment history).

Professional Attractiveness

In the second part of the survey, students were asked what they think about the attractiveness of their future profession. Most Ukrainian students gave a positive answer (68%) to the question about whether or not they have made a decision about their future profession. As for the Polish students, a half of them (50% of participants) have already decided, and the other half have not yet made a decision about their professional future.

The results of comparing the attractiveness of a future profession turned out to be interesting. In this case, students could evaluate the attractiveness of selected activities on a scale from 1 to 7.

As a result, it was observed that in both selections (Ukrainian and Polish students) there is the same tendency to view certain forms of employment as the most attractive. (Fig. 2). Namely, students identified their own

business as the most attractive form of future career (its average rating was 5.83 and 5.41 from Ukrainian and Polish participants respectively). In second place was office work with flexible working hours – on average, 5.12. and 5.31 respectively. Third and fourth places went to full-time office work and freelancing; 4.39 /4.55 and 3.83/4.47 respectively. A shortened work week showed average attractiveness – 3.95 and 4.36 respectively. The least attractive option proved to be the paperwork type with part-time (4.01/3.49), job-sharing (3.01/3.21) and working at the weekend (3.21/2.44). There was no significant statistical difference (p>0.05) found between the attractiveness ratings for Polish and Ukrainian students (Job-sharing - the employment of two or more people for the work provided by the employer for one employee. Employees divide among themselves the remuneration and responsibilities of the job; usually this division is equivalent to the time worked. [Sobolewski 2011].
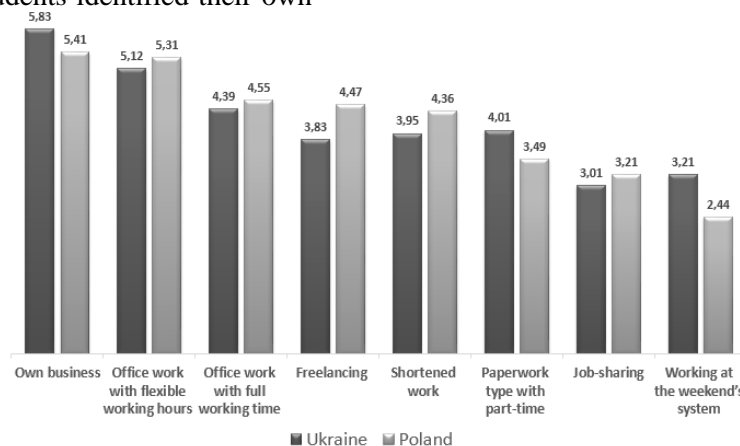

Fig. 2. The attractiveness of future professions
Rys. 2. Atrakcyjność przyszłych rodzajów działalności

The fact that students have chosen their own business as the most attractive activity is in some respects obvious. Owning one's own business is allows greater freedom in decision-making, a way to implement personal ideas and know-how, etc. But, on the other hand, also implicit is a large range of obligations and responsibilities, which is often forgotten. It should also be noted that a large number of participants would be interested in flexible

working hours, which would allow a relatively high degree of freedom to plan their job and, usually, to conduct their own business as well.

Another question, also scored on a scale of 1-7, was to investigate the level of awareness of students about choosing their future profession. The average rating (6.0) showed that most students chose their university consciously and independently, and fewer

were influenced by their parents, friends or relatives (average: 2.63). Students do not agree with the statement that their choice was strictly connected with the necessity to continue the family business (average; 1.39), as well as rejecting the statement that knowledge and skills are not important, and the most important thing is to obtain a diploma (average: 2.13).

Then the participants were asked to identify the factors which guided their choice of future profession, and therefore their choice of degree (Fig. 3).
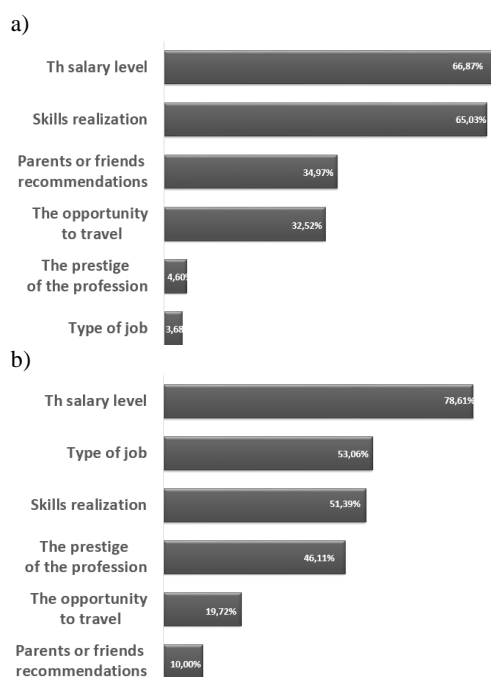
a)

b)

Fig. 3. Aspects of choosing the students' future:
a) Ukraine; b) Poland
Rys. 3. Aspekty wyboru przez studentów przyszłego zawodu: a) Ukraina; b) Polska

The following results are interesting:
− most participants from both countries specified salary as the most important aspect;
− at the same time Ukrainian students gave the next three positions to skills realisation, recommendations of family and friends and the possibility to travel. Polish students, in turn, claim the following to be important: type of work (office work, business trips, travelling), prestige of the profession and the possibility to travel;
− for Ukrainian students, the prestige of the profession and type of work have almost no

importance. Perhaps it is explained by the fact that, for Ukrainian students, prestige of the work is associated primarily with a high salary and the possibility of professional growth. Polish students, in turn, evaluate the following aspects as important: the possibility to travel and recommendations of family and friends (however, this is given the lowest position in their rating).

Let's examine the three most frequently chosen aspects. The level of salary in many cases is the most important aspect when choosing a profession; this choice by students from both countries was not a surprise. However, apart from good wages, the students also want to apply practical skills – in other words, to realise themselves in the professional area - which is extremely important and prestigious (Ukrainian students put this aspect in 2nd place, and Polish students in 3rd place in the rating of attractiveness). At the same time, Ukrainian students value highly the recommendations of family and friends. For Polish students, the type of work is among the top three aspects. The type of work associated with management is not only interesting, but also ambitious and we will further mention some challenges that must be met. On the other hand, this type of job allows a certain freedom of action and decision-making, which adds additional attractiveness. Thus, the results of the analysis, conducted on two groups of participants (Ukrainian and Polish) about the awareness of students when choosing their future profession differ from each other at the level of statistical significance ($p<0.001$).

Obtained Knowledge and Skills

The third part of the survey concerned the problems related to the knowledge obtained at university and expectations about their future jobs.

Therefore, the aim of the first question was to investigate the students' level of competence in evaluating of the education they are receiving, namely – to what extent the students are aware of the nature of their future profession and the required knowledge and skills (Fig 4).
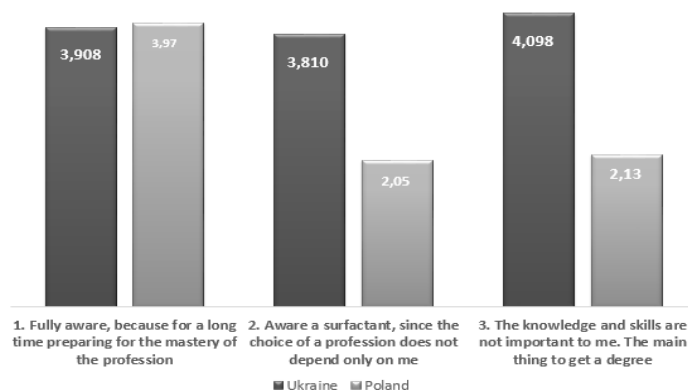
Fig. 4. Average rating of the degree of students' awareness about the nature of their future profession and the required amount of knowledge and skills

Rys. 4. Średnia ocena stopnia świadomości uczniów na temat charakteru ich przyszłego zawodu i zakresu wymaganej wiedzy i umiejętności

From the comparative characteristics of average evaluations shown in the graph, we can conclude that Ukrainian students are inclined to believe that the most important aspect of education is receiving the diploma itself. The average estimate of students' awareness concerning the process of selecting a future profession is approximately the same (3.9 and 3.97 respectively). This means that the results of the analysis performed in two groups of participants (Ukrainian and Polish) about the awareness of students of the nature of their future profession and the necessary knowledge and skills demonstrate the presence of a significant difference ($p<0.001$).

The second question was to specify whether the curriculum meets the requirements of the participants in connection to their future profession. Students had to determine in a 7-point scale: 1) whether the program fully meets their expectations; 2) what is not fully consistent with their expectations of the future profession, as well as to determine 3) whether the content of the curriculum is not important in the context of need for subsequent training in the workplace. The average rating across all the questions was 4, which corresponds to "no opinion" (Table 3).

Table 3. Average rating of the curriculum meeting the requirements of the participants in connection to their future profession

Tabela 3. Średnia ocen z weryfikacji stopnia spełnienia przez program nauczania wymagań respondentów w kontekście przyszłego zawodu

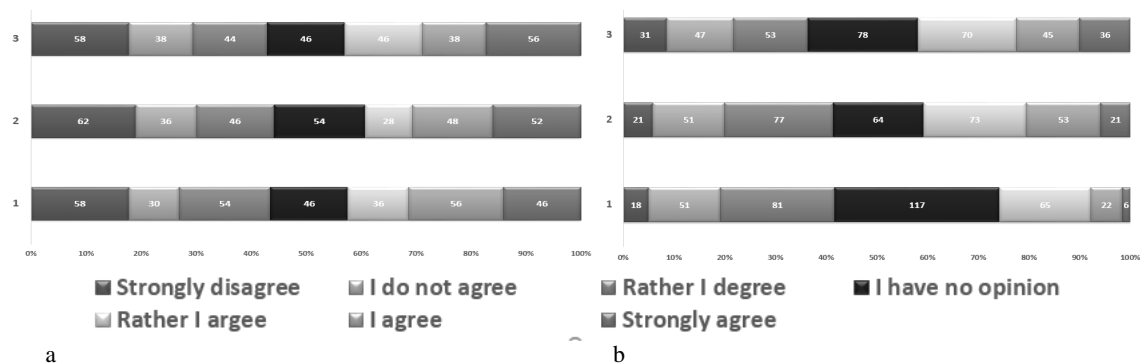| Countries	Ukraine	Poland
Whether the program fully meets their expectations	3.99	3.69
Whether it is not fully consistent with their representation of the future profession	3.93	4.00
Whether the content of the curriculum is not important in the context of need for subsequent training on the work-place	3.99	4.08
p – for Pearson's test	p>0.05	

Fig. 5. The structure of answers to the question: "Does the curriculum meet the requirements of the participants in connection to their future profession?": a) Ukraine; b) Poland

Rys. 5. Ukształtowanie się odpowiedzi na pytanie: "Czy program nauczania spełnia wymogi respondentów co do przyszłego zawodu?": a) Ukraina; b) Polska

Table 4. Average rating of providing the sufficient professional knowledge
Tabela 4. Średnia ocen dotycząca zapewnienia wystarczającej wiedzy fachowej

Countries	Ukraine	Poland
Acquired knowledge is quite enough for my future profession	4.80	3.43
I get a lot of useful knowledge, but I feel that it will not be enough	4.47	4.50
Along with useful knowledge, I get a large amount of useless information that will not be useful for me in further work	3.07	5.27
For me, the main thing is to get basic knowledge of the profession. Gaps in knowledge I will fill by myself	4.15	4.11
Knowledge is not important to me. The main thing is to get a degree	2.21	2.11
p – for Pearson's test	p<0.001	

The figure 5 shows the frequency with which the participants gave a value to each question.

It is necessary to notice a significant difference in the answers of participants from the two countries (p<0.001). Among the Polish students we see the tendency towards a neutral answer (most answers have the rating "no opinion"). At the same time, the rating "Strongly agree" has very few answers (especially for the question №3). Opinions of Ukrainian students are divided almost equally. A rather clear tendency can be seen – there are more students with a positive evaluation of the curriculum (12-15% of Ukrainian students and 1.8-11% of Polish students).In this part of the survey a clarification was added concerning the quality of the knowledge obtained by students, namely; young people were asked whether teaching provides them with sufficient professional knowledge (on a 7-point scale).

Comparative data on both selections is presented in the table 4.

Analysis of the obtained results demonstrates the following:
− as shown by the average 3.88 rating, Polish students tend not to accept the statement that they receive sufficient knowledge for their future profession. Polish students often consider that they receive a lot of useless information alongside that which is applicable to their future careers (average: 5.27). At the same time, many also feel that the knowledge they receive at university is insufficient (average: 4.5). Many students also indicate that they do not have a specific opinion on whether the basic knowledge is enough for their future profession (self-education to fill gaps in knowledge; average: 4.11);
− Ukrainian participants present a slightly different picture. The average rating

of the knowledge and skills acquired at university is rather low (3.74). However, half of the students consider that the knowledge and skills they obtain are quite enough for their future profession (average: 4.8), while the other half has doubts (average:4 .47). Moreover, Ukrainian students expect to have to rely on self-education in the future (average: 4.15).

As a recap of the answers from this section we can indicate that students are not fully satisfied with the knowledge on offer at university. They want to have wider expert knowledge more closely linked to their future professions because they are afraid that knowledge received during the study process could be insufficient for the contemporary labour market.

Employment

The fourth section of the survey is devoted to finding a job.

Table 5. Overview of answers to the question about students' workplace awareness
Tabela 5. Ukształtowanie się odpowiedzi na pytanie dotyczące świadomości studentów na temat ich przyszłego miejsca pracy

Countries	Ukraine	Poland
Yes	41 %	12 %
No	59 %	88 %
p – for Pearson's test	p<0.001	

The first question was aimed at generating a general statistic about the awareness of participants about their future place of work. A general overview of answers is presented in Table 5.

In the answers obtained at this stage, there are some interesting findings about the lack of awareness of the workplace amongst almost all (88%) students of the Polish university.The next, concerning the participants' degree of confidence in their future employment was intended to elaborate on this issue. Results of this research are presented in the figure 6.
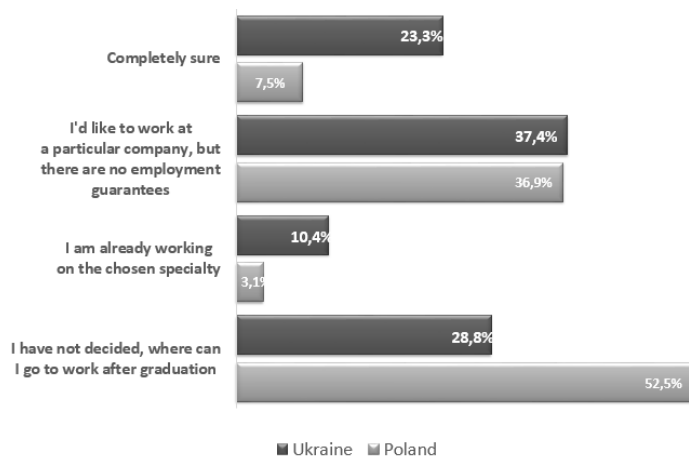

Fig. 6. Degree of participants' confidence in finding future employment
Rys. 6. Stopień pewności respondentów co do przyszłego zatrudnienia

Analysis of the results shows that most students are not sure that after graduation they will get a job in line with their education (in Ukraine – only 7.5% are sure, in Poland – 23.3%). Almost 40% of participants are focused on a particular company, but are not sure if their plan will be successful. Among Ukrainian participants, 10.4% are already working in their selected field. Few Polish students gave positive answers to this question (only 3.19%), and, as it turned out, more than

half of Polish students have not decided whether they will work in their area of study after university – which strongly correlates with the answers to the first question in this group. This means that the results of the analysis performed on two groups of participants (Polish and Ukrainian) about their confidence in finding future employment demonstrate the presence of a significant difference (p<0.001).

Young people with higher education expect good career prospects and take into consideration emigration to other European Union (EU) countries. More than half a million job offers are waiting for Poles in Western Europe. Polish employees abroad are considered diligent, well-educated and less expensive than their competitors from other EU countries [Baścik, 1974, Cyrankowski, 2003]. When Poland joined the EU on 01.05.2004, it opened up the European labour market to Polish workers, particularly nurses and midwives. That is why two more questions were developed for Polish students, concerning the possibility of employment abroad. It was decided not to include this question into the questionnaires for Ukrainian students, because the political and economic situation in Ukraine makes it impossible to evaluate the results equally.

Thus, the next two questions, which were addressed to Polish students, investigated the difficulty of finding a satisfactory job in Poland and abroad, corresponding to the students' level of education. The results are combined in figure 7 (Fig. 7). Half of the participants have problems expressing a clear opinion on these questions. Comparing the answers from all participants, we can note that more people indicate that finding a job in their home country is difficult or very difficult (104 answers), and only 77 participants (21%) believe that finding a job in Poland is easy or very easy. Concerning finding a job abroad, 46 people think that it is difficult or very difficult, but 133 people (37% of participants) believe that finding a job abroad is easy or very easy.

These polling results are highly alarming. Statistical data shows that in the last few years the number of people who have emigrated abroad exceeds 2000 per year [www.stat.gov.pl, 2016]. This number is still increasing. As our results demonstrate, many students are convinced that it is easier to find a job abroad than in their home country. These views must have some basis, which, as may be assumed, is the observation of reality.
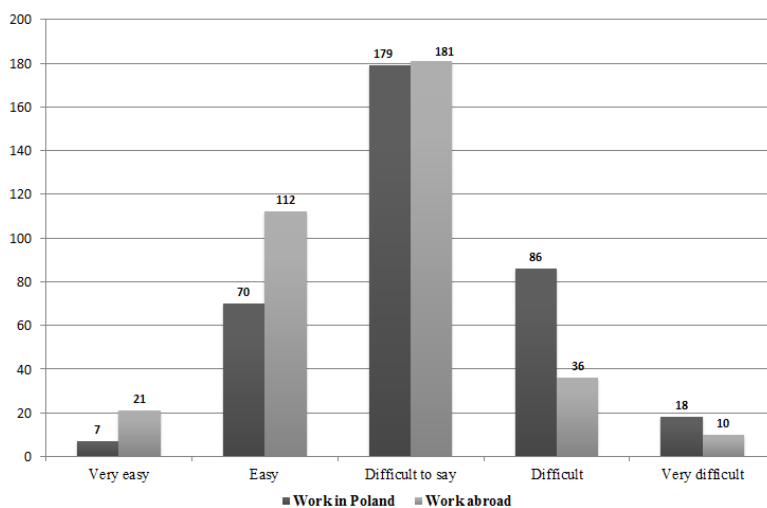

Fig. 7. Looking for job in Poland and abroad
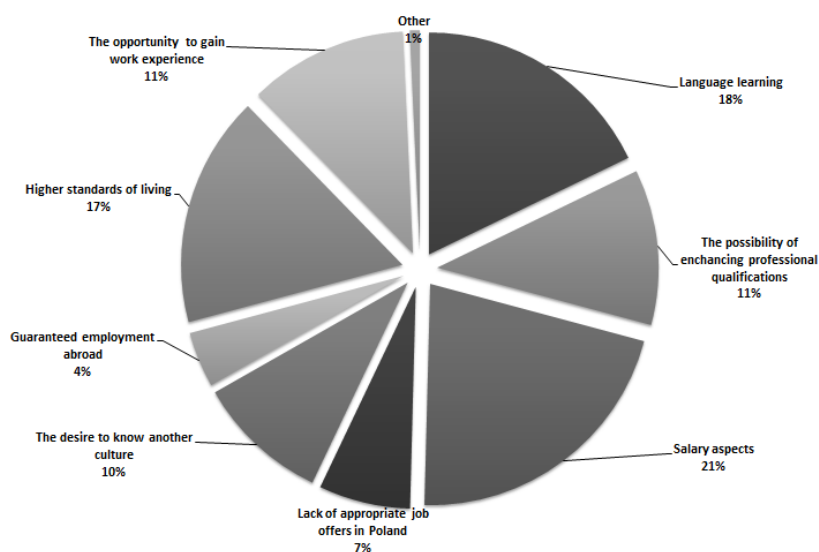Rys. 7. Poszukiwanie pracy w Polsce i za granicą

Fig. 8. Reasons for going abroad in search for jobs
Rys. 8. Przyczyny wyjazdu za granicę w poszukiwaniu pracy

Then the students were asked whether they were interested in going abroad after graduation. Only 8.9% of participants replied that they were definitely interested in going, with 26.9% of participants answering "probably yes". In contrast, 4.7% of participants consider that they definitely do not intend to leave their home country in search of work, and 25.3% of participants indicated that they are not planning such a trip. The remaining 34.3% of participants did not have a specific opinion [in comparison with Kmiotek, Polaszczyk, 2014].

A total of 129 people declared that they are interested in going abroad. That is 36% of all participants. It is therefore necessary to understand what prompts young people to go to another country. This was further examined by another survey question (Fig. 8). It was a multiple-choice question (hence the number of responses is not equal to the number of participants) and only covered people declaring their interest in traveling abroad, or those who have not decided yet (252 people in total).

As you can see from the chart, the main purpose of those interested in going abroad is paid work (57% of responses). And it is significant that these results agree with the research mentioned in the report prepared by the company Work Service, for people emigrating abroad [www.workservice.pl, 2016]. Other important factors mentioned by students considering emigration were language learning (48%) and a higher standard of living (45%). The factors with an average weight are: the opportunity to gain experience (30%) and professional development (30%). The reasons with the smallest weight are: the desire to learn another culture (26%), lack of suitable jobs in at home (18%) and guaranteed employment abroad (11%). Those who have chosen the option "other" indicated that the reason for going abroad is: the prestige of working abroad; greater civil liberties, guaranteed by law; the opportunity to travel and the desire to live in another country in order to avoid the stress caused by the fast pace of life in Poland. As well as their reasons for leaving their home country, people who had declared their willingness to go abroad or not clearly defined their position (252 participants) were asked about how long they were going to be there. The results were: from 3 months to half a year – 7.94 % of participants; from 6 months to one year – 11.11%; from a year to 2 years – 20.24%; over 2 years – 10.32%, and up to 15.08% of participants are planning to live abroad permanently.

The information above indicates that young people want to go to another country in order to improve their living standards. They also see better prospects for professional development abroad. The data indicates that a significant

proportion of participants do not see any prospects on the Polish labour market. This sends a worrying signal about the necessity of activating the professional development of graduates in Poland, because, if this potential is not realised, it could bring significant losses for the Polish economy.

The results show that, while studying at university, young people, on one hand, already have certain level of awareness of the labour market, as well as vision of their future; on the other, that only a small percentage of students have a job.

CONCLUSIONS

Analysis of the results of the survey of students of Logistics in two universities in Poland and Ukraine gives grounds to formulate definite conclusions, namely:

− a significant group of students are trying to gain experience in a specific field before choosing their area of study. However, Ukrainian students have more work experience compared to those in Poland;

− the most interesting form of activity for students from both countries is their own business and/or office work with flexible working hours;

− most students prioritise the expected high profits of their future work. However, while Ukrainian students give second place to the possibility to develop their professional skills to a full extent, Polish students pay much more attention to the type of work they get. Besides, unlike Polish students, Ukrainian students have less interest in the prestige and type of work;

− it is sad to find that the attitude of Ukrainian students towards the knowledge and skills required for their future profession is less than positive. For most of them, the main task is not to improve their knowledge, but to get a diploma. Polish students answer that they have always been aware enough of the knowledge and practical skills they expect to get at university, which they require for a career in their chosen profession;

− unfortunately, a large percentage of students from both countries state that their curriculum does not fully meet their expectations and they rely on the possibility of self-development in the workplace;

− evaluation of the level of teaching at the Polish university is much higher than at the Ukrainian one, though a certain 'information overload' is mentioned, which does not always correspond with the chosen profession;

− the presence of problems concerning future employment is mostly seen in the responses of Polish students. Most of them are not sure they will find a job or if they will work in their field of study;it is possible that the attitudes expressed in the Polish answers is connected to the fact that a significant number of Polish students believe that finding work in their home country is more difficult than working abroad; therefore, many students declare their willingness to go abroad, even permanently; they are motivated by the desire for a higher salary and living standards, as well as the ability to learn a foreign language.

The development of the world economy requires a new approach to the training of logistics professionals. Due to the increasing demand for specialists in this field, universities should significantly exceed the standard curriculum framework to enhance the competitiveness of graduates in a given discipline or those related to it. Analysing the conclusions of the research, it should be stated that in higher education major changes must be effected. Students clearly indicate that the knowledge acquired as part of the university curriculum is not sufficient. The connection of education with the practical application of the acquired knowledge is a necessary element of education. The knowledge gained by its practical application is more interesting, and encourages students to continue to expand their knowledge. Universities have to establish contacts with companies, logistics operators, institutions, the government and the economy, to provide students with a combination of academic study and practical projects, extending the scope of acquired knowledge and developing professional contacts. Also, universities should create conditions enabling students to establish contacts with communities and institutions, in which it will

be possible to continue their education or get a job after graduation.

However, an important task for the universities is to organize and enable students to participate in university research projects. Individualisation of the learning processes of students is another important criterion in adjusting the profile of graduates to market requirements.

Appropriate workshops and training courses during academic education are the perfect addition to professional attractiveness, which students can use at job interviews. It is necessary to keep in mind that not only education is important for employers, but also experience, additional qualifications and training or internships. The experience of many university graduates shows that those with even a little work experience have much better prospects on the labour market. Therefore, understanding the need to implement the above changes in higher education is the key to the integration of the two worlds - the employers' and graduates'.

However, students must themselves take responsibility for their own future career in the conditions of the increasing requirements of employers and high competition on the market. This creates the need for students to individually develop their knowledge in their chosen field. Students should also be aware that the search for work should not be accompanied by the termination of further education and self-improvement. Nowadays, attention to personal professional development and the need for learning throughout life is necessary due to the continuous changes caused by globalisation.

In order to continue to map the trends and changes in the preferences and expectations of students, it would be reasonable to repeat this study after a certain period of time (for example, after 2-3 years).

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PRZYSZŁOŚĆ EDUKACJI LOGISTYCZNEJ W POLSCE I UKRAINIE: ANALIZA PORÓWNAWCZA OPINII STUDENTÓW

STRESZCZENIE. **Wstęp:** Przyszłość zawodowa to kolejny logiczny krok studenta po ukończeniu obranego kierunku studiów. Coraz częściej, jeszcze w trakcie realizowanych studiów, młodzi ludzie poszukują możliwości uczestniczenia w różnego rodzaju konferencjach, szkoleniach, stażach, praktykach, wyjazdach za granicę itp. Wszystkie podejmowane w tym zakresie działania mają na myśli główny cel – zwiększyć swoją atrakcyjność jako potencjalnego pracownika na rynku pracy. Niezwykle ważnym więc staje się postawienie istotnych i aktualnych pytań w kierunku studenta, dotyczących pozyskiwanej w trakcie studiów wiedzy, posiadanych umiejętności czy też postrzegania swojej przyszłej pracy.

Metody: Niniejszy artykuł prezentuje poglądy studentów kierunku logistyka i jej pokrewnych w stosunku ich przyszłej pracy zawodowej. Celem prowadzonych badań było poznanie oczekiwań, kompetencji i wizji przyszłości młodego pokolenia, które stoi u progu kariery zawodowej, w dwóch państwach – Polsce i Ukrainie. Metoda badawcza, która była zastosowana do zebrania opinii to kwestionariusz ankiety.

Wyniki: Artykuł ujmuje główne przesłanki dyktowane przez rynek pracy dla młodych osób. Przedstawiają krótkie teoretyczne rozważania na temat podjętego problemu. Autorzy przedstawiają wyniki porównawcze opinii studentów dwóch uczelni wyższych w Polsce i Ukrainie w czterech obszarach: Profil Respondenta; Atrakcyjność zawodowa; Uzyskane wiedzy i umiejętności; Zatrudnienie.

Wnioski: Współczesna logistyka wymaga specjalistów najwyższej jakości, co potwierdza wiele znanych autorytetów. Badania ukazują podgląd na preferencje studentów kierunku logistyka i jej pokrewnych w zakresie przyszłej pracy, a także przekazują informację na temat pozyskiwanej w czasie studiów wiedzy. Porównanie dwóch grup studentów uczelni wyższych z różnych państw daje możliwość zaobserwowania aspiracji i wizji każdej z nich, a także wysunąć rekomendacje, mające na celu zasygnalizowanie możliwości poprawy sytuacji absolwentów szkół wyższych w stosunku do poszukiwanej pracy.

Słowa kluczowe: przyszłość zawodowa studentów, logistyka, rynek pracy, zatrudnienie, praca.

PERSPEKTIVEN FÜR DAS LOGISTISCHE BILDUNGSWESEN IN POLEN UND IN DER UKRAINE: EINE VERLEICHSSTUDIE ANHAND DER AUSWERTUNG STUDENTISCHER MEINUNGEN

ZUSAMMENFASSUNG. Einleitung: Der Einstieg in den Beruf ist ein nächster logischer Schritt eines Studenten nach dem Abschluss der von ihm ausgewählten Studienrichtung. Des Öfteren, und zwar noch während des Studiums, suchen die jungen Menschen nach Möglichkeiten ihrer Teilnahme an unterschiedlichen Konferenzen, Schulungen, studentischen und beruflichen Praktika, Auslandsreisen u. ä. Alle in diesem Bereich unternommenen Aktivitäten zielen darauf hin, dass man seine Attraktivität als eines potenziellen Bewerbers auf dem Arbeitsmarkt erhöht. Äußerst wichtig wird die Befragung von Studenten in Bezug auf das während des Studiums gewonnene Wissen, auf die beherrschten, praktischen Fertigkeiten oder auf die Wahrnehmung ihrer zukünftigen Einstellungschancen.

Methoden: Der vorliegende Artikel projiziert das Meinungsgut der Studenten von der Studienrichtung Logistik und den verwandten Studiengängen hinsichtlich derer zukünftigen Berufsarbeit. Das Ziel der durchgeführten Erforschung war es, die betreffenden Erwartungen, Kompetenzen und Visionen der jungen, an der Schwelle der Arbeitskarriere stehenden Generation, insbesondere in zwei Ländern - in Polen und in der Ukraine kennen zu lernen. Als die angewendete Forschungsmethode für die Erfassung der studentischen Meinungen galt die Inanspruchnahme von Fragebögen.

Ergebnisse: Der Artikel präsentiert grundlegende Voraussetzungen, die den jungen Menschen vom Arbeitsmarkt diktiert werden. Er stellt ferner kurze theoretische Erwägungen zum Thema der zu erörternden Problemstellung dar. Die Autoren führen dabei die Ergebnisse der Vergleichsstudie, die an zwei Hochschuleinrichtungen Polens und der Ukraine in Hinsicht auf vier Forschungsbereiche gewonnen wurden, an. Die einzelnen Forschungsaspekte waren also: Profil des Befragten, berufliche Attraktivität, gewonnene Wissen und Kompetenzen, Beschäftigungschancen.

Fazit: Die heutige Logistik bedarf Spezialisten von höchster Qualität, was viele bekannte Experten besagen. Die Forschungen veranschaulichen die Präferenzen der die Logistik und verwandte Studienrichtungen Studierenden hinsichtlich ihrer zukünftigen beruflichen Betätigung und geben über das während des Studiums gewonnene Fachwissen Auskunft. Der Vergleich der beiden Studentengruppen von den Hochschulen aus den unterschiedlichen Ländern ermöglicht, jeweils ihre Aspirationen und Visionen diesbezüglich wahrzunehmen sowie die Empfehlungen für die Bereitstellung von Möglichkeiten zur Verbesserung beruflicher Chancen der Absolventen auf dem Arbeitsmarkt zustande kommen zu lassen.

Codewörter: berufliche Zukunftsperspektiven, Logistik, Arbeitsmarkt, Beschäftigung, Arbeit

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VIRTUALIZATION OF WORK IN GLOBAL SUPPLY CHAINS

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ABSTRACT. **Background:** The paper is devoted to the notion and benefits of implementing virtual work in global supply chains. Virtual work must be understood as an intentional activity of a human being, aimed at rendering services (tangible and intangible), by means of ITC tools, performed in a distance from the traditional place of work, in a mobile manner. The empirical research were conducted on the basis of 4 case studies of global leaders of supply chains, which in accordance with M. Fisher's classification, represent two types. The case studies confirmed the positive influence of virtual work both in effective and flexible supply chains. Favourable market and technological conditions and increasing awareness of benefits of virtual work will make it more and more widespread in companies comprising global supply chains.

The aim of the study is to demonstrate the cause and effect relationships between virtual work and competitiveness of efficient and flexible supply chain.

Methods: The paper is based on the available recent scientific-theoretical research and publication. The authors analyzed 4 enterprises in Poland. The enterprises representing a flexible or an effective supply chain, either using or not a virtual work. The study carried out the authors had the form of individual interviews. The authors used case studies to show that virtual work brings notable benefits in an effective and flexible supply chain.

Results: Based on these case studies, the authors demonstrated reasons to implement virtual work in selected enterprises. The reasons to implement virtual work are determinants of possible achieve economies in effective and flexible supply chain

Conclusions: The examined case studies show that virtual work brings different benefits. In the effective supply chain, virtual workers enable to increase effectiveness and financial results for example. In the flexible supply chain the virtual work can be a way to maintain and build long-term relations with suppliers and customers.

Key words: virtual work, supply chain, supply chain management, flexible supply chain, effective supply chain, new methods of work.

INTRODUCTION

Global economic crisis significantly increases the pressure on reduction of cost and risk connected with the functioning of global supply chains. Among many ways to reduce the cost and the uncertainty of demand for the products of supply chain the essential one is the increase of information transparency due to modern ICT solutions. The popularisation of SCM class business apps not only contributes to the increase of the scope of logistic and production outsourcing, but it also creates possibilities of better usage of own resources and the control over them by implementing modern forms of work outside the companies' offices. Virtual work is such a form of work, which must be understood as an intentional human activity leading to rendering services (tangible and intangible), with the use of ICT tools, performed in a distance from the traditional place of work, in a mobile manner. Virtual work spaces is not only sharing knowledge important, having virtual shared workstations that allow real-time communication and exchange of documents is equally important [Marquez 2006]. The most

competitive companies will be those that do the best job of getting their people to work together and solve problems [Hegar 2012].

Separating virtual work from telecommuting, seems to be legitimate, because of a few features differentiating these innovative forms of work. Both one and the other form are not traditional ways of performing work, based on direct relations of superior-subordinate type. Especially that in practice, telecommuting is associated with work in call centres, telemarketing or customers' service. Fig. 1 shows similarities and differences between telecommuting and virtual work.

similarities

- performing work outside company's office,
- Access to telecommunications network,
- task-based working time,
- commuting to work,

differences

- necessity to travel,
- high flexibility in task performance,
- using mobile devices,
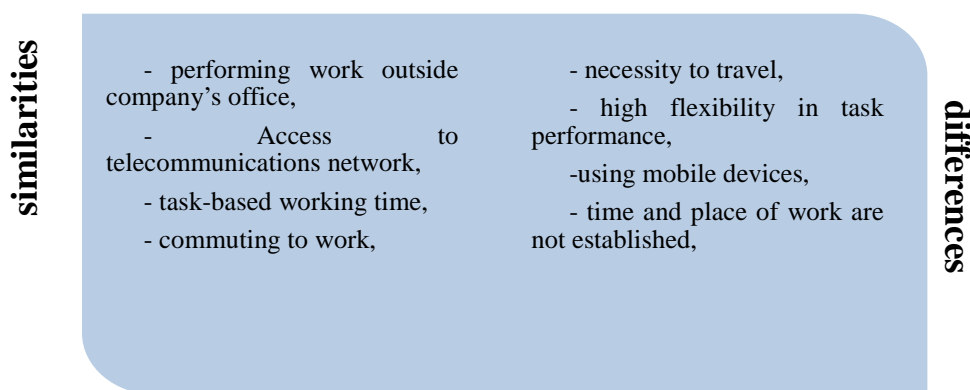- time and place of work are not established,

Fig. 1. Similarities and differences between telecommuting and virtual work
Rys. 1. Podobieństwa i różnice między telepracą a wirtualną pracą

The characteristics of virtual work are:
− work out of the office (in the office of a customer, supplier, competitor or a branch of the company)
− high mobility of the workers
− high flexibility (change of places, change of plans, and the order of their realisation)
− the usage of remote devices (a mobile phone, a portable computer, a tablet, etc.)
− the need of internet access and company's data,
− the lack of imposed working hours,
− constant actualization of obtained information.

The performance of work outside the company's office becomes more and more popular; in particular it is visible in countries, which are the leaders of e-business solutions [Waśniowski 2013]. Virtual work is a task-based system of work. The realisation of particular tasks is essential to asses and review the progress of employee's work performed for the employer. Operational goals and tasks require work, and the source of success can be the form of their performance and precious information from mobile workers [Michalski 2011]. A virtual worker, spends most of his time out of the office, hence they have the most profound knowledge of suppliers and competitors.

The concept of corporate social responsibility stresses good interpersonal relations in mutual communication. Performing work out of the company's office demands a great deal of trust on behalf of the employer and a huge freedom of working time organisation and different forms of communication with suppliers and customers. The creators of virtual work are changing circumstances. The development of virtual work is, on one hand, the resultant of market, technological and legal conditions. On the other hand, it results from the needs of an employer and employees.

VIRTUAL WORK STATION IN SUPPLY CHAINS

In the knowledge-based economy, enterprises try to obtain market information as it brings notable benefits. One of a virtual employee's tasks is to obtain, to process and to transfer information on customers, competitors, service providers and other co-operators. In particular it is possible to indicate a certain connection between the obligations of a virtual employee and the location of so called information border point in a supply chain, to which directly get through the information on actual sale and on the behaviour of final customers [Witkowski 2010]. Thanks to virtual workers it is possible to gradually move the information border point from the customers towards suppliers, which results in a significant improvement in the operation and the development of the whole supply chain. Additionally, virtual work increases the effectiveness of synchronization in supply and demand streams in a supply chain, by physically moving the border point down the supply chain, creating favourable conditions to change the principle of flow of product streams from push system (the flow pursuant to plans and forecast), into pull system (the flow pursuant to current information on actual demand). Figure 2 presents the connection between information and physical border point, and the usage of virtual work in the supply chain.
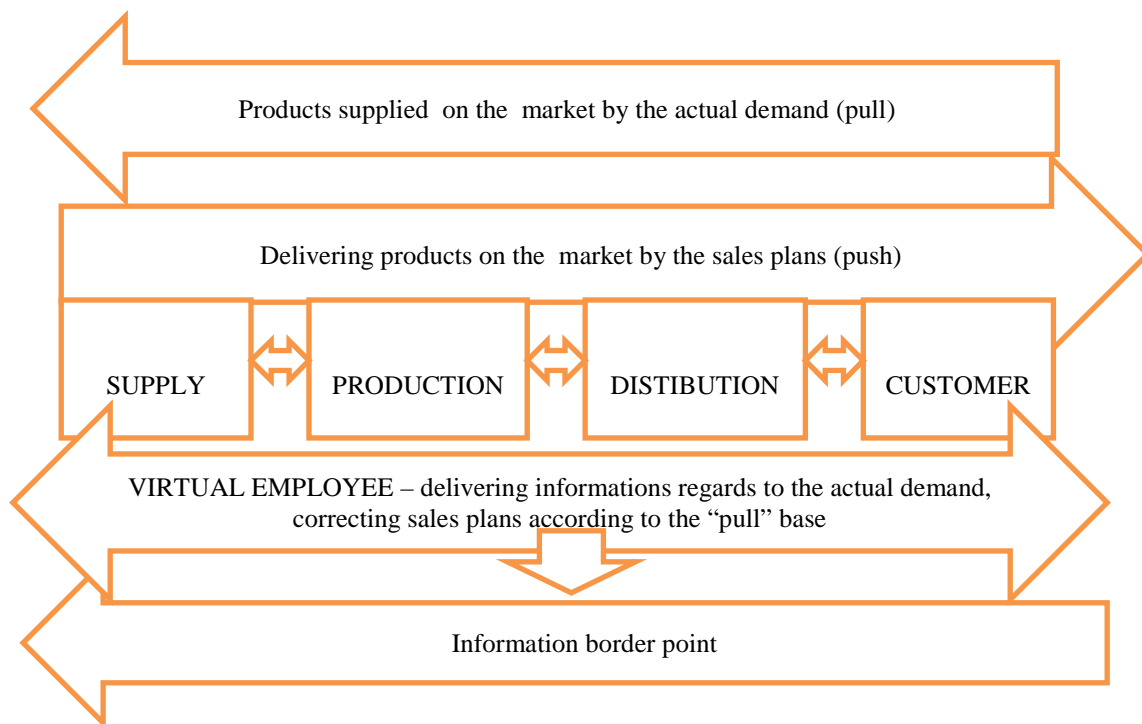

Fig. 2. The conception of virtual work in supply chain
Rys. 2. Koncepcja wirtualnej pracy w łańcuchu dostaw

The key task of a virtual employee is to transfer information on demand as far as possible down the chain. Thus, if all the participants of a supply chain will be systematically informed on the actual demand and its fluctuations, they will be able to react to such information. A virtual worker, who is closer to the customers can better understand and forecast their behaviour, at the same time having a possibility to analyse the transaction data.

The implementation of virtual work requires a deep analysis of its implementation and the character of work. It comes down to indicating the possibilities of replacing

the traditional work station by a virtual performance of tasks. It is beyond doubt, that not all positions enable working out of the office or from home; a limitation might be the time of performing tasks or the necessity of physical presence. However, as a consequence of progressive IT implementation in different areas of economy and society, more and more tasks can be performed in the virtual world by means of mobile ICT tools.

Virtual work refers to performing tasks out of the company's offices, in the field, at the customers' or co-operators' places. It requires using mobile devices to maintain constant contact and access to company's data. In the case of such form of work, employees are goal- and task- oriented, and the time and place of doing the job are less important. Thus, such form of work is not meant for everybody, and requires predispositions and very often the ability to join personal and professional life. Social and psychological basis to do work in such a form is extremely important as it influences the effectiveness of its implementation at certain positions. In order to present the areas of supply chain, where virtual work might be implemented, only possibilities and limitations connected with the transfer of some elements of employee's obligations to virtual space will be taken into account. It must be realised that many processes and activities in a supply chain require physical presence of workers. In table 1 possibilities of virtual work usage in different stages of supply chain flow are presented.

Table 1. Virtual posts in accordance with the stages of supply chain flow
Tabela 1. Wirtualne stanowiska pracy zgodnie z etapami przepływu w łańcuchu dostaw

Virtual position	Possibilities of implementing virtual work	Examples of application
PROCUREMENT		
Procurement specialist	Acquiring new suppliers	Work performed on the move, looking for new suppliers
Supplier service specialist	Common design of goods and implementation of product and organisational innovations	Constant contact with suppliers, quick information flow, new ideas
Investment consultant	Common enterprises and market analysis	Mobile work. Consultation concerning the location of manufacturing plants and warehouses
PRODUCTION		
IT specialist	Service and maintenance.	Maintenance and service by remote access to IT systems.
Project manager	Designing new solution in the production system with applying the knowledge of suppliers	Designing new solutions, in a mobile way, at home, out of the office
Technical consultant	Consultancy and intermediate trade between suppliers, manufacturer and retailer with regard to usage and value in use and utilisation of the product	Organisation of trainings at suppliers and customers, service and consultancy at the customers'' places
On-line customer consultant	On-line consultancy	On-line consultancy
DISTRIBUTION		
Sales consultant	Consultation with regard to the usage of the product and new solutions	Work at the customer's place or on-line
Data base operator	Acquiring and processing market information	Acquiring information on new markets
Mobile customer service consultant	Dealing with complaints and after-sales service	Service at the customer's place or out of the office
RETURNS		
Returns specialist	Seeking possibilities of re-use of waste, waste and returns management	Acquiring information on waste recipients, cooperation with waste recipients

Improvements in a supply chain result among others from an effective and quick information flow and a real-time access to information. It can be obtained by way of integration of IT systems of supply chain participants, which has certain limitations due to the lack of trust between partners, risk and high cost of transactions. A second way of passing current information on market situation is the workers who penetrate the market while doing their job out of the office. Considering the increasing importance

of interpersonal relations and the necessity "to be close" to the customer and co-operator, the access to such information can be much easier and more effective because of virtual employees. Exemplary processes which can be improved with the use of virtual work are (see Table 2):

1. processes connected with customer service,
2. supply and demand planning and forecasting,
3. transport processes.

Table 2. Improvements in selected supply chain processes with the use of virtual work
Tabela 2. Poprawa wybranych procesów łańcucha dostaw dzięki wykorzystaniu wirtualnej pracy

Exemplary supply chain processes	Possible improvements
Customer service processes	Information on terms and conditions of a transaction before its conclusion. Shortened lead time and increase in flexibility and reliability of deliveries during and after transaction.
Demand planning	Quicker and more effective reaction to changes in demand, analysis of changes and its determinant factors.
Sales forecasting	Greater accessibility to first-hand information, reacting to customers' needs and competitors' policy. Better preparation to promotion activities.
Transport	Planning, organizing and monitoring of transport. The choice of carrier and optimisation of routes and times of transit.

Table 3. The reasons for choosing virtual work in a supply chain
Tabela 3. Przesłanki wyboru wirtualnej pracy w łańcuchu dostaw

The reasons for choosing virtual work in a supply chain	Explanation
Savings	Savings with regard to the equipment of work stations, necessary social facilities and office space.
Acquiring information straight from the horse's mouth	Acquiring information directly from customers and co-operators.
Development of global networks	The necessity of constant relocation of employees on international supply and demand markets
Development of information technology	Possibility of performing work without being physically present at work
Fluctuations in the intensity of work	Possibility of adjusting intensity of performed tasks to the needs of an employee and an employer

Virtual work can be applied wherever there is a necessity to obtain information, contact with customers and suppliers, and the physical presence of an employee is not required at the company's office. Virtual workers can comprise a factor bonding together the management of customer relations with the management of supplier relations. A high level of mobility of virtual employees, a constant access and acquiring information from both ends indicate that virtual work in present market conditions might be an effective and future form of improving the supply chain operation. A few reasons for choosing virtual work in a supply chain are presented in table 3.

As a consequence of changes happening in economy, such as the development of information society as well as dynamization of new branches and businesses in economy, concentrated on the flow of information, the number of professions possible to perform in different forms of telecommuting (such as virtual work) and independently of location will increase [Harnik 2008]. The new form of rendering work, whose main objective is the increase of effectiveness and efficiency of supply chain operation, originates from new market needs and a new role of an employee. Both factors are strictly connected together. The development of the concept of supply chain management created new personal needs, posing new challenges to managers. The necessity to meet the customers' needs and to face competition redefined a number of issues in the current operation of a supply chain. Nowadays the management of an enterprise and a supply chain is characterised by flexibility, so the employees of different management levels need to adopt the same approach. Table 4 presents tasks and the way

of its realisation at selected virtual positions in a supply chain.

Table 4. Selected positions in a supply chain realised in the form of virtual work
Tabela 4. Wybrane funkcje w łańcuchu dostaw realizowane w postaci pracy wirtualnej

Position/function	Tasks to be performed	Implementation of virtual work
Purchasing manager	Acquiring knowledge of procurement market. Managing supplier relations.	Work out of the office, seeking new suppliers, facilitating the cooperation with current suppliers, maintaining long-term relations with suppliers. Establishing the strategy of cooperation.
Customer service manager	Prepares the standards of customer service, provides meeting the needs of a customer and supports company's operation	Acquires information directly from customers or from the sales network
Logistic services trader	Seeking and on-line sale of transport and warehousing services and other specialised services to third parties	Seeking potential customers to sale transport services (i.e. transport exchange), location of warehouses and warehouse equipment adjusted to customers' needs
Procurement manager	Identifies sources of supply globally, selects suppliers, arranges contracts and manages existing suppliers	Seeks new sources of supply globally, facilitates current cooperation through joint undertakings and maintains present contacts connected with the flow of goods and information
Supplier development manager	Monitors the efficiency of suppliers, indentifies entities which need to increase their efficiency and helps to excel the processes performed by a supplier	Coordinates the cooperation with suppliers, analyses the efficiency, timeliness of deliveries and payments in real time. Initiates and supports undertakings realised together with suppliers.
Supply chain manager	Analyses existing procedures and examines possibilities of making the processes in a supply chain more efficient, analyses the flow of capital in order to meet the requirement of final customers	Coordinates the processes realised in a supply chain, obtains the knowledge directly from the market and in accordance with the needs directs the improvements of realised processes

It must be realised, that the described tasks realised in a supply chain by virtual managers, mainly rely on the flow of information. Care and diligence, while using modern IT tools, decides on the effectiveness of their work. This is about using and on line access to company's business apps such as CRM, MRP, ERP, SCM and other functional modules connected with monitoring and informing superiors systematically on the extend of achievement of goals. They realize that although this in not their strength, developing the true supply chain manager in not something that can simply be outsourced only to human resources [Fawcett, Ellram, Ogdan 2007], because people are the most valuable asset.

BENEFITS AND THREATS OF VIRTUAL WORK IN A SUPPLY CHAIN

Virtual work, which is based on information, constitutes one of the ways of obtaining goals of a supply chain. Each participant of a supply chain expects the biggest possible benefits, which require greater trust, exchange of information and partnership [Nalebuff, Driffield et al., Ciesielski 2013]. The question is how can one achieve it while using human resources, skills and competences of employees and build permanent relations, to find and keep customers? Which benefits of virtual work implementation can be obtained by particular links of a supply chain? Due to the shorter life cycles of products, the pressure of dynamic adjust and adapt the supply chain is increasing [Gattorna 2010].

Thanks to virtual employees the exchange of information between particular links of a supply chain becomes quicker and more effective and comprises a significant element of improvement of its operation [Report HBR 2006]. Information has a big influence on each aspect of a supply chain and affects its control, whereas appropriate information may improve its operation and reacting [Chopra, Meindl 2010]. The premise to implement virtual work is acquiring and processing information, flexibility and swiftness of operation, performing work there, where it is needed at that moment. Thus, it can be stated that the usage of virtual work in a supply chain brings a lot of benefits (see Table 5).

Table 5. Selected benefits of implementing virtual work in a supply chain
Tabela 5. Wybrane korzyści wdrożenia wirtualnej pracy w łańcuchu dostaw

Benefits of implementing virtual work in a supply chain
Better usage of employees' potential and optimal adjustment of staff to the needs
Lowering the cost of administration, benefits, recruitment, trainings, etc.
Better control of effectiveness of workers, assessment of results
Possibility of hiring for seasonal jobs or specialised projects, tasks
Possibility of work in a few places at the same time (there are no spatial and timing limitations)
Joint inter-organisational planning of sale and operation
Possibility to design, conduct research for several links simultaneously
Elimination of wasting time, travel expenses, which contributes to environment protection
Higher productivity, does not interfere with the work of the whole department or the whole organisation
Lower cost of properties, office spaces and energy bills

Table 6. Selected benefit of implementation of virtual work for an employer and an employee
Tabela 6. Wybrane korzyści wdrożenia wirtualnej pracy dla pracodawcy i pracownika

SELECTED BENEFIT OF IMPLEMENTATION OF VIRTUAL WORK	
Employee	**Employer**
- an increase in efficiency of work (result-mindedness, goal achievement) - possibility of hiring disabled people and employees on a child care leave - lowering the cost of commuting - more effective time management (savings) - an increased possibility of employing people from small communities - adjusting work to one's own biological pace of life	- reducing cost of company's operation (office space, the number of paper documents) - increase in efficiency of work (nobody is late, nor stuck in a traffic jam on the way to work, reducing the periods of incapacity to work due to illnesses) - greater possibilities of acquiring workers with high qualifications - employees may demonstrate a greater willingness and readiness for work (they do not waste time and strength while commuting) - possibility to adjust the number of employees to actual needs (infrastructure savings) - possibility to employ people from small communities, where the average salary is lower

There are many benefits resulting implementation of virtual work, and the reduction of time and cost in a single enterprise, finally translates into the benefits of the whole supply chain. The set of benefit resulting from the implementation of virtual work can be divided into ones connected with an employee and ones connected with an employer. It is worth noticing, that chosen benefits, and even most of them, are strictly connected with the concept of management though goals, where the result is a significant motivation factor, not time and method or tool necessary to achieve them. Table 6 contains a set of such benefits.

The implementation of such form of work is not free from flaws, which include for example lack of control and personal contact with an employee, or also the necessity to create a new type of job contracts and compliance with occupational safety and health regulations. However, it seems that there are more such benefits. It is also important to realise, that virtual work is not the only solution in every circumstances. It depends on the type of business, performed activities and personal characteristics of workers who do such job. In enterprises and supply chains in order to obtain benefits aiming at the increase of competitiveness one needs to consider present and future condition of the environment and own abilities to take advantage of the chances created by the circumstances and counteract threats.

VIRTUAL WORK IN FLEXIBLE AND EFFECTIVE SUPPLY CHAINS - THE RESULTS OF EMPIRICAL RESEARCH

To perform empirical research 4 enterprises were chosen representing a flexible or an effective supply chain, either using or not a virtual work stations, which is illustrated in Figure 3.

The representatives of supply chains were chosen to the research since the whole supply chain is not an organisation with an established legal structure which could employ workers. The implementation of virtual work in selected links of a supply chain in cooperation with other enterprises operating together is less risky and economically justified. Such dependence is similar to joint integrated IT systems within a supply chain, which with regard to the whole supply chain also does not exist.
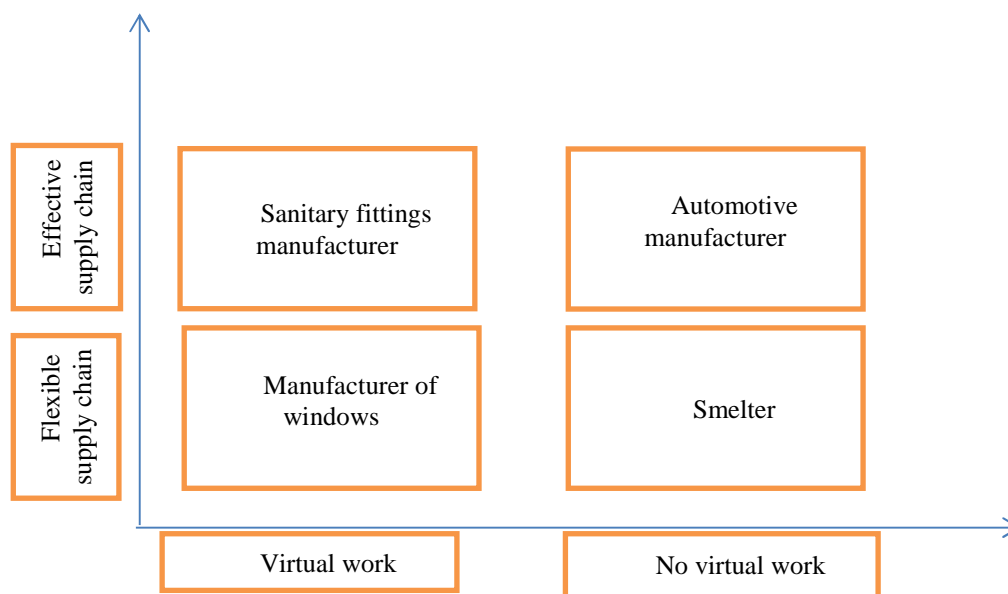

Fig. 3. A matrix of choice of supply chain to quality test with the use of case studies method
Rys. 3. Macierz wyboru łańcucha dostaw do testowania metodą studiowania przypadków

An attempt at considering the role of a human being in modern organisations, and in particular the adjustment to actual market conditions, the way of performing work, results from the need to realise the importance of the role of a human being plays in economics, with his knowledge, skills and competences. It seems reasonable then, to pose a question: firstly, how a human being along with all his attributes, which he uses at work, affects the competitiveness of enterprises and supply chains, in which he participates? And secondly, if virtual work becomes some compromise between the needs of an employer and an employee, which contributes to their economic success? More and more often, both relevant literature and practitioners stress that traditional methods of competition based on factors such as profitability and quality of product are giving way to new ones, which result from human attitudes, skills and competences of employees.

Within conducted case studies it was proved, that selected enterprises as leaders of global supply chains either successfully make use of virtual work or are interested in implementing such form of work soon. One also has to note, that depending on the orientation of a supply chain, slightly different areas were indicated, which could be improved and increase competitiveness of a supply chain. Table 7 presents an overview of key areas with regard to increase of competitiveness through implementation of virtual work for different supply chains.

Table 7. An overview of key areas with regard to increase of competitiveness through implementation of virtual work, indicated by the representatives of studied supply chains
Tabela 7. Przegląd najważniejszych obszarach zwiększenia konkurencyjności poprzez wdrożenie wirtualnej pracy, wskazane przez przedstawicieli badanych łańcuchów dostaw

Flexible supply chain	Effective supply chain
- improved customer service	- quicker information flow
- adjustment to current market needs	- real-time information on demand
- improvement of the information flow	- better planning of procurement, manufacturing and sale
- current knowledge on changes in demand	- crating partner relations in a supply chain
	- better operational factors

Possibilities of increase in competeness indicated by links in a supply chain, which do not take advantage of virtual work
- flexibility in performing duties by employees
- adjusting to the needs of an employee and the employer
- better quality of customer service

In the case of an effective supply chain, which uses virtual work, it can be stated that orientation on realisation of a triad of objectives: a supply chain, a customer and an employee, has become a permanent element to the culture of its management and supports the integration of enterprises cooperating within such a chain. In the first stage of implementation of virtual work, in an enterprise and in a supply chain, the flow of information is facilitated, long-term relations with customers are built and in consequence, due to saving resulting from better planning of demand, reducing the amount of stock and improvement of timeliness of deliveries, the economic results of the whole company as well as other cooperating links improve. Due to dynamic changes in the surroundings, high efficiency does not guarantee success, which makes the examined manufacturer of sanitary fittings improve flexibility.

However, in the case of the examined manufacturer of windows, which is a representative of a flexible supply chain, virtual work is a way to maintain and build long-term relations with suppliers and customers, which translates into many benefits, also economic ones. An integrated IT system of the whole supply chain, which the company is a leader of, is still a vision of the future. In the case of a window manufacturer, virtual workers are integrators of the manufacturing plant, suppliers and customers. It helps to facilitate the information flows, to build long-term relations with suppliers and customers,

which are oriented on a constant improvement of customer service, both with regard to timeliness of deliveries, flexibility or cost connected with maintaining stock. Sharing information with suppliers and customers brings a number of benefits, but in the case of tested company does not create any problems in the flow of information, which could endanger its market position. Thanks to virtual workers, information on actual demand reaches the supplier. Then, the supply chain links are able to react appropriately to these changes. It reduces the creation of excessive stock in the early stages of a supply chain, which is a reaction on information about insignificant changes in demand.

CONCLUSIONS

The examined case studies clearly show that virtual work brings notable benefits, both to the employers and to their employees. In the case of supply chains oriented on the reduction of costs, virtual workers enable not only to increase effectiveness and financial results, but also facilitate the increase of flexibility of its operation. However, for flexible supply chains virtual work comprises a way to improve the swiftness of reaction to customers' expectations without paying additional cost for storing and transport. The awareness of these benefits will make virtual positions more popular, even in the case of global supply chains, which have used only traditional forms of employment and performing work to date.

The aim of the case studies is to demonstrate the cause and effect relationships between virtual work and competitiveness efficient and flexible supply chain.

The aim of the study was to demonstrate the cause and effect relationships between virtual work and competitiveness of efficient and flexible supply chain. The research in the form of case studies confirmed positive relationship between the use of virtual work and the competitiveness of the supply chain. Authors have plans to continue research in a different research group and with the use of quantitive methods and testing in selected industries.

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WIRTUALIZACJA PRACY W GLOBANYCH ŁAŃCUCHACH DOSTAW

STRESZCZENIE. **Wstęp:** Artykuł poświęcony jest pojęciu oraz korzyściom z wdrożenia wirtualnej pracy w globalnych łańcuchach dostaw. Wirtualną pracę należy rozumieć jako celowe działanie człowieka, której celem jest świadczenie usług (materialnych i niematerialnych), za pomocą narzędzi teleinformatycznych, wykonywanych zdalnie od tradycyjnego miejsca pracy, w sposób mobilny. Badania empiryczne zostały przygotowane na podstawie 4 studiów przypadku globalnych liderów łańcuchów dostaw, które zgodnie z klasyfikacją M. Fishera reprezentują dwa ich typy. Studia przypadków potwierdziły pozytywny wpływ wirtualnej pracy zarówno w efektywnych i elastycznych łańcuchach dostaw. Korzystne warunki rynkowe i technologiczne oraz zwiększenie świadomości korzyści płynących z wirtualnej pracy będzie wpływało na powszechniejsze jej stosowanie w firmach tworzących globalne łańcuchy dostaw.

Metody: Praca została przygotowana w oparciu o dostępne badania zarówno teoretyczne jak i praktyczne. Autorzy przeanalizowali 4 przedsiębiorstwa w Polsce. Przedsiębiorstwa reprezentują elastyczny i efektywny łańcuch dostaw, wykorzystujące lub nie, wirtualną pracę. Badanie przeprowadzone przez autorów miały formę wywiadów indywidualnych. Autorzy wykorzystali studia przypadków w celu pokazania, że wirtualna praca przynosi wymierne korzyści w efektywnym i elastycznym łańcuch dostaw.

Rezultaty: Na podstawie studiów przypadków, autorzy wykazali przesłanki wdrożenia wirtualnej pracy w wybranych przedsiębiorstwach. Przesłanki wdrożenia wirtualnej pracy są wyznacznikami możliwości uzyskania korzyści w efektywnym i elastycznym łańcuch dostaw.

Wnioski: Badane studia przypadków pokazują, że wirtualna praca przynosi odmienne korzyści. W efektywnym łańcuchu dostaw, pracownicy wirtualni dla przykładu umożliwiają zwiększenie skuteczności jego działania i wyniki finansowe. W elastycznym łańcuchu dostaw praca wirtualna może być sposobem na utrzymywanie i budowanie długoterminowych relacji z dostawcami i klientami.

Słowa kluczowe: logistyka, wirtualna praca, łańcuch dostaw, zarządzanie łańcuchem dostaw, elastyczny łańcuch dostaw, efektywny łańcuch dostaw, nowe metody pracy.

VIRTUALISIERUNG DER ARBEIT IN GLOBALEN LIEFERKETTEN

ZUSAMMENFASSUNG. **Einleitung:** Der Artikel ist dem Wesen und den Vorteilen, die der Einführung von virtueller Arbeit in globalen Lieferketten zugrunde liegen, gewidmet. Die virtuelle Arbeit ist zu verstehen als gezielte menschliche Handlung, die es zum Zweck hat, die mithilfe von teleinformatischen Tools, auf mobile Art und Weise in Form von Fernarbeit geleisteten (materiellen und nichtmateriellen) Dienste zu vollbringen. Die betreffenden empirischen Forschungen wurden aufgrund von 4, bei globalen, führenden Betreibern von Lieferketten vorgenommenen Fallstudien, die nach der Klassifikation M. Fishers zwei deren Typen vertreten, durchgeführt. Die Fallstudien belegten den positiven Einfluss der virtuellen Arbeit auf ihre Effizienz, und dies sowohl innerhalb der effektiven als auch der flexiblen Lieferketten. Günstige, technologische und Marktverhältnisse sowie das wachsende Bewusstsein der sich von der virtuellen Arbeit ergebenden Vorteile wird die immer breitere Inanspruchnahme deren in den die globalen Lieferketten bildenden Firmen positiv beeinflussen.

Methoden: Die vorliegende Arbeit wurde aufgrund der greifbaren, sowohl theoretischen als auch praktischen, wissenschaftlichen Erkundungen ausgearbeitet. Die Autoren haben vier in Polen befindlichen Unternehmen analysiert. Die Unternehmen betreiben die flexible und die effektive Lieferkette, wobei sie dabei die virtuelle (oder keine virtuelle) Arbeit in Anspruch nehmen. Die von den Autoren vorgenommenen Forschungen hatten die Form individueller Interviews. Die Autoren benutzten die Fallstudien, um zu zeigen, dass die virtuelle Arbeit messbare Nutzen in der effektiven und flexiblen Lieferkette mit sich bringen kann.

Ergebnisse: Aufgrund der betreffenden Fallstudien zeigten die Autoren die Voraussetzungen für die Einführung der virtuellen Arbeit in ausgewählten Unternehmen auf. Die Voraussetzungen für die Einführung der virtuellen Arbeit machen Maßstäbe für die Gewinnung von Nutzen in der effektiven und flexiblen Lieferkette aus.

Fazit: Die in Angriff genommenen Fallstudien bestätigen den Sachverhalt, dass die virtuelle Arbeit auch für unterschiedliche Nutzen sorgen kann. In einer effektiven Lieferkette können beispielweise die virtuellen Mitarbeiter deren Effizienz und Finanzergebnisse erhöhen, in der effektiven dagegen kann die virtuelle Arbeit zum Aufbau und Aufrechterhalten von langzeitigen Relationen mit Lieferanten und Kunden beitragen.

Codewörter: Logistik, virtuelle Arbeit, Lieferkette, Management von Lieferkette, flexible Lieferkette, effektive Lieferkette, neue Arbeitsmethoden.

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