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INTELLIGENT FOOD PACKAGING - RESEARCH AND DEVELOPMENT

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ABSTRACT. Packaging also fosters effective marketing of the food through distribution and sale channels. It is of the utmost importance to optimize the protection of the food, a great quality and appearance - better than typical packaged foods. In recent years, intelligent packaging became very popular. Intelligent packaging is becoming more and more widely used for food products. Application of this type of solution contributes to improvement of the quality consumer life undoubtedly. Intelligent packaging refers to a package that can sense environmental changes, and in turn, informs the users about the changes. These packaging systems contain devices that are capable of sensing and providing information about the functions and properties of the packaged foods. Also, this paper will review intelligent packaging technologies and describe different types of indicators (time-temperature indicators, freshness indicators).

Key words: intelligent packaging, time-temperature indicator, freshness indicator.

INTRODUCTION

Packaging food technologies are developing as a response to consumer demands or industrial production trends towards mildly preserved, fresh, tasty and convenient food products with prolonged shelf-life and controlled quality. In addition, changes in retailing practices, or consumers lifestyle, present major challenges to the food packaging industry and act as driving forces for the development of new and improved packaging concepts that extend shelf-life while maintaining and monitoring food safety and quality [Dainelli et al. 2008]. Introduction of active and intelligent packaging can extend the shelf life of food or to improve its organoleptic properties and thus prevent food losses. According to the FDA report of 2011, every year is thrown away about 1.3 billion tons of food. Every year only in Europe, 89 million tons of wasted food, and the average European household rubbish thrown on 20-30% of food purchased. New packaging solutions allow to improve the economic aspect. Each year is grows interest in active and intelligent packaging. This is evidenced by the fact that the global market for food and beverages of active and intelligent coupled with controlled/modified atmosphere packaging (CAP/MAP) increased from $15.5 billion in 2005 to $16.9 billion by the end of 2008 and it should reach $23.6 billion by 2013 with a compound annual growth rate of 6.9%.

The interest in intelligent packaging is also reflected in the increasing number of patents granted within the field of TTIs as well as freshness and gas indicators that have been

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granted in the recent years. It is related not only to the change in consumers' lifestyle, but also to the opportunity to use the produced food in a better way. The use of intelligent packaging, i.e. freshness indicators, would help optimise the time limit of product storage. Research shows that although the majority of respondents perceive perishable food products as safe, about 90% of them are sure that freshness indicators would help them monitor the quality of food products kept at home. The respondents would accept the increase of product price related to equipping the packaging with the indicator. The acceptable increase would be USD 0.14 for fresh meat and USD 0.25 for salads [Fortin et al. 2009].

The aim of this paper is the overview of active and intelligent packaging materials, developed in relation with the search for environment friendly packaging solutions, which at the same time fulfil the requirements of clients.

INTELIGENT PACKAGING

Intelligent packaging (also more loosely described as smart packaging) is packaging that in some way senses some properties of the food it encloses or the environment in which it is kept and which is able to inform the manufacturer, retailer and consumer of the state of these properties. Although distinctly different from the concept of active packaging, features of intelligent packaging can be used to check the effectiveness and integrity of active packaging systems [Hutton 2003]. Intelligent packaging devices are capable of sensing and providing information about the function and properties of packaged food and can provide assurances of pack integrity, tamper evidence, product safety and quality, and are being utilized in applications such as product authenticity, anti-theft and product traceability [Summers 1992, Day 2001]. Intelligent packaging devices include sensors, time-temperature indicators, gas sensing dyes, microbial growth indicators, physical shock indicators, and numerous examples of tamper proof, anti-counterfeiting and anti-theft technologies. Information on intelligent packaging technology can be obtained from other reference sources [Summers 1992, Day 1989, 2001].

Another division may be made in relation to the use of measurement instruments: indicators that can be read without using measurement instruments and indicators that require such instruments. From the perspective of an individual customer, who usually uses products in unit packaging where the indicator is to show the quality of the bought product, the necessity to use measurement instruments is unacceptable. Smart packaging can be divided into three groups:

1. indicators of product exposure to high temperature and duration of activity,
2. indicators of freshness,
3. indicators of the presence of gas and indicators of integrity.

Besides, each indicator used in packaging should be characterised by the following features [Mills 2005]:

– low price,
– ability to read without having to use the apparatus,
– non-toxic,
– stability,
– sensitivity,
– reaction should be irreversible,
– easily introduced into the package.

TIME-TEMPERATURE INDICATORS (TTIS)

Time-temperature indicators or integrators (TTIs) are defined as simple, cost-effective and user-friendly devices to monitor, record, and cumulatively indicate the overall influence of temperature history on the food product quality from the point of manufacture up to the consumer [Taoukis & Labuza 1989; Giannakourou et al. 2005]. Temperature indicators show whether products have been heated above or cooled below a reference (critical) temperature, warning consumers about the potential survival of pathogenic micro-organisms and protein denaturation during, for example, freezing or defrosting processes. Furthermore, TTIs have also been applied to assess the pasteurization and sterilization process [Mehauden et al. 2007, Tucker et al. 2007, 2009].

The visible response thus gives a cumulative indication of the storage temperature to which the TTI has been exposed. TTIs may be classified as either partial history or full history indicators, depending on their response mechanism. Partial history indicators do not respond unless a temperature threshold has been exceeded and indicate that a product has been exposed to a temperature sufficient to cause a change in product quality or safety. Full history TTIs give a continuous temperature-dependent response throughout a products history and constitute the main focus of interest for research and commercial exploitation [Kerry et al 2006]. Besides, time table indicators display a continuous temperature-dependent response of the food product. The response is made to chemical, enzymatic or microbiological changes that should be visible and irreversible, and is temperature dependent [Rodrigues & Han 2003]. Wu et al. [2013] prepared TTI indicator on the basis of the chemical reaction between urease and carbamide was developed. The discoloration kinetics of urease-based TTI was explored. The mathematics formula that revealed the relationships of the change of TTI color with time and temperature has been established. The activation energy of urease-based TTI was 23.05 ± 1.15 kJ/mol (±95% confidence interval). This type of TTI indicator has the potential to apply to some time-temperature dependence foods with similar Ea values. The most popular commercial TTIs are apparently TEMPTIME (formerly LifeLine™) 3M Monitor Mark®, and Vitsab®. TEMPTIME Fresh-Scan test operates on the basis of polymerisation process. During polymerisation, the absorption of radiation is shifted in such a way that it becomes visible. Before it is used, the indicator must be stored in low temperature in order to avoid premature reaction. A suitable solution for customers is provided by the indicator TEMPTIME Fresh-Check® on self-adhesive labels. The indicator is of round shape and it is encircled with a ring of the reference colour. As the product ages, the shade of the circle surface becomes deeper. In 3M Monitor Mark, if the set parameters are exceeded, it is signalled by the change of colour of a rectangular window on the label and a moving colour. The pace of colour movement depends on temperature. The colour changes within less than 24 hours upon exceeding the set temperature by 1ºC.

VISTAB is an indicator that provides comprehensive information about all deviations from the optimal temperature during the whole distribution cycle. The indicator consists of an external rectangular body and a transparent container located inside it. The container is divided into two parts. One of them contains lipase and pH indicator, while the other - suitable fatty substance. After the activation of the indicator, which is effectuated by the destruction of the barrier between the two containers, the process of enzymatic hydrolysis of fats starts. It results in the change of pH and, at the final stage, change of the solution colour. OnVu ™ indicator is another proposal introduced in cooperation with BASF. At present, it is offered in the form of a label, but it can also be printed directly on packaging. After activation with UV radiation, the ink becomes intensely blue. During exposition to temperature, this part of the drawing is becoming more and more bright. The product is suitable for use as long as there is a marked contrast between the ink and the surface of the model.

FRESHNESS INDICATORS

The indicators of freshness are used in order to signal when the condition of the product becomes unacceptable during storage, transport, retail sale and in the consumer's house [Smolander 2003]. The signalisation operates on the basis of the change of the look of the indicator, which occurs as a result of the change of the composition of packaging atmosphere, which is a consequence of chemical and microbiological changes of the packed product. As a result of these changes, various chemical compounds, such as carbon dioxide, volatile amines, acetic acid, are emitted to the atmosphere of packaging [Smolander 2003, Kuswandi et al. 2013]. These metabolites react with the substances contained in the indicator, usually causing the change of the metabolite colour. The metabolite used most frequently for the structure of indicators is carbon dioxide. The indicator consists in a solution with a dye that changes its colour due to pH alternations, and a membrane which passes carbon dioxide which separates it from solution environment. Carbon dioxide from the atmosphere of packaging permeates through the membrane and dissolves in the solution, which leads to the change of pH. The balance is achieved very quickly, and the colour of the solution changes when the relevant concentration of hydrogen ions is exceeded. The colour change can be measured and compared with the model. The solutions based on this mechanism were suggested in numerous patents and publications.

One of the examples of application is the suggestion presented in the work of Nopwinyuwonga [Nopwinyuwong et al. 2013]. The work presents the relation between the amount of volatile compounds emerging during the storage of Thai desserts and the number of microorganisms developing within them. The products of metabolism are compounds of low molecular mass such as organic acids, ethanol, carbon dioxide, and sometimes also aldehydes or ketones. Carbon dioxide emerging as a result of decomposition was used in order to change the colour of the indicator. Freshness indicators based on the measurement of carbon dioxide are used also in order to assess the freshness of kimchi, a popular Korean dish. It consists of fermented vegetables, mainly napa cabbage, a large amount of garlic, onion and seafood. Unfortunately, the commercially available packed products still undergo fermentation; therefore, they cannot be tested without destroying the packaging. For this reason, there has been suggested a solution using carbon dioxide sensor. Another suggested way to control the composition of product packaging atmosphere is the use of the suspension of chitosan and 2-amino-2-methyl-1-propanol in distilled water. The suspension is packed in packets and placed in the packaging. Studies show that when the dish was stored, pH of the solution dropped to 5.8. At the end of the storage period, the transparency of the liquid changed considerably. When pH drops, the non-transparent white solution of chitostan gradually transforms into a solution which is visibly transparent. According to the authors, the indicator can easily be used in order to determine which product packaging is not fermented and to detect the beginning of optimal fermentation [Jung et al. 2013].

Another proposal is a colourful indicator based on bromophenol blue. It was suggested in order to assess the freshness of guava fruit (Psidium guajava L.). It operates similarly to the solutions described earlier. When the fruit ripens, the colour of the indicator changes from blue to green. Green colour means that the fruit is too ripen. The authors claim that the cost of the indicator should be relatively low (about USD 0.15) in industrial production and mass use.

A more interesting solution is the use of quaternary ammonium salts in order to solubilise pH factor in a hydrophobic polymer, e.g. ethyl cellulose. This sensor does not contain the classic water buffer, and its role is performed by tetraoctylammonium hydroxide (TOA-OH). The indicator also includes a polymer which permeates gases. The process of detecting carbon dioxide consists of several stages. In the first place, there should emerge an ion pair between protonated indicator (DH) and quaternary ammonium base (QOH). As a consequence, there emerges a hydrate with an intense colour ($D^+Q^-\cdot H2O$). The hydrate is then dissolved in polymer. The indicator obtained this way can react with CO2 in the atmosphere [Mills et al. 1992].

OXYGEN AND CARBON DIOXIDE INDICATORS

Oxygen and carbon dioxide indicators can also be used to monitor food quality. They can be used as a leakage indicator or to verify the efficiency of, for example, an oxygen scavenger. Most of these indicators are based on colour change as a result of a chemical or enzymatic reaction. These indicators have to be in contact with the gaseous environment inside the package and hence are in direct contact with the food [De Jong et al. 2005]. Conventional oxygen indicators are known to use methylene blue (methyl thionine chloride) MB, a dye that reversibly changes its color upon oxidation and reduction [Sumitani et al. 2004]. Lee et al. [2008] developed a new range of colourimetric oxygen indicators that are irreversible, reusable, and UV-light activated. Such "intelligent ink" oxygen sensors comprise a UV-absorbing semiconductor, such as TiO_2, a redox-indicator, such as methylene blue, a sacrificial electron donor, such as triethanolamine, and an encapsulating polymer such as hydroxyethyl cellulose; the ingredients are mixed together, with water as the solvent, to form an ink. The ink can be coated or printed subsequently onto a variety of substrates to produce a blue oxygen indicator film, which, when activated by UV light, becomes colourless. The activated, that is, UV-photobleached, film remains colourless unless, or until, exposed to oxygen, at which point the reduced methylene blue is reoxidised back to its original blue form. Indicator is not active until it is exposed with UV light.

There are indicators based on fluorescence. The reaction is based on the phosphor layout has been extinguished when in contact with molecular oxygen. Luminescent compounds are placed in the gas permeable and impermeable to ions materials such as silicone rubber or an organic polymer, such as poly(vinyl chloride), to create thin film, oxygen indicators [Mills & Thomas 1997]. One of most popular is tris (4,7-diphenyl-1,10-phenanthroline) ruthenium (II) perchlorate, i.e. $[Ru(dpp)_3](ClO_4)_2$, where dpp is the complexing ligand, 4,7-diphenyl-1,10-phenanthroline. The most commonly-employed leak indicator used in food packaging is a colorimetric redox dye-based indicator [Mills 2005].

Changes in the concentration of organic acids such as n-butyrate, L-lactic acid, D lactate and acetic acid during storage offer potential as indicator metabolites for a number of meat products [Shu et al. 1993]. Colour based pH indicators offer potential for use as indicators of these microbial metabolites. Another example of microbial indicators is system based on immunochemical reactions that occur in the barcode [Goldsmith 1994], and the barcode will become unreadable when a particular microorganism is present [Rodrigues & Han 2003].

Ethanol, like lactic acid and acetic acid, is an important indicator of fermentative metabolism of lactic acid bacteria. Randell et al. [1995] reported an increase in the ethanol concentration of anaerobically MA packaged marinated chicken as a function of storage time. The Lawrence Berkeley National Laboratory has developed a sensing material for the detection of Escherichia coli 0157 enterotoxin [Cheng & Stevens 1998]. The material is composed of cross-polymerized polydiacetylene molecules that can be incorporated into the packaging film. As the toxin binds to the molecules, the color of the film changes permanently from blue to red [Smolander 2000].

According to Mills, an ideal oxygen indicator for the food packaging industry should also exhibit an irreversible response towards oxygen. Indicator should illustrate why this latter feature is so desirable it is worthwhile considering the response of a reversible oxygen indicator in a MAPed food package that, in a not too unlikely scenario, sometime later develops a small leak. Obviously, the indicator will show no oxygen is present in the package until the leak develops, at which time it will indicate the presence of oxygen. However, if the leak is small, it is very possible that the subsequent rapid increase in microbial growth will be such that within a short time the oxygen in the atmosphere in the package will be converted to carbon dioxide and the rate of bacterial metabolism will be matched by the rate of oxygen ingress. Besides, an ideal oxygen indicator should be easily incorporated into the food package and so is best applied as an ink, which must be printable on paper and plastic. In the food industry such an ink falls under the umbrella heading of intelligent packaging. Besides, this is technology able to monitor and/or give information about the history and/or quality of the packed food [Mills 2005].

CONCLUSIONS

Changes in consumer preferences have led to innovations and developments in new packaging technologies. Research and development in the field of active and intelligent packaging materials is very dynamic and develops in relation with the search for environment friendly packaging solutions. Active and intelligent packaging is becoming more and more widely used for food products. Application of this type of solution contributes to improve the quality of consumer life, undoubtedly the consumer. Besides, innovation systems will improve the product quality, enhance the safety and security of foods, and consequently decrease the number of retailer and consumer complaints.

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INTELIGENTNE OPAKOWANIA - BADANIA I ROZWÓJ

STRESZCZENIE. Opakowania umożliwiają efektywny marketing żywności przy zastosowaniu różnych kanałów sprzedaży i dystrybucji. Najważniejszym zadaniem jest optymalizacja ochrony żywności, jej jakości i wyglądu. W przeciągu ostatnich lat, wzrasta popularność opakowań inteligentnych, które zaczynają być stosowane dla coraz to większej liczby produktów żywnościowych. Zastosowania ich przyczyniają się do poprawy życia konsumenta. Określenie "opakowania inteligentne" stosuje się do opakowań wyczuwających zmiany w otoczeniu oraz będących w stanie informować o tych zmianach. Systemy opakowaniowe zawierają w sobie urządzenia wykrywające i dostarczające informacji dotyczących stanu zapakowanej żywności. Praca ta dokonuje przeglądu technologii opakowań inteligentnych oraz opisuje różnego rodzaju wskaźniki (temperatury, czasu i świeżości).

Słowa kluczowe: opakowanie inteligentne, wskaźnik temperatury, wskaźnik świeżości.

INTELLIGENTE VERPACKUNGEN - FORSCHUNG UND ENTWICKLUNG

ZUSAMMENFASSUNG. Verpackungen ermöglichen ein effizientes Marketing von Nahrungsmitteln mit der Anwendung verschiedener Verteilungs- und Verkaufskanäle. Die wichtigste Aufgabe dabei stellt die Optimalisierung des Schutzes von Nahrungsmitteln, deren Qualität und Aussehen dar. In den letzten Jahren wächst ständig die Popularität von intelligenten Verpackungen, die bei immer höherer Anzahl von Nahrungsmitteln Anwendung finden. Deren Anwendung trägt zur Verbesserung des Kunden-Lebens bei. Die Bezeichnung "intelligente Verpackungen" nimmt man in Anspruch für die Verpackungen, die auf die Veränderungen der Umwelt zu reagieren und über die sich vollziehenden Veränderungen zu informieren imstande sind. Systeme für die intelligenten Verpackungen haben Einrichtungen zur Ermittlung und Mitteilung von relevanten Informationen über den Zustand der verpackten Nahrungsmittel inne. Die vorliegende Arbeit nimmt einen Überblick über die Technologien für intelligente Verpackungen vor und beschreibt verschiedenartige Anzeigegeräte für die Temperatur-, Zeit- und Frischwerte.

Codewörter: intelligente Verpackungen, Temperatur-Anzeiger, Frischzustand-Anzeiger

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LEAN AND RELIABLE DIGITAL SUPPLY CHAINS - CASE STUDY

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ABSTRACT. Background: Existing business model supply chains organisation results in inefficient use of transport resources, high transport costs, increasing congestions and CO_2 emission. This effect has been demonstrated by research conducted by the author as well as by the European Environmental Agency. To change this situation companies are in need of affordable, realisable and trusted data-interchange solutions to take part in international trade and commerce flows. The aim of this paper is to present practical implementation of the developed by the authors concept of global freight management ecosystem and its practical implementation using T-Traco platform.

Methods: Survey, desk research and real case study results were used in the paper.

Reults and conclusions: Real time and global data exchange 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: digital supply chain, global communication, mobile applications, track and trace.

INTRODUCTION

The European economy has been experiencing some radical changes in the last few years. The analysis of the data of the European Statistical Office shows a 5% increase in the sales and turnover in wholesale and retail trade in European Union states. The effects of the global economic recession appeared in 2009, causing the slowdown of the economic progress. Still, companies have remained active and have been adjusting their strategies to the changing market conditions [Hajdul, Golinska, 2012]. Merges of companies take place, new process management concepts are introduced. At the same time, competition gets stiffer and consumers' expectations grow. It should be also noted that regardless of the economic growth rate, the transportation of goods by road increased in the last four years. As an example, on the basis of the latest data made available by the European Statistical Office (Eurostat), the share of road transportation in goods shipping in Europe was 79% in total inland freight tonne-km [Energy, transport and environment indicators, 2012].

These changes forced companies who not only wish to survive, but also to develop and bring the expected profits, to introduce changes to their operation. This is at the same time an opportunity for companies, particularly SMEs, and a challenge. The opportunity lies in the possibilities to participate in large national and international networks and to enlarge market reach. The challenge lies in the complexity of the environment of trade and transport with its complexities of distance and time, language and cultural barriers, and its meriad of national and international rules and regulations.

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This holds especially for the companies that are active in the facilitation of international trade logistics. Apart from a few very large multinational businesses, this industry consists of SMEs, often playing their role in logistics chains in a very local fashion. Their role is often the local representation of large or international players. This means they hardly communicate with their chain partners overseas or in other parts of Europe, they struggle to follow the innovations in the digital exchange of information. As a conclusion the chains that those SMEs are part of perform well below optimal efficiency.

At the same time, innovation in trade and transport processes is receiving increasing attention from Customs agencies world-wide, including the European Commission (DG Taxud), WCO and UN-Cefact. The European Commission has funded various EU projects such as INTEGRITY, SMART-CM, CASSANDRA, COMCIS and iCargo, looking also at those issues. These projects lead to new solutions for information exchange, such as the data pipeline, and the common framework [Improving sustainability through intelligent cargo and adaptive decision making, 2012].

Therefore, the paper's objective is to present a case study of implementation of low cost and easy to use data exchange tool that support co-competition in the supply chains. Co-opetition in this paper is defined as a business strategy based on a combination of cooperation and competition, derived from an understanding that business competitors can have benefits when they work together [Chieh-Peng, Yi-Ju, Yuan-Hui, Yu-Fang, 2010, Lacoste, 2012, Miriam, 2011]. The implementation has been carrying out within members of ECR Poland.

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

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

LEAN AND SECURE ECOSYSTEM OF COMPANIES

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

The above situation is confirmed by the research of the European Environment Agency. The research shows that the utilization of the available load capacity of transportation means is poor across UE states. In case of the most popular type of transportation, namely road transportation, the average utilization of the available load capacity of trucks for delivery or distribution purposes is at 54% [Road freight load factors, 2012]. Naturally, the situation varies among specific countries.

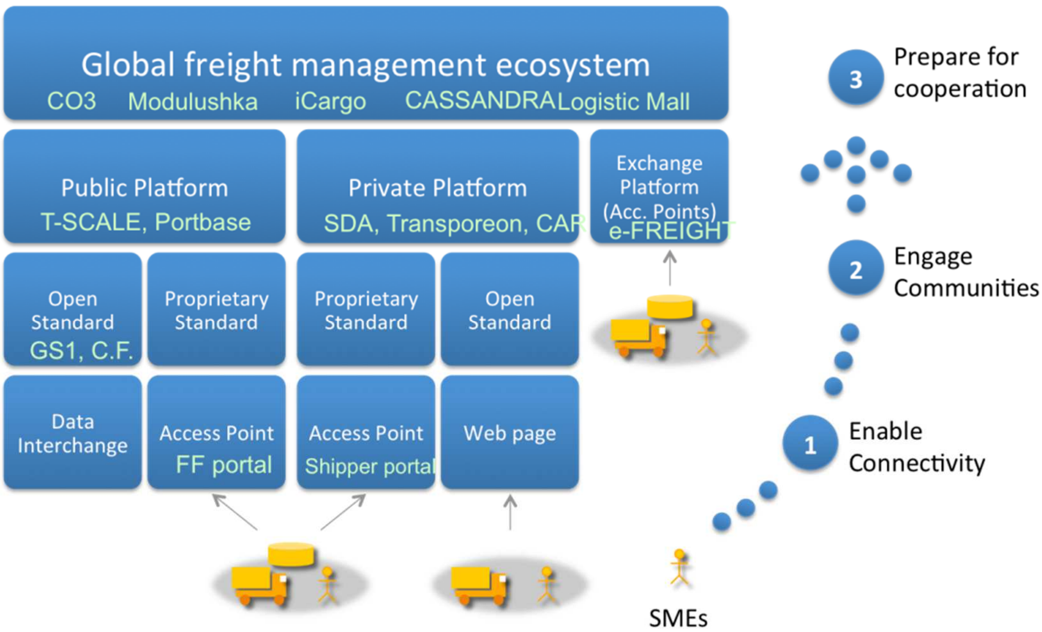
These results were confirmed by research conducted by the European Statistical Office and Professor Alan McKinnon of the Heriot-Watt University. According to his analyses the EU average percentage share of empty runs, as a total number of covered kilometres, for road transportation is at 25% [McKinnon,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

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

This may be eliminated through implementing of new model for collaboration of independent companies, either associated in clusters or functioning in close proximity. The collaboration should apply to common organization of transport processes within supply chains and their proper coordination in order to achieve the effect of synergy [Hajdul 2010, Hajdul, Golinska 2012]. However, collaboration requires secure, reliable and dynamic data exchange within ecosystem of companies.

Taking into consideration market needs described above multimodal transport in Europe is also undergoing a radical innovation. The developments in e-freight solutions enable a further integration between transport mode and supports creation of global freight management ecosystem.

The role of this ecosystem is to manage their data, connect to networks of their partners in an easy, cost effective way, as well as share data with partners around the world securely and efficiently, adopts standards that are commonly used, available or forced upon them by governments or multinationals while still maintaining a profitable business model in the end.



Source: own study

Fig. 1. Concept of the global freight management system
Rys. 1. Koncepcja system globalnego zarządzania transportem

RESULTS OF RESEARCH ON THE USE OF THE STATUSES FOR EVENT MANAGEMENT

One of the crucial issues of the data sharing is to precisely know what type of information is essential for the companies (small, medium and large ones) in the freight management. Institute of Logistics and Warehousing, as one of the actors developing global freight management ecosystem in Poland, carried out a survey on 40 companies from ECR Poland (http://ecr-all.org/poland/ecrpolsk/czlonko-wie/) and GS1 Poland. The aim of this survey was to define list of statuses that are essential for monitoring of transport order execution in the group of cooperating independent transport users and transport service providers.

From the list of 90 pre-defined statuses, according to the Pareto analysis, the most important ones, representing 80% of the analysed population, were selected.

Table 1. Key Dates
Tabela 1. Dane kluczowe

Status	% share of responses
Delivered	100,0%
Arrival	97,5%
Delivered, irregularity occurred	95,0%
Refusal to accept delivery - goods not ordered	95,0%
Refusal to accept - delivery doubled	95,0%
Refusal to accept - delivery damaged	92,5%
Not delivered - receiver not available	92,5%
Unloading starts	90,0%
Unloading ends	87,5%
Loading ends	87,5%
Not delivered - wrong address	85,0%
Not delivered - another reason	85,0%
Car breakdown	82,5%
Loading starts	82,5%
Accident	80,0%

Identified statuses were used in the T-Traco platform, a dedicated communication platform developed by the CallFreedom company and the Institute of Logistics and Warehousing, during its implementation in member companies of ECR Poland. The truck driver has an access to the mobile version of the T-Traco platform (on Android platform) and can easily and low cost update in real time statuses concerning concrete transport order. Updated statuses are visible to all other actors involved in the process. Details about T-Traco platform and its implementation are presented in chapter "Innovative monitoring of transport assets".

A REVIEW OF EXISTING SOLUTIONS THAT ENABLE MONITORING OF ROLLING STOCK IN REAL TIME

A key element that enables efficient and effective management of transport assets is access to credible information in real time on the current status of specific cars and locomotives.

There are solutions, based on the Global Positioning System (GPS) and the General Packet Radio Service system (GPRS), which enable monitoring means of transport and, occasionally, cargo units (mostly shipping containers). In order to enable real time monitoring of rolling stock, cars and locomotives must be fitted with monitoring equipment. Monitoring devices consist of three basic components [Szymczak, 2001]:

- a GPS module which enables determination of the location of the monitored means of transport,
- a GSM module with a SIM card of a mobile telephony operator which enables sending information to the server over the GPRS channel with current location of the monitored means of transport,
- a battery which supplies the energy required to support the operation of the rolling stock monitoring device.

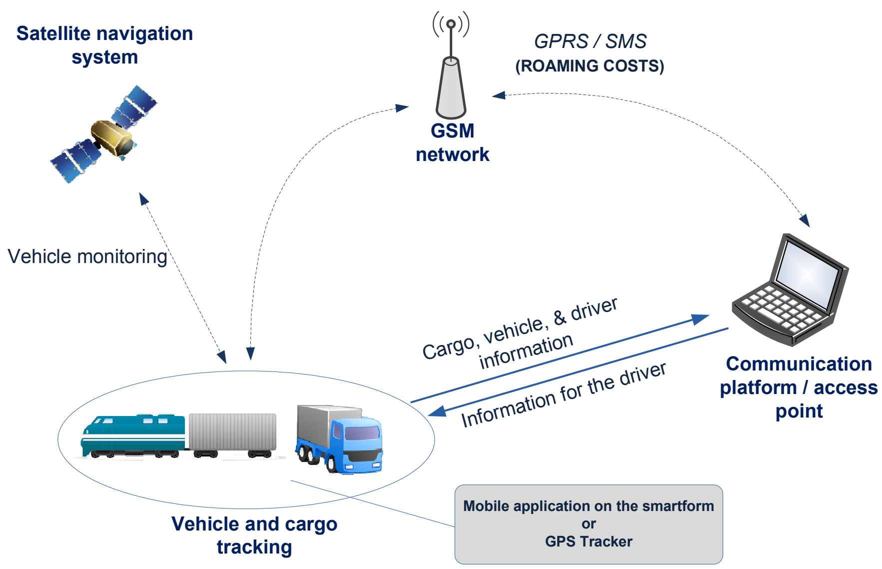
The GPS module enables using the Global Positioning System. The GPS system is a satellite navigation system developed by the United States Department of Defence that covers the entire globe. The system consists of three segments [GPS. 2014]:

- the space segment: 31 satellites that orbit the Earth on the Medium Earth Orbit,
- the ground segment: control and monitoring stations on the ground; and
- the user segment: signal receivers, i.e. the monitored devices installed, e.g. on a railroad car.

The purpose of the system is to provide the user with information on his or her location. The information is delivered in a text form with data on the current longitude and latitude of the user. The data is then sent, with the GPS module and the SIM card, to the user's server where it is displayed on a map. Figure 2 contains a diagram showing the operation of the system.

Currently, there are about a dozen solutions that enable monitoring of rolling stock in real time. The analysis covers selected products offered worldwide.

In the table 2 there are presented selected products offered on different continents.



Source: Prepared by the authors based on the information found at www.t-traco.com

Fig. 2. Schematic diagram of operation of systems for real time monitoring of rolling stock
Rys. 2. Schemat operacyjny systemów monitorowania w czasie rzeczywistym przemieszania się ładunku

Table 2. An analysis of selected solutions that enable real time management of rolling stock
Tabela 2. Analiza wybranych rozwiązań monitorowania w czasie rzeczywistym przemieszania się ładunku

Product name and website address	Main functionalities
AFRICA	
Trackntrace http://www.trackntrace.co.ke/index.php	• Information on fuel consumption, theft prevention. • Detailed location on an online map. • Data transfer over the GPRS.
PearTrack Systems Ltd http://www.peartrack.com/	• Access to location without the need to charge the devices for up to 10 years. • Temperature monitoring and reports on opened doors. • Alarms concerning unauthorized movements of the means of transport. • Data transfer over the GPRS.
NORTH AMERICA	
Track Your Truck http://www.trackyourtruck.com/	• Identification of location on a map and route history. • Mobile access from the telephone level. • Reporting of vehicle activity. • Data transfer over the GPRS.
FreightWatch International http://www.freightsecurity.net/	• Access to the location through Google Maps. • Mobile access from the telephone level. • Battery operation for 1 year. • Alarm module and notifications. • Data transfer over the GPRS.
Wireless Matrix http://www.wirelessmatrix.org/	• Access to the location through Google Maps. • Alarms tripped in the case of unauthorized movements of goods. • Battery operation for up to 7 years. • Data transfer over the GPRS.
Safety Track of Michigan http://www.safetytrackofmichigan.com/	• Access to the location through Google Maps. • Battery operation for up to 5 years. • Information on changed location every 15 minutes. • Data transfer over the GPRS.
AUSTRALIA	
Navmann Wireless www.navmanwireless.co.nz	• Access to the location through Google Maps. • Battery operation for up to 7 years.

Product name and website address	Main functionalities
	• Easy installation of the device (using a magnet). • Archiving of the cargo movements history. • Data transfer over the GPRS.
EUROPE	
Visirun http://www.visirun.pl/index.php/pl/	• Location shown on a map in real time. • Reporting. • Mobile access from the telephone level. • Data transfer over the GPRS.
Finder http://www.finder.pl/	• Access to the location through Google Maps. • Reporting. • Mobile access from the telephone level. • Data transfer over the GPRS.
Satis http://satisgps.com.pl/	• Location shown on a map in real time. • Reports and analyses • Data transfer over the GPRS.
Tronik http://tronik.pl/	• Location shown on a map in real time. • Data transfer over the GPRS.
Data System Group http://www.datasystem.pl/	• Location shown on a map in real time. • Mobile access from the telephone level. • Data transfer over the GPRS. A lump-sum fee for data transfer in roaming in the European Union.
Frotcom International http://www.frotcom.com	• Location shown on a map in real time. • Detailed information on the route of the means of transport. • Possible generation of alarms. • Data transfer over the GPRS.
Tracks360 Ltd – Wireless Asset Tracking Specialists http://www.tracks360.com/	• Location shown on a map in real time. • Possibility to select batteries of various capacities/operation periods. • Data transfer over the GPRS.

Source: prepared by the authors

In conclusion of the analysis of different products presented in Table 2, one can identify the following main characteristics of the currently offered systems:

- access over a web browser and visualization of current location of monitored means of transport on a map,
- identification of the location of the means of transport using a mobile device with an integrated GPS module, GPRS module, and battery; and
- access to a module that enables preparation of reports.

The key disadvantage of all the analyzed systems is the fact that all of them use the GPRS system for transfer of information about the location of the means of transport. Moreover, none of the providers of the analyzed systems offers its services globally, which is due to huge costs of roaming. If a customer wants to use monitoring services outside of a country, the other countries where the vehicle will travel must be specified. Based on this information, the monthly fee for the monitoring service is estimated.

The use of GPRS modules for data transfer and the associated high roaming costs significantly limit the global popularity of the existing products.

The cost of the currently existing systems limits their use by only mid-sized and large companies and only locally, in a single country. As a result, companies that use and provide logistical services are unable to take the full advantage of the available logistical resources [Chopra, Meindl, 2004].

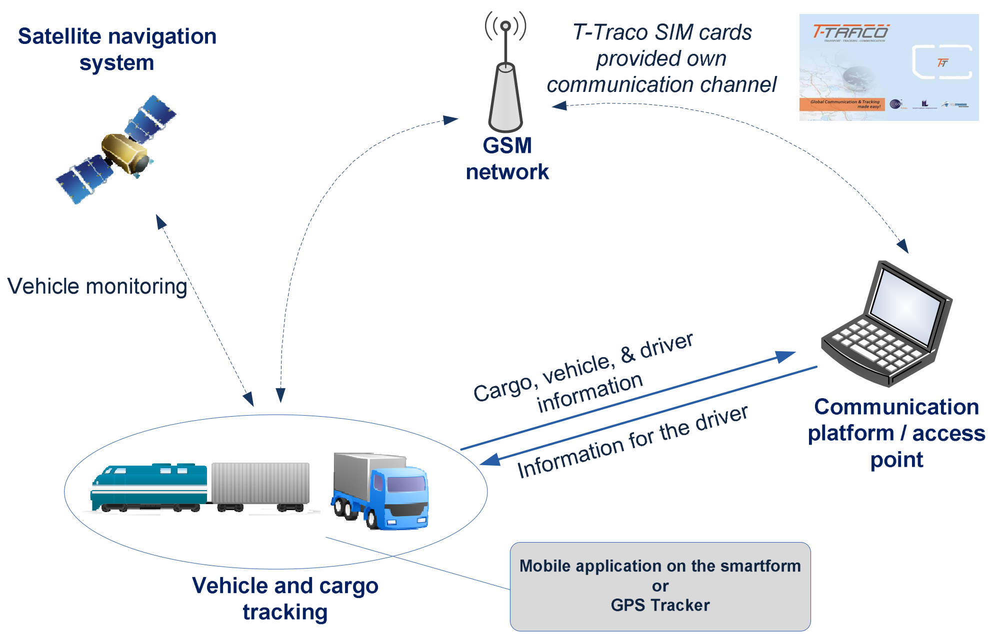
INNOVATIVE MONITORING OF TRANSPORT ASSETTS

The main disadvantage of the existing systems is the high cost of the associated service, which practically prevents global monitoring of transport assets. For example, Industrial Supply Service GmbH offers railroad car/container positioning services for the price of 108 Euros a month. This fee covers information sent to the user on the location of the monitored means of transport every 60 minutes. Moreover, the service works only in selected countries (China, Russia, Belarus, Poland, Germany, and the Netherlands).

Knowing the limitations of the existing systems, the Institute of Logistics and Warehousing from Poznan, together with CallFreedom Sp. z o.o. from Bydgoszcz, has developed an innovative solution that enables global monitoring of means of transport without absolutely any roaming fees. The fundamental innovation in the system is the use of a method of data transfer from the mobile device to the server that is an alternative to the GPRS system. For this purpose, a device has been used that consists of three elements, two of which are identical as those used in other existing monitoring systems [T-Traco, 2014, Christopher, 1998]:

- a GPS module which enables determination of the location of the monitored means of transport,
- a GSM module with a SIM card of a mobile telephony operator which enables sending information to the server over the technical channel with current location of the monitored means of transport [Dabas, Dabas, 2009],
- a battery which supplies the energy required to support the operation of the rolling stock monitoring device.

A schematic diagram showing the operation of the system that uses the technical channel for transmission of data on the location of the means of transport is shown in Figure 3.



Source: prepared by the authors based on the information found at www.t-traco.com

Fig. 3. Schematic diagram showing the operation of the system for monitoring means of transport developed by CallFreedom and the Institute of Logistics and Warehousing
Rys. 3. Schemat operacji systemu monitorującego środki transportu stworzony prze CallFreedom oraz Instytut Logistyki i Magazynowania

The basic advantage and innovation of the system developed by CallFreedom with the assistance of the Institute of Logistics and Warehousing is the use of the technical channel for data transfer. The key advantage of the technical channel is its global reach and the lack of high roaming fees which so far have prevented broad implementation of the intelligent cargo concept [Herwono, 2000]. The major limitation is the size of the transferred data packet - not more than 180 characters in a single transfer. What is also important is that this channel is only accessible to mobile telephony operators. It can be compared to internal text messages (SMS) which are accessible only to mobile telephony operators. This is the line of business line of CallFreedom.

As the research that has been conducted has proven, the system based on the technical channel, developed by CallFreedom and the Institute of Logistics and Warehousing, is unique on the global scale and ensures much more efficient, cheaper and more stable operation compared to the existing Track&Trace systems in operation worldwide.

All the solutions offered in the market use GPRS or SMS communication for transfer of data to the user's server. In the case of the GPRS system, the roaming data transfer fees are much higher than the domestic fees. Another very important aspect is the rate of utilization of the network resources and the resulting delays in data transfer.

This has been confirmed in the research performed by the authors on selected routes in selected countries of the European Union. For example, two devices were compared along the 162 km long route from Bydgoszcz to Płock in Poland. One of the devices sent data on the position of the vehicle over the GPRS system (using SIM cards of selected Polish operators), while the others used the technical channel using SIM cards provided by CallFreedom. The purpose of the research was to detect delays in the transfer of data using the aforementioned two alternative communication solutions. The research was performed using mobile devices coming from the same manufacturer (Sony Xperia S). On the 162 km long route, each device sent a total of 594 packets with data on the longitude and latitude, the current speed, and the time of measurement. In the case of the device based on the GPRS system, 511 data packets were sent with a delay of at least 1 minute. Thus, as much as 86% of information reached the server with a delay. 408 packets, or 68.7% of all transferred data packets, reached the server with a delay of 10 to 30 minutes. On the other hand, the device based on the technical channel sent 589 out of 598 packets, or 99.2% of all packets, without any delay. Only 5 data packets reached the server with a delay equal to approximately 1 minute, but this was due to a change of the BTS transmitters owned by different operators (mobile devices with SIM cards provided by CallFreedom log in with the operator whose GSM signal is the strongest in a given region).

Table 3. Results of the research on the reliability of the GPRS channel and the technical channel used in rolling stock monitoring systems
Tabela 3. Wyniki badań nad niezawodnością kanałów GPRS i technicznego stosowanych w systemach monitorowania ładunków

Position	Positions sent over the GPRS channel		Positions sent over the technical channel	
	pcs	%	pcs	%
total number of positions sent	594	100%	594	100%
delay >= 30 min < 1 h	16	2.694%	0	0.000%
delay >= 10 min < 30 min	408	68.687%	0	0.000%
delay >=5 min < 10 min	46	7.744%	0	0.000%
delay >= 3 min <5 min	23	3.872%	0	0.000%
delay >= 2 min <3 min	6	1.010%	0	0.000%
delay >= 1 min < 2 min	12	2.020%	5	0.842%
no delay in position data transfer	83	13.973%	589	99.158%

Source: prepared by the authors

In conclusion, the system developed by CallFreedom with the assistance of the Institute of Logistics and Warehousing enables very effective, global, and inexpensive monitoring of means of transport. This is possible thanks to a combination of existing GPS and GSM technologies. The system developed by CallFreedom and the Institute of Logistics and Warehousing is the subject of a patent application submitted at the European Patent office and is protected in accordance with applicable regulations (patent application no. EP13460072.5 dated 30 November 2013).

AN EXAMPLE OF REAL TIME ROLLING STOCK MANAGEMENT

This present article describes an example of practical management of rolling stock using system based on the solution developed by CallFreedom and the Institute of Logistics and Warehousing.

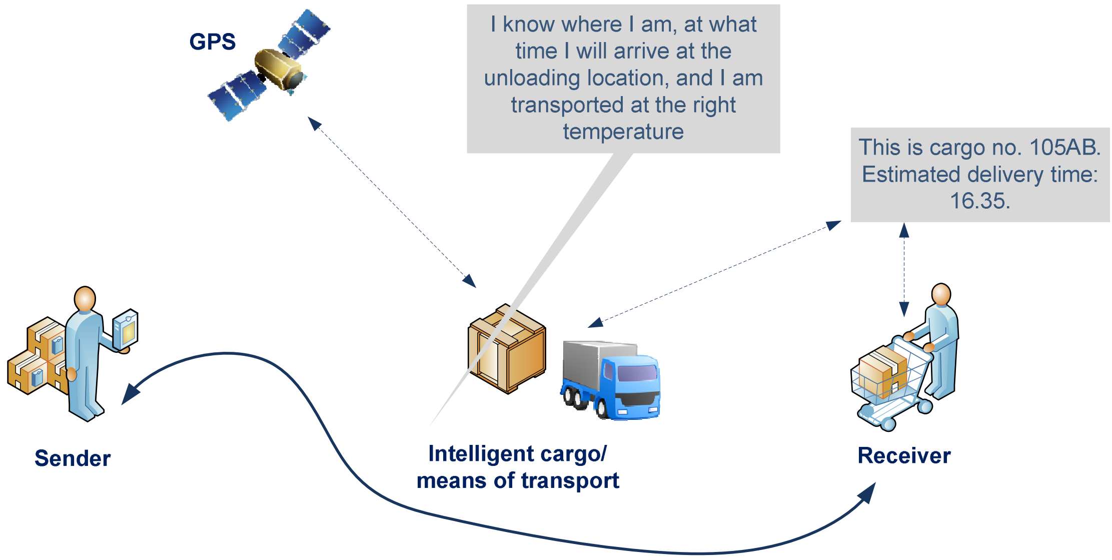
The comprehensive system (T-Traco) consists of the following components:

- a communication platform that enables management of rolling stock in real time,
- mobile measurement devices installed on railway cars; and
- a mobile application available for smartphones with the Android system which enables visualization of the location of selected cars.

Two categories of users have access to the platform:

- transport service providers,
- customers - the owners of the goods shipped in the car.

This enables the car owner not only to monitor in an ongoing manner the position of the car and the task that is being performed, but also to share this information in real time with the owner of the cargo who has commissioned the shipment. This enables automatic notification of the consignor and the consignee about the status of the shipment. This is shown in Figure 4.



Source: prepared by the authors

Fig. 4. The intelligent cargo concept in practice
Rys. 4. Koncepcja inteligentnego ładunku w praktyce

The T-Traco system enables global monitoring of transport assets in real time. The user can identify the travel time of each car, as well as the times and locations of demurrage. Figure 5 below shows the view of the application that can be accessed by the user via a web browser. The system enables defining any zones corresponding to the location of a specific facility, e.g. a shipping container terminal. As a result, the user receives not only information about the current location of each vehicle, but also information about when it entered or left a specific point - zone.

In the case of fleets of several hundred vehicles, their management without an appropriate alert system would not be possible. The T-Traco system enables the user to freely configure the platform so as to receive only the key information. The user can automatically receive the following information, via email or SMS:

- vehicle in movement,
- vehicle demurrage,
- vehicle entered a point,
- vehicle left a point,
- vehicle entered a zone,
- vehicle left a zone; and
- estimated date of arrival of vehicle in a point/zone.

The number of automatic messages depends on the mobile devices that are used. Even the simplest devices installed on vehicle enable sending the above information (figure 5). If the user wants to monitor such elements as opening of doors or cargo temperature, additional measuring sensors must be used.

Table 4 presents a comparison of the fees and the reliability of the T-Traco system and the competing solutions presented in chapter "A review of existing solutions".

Source: prepared by the authors

Fig. 5. The mobile device used in the T-Traco system
Rys. 5. Urządzenie mobilne stosowane w systemie T-Traco

Table 4. Comparison of the operating costs and reliability of various rolling stock monitoring solutions
Tabela 4. Porównanie kosztów operacyjnych i niezawodności różnych rozwiązań monitorowania ładunku

Characteristic	Traditional rolling stock monitoring systems	T-Traco system
Monthly fees (24-months long contract)	Roaming fees - system operational only in selected countries	No roaming fees - global operation of the system within one flat subscription fee.
Reliability of the data transfer channel	GPRS channel - delays	Technical channel offered by CallFreedom - no delays

Source: prepared by the authors

CONCLUSIONS

The intensive development of Business Intelligence and Competitive Intelligence tools, access to information from multi-dimensional data analysis [Sołtysik-Piorunkiewicz, 2009] aggregated from various enterprise IT systems sources (usually in case of heterogeneous environments) has been significantly facilitated in recent years. However, vast majority of available tools supports only classical approach to organisation of transport processes within supply chains. To improve effectiveness and efficiency of transport processes a new approach is a must in the near future [Golinska, Hajdul, 2012]. Companies need to collaborate based on the agreed data standards within secure and reliable virtual supply chains. However, while development of solutions within global freight management system, such as T-Traco, the objectives must be taken into account:

- to provide fast and affordable methods for logistic SMEs (forwarders and transport operators) to connect to data interchange networks established at local, national or international level that enable them to collaborate and possibly increase their profit,
- to allow consolidation of data across networks operating at the different levels, e.g.: to share at the national level local information from different forwarders and to monitor cargo flows by linking and consolidating data from independent sources,
- to demonstrate and assess the benefits achievable through large scale adoption of the proposed solution, in terms of:
  - better utilization of vehicles and less administrative costs for SMEs,
  - increased load factor,
  - better synchronization of freight traffic through ports, road and rail infrastructure.

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

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

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

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WIARYGODNE ELEKTRONICZNE ŁAŃCUCHY DOSTAW TYPU LEAN - STUDIUM PRZYPADKU

STRESZCZENIE. **Wstęp:** Istniejące modele współpracy w łańcuchach dostaw charakteryzują się mało wydajnym wykorzystaniem dostępnych zasobów transportowych, wysokimi kosztami transportu, rosnącym natężeniem ruchu na drogach oraz emisją CO2. Potwierdzają to badania przeprowadzone przez Europejską Agencję Ochrony Środowiska jak i samych autorów. Aby zmienić istniejącą sytuację przedsiębiorstwa potrzebują skutecznie, bezpiecznie i efektywnie kosztowo wymieniać informacje pomiędzy uczestnikami łańcucha dostaw. Celem artykułu jest zaprezentowanie praktycznego przykładu globalnego zarządzania łańcuchem dostaw przy wykorzystaniu platformy komunikacyjnej T-Traco.

Metody: W pracy wykorzystano badania ankietowe, przegląd literatury jak i rezultaty z praktycznego wdrożenia platformy T-Traco.

Wyniki i wnioski: 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, globalna komunikacja, aplikacje mobilne, track and trace

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SCHLANKE UND GLAUBWÜRDIGE, DIGITALE LIEFERKETTEN - EINE FALLSTUDIE

ZUSAMMENFASSUNG. Einleitung: Die bestehenden Organisationsmodelle von Lieferketten nutzen uneffektiv die zur Verfügung stehenden Transport-Ressourcen, charakterisieren sich durch hohe Transportkosten und verursachen ständigen Wachstum von Verkehrsstaus und der CO2 -Emission. Die Erkundungen wurden sowohl in den Forschungsergebnissen des Autors, als auch des Europäischen Ausschusses für Umweltschutz dargestellt. Zwecks Veränderung der betreffenden Situation bedürfen die Unternehmen effizienter, glaubwürdiger und zuverlässiger Lösungen für den Datentransfer innerhalb von Materialflüssen im internationalen Handel.
Methoden: Das Ziel der Arbeit ist es, eine praktische Anwendung des autoreneigenen Konzeptes eines Öko-Systems für Transport-Management im globalen Ausmass sowie dessen praktische Einführung bei der Inanspruchnahme der T-Scale-Plattform zu projizieren.
Ergebnisse und Fazit: Die T-Scale-Plattform ermöglicht ein Zusammenwirken von unabhängigen Transport-Benutzern und Anbietern von Transportdienstleistungen. Im Rahmen der vorliegenden Arbeit sind die aus einer solchen Zusammenarbeit resultierenden Vorteile, die von einer Gruppe von Unternehmen aus der FMCG-Branche in Polen erzielt wurden, zusammengestellt worden.

Codewörter: digitale Lieferkette, Zusammenarbeit, Transport, mobile Technologien

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MODELING AND PERFORMANCE IMPROVEMENT: THE REMEDY TO TREAT SOCIAL AND ENVIRONMENT ISSUES FOR ENTERPRISES IN TODAY'S DIFFICULT ECONOMIC CLIMATE

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ABSTRACT. Background: European economies have been deeply affected by different crises. The impact of the economic crisis on enterprises is now recognized by everybody. Enterprises need to reorganize in order to be better adapted to this situation and to integrate new dimensions in their development. Reduction of cost is not the only way for making enterprises more efficient. It is now clear that a mono-criterion analysis is not adapted to the actual enterprise situation. Enterprises need a multi-criteria analysis by combining quality, cost, lead time but also carbon management, social societal and environmental dimensions. If QCD criteria are already considered as necessary for obtaining the optimum enterprise system, it remains difficult to convince the enterprise management of the opportunity to integrate social, societal and environmental dimensions for improving cost. This need still needs to be clearly demonstrated.

Method: This paper introduces concepts for showing that enterprises would be more efficient, better-organized and adapted to the new changes in society.

Conclusions: The reduction of cost is necessary, the increase in enterprise turnover too, but it is also indispensable to change the structure of enterprises. Enterprise modeling (GRAI Methodology) and a tool is used for illustrating the concepts presented through a detailed case study.

Key words: Carbon Management, Sustainable Supply Chain Management, Quality Management, Knowledge Management, Energy Reduction.

INTRODUCTION

No one can dispute the present plight of many European countries. However it would be a mistake to regard the entire performance in purely economic terms. In the actual global reference model (capitalism), the main enterprise performance criterion is based on economic values. It is clear that we are nowadays at the limits of this model. For instance, in Europe, debt has increased by 450 billion € despite cost reductions imposed by the IMF (International Monetary Fund) and European governments. The only prescription offered to the PIIGS and other European countries is an increase in taxation and a reduction in government expenditure. Furthermore, the countries concerned are exposed to speculation and no alternative solution to the actual situation has been offered to them. Indeed, it is quite different in enterprises because of the introduction of quality and lead time as criteria for completing cost (Quality, Cost and lead time (QCD)). The choice of performance criteria is important for an enterprise. Indeed, this enterprise could evaluate its performance according to these criteria and prepare action plans if necessary. Since 2008 and the beginning of the crisis, the

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failings of the capitalism system have become more apparent. Then in parallel to European countries, enterprises are searching for the ideal solution. Nobody knows exactly how to solve the situation not only in terms of the global economy but also in terms of performance for enterprises.

Many of these enterprises have understood that for being efficient, they need to satisfy not only customers, shareholders and but also suppliers and employees. The case of an enterprise is not just limited to production for satisfying customer demand and shareholders. Nowadays an enterprise is a multi-criteria system integrating social, societal and environmental dimensions in addition to QCD for its improvement (figure 1). The definition of a new sustainable reference model for enterprises integrating these criteria is necessary.

Enterprise modeling is regularly used to prepare enterprises for the outcome of the crisis. Enterprises need to find the best way to resist the present crisis and then to improve in order to be more efficient. GRAI Methodology is one of the three main methodologies (with PERA, CIMOSA) of enterprise modeling. To support this methodology different tools have been developed. GRAIMOD is the latest one being developed by using JAVA technology, JADE and JESS platforms, and an open architecture and structure.

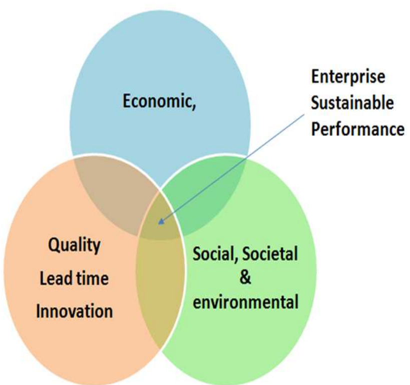


Fig. 1. Enterprise sustainable performance
Rys. 1. Zbalansowana działalność przedsiębiorstwa

This paper summarizes the research done at Icam Vendee in this area. Two different objectives could be defined.

- The Industrial and societal organization research team is working on the elaboration of a much-needed new reference model to replace the capitalist one. What type of society do we want in the future, what balance, which optimum to have. What organization should be adopted by local authorities taking into consideration the present parameters and how to define tomorrow's enterprise in accordance with the society we want to live in?
- The use of actual organization for defining how to progressively improve enterprises. In this context, reference models are being elaborated according to activity domains. A supporting tool is also being developed according to the concepts of GRAI Methodology.

The elaborated concept aims to consider future manufacturing, supply chain, enterprise, local authority needs etc. The choice made is to define these concepts by introducing sustainable values in the proposed changes.

The aim of this paper is to show the method to change a structure of enterprises by a multi-criteria analysis by combining quality, cost, lead time but also carbon management, social societal and environmental dimensions.

GRAI METHODOLOGY AND GRAIMOD

The objective is to use reasoning (e.g. CBR or decomposition), enterprise typology, expert systems, Multi-agents systems, enterprise knowledge for defining a tool (GRAIMOD) destined to improve enterprise performance. This tool will support GRAI Methodology.

The objective of this research is to:

- Allow enterprises to evaluate their performance and to drive the change of their economic model by integrating the social, societal and environmental aspects.
- Aid enterprises towards ecologic and energy transition,

– To improve progressively and sustainably enterprise supply chains

GRAI Methodology is one of the three main methodologies used for analyzing and designing enterprises. The GRAI approach (figure 2) is composed of four phases: An initialization phase to start the study, a modeling phase where the existing system is described, an analysis phase to detect the inconsistencies of the studied system and a design phase during which the inconsistencies detected are corrected and a new system proposed. These concepts could be used to ensure the transformation of enterprises to meet the real market needs (globalization, relocation, capacity to be proactive, cost optimization, lead time, quality, flexibility, etc….) and need to be adapted. An enterprise is completely described according to GRAI Methodology by finding five models: functional (functions of the enterprise and their links), physical (the production system), informational (the network, tools and informational flows), process (suite of sequences or tasks) and decisional (structure of orders, hierarchic organization). Then these models could be improved to enhance enterprise performance.

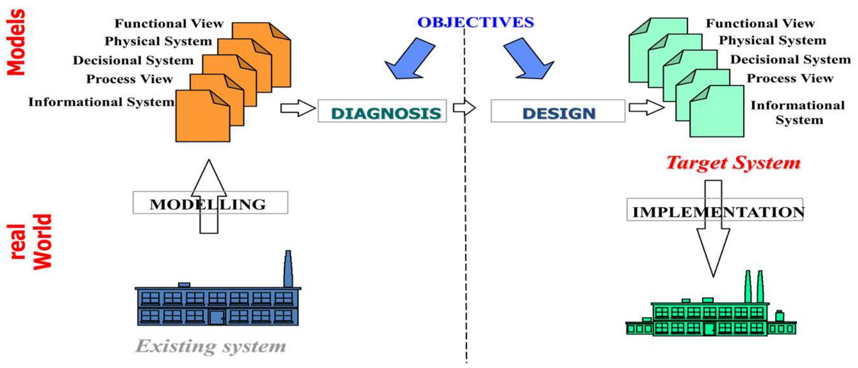


Fig. 2. GRAI approach
Rys. 2. Podejście GRAI

GRAIMOD is a new tool being developed by ICAM Engineer School for proposing concrete solutions to improve enterprises according to new market evolutions. At present, it contains five modules working around three sub modules (figure 3). The tool is divided into two parts: the interface containing modules for modeling enterprises and the analysis & improvement part for changing the existing system and proposing new organizations.

GRAIKERN, a graphic editor used for representing the different models associated to GRAI methodology, is an interface. GRAIWORKER is the work base elaborated for managing, modifying and capitalizing knowledge about the studied case.

GRAITRANS is a Transfer Interface used for putting the new case in GRAIXPERT in order to improve its Cases Base. The reference model elaborated for each enterprise domain will be improved by the acquisition of this new model in GRAIXPERT between the different modules

GRAIXPERT is a hybrid expert system for managing the analysis of the existing system and proposing a new system (figure 4). It is composed of two sub-modules in interaction with GRAIKERN: the Knowledge Capitalization (KCM) and the Knowledge Based System (XPERTKBM). GRAIMANAGER is a management module used for organizing the different interactions between the modules of GRAIMOD. It controls and manages the system's interactions with the users.

GRAISUC is a module used for managing the choice of an ERP or SCM tool for an enterprise. It is composed of two sub-modules SpeMM and SpeCM. The Specification Management Module (SpeMM) is used for choosing the appropriate ERP or SCM Tool of an enterprise. The specifications obtained are capitalized in the Specification Capitalization Module (SpeCM).

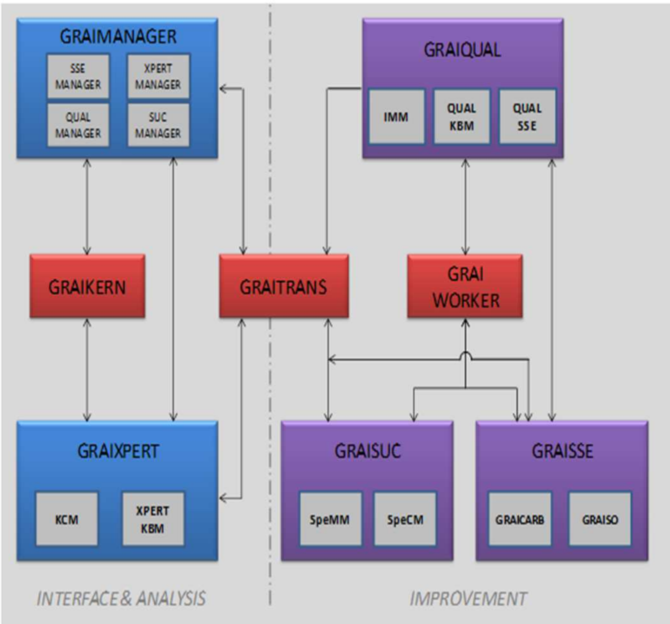


Fig. 3. Achitecture of GRAIMOD
Rys. 3. Architektura GRAIMOD

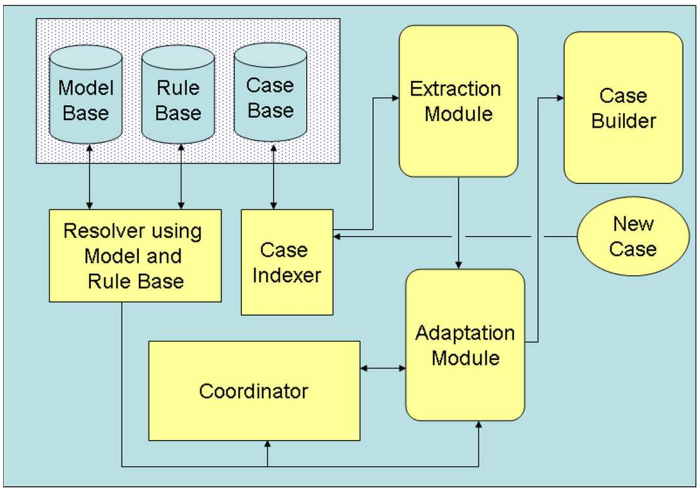


Fig. 4. GRAIXPERT structure
Rys. 4. Struktura GRAIXPERT

GRAIQUAL is a module used for managing quality approach implementation or quality improvement in an enterprise. It contains two sub-modules IMM and QUALKBM. The Improvements Management Module (IMM) is used for managing the different quality action plans of the enterprise. The Quality Knowledge Base Module (QUALKBM) is being elaborated for containing the rules related to quality certifications in order to use them for improving or elaborating quality in an enterprise.

A new module GRAICARB is being added to GRAIMOD in order to pinpoint the environmental, societal and social dimensions in enterprises. This module would integrate for example changes associated to carbon management, IS0 26000, ISO 14000 implementations, social and societal evolution impact not only on enterprises but also territorial collectivities (states, associations, local authorities, etc.).

Unlike GRAIQUAL whose goal is to improve enterprise performance by using the criteria defined, GRAISSE focuses only on the social, societal and environmental aspects. This module is composed of two sub modules:

- GRAICARB to calculate enterprise carbon footprint and to propose environmental improvements according to ISO 26000 norm
- GRAISO focusing on the improvement of social and societal aspects in enterprises.

Carbon management is an approach based on the setting up of a project for the evaluation and reduction of gas emissions consisting of six main stages:

1. Awareness of Greenhouse gas emissions
2. Definition of the area to be studied
3. Data acquisition
4. Exploitation of findings
5. Establishment of reduction action plan
6. Execution of reduction action plan

In GRAICARB the ADEME (French environmental agency) method is promoted according to ISO 14000 norms. This method proposes the use of a step by step approach of calculation rules, of calculation software and of associated documentation. The database used is "Carbon base" and external data could also be used by the users.

This method is used in three stages:

- The preparation for defining the perimeter of the study.
- The accounting analysis for collection of precision data
- And strategic analysis classifying the critical areas and those at risk. The action plans are elaborated after that for correcting the situation.

The concepts contained in the ADEME Method are combined to the Greenhouse Gas (GHG) Protocol, the regular guide for Gas management and data from the "coach carbone" tool. The GHG protocol describes principles and requirements for quantifying enterprise activities, gas emissions and defining accounting and reporting principles.

The methodological guide describes the way to follow to obtain an official Gas emission management.

The "coach carbone" tool is developed by FHN (Nature and Human Foundation) and ADEME. It allows to visualize the energy consumption in Kwh and liters of fuel and to compare it with other enterprises. The tool also allows to generate savings in Euros and in CO_2.

GRAISO is dedicated to social and societal aspects according to concepts of ISO 26000 and Lucie Label, which will be presented later. With ISO 26000 there is no certificate contrary to Lucie which issues a certificate to validate the work done.

ENTERPRISE TYPOLOGY AND REFERENCE MODELS

In regards to the actual situation of enterprises and new constraints of the market, the use of a structured approach for improving enterprises is pertinent. GRAIMOD is being elaborated by using different types of reasoning and applying them to enterprises: decomposition reasoning, CBR (Case Based Reasoning), Rules Based reasoning, transformation reasoning. The objective is to define formalized processes of enterprise improvement and to be able to manage each step of these processes and defining action plans for short, middle and long terms.

Then, three modes of knowledge representation are used in GRAIMOD:

– The reference models show the standard for a given sector of activity. They allow to define an ideal for each sector of activity, which can be used as a reference in the elaboration of the future model (TO BE model).
– The cases studied are capitalized in order to enrich the knowledge capitalization module of GRAIXPERT with the objective being to improve the use of CBR (Case Based Reasoning).
– The rules are used throughout the different phases of the operation of GRAI methodology. Not only do they serve to elaborate the modules concerning the existing situation of the enterprise (AS IS) but also to detect the malfunctions of the enterprise and establish its strengths and weaknesses and finally during the design phase of the future system (TO BE).

The use of a generic model corresponding to a precise activity sector appears as pertinent. A new enterprise typology (figure 5) based on four criteria is established and a reference model according to each defined domain is being elaborated.

The first criterion chosen is the economic sector:

– The Primary sector is composed of activities linked to the natural resources exploitation such as agriculture, forestry; fishing and mining are included in the primary sector. It also includes all activities producing unprocessed raw materials.
– The Secondary sector corresponds to activities linked to the processing of raw materials from the primary sector in production and consumption goods are included together with the construction or manufacturing industry.
– The Tertiary sector contains service activities linked to that sector. We can find very wide types of activities such as commerce, administration, transport, financial and real estate activities, services to businesses and individuals, education, health and social action.

This sector decomposition is used by both economists and geographers. The sectors correspond to the three main economic sectors and are widely used.

The second criterion used is defined as size:

– Small companies correspond to enterprises with employees from 0 to 49
– Medium companies are composed of employees from 50 to 499
– Large companies correspond to enterprises with more than 500 employees

For reducing the number of reference models to elaborate, only three sizes are defined.

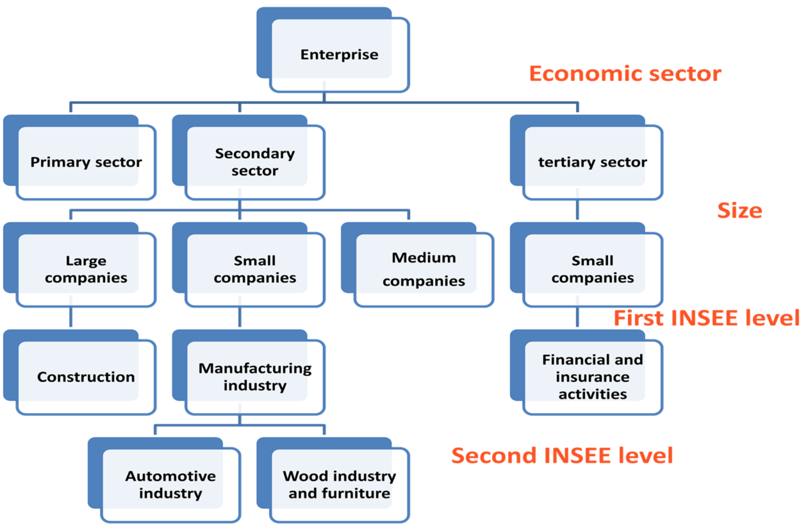


Fig. 5. Enterprise typology
Rys. 5. Typologia przedsiębiorstw

The third criterion chosen (first INSEE level) is activity domain according to NAF code. A SIREN number is assigned to any French companies during their registration and this number is used for the lifetime of the company. As soon as the SIREN number is assigned, the company needs to select an APE code (Main Activity Practiced) which characterizes the activity. This code is used for the nomenclature of French activities (NAF).

The APE code is fundamental information for statistical data companies because all the rankings of firms by industry are based on it. The quality of the studies about the economic and the structural situation also depends on it.

We decided to only use the first level of the NAF for the primary and tertiary sectors (sections A, B, G … in the table in the previous page). The explanation of this decision is because we are convinced that the performance models of these companies would be close to each other. But the second INSEE level, the fourth criterion is used for dividing manufacturing industry into activity domain.

TEST OF THE DEFINED TYPOLOGY: RANGE OF ENTERPRISES

The elaboration of reference models for each domain has been undertaken. The process of elaboration is the same: acquisition of context, existing system modeling, analysis, design and finally proposition of reference model.

All the enterprises of Vendee are chosen as a study area. Indeed, there are more than seven thousand enterprises in Vendee, corresponding well to a quota of all enterprises in France for making a scientific study. The result of the study could easily be extended to enterprises nationwide in France, then throughout Europe. The quota chosen is really representative. So, Vendee enterprises represent for the study the global mathematical population. A meeting with the Chamber of Commerce allows to define how many enterprises would give an answer to a questionnaire sent to them for acquiring context and to make an enterprise classification. Because of the crisis and the difficult economic situation of enterprises, enterprises find it difficult to allocate the time to answer to this kind of questionnaire; only 10% would surely give an answer. For the population, it means that 700 enterprises would be ready for giving us data for our analysis.

The proposition of an extension of GRAIMOD is in order to treat the data obtained and exploit it for elaborating reference models. GRAICARB, this extension, contains a data base with the questionnaire in which the responses will be studied. It allows to find good habits of enterprises by taking into account social, societal and environmental dimensions. The use of GRAIMOD for improving enterprise performance is now already efficient. Indeed, for an enterprise, the modeling, the analysis and the design phase are really well managed by the tool. The tool is also efficient for reducing lead time, choosing and implementing new tools in the enterprise, and implementing quality approach. But it is clear that the tool is less efficient in the management of improvement integrating carbon footprint reduction, social and societal dimensions, and respect of environmental norms. Then, GRAICARB will bring this efficiency, by focusing only on this criterion. The linear combination with the other performance criteria would be managed by GRAIMANAGER.

The ISO 26000 norm presents the main lines for all organizations wanting to assume the impacts of their decisions and activities. The societal responsibility is defined as the responsibility of an organization according to its decisions and activities towards society and the environment through an ethical and transparent approach which

- Contributes to the sustainable well-being including health and development of society.
- Takes into account all interested parties.

- Respects laws and is adapted to international norms.
- Is integrated to all the organization and is used in its relations.

For guiding the discussions between all the parties, the designers identified seven main questions:
- Environment
- Loyal practices
- Community and local development
- Organization governance
- Relations and working conditions
- Questions related to consumers
- Human Rights

Each of these questions is divided into action domains, explaining the main lines to be followed. An ISO 26000 approach respects three major steps:
- The realization of a diagnosis for defining action priority
- The deployment of identified actions
- The phase of account making
- The diagnosis management is based on:
- The definition of the perimeter of societal responsibility
- The identification of the parties concerned and their interest
- The review of the seven main questions

The diagnosis serves to identify pertinent action domains on which the organization could be based for fixing its priorities. Then an auto-evaluation could be done according to requirements referential or an evaluation by an outside party could be done according to universal requirements referential.

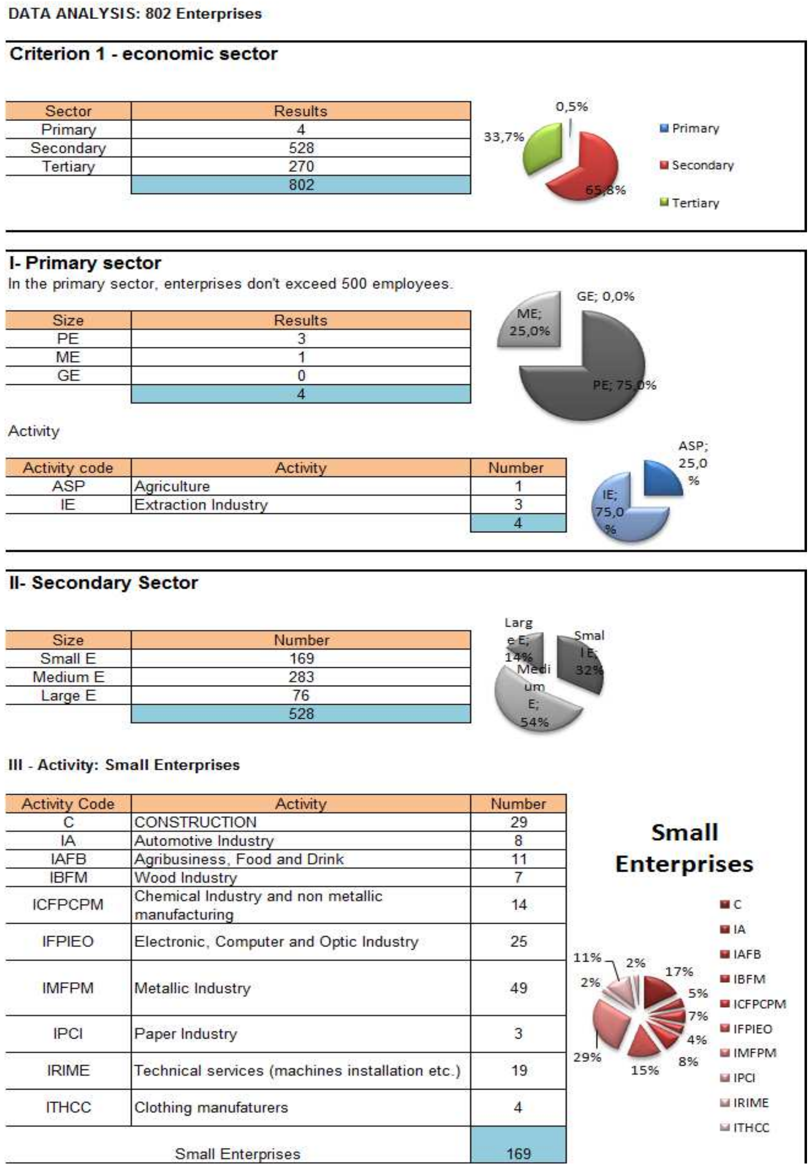
The deployment implies the study of the organization values for defining strategy, objectives, resources and skill development. The results are followed by the regular review as part of a dynamic continuous improvement process.

The last step is destined to summarize what has been done and how to address what remains to be done.

The result of the questionnaire would allow to adjust the enterprise typology elaborated. It would show us the enterprises which changed their economic model by integrating other dimensions than cost, quality and lead time. For instance, some of them are green, ecological, virtuous, showing solidarity, ethical, or responsible enterprises. The study allows to focus on this kind of enterprises and to valorize them (figure 6). The objective is to show those not having chosen to follow this way the real advantages of such an approach and for those who have already started to help them become even more efficient.

Fig. 6. Collection of best practices

Rys. 6. Zbiór najlepszych praktyk



DATA ANALYSIS: 802 Enterprises

Criterion 1 - economic sector

Sector	Results
Primary	4
Secondary	528
Tertiary	270
	802

I- Primary sector

In the primary sector, enterprises don't exceed 500 employees.

Size	Results
PE	3
ME	1
GE	0
	4

Activity

Activity code	Activity	Number
ASP	Agriculture	1
IE	Extraction Industry	3
		4

II- Secondary Sector

Size	Number
Small E	169
Medium E	283
Large E	76
	528

III - Activity: Small Enterprises

Activity Code	Activity	Number
C	CONSTRUCTION	29
IA	Automotive Industry	8
IAFB	Agribusiness, Food and Drink	11
IBFM	Wood Industry	7
ICFPCPM	Chemical Industry and non metallic manufacturing	14
IFPIEO	Electronic, Computer and Optic Industry	25
IMFPM	Metallic Industry	49
IPCI	Paper Industry	3
IRIME	Technical services (machines installation etc.)	19
ITHCC	Clothing manufaturers	4
	Small Enterprises	169

Fig. 7. Example of typology structure
Rys. 7. Przykładowa struktura typologii

GRAICARB would be used for doing carbon management, implementing ISO 26000, managing ergonomic practices, managing how to make employees happy with their job and more efficient for the enterprise. The societal aspect could also be managed. The tool would also serve for improving local authorities.

To conclude, the study extended to the department of Vendée has been undertaken (figure 7). The first step was finished in February 2013. Then the typology elaborated will be adjusted and reference models developed for each new class. The next step will be modeling of the enterprises which will start using specific models in order to improve the reference models defined. Simultaneously, the elaboration of another economic model more adapted to the actual context and able to protect enterprises in the future will be developed.

NEW ECONOMIC AND SUSTAINABLE MODEL

Existing economic models, including the capitalist one which many consider to be behind the actual world crisis, have shown their limitations. It is necessary to think about a new model that will be adapted to the actual world context and more efficient.

The objective is to develop a model with a complete break from a purely liberal one. This model has to take into account the reason of the actual crisis and parameters such as the environment, society, social view, and to offer an optimization in terms of a balanced model.

The particularity of the new proposed model would be to think globally about local organization, an enterprise, a department or a country. It means that all parameters would have to be integrated in the definition of the model without giving priority for one criterion as it was in the old capitalist model.

For instance, for energy independence, it would be to think about how to implement a global energy vision according to a department or town. For the department of Vendee an audit would be done for analyzing in detail the existing system and then detect inconsistencies, and deduce points to improve. The next step would be to define a new specific Vendee model in accordance with other best models used in the world according to energy optimization but with the specificity and the identity of Vendee. The result would be a combination of best energy transition habits, integrating biomass and waste energy, or solar energy, wind energy, thermal resource energy, and so on. The model would be according to the parameters the most balanced possible. For validating this model, a demonstrator would be designed, elaborated and exploited on a new ICAM school for example. The model obtained and validated only by focusing on one aspect would be improved by introducing the other aspects in order to define an optimum.

This approach proposed for the energy self-sufficiency problem, would be generalized to all the previous questions in order to build reference models adapted to specific problems of enterprises and local government.

To conclude we could say that the department of Vendee department will serve as an example which will be studied completely and statistically with a scientific approach for defining a new economic and sustainable model.

CONCLUSIONS

Enterprise modeling is used for preparing enterprises for the post-crisis period by reorganizing them according to the evolution of society and globalization rules. It is important to show them how to integrate different new parameters in order to adapt to future conditions. The objective to make enterprises sustainable needs to redefine an optimum including environmental, social and societal dimensions in addition to the main performance criteria (QCD). GRAI Methodology supported by GRAIMOD a new software tool, allows to improve the global performance of Enterprises and particularly SMEs. A focus is made on GRAISSE and GRAICARB dedicated for managing carbon footprint and social, societal and environmental aspects in enterprise improvement.

In this paper, the process of reference models elaboration is presented. An enterprise typology is also proposed with the objective to give the most appropriate model to each enterprise which desires to improve its performance. The new economic model is being elaborated and will be presented in detail in future papers. The proximity of Icam Vendee to enterprises will allow not only to enrich the case base of GRAIMOD by doing modeling of them but also to improve the reference models and the typology elaborated.

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POPRAWA MODELOWANIA I REALIZACJI: PODEJŚCIE DO ZAGADNIEŃ SOCJALNYCH ORAZ OCHRONY ŚRODOWISKA W PRZEDSIĘBIORSTWACH W OBECNYM TRUDNYM KLIMACIE EKONOMICZNYM

STRESZCZENIE. **Wstęp**: Gospodarki europejskie zostały dotkliwie dotknięte przez różne kryzysy. Wpływ kryzysu ekonomicznego na przedsiębiorstwa dostrzegany jest obecnie wszędzie. Przedsiębiorstw te musze poddać się gruntownej reorganizacji oraz dodać nowe elementy i wymiary do własnego rozwoju. Redukcja kosztów nie jest jedyną metodą poprawy sytuacji przedsiębiorstwa. Wymagana jest wielokryteriowa analiza, obejmująca jakość, koszt, czas reakcji jak również zużycie dwutlenku węgla, oddziaływanie na środowisko czy aspekty socjalne. Kryteria QCD są obecnie uznawane jako niezbędne do osiągnięcia optymalnego systemu zarządzania, tak jest trudnym zadaniem przekonanie zarządzających firmą o konieczności i wynikających z nich też korzyściach dla optymalizacji kosztów, wprowadzenia również wymiarów socjalnych i środowiskowych.
Metody: Praca przedstawia koncepcję, która umożliwia stworzenia przedsiębiorstwa jako bardzo efektywnego, lepiej zorganizowanego i dostosowanego do zmieniającego się społeczeństwa.
Wnioski: Redukcja kosztów jest niezbędna, tak samo jak wzrost obrotów, ale jednocześnie konieczne jest zmienienie struktury przedsiębiorstwa. Modelowanie przedsiębiorstwa (metodologia GRAI) została użyta jako do zaprezentowania koncepcji w szczegółowych studium przypadku.

Słowa kluczowe: zarządzanie emisją dwutlenku węgla, zrównoważone zarządzenie łańcuchem dostaw, zarządzanie jakością, wiedza menadżerska, redukcja zużycia energii

VERBESSERUNG DER UNTERNEHMENSMODELLIERUNG UND IHRE DURCHFÜHRUNG: EIN HERANGEHEN AN SOZIALE FRAGEN UND DEN UMWELTSCHUTZ IN UNTERNEHMEN IM GEGENWÄRTIGEN SCHWIERIGEN WIRTSCHAFTSKLIMA

ZUSAMMENFASSUNG. Einleitung: Die europäischen Landeswirtschaften wurden von verschiedenen Krisen schwer betroffen. Überall wird heutzutage der Einfluss der Wirtschaftskrise auf Unternehmen wahrgenommen. Die davon betroffenen Unternehmen müssen sich einer grundlegenden Reorganisation ergeben und neue Elemente, Ausmaße und Impulse für ihre Entwicklung in Angriff nehmen. Die weitgehende Kostenreduzierung vermag nicht die einzige Methode

einer Verbesserung der Situation im Unternehmen zu sein. Es wird dabei eine Mehrkriterien-Analyse benötigt, die die Qualität, Kosten, Reaktionszeiten, sowie die Kohlenstoffdioxid-Emission, die Umweltbeanspruchung und soziale Aspekte umfasst. Die QCD-Kriterien gelten heutzutage als unentbehrlich für die Erzielung eines optimalen Management-Systems, es fällt allerdings schwer, die Geschäftsführer davon zu überzeugen, dass die nötige Einfügung von sozialen und umweltschutzmäßigen Aspekten in die Managementsmodelle viele Optimierungsvorteile mit sich bringen kann.
Methoden: Die vorliegende Arbeit stellt ein Konzept für die Etablierung eines sehr effizienten, besser organisierten und an die sich verändernde Gesellschaft angepassten Unternehmens dar.
Fazit: Die Kostenreduzierung ist unentbehrlich, ähnlich wie die Umsatzerhöhung. Gleichzeitig bedarf das Unternehmen einer Veränderung seiner Struktur. Die Modellierung des Unternehmens (gemä? der GRAI-Methodologie) wurde als Methode für die Darstellung des Konzeptes im detailierten Fallstudium angewendet..

Codewörter: Management der Kohlenstoffdioxid-Emission, ausgewogenes Management der Lieferkette, Qualitätsmanagement, Management-Wissen, Energiereduzierung

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THE ROLE OF THE CONTINUOUS IMPROVEMENT TOOLS OF PROCESSES IN BUILDING RELATIONSHIPS IN SUPPLY CHAIN

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ABSTRACT. Background: The aim of this paper is to determine the importance of the quality management and environmental management systems as well as operational improvement tools (such as TPS, Six Sigma, and Lean Management) in building partnerships in supply chain.
Methods: This paper contains the results of survey in companies operating in Poland and an analysis of the requirements for suppliers in the implementation of the quality and environmental management systems elements as well as recommendation for them to implement process improvement tools (such as elements of the TPS, the concept of Lean Management and Six Sigma methodologies).
Results: The results of the survey and the analysis of the examples show that companies that are buyers in the B2B market often define the very individualized to suppliers needs through detailed specifications defining the requirements for quality assurance, performance increases, (for example, shortening implementation cycles), efficiency (cost reduction), safety, reducing the negative impact on the environment.
Conclusions: The effectiveness of the action on improving the quality of processes and products by building relationships with suppliers depends largely on the support provided to them. To achieve these objectives many companies introduce special development programs for suppliers.

Key words: continuous improvement, supply chain management, supplier relationship management, sustainable development.

INTRODUCTION

Building partner relationships in supply chain is largely the result of some kind of evolution from the repetitive transactions based on loyalty to the source of purchase and trust between partners. Recurring transactions are often transformed into long-term relationships in which mutual relations are governed by contract. If the parties are satisfied with the implementation of the provisions contained in them that such cooperation can become a close partner relationships. They can lead to many mutual benefits such as improving product quality and service, shorten order fulfillment cycles, purchasing efficiencies, improve communication between the supplier and the recipient or joint research and development. The observation of business practice shows that many enterprises improving the processes in a supply chain focus on the implementation of quality, environmental and safety management systems conform to international standards requirements as well as operational excellence tools like Toyota Production System, Lean Management and Six Sigma methodologies. Many companies often define their suppliers individualized requirements through specifications to determine not only the issues related to quality assurance, but also organizational performance related to the increase of efficiency (cost reduction),

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reducing the negative impact on the environment. Suppliers adapting to these requirements make a platform for building partnerships with business clients[Lofti, Sahran, Mukhtar, Zadeh 2013].

BUILDING RELATIONSHIPS IN THE SUPPLY CHAIN

Supply Chain Management is a fundamental concept of logistics that has evolved to enable organizations to improve their efficiency and effectiveness in the global and highly competitive environment in the twenty first century. This conception comprises processes connected with planning, completion and evaluation related to the flow of materials, equipment, information and human resources among organizations to ensure effective and fast delivery of tangible products and services between the supplier and the customer [Ballou 2004, Stonebraker 2004, Narasimhan, Matthews 2006]. Building a competitive advantage in particular is subject to shaping the long-term partner relationships between companies and their customers and suppliers. Individualized, trust-based approach towards the establishment of contacts, interests and possibilities of cooperation offer, the negotiation and execution of transactions with parties guaranteeing their equivalent positions (called win-win). Positive evaluation of these activities is essential to maintain these relationships and a sign of readiness for further cooperation partners, by which each party can see the number of measurable benefits. The condition of their feelings is effective communication in the form and content of communication should meet the expectations of each partner [Prahinski, Benton 2004, Miocevic 2008].

The activities of multinational corporations, which introduced the concept of sustainable development is heavily focused on collaboration with its partners in the supply chain (suppliers and customers). Large corporations are increasingly offering their support through joint ventures, such as deployment projects operational improvement tools (environmental and safety management systems, Lean Management, Six Sigma, TPS), or develop concepts for new products. Build partnerships with customers and suppliers, can bring the supply chain many important benefits such as:

- Shortening the time for new products (and reducing the associated costs);
- To ensure business continuity, together with the methodology developed for the identification, analysis, and hazard mitigation (associated with the product and the processes implemented in the supply chain);
- Increased flexibility, efficiency and effectiveness of the processes through an efficient and rapid communication (aimed at forecasting demand, joint planning of resource use; use of a compatible infrastructure and the use of operational improvement tools [quality management systems / environment / safety, as well as Toyota Production System (based on Kaizen philosophy), Lean Management, and Six Sigma]);
- Promotion of ethics in economic activity, through the avoidance of corruption, discrimination (using monopolistic practices), the discharge of contracts (including trade secrets), and compliance with regulatory requirements, design and analysis of product life cycle (according to the guidelines contained in ISO standards series 14 040) [Aboelmaged 2010, Mollenkopf et al. 2010, Goebel 2012].

A partnership comprises a process in which the customer and the supplier gradually build strong and extensive social, economic and technical relations. Creating partnerships usually results from some kind of evolution beginning with repeated transactions based on loyalty to the source of purchase and on confidence related to a positive image of a particular partner. Repeated transactions often transform into long-term connections in which relations are regulated by agreements. If parties are satisfied with keeping arrangements set out in the agreements, their cooperation may transform into a close partnership [Wagner 2011]. This may produce lots of benefits for the partners and these are: improved quality of products and services, prompter carrying out of orders, preferential prices, improved communication between the supplier and the recipient (quicker and more complete exchange of information), joint research and development [Beverland, Lindgreen 2005]. The benefits enhance positive images of partners. In some cases, a partnership between the supplier and the customer may transform into a strategic alliance which is based on joint achievement of specific long-term goals.

THE ROLE OF QUALITY AND ENVIRONMENTAL MANAGEMENT STANDARDS IN COOPERATION WITH SUPPLIERS

Building a partnership with suppliers is dependent on specifying the requirements they must meet and on the efficiency of employing tools which will make them fulfil the requirements, e.g. audits, supplier evaluation sheets (which are based on an indicator analysis concerning meeting requirements in the area of technical quality, meeting deadlines, price competitiveness, providing services). Significant conditions shaping this partnership are the speed of information exchange and individualization of approach, e.g. by means of offering a wider and wider range of services by the supplier and getting involved in joint research and development of new products. The most common organizational standard used by companies to ensure the required quality and raising its level with the growth expectations of the buyers are the guidelines contained in ISO 9001.The guidance in this standard includes criteria for the implementation of operational processes (related to product design, purchasing, production, transportation, storage and delivery of goods, installation of equipment at the customer service after the sale). The standardization of these processes is achieved through Standard Operating Procedures (SOP) and/or employee training programs, provision of resources (personnel qualifications maintenance of facilities, supervised environment), and the use of monitoring and measurement methods which allow the quality level of provided services to be reached and improved. The selection of suppliers is usually preceded by an audit. During the audit clients particularly focus on the evaluation of the capacity of the suppliers. This assessment includes the following elements: infrastructure (buildings, equipment manufacturing), maintenance and efficiency of IT equipment. The periodic classification of suppliers is carried out through continuous monitoring and measurement using indicators relating to the quality of the products entrusted supply (no damage, theft, shortage), timeliness of delivery (no delays in deliveries), responsiveness to complaints, compliance with delivery of documents, and flexibility (the possibility of changes in the size and timing of deliveries). Performed by the customers, periodic surveillance audits at suppliers' plants include not only the verification of compliance with organizational standards requirements. Audits also provide arrangements for process improvement by reducing the level of risk, the risks associated with quality products, improving the environmental impact and exchange of information (including documents and records). Some international companies require from suppliers regular reports on progress in the improvement of management systems (Feedback Reports Cards) which contain data on cost reduction, reduction of non-compliance, improvement of efficiency and effectiveness indicator processes, reduction of energy consumption, a cutting of cycle times of processes, and optimization of capacity utilization [Zhao, Huo, Sun, Zhao 2013]. More and more enterprises, before starting collaboration with suppliers, take into account the introduction of environmental management standards based on the monitoring of environmental aspects. These standards emphasize the objectives (based on the environmental aspects) and programs to improve the impact on the environment, as well as legal compliance in this area. During the audit suppliers are assessed for compliance with the requirements of international environmental management standards ISO series 14000 and legal requirements for the protection of the environment (in particular Directives of the European Union [MacDonald 2005, Fuentes-Fuentes, Lloréns-Montes, Molina-Fernanández, Albacete-Sáez 2011, Igarashi, de Boer, Fet 2013, Wiengarten, Pagell, Fynes 2013]. Many companies also assess suppliers on the basis of their level of management focusing on the requirements of ISO 9001 and ISO 14001 standards. Many international companies publish their own holistic requirements (in the form of Supplier Quality Requirements Manuals, Supplier

Quality and Excellence Manuals, Customer-Specific Requirements) which are relevant to a wider range than those of international standards. Compliance with these requirements the clients are verified by the client through the audits and self-assessment of suppliers. Auditing suppliers and their implementation of an environmental management system is particularly noticeable in case of international concerns. During those audits particular attention is paid to:

- documents which are used (procedures and instructions), their legiblity, identification and accessibility;
- recording of processes (control and use of statistical methods);
- identification of processes and products;
- work safety conditions;
- management of environmental aspects.

The criteria which may determine temporary evaluation of a supplier include: the level of technical quality which is offered, advantageous price conditions, deliveries meeting deadlines, favourable payment deadlines, having a quality system, the level of assistance, responding to complaints. Many companies also assess suppliers on the basis of their level of management focusing on the requirements conform to ISO 9001 and ISO 14001 standards. They also audit suppliers periodically. Some international companies require regular reports on progress in improvement of management systems while monitoring suppliers. They also keep monitoring them regularly by means of Supplier Performance Feedback Reports Cards which contains data on lowering costs, reducing incompatibility, improving effectiveness indicators and process efficiency indicators, reducing energy consumption, shorter cycles of process completion, and optimization of using production capabilities. The above-described behaviour may be presented as a cycle of constant improvement. Companies implementing management systems which conform to organisational standards more often complete sheets and use periodical evaluation indicators as well as audit their business partners when shaping their relations with suppliers compared to companies which do not implement systems of this type. They also require cerificates which conforme the implementation of quality and environmental management systems [Pojasek 2008, de Souse Jabbour, Jabbour, Latan, Teixeira, de Oliveira]. Creating partnerships with the suppliers transform commercial cooperation into various types of alliances and, thus, gain a range of benefits:

- time saving connected with choosing a supply source;
- reduced risk which connected with choosing a new supplier or buying a new product (brand);
- quicker and more effective flow of market information;
- joint solving of technical and (sometimes) organisational problems, which allows greater effectiveness of using resources in process enhancement.

More and more often institutional clients (especially producers) begin to concentrate on the selection of key suppliers, shaping long-term relations with them based on the advancement of the technical quality of product solutions (running research and development projects together), reliability of deliveries (based both on their flexibility and shortening of the order cycle). These actions executed by both sides lead to decreasing costs [Krause 1997, Casadesús, de Castro 2005, Mistra, Patel 2010, Arumugem, Derakhshan, Boon 2011, Garfamy 2011, Ylimäki 2014].

THE ROLE OF OPERATIONAL IMPROVEMENT TOOLS IN BUILDING RELATIONSHIPS BETWEEN PARTNERS IN THE SUPPLY CHAIN

Institutional purchasers, particularly large multinational companies, increasingly attach importance to ensure continuity flows in the supply chain (exchange of products and information) and to improve efficiency. They use this to improve efficiency and effectiveness of processes using operational improvement tools such as the elements of the Toyota Production System (which includes, Kaizen, 5S, Total Productive Maintenance), the concept of Lean Management, and Six Sigma methodologies. The implementation of these tools is often seen as a collaborative project by the partners in the supply chain. To ensure continuity in the flow of products and information Total Productive Maintenance (TPM) is particularly important and aiming to prevent unexpected failures of infrastructure. Through the introduction of TPM one can avoid discrepancies relating to the flow of information (in case of hardware failure or a computer network), as well as products in the processes of production, storage, transport and related losses (non-compliance, failure of goods or delays in the timely performance of the contract and delivery to the buyer). Enterprises wanting to further eliminate possible losses associated with the flow of products and information decide to implement the concept of Lean Management [Konecka 2010]. This concept is often introduced by using the Six Sigma methodology. The most commonly used methodology is DMAIC (Define-Measurement-Analyze-Improve-Control), which focuses on improving existing processes and products. The second methodology is DMADV (Define-Measurement-Analyze-Design-Verify), which is used in the implementation of new processes and products. Joint implementation projects, Lean Six Sigma and Six Sigma allows supply chain partners to achieve many benefits, such as improving the technical quality of products, shortening cycles, improve efficiency of processes, increase the effectiveness of internal and external communications, as well as helps to improve safety of processes and reduce environmental negative impact [Aboelmaged 2010, Jauhar, Tilasi, Choudhary 2012, Mollenkopf, Stolze, Tate, Ueltschy 2010].

RESULTS OF THE SURVEY

The subjects of the empirical studies described in this paper were to identify the roll of continuous improvement tools (as QHSE systems as well other concepts as Toyota Production System in building the relationship with suppliers and business clients. The research was carried from September till December 2013. Questionnaires were sent to 3857 operators in Poland in the form of mail survey. 170 questionnaires were successful full completed returned (the result was at 4.4%. response rate). In study were used the purposeful selection of companies (manufacturing and service) located in the base ISO Guide 2012 with the implementation of quality management systems in accordance with international standard ISO 9001. In the study were used a purposeful selection of companies registered in the base ISO Guide 2012. All surveyed companies have implemented quality management systems in accordance with international standard ISO 9001. An important research problem was to determine the segments of the enterprise for which the implementation of continuous improvement tools is the importance of building relationships with partners in the supply chain The results of the survey were presented in the tables below.

Table 1. Number of surveyed companies in terms of implemented continuous improvement tools
Tabela 1. Liczba przedsiębiorstw poddanych badaniu w zależności od wdrożonych narzędzi ciągłego doskonalenia

Segment of enterprises	ISO 9001	14001	OHSAS 18001 /PN-N 18001	TPS	Lean Management	Six Sigma
General	170	63	36	23	25	18
Producers	115	42	22	20	20	15
Service providers	55	21	14	3	5	3
SME (-250 employess)	132	39	23	12	14	9
Large companies	38	24	13	11	11	9
Enterprises with foreign capital	36	22	11	13	15	10
Enterprises with domestic capital	134	41	25	10	10	8

Source: author's research

Table 2. The role of continuous improvement tools in building relationships with clients (percentage rate; comparison of organizations general and in terms of sector, number of employees and origin of capital)
Tabela 2. Rola narzędzi ciągłego doskonalenia w budowaniu relacji z klientami (udział procentowy, porównanie pomiędzy badanymi przedsiębiorstwami ogółem i w zależności od liczby zatrudnionych pracowników oraz od pochodzenia kapitału)

Segment of enterprises	ISO 9001	14001	OHSAS 18001/PN-N 18001	TPS	Lean Management	Six Sigma
General	64.12	44.44	41.67	26.09	20.00	22.22
Producers	65.22	42.86	31.82	25.00	15.00	13.33
Service providers	61.82	47.62	57.14	33.33	40.00	67.67
SME (-250 employess)	61.36	46.15	47.82	16.66	14.29	11.11
Large companies	73.68	41.67	30.77	36.36	27.27	33.33
Enterprises with foreign capital	66.67	45.45	45.45	30.76	30.00	30.00
Enterprises with domestic capital	63.43	43.90	40.00	20.00	10.00	12.50

Source: author's research

Table 3. The role of continuous improvement tools in building relationships with suppliers (percentage rate; comparison of organizations general and in terms of sector, number of employees and origin of capital)
Tabela 3. Rola narzędzi ciągłego doskonalenia w budowaniu relacji z dostawcami (udział procentowy, porównanie pomiędzy badanymi przedsiębiorstwami ogółem i w zależności od liczby zatrudnionych pracowników oraz od pochodzenia kapitału)

Segment of enterprises	ISO 9001	14001	OHSAS 18001/PN-N 18001	TPS	Lean Management	Six Sigma
General	51.76	23.81	22.22	17.39	28.00	22.22
Producers	47.83	21.43	18.18	10.00	20.00	13.33
Service providers	60.00	28.57	28.57	66.67	60.00	67.67
SME (-250 employess)	49.24	28.20	34.78	8.33	21.43	11.11
Large companies	60.53	16.67	15.38	27.27	36.66	33.33
Enterprises with foreign capital	50.00	9.09	9.09	23.08	33.33	30.00
Enterprises with domestic capital	52.24	31.71	28.00	10.00	20.00	12.50

Source: author's research

The results of the study indicate that the use of process improvement tools in building relationships with supply chain partners are interested the service companies. One could that small and medium-sized enterprises by building relationships with customers and suppliers are focused on the implementation of environmental as well as health and safety management systems (EHSMS). On the other hand, large organizations (employing more than 250 employees) and enterprises with foreign capital by building relationships with partners attach particular importance to the implementation of process improvement tools such as concepts like Toyota Production System, Lean Management and Six Sigma. The implementation of these tools brings the partners undoubtedly many significant mutual benefits such as ensuring the quality (technical quality guarantee), increasing the effectiveness (shortening implementation cycles), efficiency (cost reduction), security of processes, reducing the negative impact on the environment, improving the effectiveness of communication in the supply as well the implementation of join project which are focus on product and process innovations.

SUPPORTING PROGRAMS OFFERING FOR TO SUPPLIER TO ACHIEVE CONTINUOUS IMPROVEMENT TOOLS OF PROCESSES

Many international companies seeking to help local suppliers to meet their stringent requirements offer assistance in the form of consulting and training in quality management (for example "Mazda Quality Classes"), or improvement of management systems, especially in areas related to safety and the environment (such as Alcan's Drive for Procurement Excellence, HSE). A similar initiative in establishing this program has Intel Supplier Continuous Quality Improvement (SCQI), which purpose is to assist suppliers in complying with the requirements of the quality management system, environment and safety. Activities in this field by Siemens is also implementing a program PROMEHS (Process Management for Environment, Health & Safety), and setting Assus Green ASUS (GA) - Green Supply Chain Management ASUS, focused on a set of system requirements for improving the environmental aspects of the supplier-Green Product Management System (GPMS). Bosch is trying to educate its suppliers on operational improvement tools like Six Sigma, TPS, or lean management consulting with them on joint projects within the Supplier Development Program. Similar activities also keep the air company British Aerospace, which introduced the Supply Chain Excellence Program, Hewlett Packard taking The Focused Improvement Suppliers Initiative, and LG implementing a Win-Win Partnership Program. Building relationships with customers and with suppliers is a prerequisite for improving the organization and its processes, realized not only through the requirements of quality management standards, environmental, or security management standards, but also other tools such as TPS, Six Sigma, and Lean Management [Arnheiter, Maleyeff 2005, Klefsjö, Bergquist, Garvare 2008, Praxmarer-Carus, Sucky, Durst 2013, Dou, Zhu, Sarkis 2014].

CONCLUSION

Recapitulating, it should be noted that the enterprises define customized requirements to their suppliers through detailed specifications, which determine not only the issues related to ensuring the quality (ensuring technical quality), but also related to the increase in organizational efficiency (shortening implementation cycles), efficiency (cost reduction), safety (working conditions, information management) , reducing negative impact on the environment, and implementation of product and process innovations [We, Wu 2009, Wiengarten, Pagell 2012]. This approach is an important incentive for companies to improve the management system by introducing environmental and safety organizational standards, as well as other excellence tools that require more active involvement of employees in order to improve the performance of operational processes. The actions taken by the company in the field of continuous improvement has a significant impact ongoing globalization. International expansion of many companies, especially global companies increases the importance of technical standardization (to ensure consistent quality required), and organization standardization. This is particularly important in countries where investments are located due to lower labor costs like Central and Eastern Europe and Asia. In these countries, one could perceive a gap in the field of organizational solutions between international corporations and indigenous businesses. In many cases this gap is outweighed by the introduction of the concept of sustainable development. International companies which implement this concept focus on cooperation with their partners in the supply chain (suppliers and customers), offering them support through joint projects. These initiatives are aimed at improving common processes and developing concepts for new products. For many companies, relationships with suppliers are not limited to putting their stringent requirements and continuous improvement on sustain development [Huq, Stevenson, Zorzini, 2014, Fabbe-Costes, Rousst, Taylor, Taylor 2014]. It is increasingly being recognized that the creation of competitive advantage requires the companies to build relationships with suppliers, which manifests itself in joint projects. These projects focus on implementation of product innovations (improving the technical parameters of existing and implementation of a completely new product), and contribute to improvement of organizational performance as well as process efficiency through reducing costs by increasing employee productivity, infrastructure capacity, and eliminate wastes.

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ROLA CIĄGŁEGO DOSKONALENIA NARZĘDZI BUDOWANIA RELACJI W ŁAŃCUCHU DOSTAW

STRESZCZENIE. **Wstęp:** Celem artykułu jest określenie znaczenia systemowego zarządzania jakością oraz środowiskiem, a także narzędzi doskonalenia operacyjnego (takich jak TPS, Six Sigma, czy Lean Management) w budowaniu partnerskich relacji w łańcuchu dostaw.

Metody: W artykule przeanalizowano wyniki badań ankietowych oraz wymagania stawiane dostawcom w zakresie wdrażania elementów systemowego zarządzania jakością oraz środowiskiem, a także zalecenia stawiane im w zakresie wdrażania narzędzi doskonalenia procesów (takich jak elementy TPS, koncepcja Lean Management, czy metodyki Six Sigma).

Wyniki: Przedstawione wyniki badań ankietowych przedsiębiorstw działających w Polsce analiz na zaprezentowanych przykładach wskazują, iż przedsiębiorstwa definiują wobec dostawców często bardzo zindywidualizowane oczekiwania poprzez szczegółowe specyfikacje określające wymagania dotyczące zapewnienie jakości, podwyższaniem sprawności (np. skracanie cykli realizacji), efektywności (obniżaniem kosztów), bezpieczeństwa, zmniejszania uciążliwości dla środowiska.

Wnioski: Na skuteczność podejmowanych działań w zakresie doskonalenia jakości procesów i produktów poprzez budowanie relacji z dostawcami zależy w dużej mierze od udzielonego im wsparcia. W tym celu wiele przedsiębiorstw będących nabywcami wprowadza specjalne programy rozwoju dostawców.

Słowa kluczowe: relacje z dostawcami, systemowe zarządzanie jakością i środowiskiem, narzędzia doskonalenia operacyjnego procesów, TPS, Lean Management, Six Sigma.

ROLLE EINER STÄNDIGEN VERVOLLKOMMNUNG VON VERBESSERUNGS-TOOLS FÜR DEN AUFBAU VON ZUSAMMENHÄNGEN INNERHALB EINER LIEFERKETTE

ZUSAMMENFASSUNG. Einleitung: Das Ziel dieses Artikels ist es, die Bedeutung der Qualitäts-und Umweltmanagementsysteme sowie operative Verbesserungs-Tools (wie TPS, Six Sigma und Lean Management) beim Aufbau von partnerschaftlichen Beziehungen innerhalb einer Lieferkette zu ermitteln.
Methoden: Dieser Artikel enthält eine Analyse der Anforderungen an Lieferanten bei der Umsetzung von Elementen der Qualitäts- und Umweltmanagementsysteme, sowie Empfehlungen für sie, wie man die Prozessverbesserungs-Tools (z. B. Elemente der TPS, das Konzept des Lean Managements bzw. die Six Sigma-Methodik) implementieren soll.
Ergebnisse: Die dargestellten Ergebnisse der Analyse zeigen an präsentierten Beispielen, dass die Unternehmen, die Käufer auf dem B2B-Markt sind, oft sehr individualisierte Erwartungen gegenüber Lieferanten definieren und zwar durch detaillierte Spezifikationen der Anforderungen in Bezug auf die Qualitätssicherung, Leistungssteigerung, (z.B. Verkürzung von Umsetzungszyklen), Effizienz (Kostensenkung), Sicherheit, Reduzierung negativer Auswirkungen auf die Umwelt.
Schlussfolgerungen: Die Wirksamkeit der Maßnahmen zur Verbesserung der Qualität von Prozessen und Produkten durch den Aufbau von Beziehungen mit Lieferanten hängt weitgehend von der Unterstützung ab, die ihnen geleistet wird. Um diese Ziele zu erreichen, leiten viele Unternehmen spezielle Entwicklungsprogramme für die Lieferanten ein..

Codewörter: Beziehungen mit Lieferanten, Qualitäts- und Umweltmanagementsysteme, Werkzeuge der operativen Prozessverbesserung, TPS, Lean Management, Six Sigma.

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THE SURVEY ON CORES SUPPLIES IN THE SME IN AUTOMOTIVE REMANUFACTURING SECTOR

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ABSTRACT. Background: Remanufacturing of automotive components is a developing sector. The majority of companies in this sector belong to the group of SMEs. The remanufacturing benefits to the circular economy concept. The used products referred as "cores" are in the remanufacturing process bring back to as good as new condition. Supply management of cores faces a number of problems, which are discussed in the literature but there is still a lack of empirical studies in this domain.

Material and methods: The research methodology consists of a literature review, where research papers from the Scopus, Science Direct and Business Source Premier databases were used. On the basis of literature review the problems are identified. The pilot survey was elaborated in order to get in depth knowledge on the organization of the cores' supplies in small and medium-sized enterprises (SMEs).

Results: The survey was conducted among 40 SMEs in automotive remanufacturing sector. The paper presents the characteristics of the respondents and it identifies sources of the cores supplies. Authors discuss also the main problems which appear by organization of these supplies.

Conclusions: A remanufacturing process is more complex than the respective production process. The cores' supply management is crucial for profitability of remanufacturing. This paper provides in depth view on the practical issues in the cores supply management regarding source of cores, quality problems, material matching restriction problems and high variety of cores.

Key words: remanufacturing process, suppliers, cores.

INTRODUCTION

Remanufacturing is an industrial process, which allows to bring back the obsolete or worn out products to "like a new" condition. Sudin [2006] defined "remanufacturing is often a more complex process than manufacturing, due to a higher level of uncertainty in process steps and time, as well as unpredictability of cores' (returned products or their parts) quality and quantity". Ostlin et al. [2009] stated "Remanufacturing is an industrial process whereby used/broken-down products (or components) - referred to as "cores" - are restored to useful life". Remanufacturing companies especially small and medium-sized face problems to achieve adequate economy of scale of their operations and an operational excellence. One of the problems which appear is the organization of the supplies of the cores of sufficient quality and quantity.

This paper presents the overview of the literature analysis on management of the cores' supplies. The results of the pilot surveys in Polish SMEs, that are involved in automotive part remanufacturing are presented. At the end of this paper are stated conclusions and are described further research steps.

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THEORETICAL BACKGROUND - CORES SUPPLIES

In the remanufacturing process the equivalent to the raw materials input are used products (known as cores), which are collected from the consumers and then transformed into recovered products. A core has multiple modules that are materially recycled, reused, refurbished or disposed [Jayaraman 2006]. According to Souza [2008]:

- the input to the remanufacturing process (product returns) is uncertain in quality, quantity and timing of arrival,
- the network for collection might be different than forward distributions channels,
- returns with different quality levels have different lead times, costs and capacity usage,
- some returns are unsuitable for remanufacturing and might be scraped or recycle,
- unsuitable cores might be salvage for spare parts.

Guide [2000] indicated some more problems which are relevant to supply of cores:

- the uncertain timing and quantity of returns,
- the need to balance returns with demands,
- the uncertainty in materials recovered from return items,
- the requirements for a reverse logistics network,
- the complication of material matching restrictions.

An efficient cores management process is the backbone of all remanufacturing [Subramoniam et al. 2010]. For that reason the topic of cores' supplies has attracted in recent years attention of researchers in different countries. The recent research on cores' supplies management can be divided as indicated in Table 1.

Table 1. Research related to supply of cores
Tabela 1. Powiązane badania dotyczące dostaw rdzeni

Research problem domain	Main tasks	Example of paper
Pricing of cores	Price setting Relation of production planning and pricing Price sensitivity of supply Core acquisition policy	[Liang et al. 2008]; [Qu,& Williams 2008] [Bakal Akcali 2006] [Teunter, & Flapper 2011]
Demand and supply synchronization	Matching demand with supply Take back policies	[Guide 2003] [Gouza 2008]
Supply chain relationship management	Collection management Relation among stakeholders Closed loop supply chain with remanufacturing Recovery network configuration	[Sundin &Dunback 2013] [Lind et al. 2011] [Wikner & Tang 2008] [Golinska & Kawa 2011]
Decision making on recovery strategy	Remake versus buy Strategic decision framework	[Martin et al 2010] [Subramoniam et al 2010]

Source: own elaboration

This paper contributes to the body of literature on cores' collection. Lind et al. [2011] stated that it is one of the main challenges in the remanufacturing to achieve a steady flow of cores.

There are several ways of organization of core collections. The most common sources of cores are:

- a product exchange (at the end of lease period, or after purchase of new product when the dealership collects the returned cores from the end consumer and sends them back).
- core broker relationship,
- remanufacturing contracts when remanufacturer doesn't owned the core but just provide service,

- deposit systems, when customer at purchase time is placing a deposit, which is given back when the used produced is returned,
- rejected parts from the production plants,
- scrap yards and dismantling stations.

According to the findings of the literature review, companies usually need to apply multiple sourcing strategy in order to achieve steady flow of cores. The literature review helped us to identify also a number of problems which are connected with cores' supplies. The survey on the cores' supplies is discussed in the next section.

THE SURVEY DESIGN

A questionnaire was used to carry out the survey, because it is the most popular tool for collection of an empirical data. To create an on-line survey form was used Google Docs application located on Google. Ability to integrate and transmit data directly into a spreadsheet greatly facilitates the analysis of collected responses. The advantage of this online tool is that results can be presented as statistical charts, cumulative summary of responses, with the possibility of sharing the results obtained so far from all respondents.

The questionnaire consisted of 20 questions (open, closed, semi-open). The semi-open and open questions were structured depending on the topic as e a single choice, multiple choice and Likert's scale questions. Survey is intended to verify the theoretical findings with the facts observed in the companies. Respondents belong to the group of companies specializing in the remanufacturing of automotive parts. Findings are presented in the form of aggregated statistical charts. The respondents gave the answers anonymously. The questionnaire consisted of 4 main domains:

- part 1 characteristics of respondents: including the location, the time company exists on the market, the size of the company and major groups of products.
- part 2 cores supplies organization: including sources of supply of cores and the relationship between remanufacturer and suppliers, quality of supplies, problems in organization of supplies.
- part 3 issues concerning the characteristics of the remanufacturing process: standard lot size, the average duration of the remanufacturing cycle and workload of various stages of remanufacturing process, the level of recovery of remanufacturing, difficulties of cleaning products with dangerous substances, problems with missing spare parts, inventory management issues.
- part 4 barriers to development of remanufacturing.

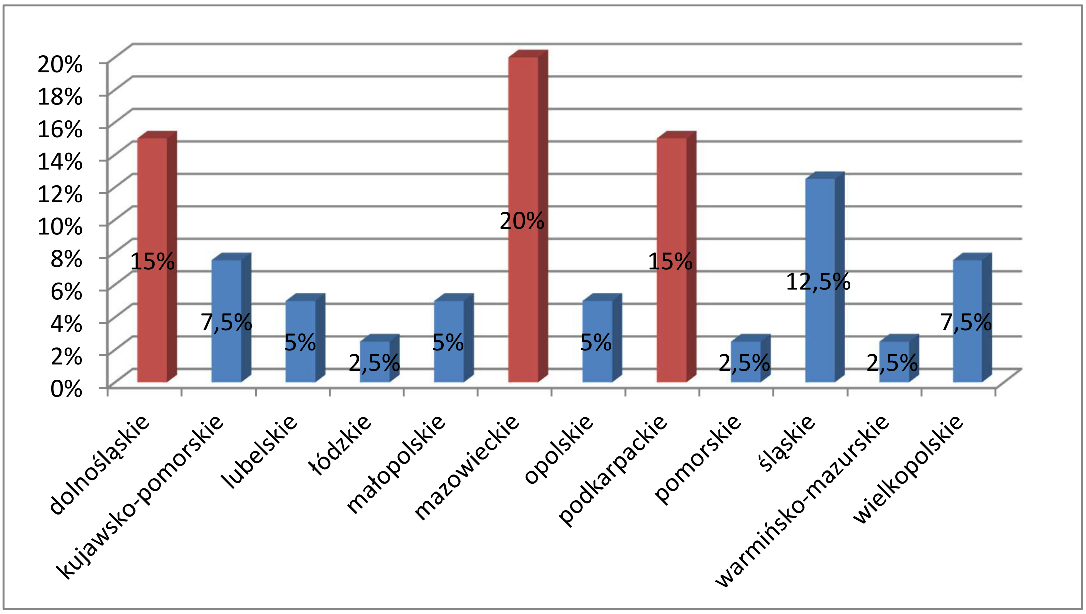
This paper discussed mainly results from part 1 and part 2. The analysis of cores' supplies are performed in order to provide more in depth insight into the problems identified in literature by e.g. Ostlin and Ekholm [2007], Hammond et al. [1998] or Rubio and Corominas [2008]. The main problems of remanufacturing in the areas related to cores supplies, are as followed:

- insufficient availability of the good quality cores,
- high product variability,
- variation of the rate of materials recovered and materials matching problems.

The company for the pilot study were selected based on Internet search with key word: remanufacturing, automotive parts, regeneration. Among companies specializing in remanufacturing of automotive parts, randomly was selected group of 70 companies. Finally 40 of them replied in the framework of the questionnaire. The original method of research was supposed to be the electronic survey, which was sent on given by the respondent (during a brief phone call) email inbox. Because the respond rate was not satisfactory (approx. 4,5 %), the companies were contacted again. In the second round the most of the surveys were conducted as telephone survey (92.5% of the sample) based on the same electronic form which was previously received by the companies. The research team was entering the answers on behalf of the respondents to on-line form during phone conversation. The results of the study are resented in the next section.

SURVEY RESULTS

In the survey was included responds from 40 enterprises specializing in remanufacturing of automotive parts. The survey was addressed to the companies located in all Polish regions. The received responses were from 11 Polish provinces (Figure 1). Most of the surveyed companies, have their headquarters in Mazowieckie Voivodeship (8 companies), Dolnoslaskie and Podkarpackie (6 companies). None of the respondents is located in the administrative district: Świętokrzyskie, Podlaskie, Lubuskie and Zachodniopomorskie Voivodeship (see figure 1).



Source: own elaboration

Fig. 1. Geographical dispersion of the respondents
Rys. 1. Rozmieszczenie firm ankietowanych na terenie Polski

Table 2. Age of companies and the employment - crossed table
Tabela 2. Tabela krzyżowa czasu działania firm na rynku oraz wielkości przedsiębiorstw

	Less than 5 years		5-10 years		More than 10 years	
Small enterprise (up to 49 employees)	0	0%	1	12,5%	3	11%
Micro enterprise (up to 9 employees)	4	100%	7	87,5%	25	89%

Source: own elaboration

Respondents are mainly companies with over 10 years of experience (28 companies) in remanufacturing of automotive parts. The size of companies was as follows: 89% are micro-enterprises employing up to 9 persons, rest of the companies were declaring that their employment is below 49 people.

The analyzed companies specialized in remanufacturing of turbochargers (16 companies), steering gear (9 companies) and cylinder heads (7 companies). Among these can be distinguished companies that specialize in one type of products' group, or those whose activity is enhanced by additional products. The most typical lot size (87.5% of the sample) is single product's group. The main reasons which the companies gave in order to explain a strong focus on single products' group were, as followed:

- different types of products from different car models whose dismantling instructions are different,
- each core having different worn components,

– the degree of consumption of individual elements is different for each cores.

The answers obtained from companies confirmed the theoretical statement that in remanufacturing there is a very high variety of products models (products proliferation). The respondents explained that despite remanufacturing of single products' group (e.g. turbochargers) they still have to deal with hundreds of different variants of products, which belonged to different products' generation.

In order to additionally verify the problem of products proliferation, the companies were asked about the standard size of lot size in their remanufacturing process. As presented in Figure 2, majority of respondents (87,5%) remanufactured mainly one-piece orders. Only 5% of respondents are able to achieve the lot sizes of 6-20 pieces. Such situation influences organization of the cores because companies have to deal with high variety and complexity. This remark is consistent with the results of previous research.

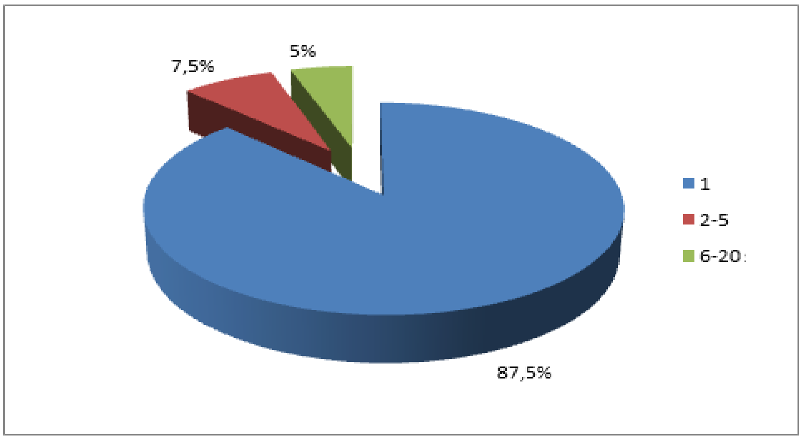


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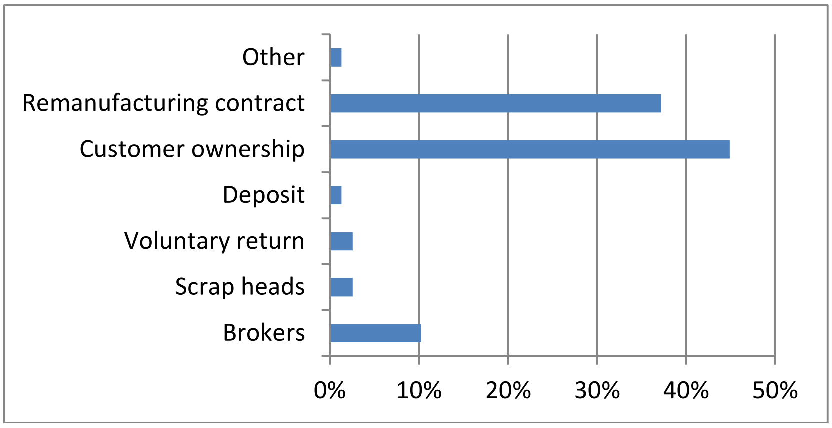
Fig. 2. Typical lot size in analyzed remanufacturing companies
Rys. 2. Najbardziej typowe wielkości partii poddawane regeneracji fabrycznej



Source: own elaboration

Fig. 3. Sources of cores
Rys. 3. Źródła pozyskiwania rdzeni

The respondents gave answers to various questions relating to the way in which they acquire cores for the remanufacturing, the countries from which they came from, and the barriers they encounter when obtaining cores.

The companies were also asked about the frequency of orders, standard delivery time, as well as problems with the quality of the supplied cores.

Figure 3 presents the sources of cores' deliveries. This question was a multiple choice from the available suggestions, which were identified, based on the literature review and were defined as followed:

- purchase from core broker (B),
- purchase from scrap yard or dismantling station,
- voluntary free of charge return by user,
- deposit agreement,
- remanufacturing service for individual customer (customer ownership (C)),
- remanufacturing contract for services for another company (client provides cores (RS)),
- other.

Most companies remanufacture products which are owned by customers (35 replies) or they remanufacture for companies with whom they have agreements for services (29 replies). Those who take the challenge to acquire cores from intermediaries usually decided to cooperate with so-called. brokers cores (8 replies) or they buy products, e.g. through the website. Most of the companies apply mixed approach to the cores purchase and they use more than one source of supplies.

Most of the respondents obtained cores exclusively from Poland (30 companies). Several companies (22.5% of the sample) apply mix sourcing and they obtain cores from Polish and from an import. Only one company declares that the cores come exclusively from the import. Respondents indicated the countries from which most imported cores are coming from, which are: Germany and the United Kingdom (each gets 6 replies), and France (4 replies). In case of countries from outside the European Union dominates Ukraine (3 replies).

The next question focused on the problems with obtaining cores from Poland. The results are presented in Figure 4.

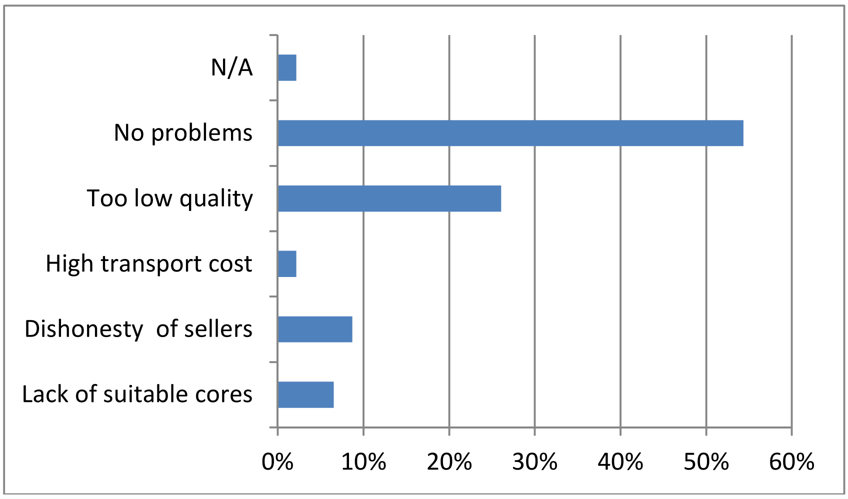


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Fig. 4. Problems by cores' supplies from Poland
Rys. 4. Problemy podczas pozyskiwania rdzeni z Polski

Barriers encountered when acquiring cores to remanufacturing from the territory of Poland are not big (Fig. 4). Mainly it's too low quality of obtained cores. A small group of companies complain about dishonesty of sellers (4 respondents). Most companies believe that the difficulties in getting the cores from the territory of Poland do not exist. The opinions of the respondents are mainly influenced by the fact that most of them provide mainly remanufacturing services for individual customers and other companies, so they don't need to buy cores.

Analogical question was stated in order to identify problems which might appear by import of cores but due to the fact that very few respondents are importing the cores the results are not analyzed in this paper.

The other aspect which was analyzed was frequency of cores supplies. Figure 5 presents the results. The frequency of placing orders for cores was very difficult to define. Most of the companies (65% respondents) have stated that they don't monitor order placing frequency because it is unpredictable and it depends solemnly on customer demand, which varies seasonally. Hence the conclusion is that the lack of order, results in the lack of a specific delivery date for cores, and so it is impossible to specify the length of the delivery lead time. The next group of companies (25% of the sample) admits that customers provide the cores to every day, therefore it can be concluded that by them the order takes place with such frequency.

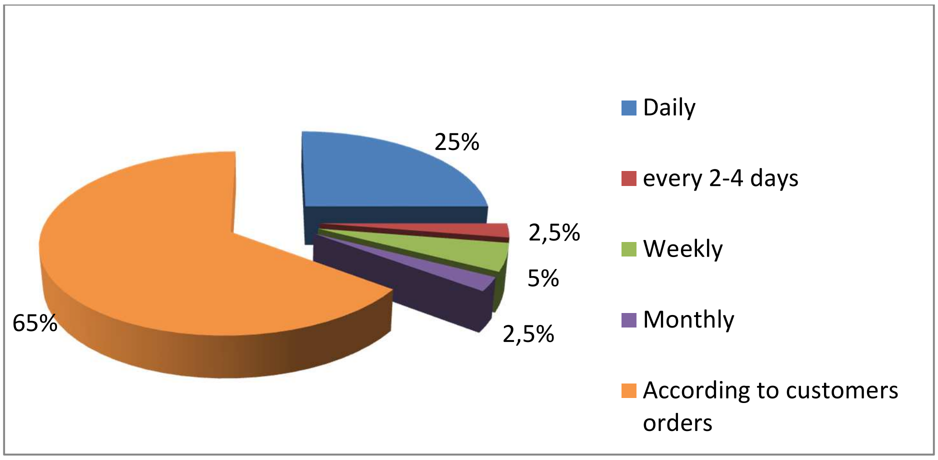

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Fig. 5. Frequency of placing orders
Rys. 5. Częstotliwość składania zamówień na rdzenie

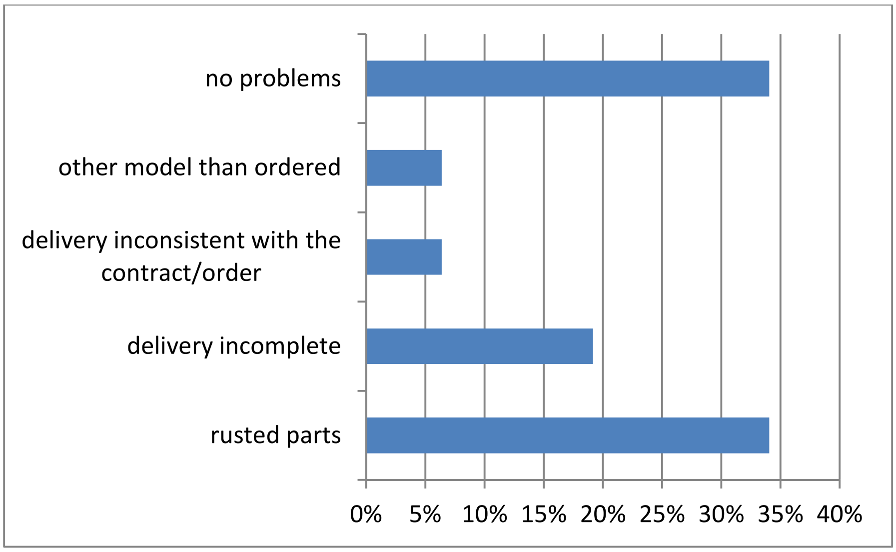

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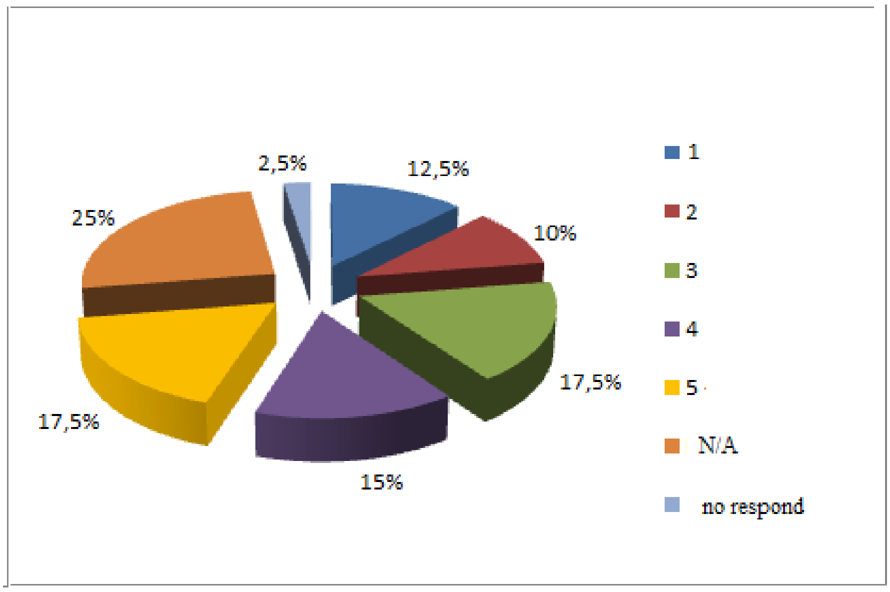
Fig. 6. Quality problems in cores' delivery
Rys. 6. Pojawiające się problemy, z jakością rdzeni

The next problem which is addressed in the survey is quality of cores (see Fig 6). The interviewers suggested several typical difficulties described in literature (multiple choice question):

- rusted parts,
- delivery incomplete,
- delivery inconsistent with the contract/order,
- other model than ordered,
- no problems with quality.

Companies have confirmed that frequently appearing problem is corrosion of parts and the incomplete deliveries. A significant proportion of respondents declared that there is "no problems". In addition to rusted parts, it is the most common answer among respondents. This finding might result in the fact that when providing remanufacturing services and dealing with one piece lot size companies are used to remanufacture any core disregarding its quality.

The last factor that strongly affects remanufacturing process is the lack of spare parts used for re-assembly stage. The problem is related to the time of launching the product on the market. Among the available models of cores are both old and new models. They have a limited number of spare parts, as partially or completely withdrawn them from the market already (old products) or have not yet been introduced to the market (new products).



Source: own elaboration

Fig. 7. Problems with matching parts in cores
Rys. 7. Trudność z brakującymi elementami zamiennymi do powtórnego montażu

We have examined the importance of this issue. The respondents have assessed this problem on Likert scale where: 1 means low importance of this problem, and 5 means very high importance of this problem. The results are presented in Figure 7. Majority of companies confirm that the matching parts problem is important regarding cores' management (answers on Likert scale from 3 to 5). Very few of the respondents (2,5%) denied to answer this question. A big group of companies (25%) stated that this problem is not applicable (25%) to them. That finding might result from the fact that remanufacturing companies, which provide remanufacturing services try to fullfill any order they received and try to make in-house missing components.

CONCLUSIONS

The paper presents the summary of the literature study on cores' supply organization. The theoretical findings were then empirically verified in the pilot study, which was conducted in SMEs in automotive remanufacturing sector. The respondents provide the empirical data in domains:

- identification of cores supply,
- problems by cores' supply,
- products proliferation,
- quality of cores,
- material matching problems.

Authors in the survey try to receive in depth inside in cores' supply organization regarding the problems described in the literature, such as:

- insufficient availability of the good quality cores,
- high product variability,
- variation of the rate of materials recovered because of materials matching problems.

Most of the respondents remanufacture one piece lot sizes. The variety of products is very high. About 50% of companies confirm that material matching restrictions are an important problem (assessment 3-5 in Figure 7). Regarding quality problems companies mainly have to deal with rusted parts and incomplete deliveries. Significant group of companies declare that quality of cores problem is not relevant to their case. During phone survey they explain that such statement is based on the fact that they don't owned the cores. The further research step will include the extension of the respondents group and continuation of the pilot study with focus on medium size companies.

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BADANIE ORGANIZACJI DOSTAW "RDZENI" W MŚP ZAJMUJĄCYCH SIĘ REGENERACJĄ CZĘŚCI SAMOCHODOWYCH

STRESZCZENIE. **Wstęp:** Regeneracja części samochodowych jest rozwijającym się sektorem w Polsce. Większość firm w tym sektorze należy do grupy małych i średnich przedsiębiorstw (MŚP). Regeneracji pozwala osiągnąć korzyści wynikające z zamykania pętli przepływów materiałowych w łańcuchu dostaw. Używane produkty określane jako "rdzenie" są w procesie regeneracji przywracane do stanu pierwotnego. Zarządzanie dostawami rdzeni jest kluczowe dla opłacalności procesu regeneracji jednak napotyka na szereg problemów, które zostały omówione w literaturze, ale nadal brakuje badań empirycznych w tym obszarze.
Metody: Przeprowadzono badania literaturowe, w tym celu przeszukano bazy Scopus, Science Direct and Business Source Premier dla kryterium "remanufacturing" i "cores". Na podstawie przeglądu literatury zostały zidentyfikowane problemy w obszarze organizacji dostaw rdzeni. Następnie zostały zrealizowane pilotażowe badania w celu uzyskania dogłębnej wiedzy na temat organizacji rdzeni dostaw w małych i średnich przedsiębiorstwach (MŚP).
Wyniki: Badanie zostało przeprowadzone wśród 40 przedsiębiorstw z branży zajmującej się regeneracją części samochodowych. Artykuł prezentuje charakterystykę respondentów oraz identyfikuje podstawowe źródła dostaw rdzeni w analizowanych przedsiębiorstwach. Autorzy również omawiają główne problemy, które pojawiają się przy organizacji dostaw rdzeni. Artykuł prezentuje analizę odpowiedzi respondentów w zakresie identyfikacji źródeł dostaw rdzeni, problemów związanych z jakością rdzeni oraz z czasami dostaw.
Wnioski: Proces remanufacturingu jest znacznie bardziej skomplikowany niż proces produkcji pierwotnej dla analogicznego produktu. Zarządzanie dostawami rdzeni ma kluczowe znaczenie dla rentowności regeneracji. Ten artykuł prezentuje próbę analizy zagadnień dotyczących: źródła pochodzenia rdzeni, problemów z ich jakością, trudności związanych z doborem brakujących elementów w rdzeniach, różnorodność rdzeni.

Słowa kluczowe: proces remanufacturingu, rdzenie, dostawcy

Golinska-Dawson P., Nowak A., 2015, The survey on cores supplies in the sme in automotive remanufacturing sector. LogForum 11 (1), 51-61. DOI:10.17270/J.LOG.2015.1.5
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UNTERSUCHUNG DER ORGANISATION VON ANLIEFERUNGEN DER "KERNE" IN KLEIN- UND MITTELSTÄNDISCHEN UNTERNEHMEN, DIE SICH MIT REGENERATION VON AUTOERSATZTEILEN BESCHÄFTIGEN

ZUSAMMENFASSUNG. Einleitung: Die Regeneration von Autoersatzteilen stellt einen sich sehr gut in Polen entwickelnden Sektor dar. Die meisten Firmen in diesem Segment gehören zur Gruppe klein- und mittelständischer Unternehmen (KMS). Die Regeneration erlaubt es, die aus der abschliessenden Abrundung von Materialfluss-Zirkulationsschleifen in der Lieferkette resultierenden Vorteile zu erzielen. Die angewendeten, als "Kerne" bezeichneten Produkte werden im Prozeß der Wiederaufbereitung bis auf ihren Primärzustand zurückgewonnen. Das Management von Anlieferungen der Kerne ist ausschlaggebend für die Rentabilität des Wiederaufbereitungsprozesses. In der Praxis stießt er aber auf eine Reihe von Problemen, die zwar in der Gegenstandliteratur behandelt wurden, wobei immer noch empirische Untersuchungen in diesem Bereich ausbleiben.

Methoden: Es wurde eine gezielte Litraturrecherche vorgenommen. Zu diesem Zweck hat man die Basen: Scopus, Science Direct und Business Source Premier für die Kriterien: "remanufacturing" und "cores" (Regeneration und Kerne) in Anspruch genommen. Auf Grund der Literaturrecherche wurden die im Bereich der Organisation bei der Anlieferung der Kerne auftretenden Probleme identifiziert. Demzufolge wurden die einleitenden Untersuchungen zwecks Ermittlung eines Fachwissens zum Thema der Anlieferungen der Kerne in den klein- und mittelständischen Unternehmen (KMS) in Angriff genommen.

Ergebnisse: Die Untersuchungen wurden in 40 Unternehmen aus der Branche der Wiederaufbereitung der Autoersatzteile durchgeführt. Der Artikel stellt eine Chrakteristik der betreffenden Respondenten dar und ermittelt die Haupt-Bezugsquellen für die Kerne innerhalb der analysierten Unternehmen. Die Autoren gehen auf die wesentlichen Probleme, die bei der Organisation der Kerne-Lieferungen auftauchen, ein. Darüber hinaus pojiziert der Beitrag die Analyse der Antworten seitens der Respondenten bezüglich der Identifikation der Bezugsquellen für die Kerne, ferner der mit der Qualität der Kerne zusammenhängenden Probleme sowie bezüglich der betreffenden Lieferzeiten zuletzt.

Fazit: Der Wiederaufbereitungsprozeß ist viel mehr komplizierer als der Proze? primärer Herstellung des analogischen Produktes. Das Management der Lieferketten bei der Anlieferung der Kerne hat daher eine grundlegende Bedeutung für die Rentabilität des Regenerationsprozesses. Der Artikel präsentiert Versuche einer Beantwortung der folgenden Fragen, die auf die Analyse der Bezugsquellen für die Kerne, auf die Analyse der die Qualität anbetreffenden Probleme, ferner der mit der Auswahl von fehlenden Elementen und Baugruppen zusammenhängenden Schwierigkeiten sowie auf die Vielfalt der Kerne zurückgehen..

Codewörter: Wiederaufbereitungsprozeß, Kerne, Lieferanten

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MODELLING AND SIMULATION OF THE INTEGRATION OF THE SUPPLY CHAIN OF FORWARD AND BACKWARD TYPE

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ABSTRACT. Background: The integration, besides synergy and convergence, is regarded as a leading orientation in modern logistics. The connection of various participants within supply chains enables the integration of actions and allows to fulfill growing customers' demands in an effective and economically efficient way. In times of a concept of the balanced development, growing interest in utilization of recycled material, connected with possibilities to consolidate logistic activities, can be observed. According to the scientific literature (integration models) as well as practical business cases, supply chains of forward and backward type (two-directional) are the area of logistics of the intensive development.

Material and methods: The paper presents the Authors' model and methodology of modeling of the integration of supply chains, which realizes the flows of forward and backward type (two-directions). The empirical material was obtained during modeling and simulation of processes in the environment of iGrafx Process 2013 for Six Sigma with the support of Minitab 17 (for planning of experiments). The method of the verification of statistical hypotheses was used. As a first step, the correlation between the level of the integration and the global service level for the supply chain was conducted using the method of Pearson's coefficient. The test of relevance of correlation coefficient was conducted by the use of t-distribution method. Then the verification of statistical hypotheses was made, based on the method using the Z-statistics.

Results: The obtained results indicate clearly the strong relationship between the level of the integration of a supply chain and the obtained service level (values of Pearson's correlation coefficient and results of t-test). The detailed statistical researches of authors indicate that the increased level of the integration leads to the increase of the average value of service level coefficient (results of Z-statistics). Concluded, the analyze of the service level indicator shows its growth together with the growth of the integration level.

Conclusions: Based of integration aims, the integrated systems should have bigger possibility of activity. The possibility to obtain higher customer service level is one of postulated effects ("gains") of the integration of supply chains. The results of Authors' researches confirmed such statement in quantitative way, and not only in a describing one. The conclusions from conducted researches encourage to integration activities within supply chains of forward and backward type.

Key words: supply chain of forward and backward type, supply chain models, methodology of integration of supply chain, customer service level in supply chain.

INTRODUCTION

The integration is the process of creation the wholeness from many parts [Sobol 2001]. The integration means connection, consolidation, merge or unification, which could embrace companies, departments of companies as well as whole processes (functions) covering business relationships between partners.

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According to the traditional approach, most of companies see themselves as individual units, operating independently and competing with others on the market. But in fact, not individual companies but whole supply chains should compete with each other. The first phase of the integration is the internal integration with the focus put on the creation of close interfunctional connections within the organization. The second direction of the integration is the external integration, focused on the creation of close connections between partners operating within the same supply chain as well as on the managing of this supply chain [Hadaś 2010].

The problem of the integration of different operational systems occurs during the process of the creation of a supply chain or a logistic network. There are various reasons of the connection of different systems. The most common one is the attempt to enlarge the power of the system as well as to increase the level of reliability and affectivity of the operational activity [Konieczny 1983]. The result of the integration process is the affiliation to one integrated system. And this is the source of gains as well as integration costs for every system. The integrated systems should have bigger operational possibility and at the same time lower system wastes (integration gain). The integration process gives also negative effects, especially in case when too many efforts are put into the support of integration connections. In such situations, the integration gain is very small and sooner or later the integration of systems breaks down [Brzeziński 2007]. The modeling and process simulation tools are presently used to support the researches of the integrations [Adamczak, Domański, Cyplik, Pruska 2013]. The main trend is to assure the effective complex material flow, which determines various factors [Śliwczyński, Koliński 2012].

Many scientists have opinion that the solution of problems in reality should be analyzed by the use of models [Cempel 2003]. The model means the simplified representation in time and space, created for better understanding of a real system. And the modeling process means searching for features and connections within the system, which are essential for a given aim. The simulation means the model manipulation in such a way, that it works in different scale in time and/or space-time dimension and enables to observe behaviors and influences, which are usually difficult or unable to be observed. Therefore the simulation means the compression or expansion of time-space scale of phenomenon on demand [Cempel 2006]. And thanks to this feature, the simulation is a desirable tool both in original as well as in applied researches [Cempel 2003].

LOGISTIC CHAINS OF FORWARD AND BACKWARD TYPE

The supply chains were originally created to support the flows from the production of raw materials up to finals customers. But at present the return flows within these chains become more and more important as well [Sadowski 2010]. The modern logistics has to be able to solve problems of remains of production batches, goods returns, warranty and post-warranty service, production wastes, packaging and packaging wastes. All these issues are covered by so-called reverse logistics [Brdulak 2012].

The common element of presented definitions is the direction of the flow - return to traditional operations of logistic chain, i.e. from the point of creation of wastes, consumer or consumption place to the place of the utilization or the place of the origin. The citied definitions differ from each other in the aim of undertaken operations - it could be the reuse of materials, return of the value of products taken from the market, the proper recycling or the optimization of after-sale services and the reduction of costs.

The logistic chain of forward type (traditional forward chain) covers the processes related to the production and the distribution of goods, i.e. their flow from the place of origin of raw materials to the place of their final consumption (i.e. final customer). The logistic chain of backward type (return chain) covers the processes of the return and the collection of used products [Seitz, Wells 2006], as well as the processes connected with their recycling, i.e. their flow from the place of final consumer to the producer (from the point of view of a given chain). The returned product can be disassembled up to modules, parts or materials [Wikner, Tang 2008] during the backward processes. The aim of this process (e.g. during recycling) is to restore the original market value of the product [Gupta, Pochampally 2004]. The flow from the moment of the realization of any operation on the product such as segregation, washing, repairs or recycling, is considered to be the flow of forward type.

Table 1. Selected definitions of reverse logistics
Tabela 1. Wybrane definicje logistyki zwrotnej

APICS dictionary	The whole supply chain covering the return flows of goods and materials in order to return them, repair them, regenerate them and/or recycle them.
Council of Logistics Management	The reverse logistics covers the logistics management of abilities and operations of recycling and management of products' and packaging' wastes. It includes the reverse distribution, which causes the flow of goods and information in the opposite direction to standard logistic operations.
Reverse Logistics Association	All operations connected with the product or service, which take place after the moment of the sale transaction, focused mainly on the optimization of after-sale operations and therefore on the cost reduction.
Reverse Logistics Executive Council	The process of planning, implementation and controlling of the flow of raw materials, stocks and used products, as well as information flows connected with them, from the place of consumption to the place of origin of the goods, which is conducted to restore their value or at least of part of invested resources or leads to the proper utilization of the product

Source: own s [based on: Szołtysek 2009, Brdulak 2012]

OVERVIEW OF MODELS OF THE INTEGRATION OF SUPPLY CHAIN

The authors of 5-level model of the development of a supply chain (so called Compass model) state, that obtaining higher consecutive level depends on the implementation of more and more sophisticated information technologies [Simichi-Levi, Kaminsky, Samichi-Levi 2000]. These technologies change together with changes occurring in the supply chain and should be adjusted to present organization solutions and planning systems. According to authors of a described model, each type of company activity could be at different level of the integration of the supply chain.

Table 2. 5-level model of the development of a supply chain (so called Compass model)
Tabela 2. Pięciopoziomowy model rozwoju łańcucha dostaw - model Kompasu

Name of the level	Criteria			
	aim	organization	planning	information technology
I Basic	quality and cost	independent sections	calculating sheet	atomization and MRP
II interfunctional teams	customer service	creation of logistics departments and operational management	goals setting e.g. CPM, PERT	MRP II
III integrated company	reaction on profitable clients	integrated internal supply chain	planning of company's supply chain	ERP
IV expanded supply chain	profitable growth	integrated external supply chain	planning of sale points in a supply chain	CRM
V community of the supply chain	market leadership	ability of the prompt reconfiguration	synchronized planning of a supply chain	net trade

Source: Witkowski 2010

According to first version of Ch.C.Poirier's model, the advanced supply chain can be reached by the 4-step method, consisting of two levels of the internal integration and consecutive two levels of the external integration [Poirier 1999]. According to

Ch.C.Poirier, as many as 80% companies do not go further than only to the second level. The most difficult level is connected with overcoming the borders of an own company. Therefore the newest version of this model includes 5 levels of integration with one additional level of the external integration consisting in starting the cooperation with partners [Poirier, Quinn 2004].

Table 3. 4-level model of supply chain development according to Ch.C. Poiriera
Tabela 3. Czteropoziomowy model rozwoju łańcucha dostaw Ch.C. Poiriera

Elements	Level			
	internal		external	
	purchase and logistics I	internal perfection II	network construction III	leadership in sector IV
initiator	manager of purchase department (under pressure)	manager of IT department of future chain leader	leaders of business units	management team
profitability	increase of savings	priority improvement	results of best partnership	network profits, profitability
concentration	stocks, logistics, transport, orders fulfillment	redesigning of processes, improvement of systems	forecasting, planning, customer service, extended company	client, network
tools	team work, functional perfection	benchmarking, best examples, balance of operational costs	coefficients, databases, e-trade	Intranet, Internet, common information systems
area of operations	middle level of company	various levels of organization	whole organization	whole company
points of reference	cost registry	map of processes	advanced cost models, differentiation of cost	demand-supply relation
model	lack	internal supply chain	extended company	global market
alliances	consolidation of supplies	best partner	formal alliances	Joint venture
schooling	team	leadership	partnership	network

Source: Witkowski 2010

Table 4. Stevens' four-level model of the development of the supply chain, extended by Potter and others
Tabela 4. Czteropoziomowy model rozwoju łańcucha dostaw Stevensa rozwinięty przez Pottera i innych

Characteristics		**Phase I**	**Phase II**	**Phase III**	**Phase IV**
Flow of goods		functional, uncoordinated	internal coordination within the organization	external coordination within the organization	integrated within the supply chain
Stocks		high level, double stocks	buffered for each function	unaccepted within the organization	minimized within the supply chain
customers' service level		low	reduced within the organization	reduced within the supply chain	high
informantion flow	decisions centers	many	one for the process	one for organization	steering is coordinated within one center
	data transfer	traditional, paper documents	based on personal computers	E-commerce	E-business
	data availability	lack	within internal logistic processes	within the organization	full accessibility within the supply chain
information systems		separated, incompatible	MRP type	ERP type	integrated DRP
orientation		recourses	internal costs	external costs	oriented on client
relations management		contracts, agreements	extended cooperation	common management at the organizational level	common management at all levels
basic indicators		lack	functional	operational	for supply chain

Source: Potter et al., 2005

Stevens [1989] distinguished four phases of the evolution of a supply chain with the growing level of the integration. Potter, Mason, Naim and Lawlani [2005] extended this model und added four basic characteristics of the supply chain, which were referred to four integration phases.

The research model of the integration, based on the model of Cai, Jun and Kim [Cai, Jun, Kim 2009], is presented by M.D.Dobrzyński. The model consists of three main areas: supply chain, IT technologies and behaviors. The integration factors are selected within these perspectives. According to the author, the choice of integration measures is made quite freely by researchers and is weakly argued. The higher level of specification of the measurement of the integration of the supply chain allows the objective estimation of individual characteristics in practice [Dobrzyński 2008].

Table 5. Dobrzynski's four-level model of the development of the supply chain
Tabela 5. Czteropoziomowy model rozwoju łańcucha dostaw M.D. Dobrzyńskiego

Characteristics	Internal integration		External integration	
	phase I	phase II	phase III	phase IV
flow of goods	uncoordinated	internal coordination within the organization	external coordination within the supply chain	external coordination within the global supply chain
stocks management	many decision centers	one center for organization	common management within the supply chain	common management within the global supply chain
identification of stocks level	based on historical data for organization	based on current stocks for organization	based on historical data for supply chain	based on current stocks for supply chain
data transfer	traditional, on paper	local computer network LAN	Internet	Internet and Intranet
information systems	separated	MRP type	ERP type	DRP type
sale support	cooperation within the organization	occasional cooperation of sale represents within the supply chain	common marketing cooperation	cooperation at the level of designing and introduction of a product
management of relationships between participants	informal relationships	cooperation within organization	agreements, contracts, common standards of operational management	common standards of strategic management
effectiveness indicators	lack	operational ones for organization	operational ones for supply chain	strategic ones for supply chain

Source: Dobrzyński 2009

Three levels of the development of the supply chain were identified during the research conducted by the A.T. Kearney company, which correspond to levels of the integration of its parts [Rutkowski 1999]. In this case, the bigger number of characteristics (comparing to Compass model) to distinguish following levels of the perfection of integrated supply chains were adopted. According to authors, although the trend to the cost reduction is the most important one at the level of the internal integration, the main goal of the integrated supply chain is the maximization of gains and market shares, which leads to the increase of the value of participants.

The oldest type of models of a supply chain is so called model of maturity of the supply chain. The model of maturity of the supply chain is presented in SCOR model (Supply Chain Operations Reference) consisting of four levels [Cohen, Roussel 2004]:

- level 1 - functional integration - the goals are set for separate functional areas of the company,
- level 2 - internal integration - the goals are set for whole company, during optimization

processes, the best solutions are searched based on clients' needs and availability of resources,
- level 3 - external integration - the goal are set not only for one organization but as well for companies cooperated with it,
- level 4 - cooperation of companies - sharing of strategy, risks and market possibilities.

Table 6. Three-level model of the development of the supply chain accoridng to A.T. Kearney
Tabela 6. Trójpoziomowy model rozwoju łańcucha dostaw A.T. Kearney

Area	Level I	Level II	Level III
orientation on client	– treating each transaction uniquely	– all clients are treated in the same way – achieving internal goals – monitoring of clients' expectations	– providing differential services – fulfillment of clients expectations
integrated long-term planning	– partial planning – concentration on the budget of a department	– MRP philosophy – small range – (e.g. of production) – concentration on stocks – 1-3 years time fence	– full range of logistics services – optimization of integrated added value – integrated procedures and systems – (e.g. MRP, DRP) – 3-5 years time fence
partnership with suppliers	– crisis situations – spontaneity – contrast	– main criteria - costs – many sources – orientated on auctions (competition)	– main criteria - results – partnership – common improvement
above-functional planning of operational activities	– current – occasional (each transaction)	– periodical (e.g. quarterly) – based on budget period	– time continuity – integration of all functions
continuous improvement of processes	– improvement by "repairing of damages"	– formalization of the process – cost reduction – average quality	– acceptance of CEO – continuous improvement by objectives – quality and effectiveness
competences of employees	– management against employees	– limited engagement of employees	– schooling – competences – common goals (rewards)
integrated IT system	– IT processing of transactions – lack or not enough data – lack of analytical abilities	– periodical reports of financial results – fragmentary data – limited abilities of analysis	– planning process based on operational data – easy access to common data – flexible possibilities of analysis
monitoring, comparing and undertaking repair actions	– comparing costs with previous year – costs as percentage of sale	– costs vs. budget – increase of productivity – competitiveness of services	costs vs. standard productivity vs. aim services in accordance with clients' expectations

Source: Witkowski 2010

The other model of the maturity of the supply chain can be found in researches of Pache and Spalanzanihave [Pache, Spalanzanihave 2007]. They proposed five-level model including social elements:
- level 1 - internal maturity of the organization - effectiveness is achieved by the integration of various functional areas within the organization,
- level 2 - maturity among organizations - cooperated companies (suppliers, services suppliers and clients) are engaged in achieving better effectiveness,
- level 3 - extended cooperation among organizations - all cooperated companies (suppliers, services suppliers and clients) are engaged in achieving better effectiveness,
- level 4 - maturity among supply chains - companies, being a part of few supply chains at the same time, are able to increase the effectiveness through the cooperation with big number of other entities,
- level 5 - social maturity - organizations look for best solutions not only for themselves but also for the whole

community, within which they function, the emphasis is put on the balanced development.

MODELS OF A SUPPLY CHAIN INCLUDING THE BACKWARD FLOWS

The authors' team from Lisbon [Cardoso, Ana Paula, Barbosa-Povoa, Relvas 2013] proposed the model of a supply chain, realizing two-direction flows. The aim of this model is to create a structural solution (choice of the structure of a supply chain) to maximize NPV indicator (net present value) in the situation of the uncertainty of the demand. The elaborated model describes four levels:

- producer - conducts the production process, utilizes the raw materials, delivers final goods, disassembles the used goods,
- warehouse - stores the final goods, disassembles the used goods (including the completion for the purpose of sale),
- sale network - provides goods to the market and keeps them in form of stocks in distribution network,
- market - generates the demand, utilizes final goods, provides used goods.

The final goods, in the described model, can be destined to the market through the distribution network, from the warehouse or directly from the production plant. The backward flow of used goods takes place from a client (market) to various points of the supply chain. The used goods (or their parts) go also outside the described structure and are identified with wastes (are not used within the analyzed chain structure).

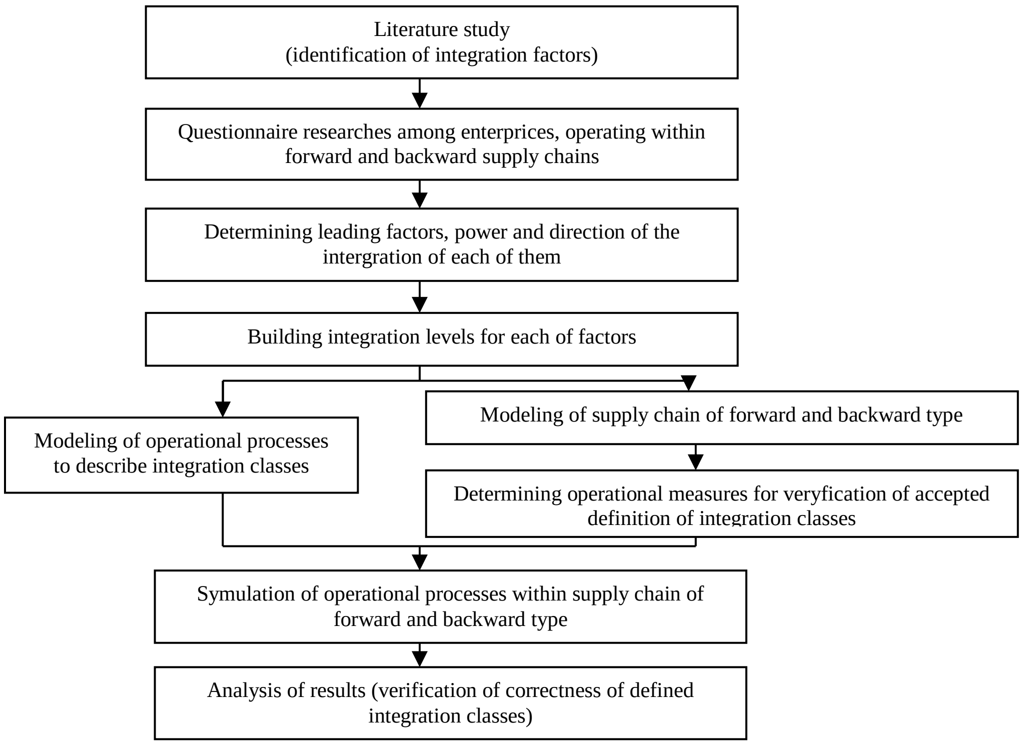
The authors' team from Indonesia and China [Jonrinaldi, Zhang 2013] presented the proposal of the model of the integration of products and stocks with regards to backward logistics in a finite time period. Total costs of functioning of the supply chain (of each part among mentioned below) are the aim function of this model. The model assumes the existence of a supply chain of 6-level structure. Its elements are:

- suppliers of 2nd degree - e.g. suppliers of raw materials,
- suppliers of 1st degree - e.g. entities processes the raw materials into components,
- producer - entity manufactures components and assemblies final goods,
- distributors - entities, which are responsible for storing final goods and delivering them to sale networks,
- sale networks - deliver of final goods directly to final customers,
- logistic partner - entity, which specializes in collecting used goods from the market and delivering them to the producer.

The described model was used by authors to inspect the influence of the coordination of the production process with stocks in conditions of the supply chain performing both forward (from producer to client) and backward (from client to producer) goods' flow on total costs of functioning of such supply chain.

AUTHORS' METHODOLOGY OF MODELING OF THE INTEGRATION OF A SUPPLY CHAIN

Modeling of the integration of a supply chain is a process connecting both theoretical and practical aspects. The first step in preparing such model is the identification of integration factors by the analyze of the scientific literature. Based on the definite set of integration factors, the questionnaire form was prepared as a research tool. Then based on questionnaire results, the leading factors, powers and directions of the integration of each factor were determined. As a result of this, the integration levels within each factor were distinguished. Each of these levels (A, B, C, D, where A is the highest one) has a defined characteristics of activity, which allows to estimate its activity within the supply chain (by assigning to the proper level). While characterizing the integration levels, the focus was put by authors on the integration symptoms or the lack of them. The actions of the following step can be realized simultaneously. Namely, operational processes within a supply chain are modeled together with their measures of the effectiveness. Additionally the presentation of the integration level is worked out. The realization of this last mentioned task means to modify operational processes in such a way, that the features, identified at the phase of building of integration classes of individual factors, are assigned to them. The last step of this methodology is the simulation of operational processes in various variants of the integration levels of the supply chain. The schematic presentation of the methodology of modeling of the supply chain is presented at the figure 1.



Source: own study

Fig. 1. Author's methodology of modeling of the integration of a supply chain
Rys. 1. Autorska metodyka modelowania integracji łańcucha dostaw

The most important element of presented methodology is the verification of the correctness of defined integration classes. This action allows to verify the correctness of accepted assumptions and at the same time to prepare the recommendations for practicians regarding the effectiveness of individual integration activities. The verification method is presented in the chapter "Results" of this paper.

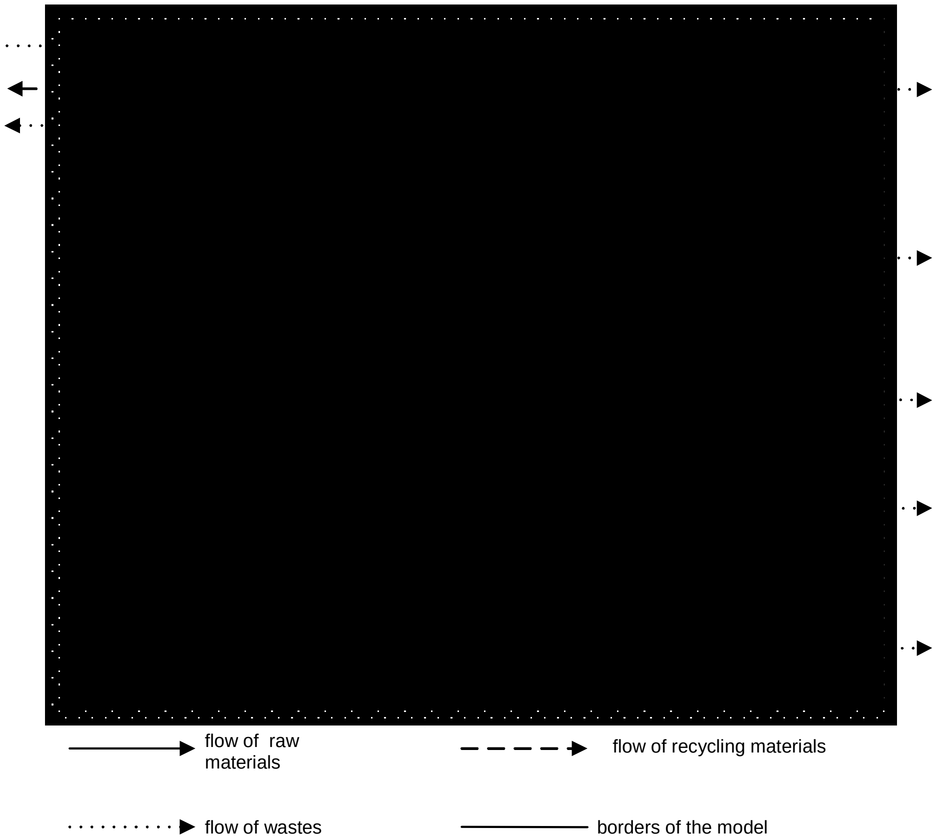
DESCRIPTION OF THE SIMULATION MODEL

Based on the models of the integration of the supply chain, both realizing only one-direction flow (only forward) or two-direction flow (both forward and backward), the authors of this paper created their own model of the supply chain, which covers both the flow of original materials as well as waste and recycling materials. The structure of modeled supply chain with the schema of the flow of raw materials, goods, wastes and recycling goods is presented at the figure 2.

The model assumes functioning of a supply chain of a 5-level structure. These levels are as below:

- suppliers of raw materials - e.g. companies offering raw materials,

- agents in trade of recycling materials - e.g. companies storing and offering recycling materials, recycling exchange,
- producer - company manufactures final goods and their parts, both from raw materials and recycling materials,
- distributors - companies responsible for storing of final goods and providing them to sale networks,
- sale networks - companies providing final goods directly to final customer.



Source: own study

Fig. 2. Authors' model of the integration of a supply chain realizing both forward and backward flows (two-direction)
Rys. 2. Autorski model integracji łańcucha dostaw realizującego przepływy forward i backward (dwukierunkowe)

Three basic measures were selected for the purposes of the estimations of the supply chain within the created model:

- customer service level - ratio of pieces of goods sold to final customers to pieces ordered by them (quantitative level of fulfillment of orders)
- profitability - ratio of obtained gains to incomes,
- cash flow - average quantity of cash, available at the given time in the company.

The integration of the supply chain in the presented paper is estimated only taking into account one of above mentioned measure, i.e. the customer service level.

RESULTS OF RESEARCHES

For the purposes of the analysis of the results of the simulation of processes realized within the supply chain with different integration levels, the transcription of class symbols into values were made using the following system: A=4, B=3, C=2, D=1. The aggregated measure of the integration of the supply chain was presented as the sum of class values for each factor. Thanks to these assumptions, there was a possibility to calculate the value of correlation indicator for pairs of data built at the level of the integration and the selected measure indicator of the estimation of the supply chain. The service level was selected as an indicator due to the fact, that this indicator presents in the best way the perfection of the supply chain from the customer's point of view. The following hypotheses were taken into consideration during the analysis of results of the simulation:

- H_o: there is no correlation between the level of the integration of the supply chain and the value of service level indicator - $r_{xy} = 0$,
- H_1: there is a correlation between the level of the integration of the supply chain and the value of service level indicator - $r_{xy} \neq 0$.

To verify the above presented hypotheses, the correlation indicator between the integration level and the value of the service level indicator was calculated. The date for the calculation of the correlation indicator came from 96 simulations (each in different configuration of integration classes), conducted in situations related to business environment of real supply chains. The value of so calculated correlation indicator was r_{xy} = 0,9590. It shows the high correlation between the level of the integration of the supply chain and the offered customer service level. To confirm this statement, the test of significance of correlation indicator was conducted by the use of the t-test and by the implementation of the following formula:

$$t_{emp} = \frac{r_{xy}\sqrt{n-2}}{\sqrt{1-r_{xy}^2}}$$

where:

n - number of observations,
r_{xy} - Pearson's correlation indicator.

The calculated empirical value of t-statistics is equal to:

$$t_{emp(0,9590)} = 32,8075$$

The value t_{emp} was compared to limiting value taken from the statistical table of the t-Student distribution for two-side critical area of significance level α=0,05 and n=90 degrees of freedom. The critical value t is equal to:

$$t_{(0,05)}^{96-2} = 1,98667$$

In case when there is a relationship

$$|t_{emp}| \geq t_{(0,05)}^{96-2}$$

for calculated Pearson's correlation indicator, the hypothesis H_o has to be rejected.

The inequality authorizing to reject the hypothesis H_o occurs in favor for the hypothesis H_1. Therefore it was stated that there is a relationship between the level of the integration of the supply chain and the value of the service level indicator. Leading to further explanations of above presented relationships, the diagram was prepared to show the level of customer service realized at different levels of the integration of the supply chain (Fig 3).

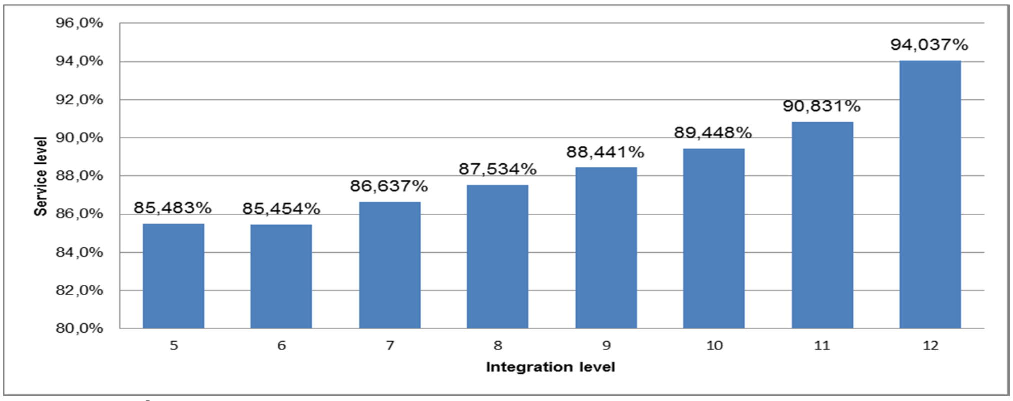
Based on the diagram presented on Figure 3, it can be concluded, that the customer service level offered by the supply chain increases with its integration level. But whether the increase of the integration level influences on the customer service level from the statistical point of view? To answer this question, the two hypotheses were taken:

- H_o : the increase of the integration level from 5-8 till 9-12 causes the decrease of average value of service level indicator or causes no change of this indicator $\mu_1 \geq \mu_2$,
- H_1 : the increase of the integration level from 5-8 till 9-12 causes the increase of average value of service level indicator $\mu_1 < \mu_2$.

Due to the big sample (n_1>30 and n_2>30) and known values of standard deviations, the verification of above-stated hypotheses was made by the use of Z statistics, the value of which was calculated by the formula:

$$Z = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{\delta_1^2}{n_1} + \frac{\delta_2^2}{n_2}}}.$$

The critical value of the statistics Z at the significance level $\alpha = 0{,}05$ in one-sided test is equal to $Z_\alpha = 1{,}645$. The calculated empirical value of statistics Z is $Z = -2{,}196$. Therefore there is a dependence $Z < -Z_\alpha$ which authorizes to reject the hypothesis H_o in favor of alternative hypothesis H_1. Based on that, the conclusion was made, that the increase of integration level from 5-8 to 9-12 causes the increase of the average value of the service level indicator.



Source: own study

Fig. 3. The customer service level realized at various level of the integration of the supply chain
Rys. 3. Realizowany poziom obsługi klienta na poszczególnych poziomach integracji łańcucha dostaw

The analysis of the operational indicator of the service level shows its value together with the increase of the integration level. This effect is one of postulated results of the integration of the supply chain (integration profit). At the same time the postulate made by J.Konieczny of the influence of the integration on the reliability of the system was confirmed. This confirmation is of a quantitative nature for selected set of factors of the integration of supply chains of forward and backward type.

CONCLUSIONS

Base of the previous literature review the following statements can be made:

– the process of the integration of the supply chain is of the evolutionary nature, usually the whole process is divided into several phases by authors. Special features are assigned to each of these phases,
– there are two basic integration phases: internal integration (within the organization) and the external integration (connecting the participants of the supply chain),
– authors freely choose the measures of the integration, but this choice is weakly argued,
– in case of using the integration model to research the real supply chains, authors mainly use the change from qualitative methods to the quantitative ones [Dobrzyński 2009],
– the integration can have a companies' dimension (concentrated on the quantity of companies involved in the process) or a functional dimension (related to the functions, among which the integration occurs),
– the integration has a positive influence on the operational measures of the supply chain (including service level indicator), independently whether the realized flow is of forward, backward or both types.

The possibility to estimate the integration of the supply chain based on values of levels of various integration factors allows to implement such methods for practical solutions. It enables various configurations of the supply chain starting from the designing phase (modeling phase) and finishing on its work (the phase of the simulation of operational processes within individual functional areas).

Simulation researches allows to determine precisely, in a quantitative way, the influence, direction (positive, negative, neutral) and strength (significant, marginal) of the integration on operational measures of the supply chain. The presented results, referring to the service level indicator (one of integration measures) allows to choose the right strategy of the implementation of activities of the integration of supply chains. In the future, the authors plan to compare service level indicators with other measures - mainly profitability as well as cash flow. The confrontation of obtained effects (service level) with bearing expenses will make possible to conduct the estimation of the profitability of functioning of the supply chain in given configuration of integration levels. Then, the conviction of the correctly chosen strategy of the implementation of integration activities will be stronger, thanks to more convincing argumentation.

The methodology and the model of the integration of the supply chain, created during the research work, allow to predict results of the implementation of activities of the integration of the supply chain. The results of the service level indicator, presented in this paper, show the global functioning of supply chains in this range. Therefore, Authors' researches have no sign of local optimization, which often exclude and cancel each other. Although the aim of this research was the operational level, it should be remembered, that the chosen way of the configuration of the integration of the supply chain cannot conflict with goals, determined at the strategic level.

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MODELOWANIE I SYMULACJA INTEGRACJI ŁAŃCUCHA DOSTAW TYPU FORWARD I BACKWARD

STRESZCZENIE. Wstęp: Integracja, obok synergii i konwergencji, jest uważana za jedną z dominujących orientacji we współczesnej logistyce. Łączenie się podmiotów w łańcuchy dostaw umożliwia integrację działań, pozwalając realizować coraz bardziej specyficzne wymagania odbiorców w sposób nadal skuteczny i korzystny ekonomicznie. W dobie koncepcji zrównoważonego rozwoju rośnie zainteresowanie wykorzystaniem surowców wtórnych połączone z możliwościami konsolidacji działań logistycznych. W świetle analizy literatury naukowej (modele integracji) oraz obserwacji przykładów z praktyki biznesowej, łańcuchy dostaw typu forward i backward (dwukierunkowe) stanowią intensywnie rozwijający się obszar logistyki.

Metody: Praca zawiera autorski model oraz autorską metodykę modelowania integracji łańcucha dostaw realizującego przepływy forward (w przód) i backward (dwukierunkowe). Materiał empiryczny uzyskano w wyniku modelowania i symulacji procesów w środowisku iGrafx Process 2013 for Six Sigma, wykorzystując także pakiet Minitab 17 na potrzeby planowania eksperymentów. W pracy posłużono się metodą weryfikacji hipotez statystycznych. Najpierw przeprowadzono badanie korelacji pomiędzy poziomem integracji a globalnym poziomem obsługi klienta łańcucha dostaw metodą współczynnika Pearsona. Przeprowadzono również test istotności współczynnika korelacji z wykorzystaniem statystyki t. Następnie dokonano weryfikacji hipotezy statystycznej w oparciu o test, którego sprawdzianem jest statystyka Z.

Rezultaty: Wyniki autorów jednoznacznie wskazują na wysoki związek pomiędzy poziomem integracji łańcucha dostaw a uzyskiwanym poziomem obsługi klienta (wartość współczynnika korelacji Pearsona oraz rezultaty testu statystycznego t). Szczegółowe badania statystyczne autorów ukazują, że podniesienie poziomu integracji z niższych do wyższych stanów integracji powoduje zwiększenie średniej wartości wskaźnika poziomu obsługi klienta (wyniki statystyki Z). Konkludując, analiza wskaźnika poziomu obsługi klienta pokazuje, że wzrasta on wraz ze wzrostem poziomu integracji.

Wnioski: Zgodnie z celami integracji systemy zintegrowane powinny mieć większą możliwość działania. Jednym z postulowanych efektów ("zysków") integracji łańcucha dostaw jest m.in. możliwość osiągnięcia wyższego poziomu obsługi klienta. Rezultaty badań autorów potwierdzają taki stan faktów, co bardzo cenne w postaci kwantytatywnej a nie opisowej, wpisując się w poglądy nauki i praktyki. Wnioski płynące z przeprowadzonych prac badawczych zachęcają do podejmowania działań integracyjnych w łańcuchach dostaw typu forward i backward.

Słowa kluczowe: łańcuchy dostaw typu forward and backward, modele łańcucha dostaw, metodyka integracji łańcucha dostaw, poziom obsługi klienta w łańcuchu dostaw

MODELLIERUNG UND SIMULATION DER INTEGRATION INNERHALB DER LIEFERKETTE VOM TYP FORWARD UND BACKWARD

ZUSAMMENFASSUNG. Einleitung: Die Integration wird neben Synergie und Konvergenz als eine der dominierenden Ausrichtungen der gegenwärtigen Logistik angesehen. Der Zusammenschluss von Subjekten in Lieferketten ermöglicht eine weitgehende Integration von Aktivitäten und erlaubt es, den immer spezifischer werdenden Anforderungen der Kunden effektiv und wirtschaftlich vorteilhaft gerecht zu werden. In der Zeit der ausgewogenen und nachhaltigen Entwicklung wächst das Interesse für die Inanspruchnahme von Sekundärstoffen in Verbindung mit der Möglichkeit einer Konsolidierung der logistischen Aktivitäten. Angesichts der Analyse der betreffenden wissenschaftlichen Literatur (Integrationsmodelle) und der Wahrnehmung von Beispielen aus der Wirtschaftspraxis stellen die Lieferketten vom Typ forward und backward (in zwei Richtungen) einen sich sehr intensiv entwickelnden Bereich der Logistik dar.

Methoden: Die vorliegende Arbeit beinhaltet ein autoreneigenes Modell sowie eine autoreneigene Methodik für die Modellierung der Integration der Lieferkette, in der der Materialfluss vom Typ forward (vorwärts) und backward (in zwei Richtungen) vorkommt. Das empirische Material erzielte man in Folge der Modellierung und Simulation von Prozessen im Medium iGrafx Process 2013 for Six Sigma, wobei bei der Planung von Experimenten auch das Minitab 17-Paket in Anspruch genommen wurde. Im Rahmen der Arbeit griff man nach der Methode der Verifizierung statistischer Hypothesen. Eingans wurde eine Überprüfung der Korrelation zwischen dem Niveau der Integration und dem globalen Niveau des Kundenservices innerhalb der Lieferkette mittels der Methode des Pearson-Koeffizienten durchgeführt. Man hat dabei auch einen Test für die Relevanz des Korrelationskoeffizienten unter Anwendung der T-Statistik vorgenommen. Demzufolge wurde eine Verifizierung der statistischen Hypothese in Anlehnung an den Test, der mit Hilfe der Z-Statistik überprüft wird, durchgeführt.

Ergebnisse: Die Ergebnisse des Autoren-Teams weisen eindeutig auf eine hohe Korrelation zwischen dem Niveau der Integration der Lieferkette und dem Niveau des Kundenservices (der Wert des Koeffizienten der Pearson-Korrelation und die Resultate des statistischen T-Testes) hin. Die detailierten statistischen Forschungen der Autoren projizieren die Tatsache, laut deren das Erheben der Integration von niedriegeren auf die höheren Niveaus von Integrationszuständen

einen Anstieg des Mittelwertes des Koeffizienten in bezug auf das Niveau des Kundenservices (Resultate der Z-Statistik) zur Folge hat. Der Analyse des Koeffizienten des Niveaus des Kundenservice ist also zu entnehmen, dass er mit dem Anstieg des Integrationsniveaus wächst.
Fazit: Gemäß den Integrationszielen sollen die Integrationssysteme mit einer größeren Handlungsfreiheit ausgestattet werden. Einer der postulierten Vorteile ("Effekte") der Integration der Lieferkette ist u.a. die Möglichkeit der Erzielung eines höheren Niveaus des Kundenservices. Die vom Autoren-Team gewonnenen Forschungsergebnisse bestätigen die betreffenden, quantitativen und nicht nur die beschreibenden Gegebenheiten und Zustände, was den wissenschaftlichen Anschauungen und praktischen Erkundungen entgegentritt. Die aus den Forschungsarbeiten resultierenden Ergebnisse motivieren die daran Interessierten zur Aufnahme von Integrationsaktivitäten innerhalb der Lieferketten vom Typ forward und backward.

Codewörter: Lieferketten vom Typ forward und backward, Modelle der Lieferkette, Methodik für die Integration der Lieferkette, Niveau des Kundenservices in der Lieferkette

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LEARNING FROM EXPERIENCES IN SUSTAINABLE TRANSPORT PRACTICE: GREEN FREIGHT EUROPE AND THE IMPLEMENTATION OF A BEST CASES DATABASE

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ABSTRACT. Background: For many logistics service providers and shippers sustainable transport is still a relatively recent issue, even if almost every transportation company is engaged in sustainability. Each has had different experiences with making transportation more sustainable. By looking at the efforts and successes of others sharing these experiences could help shippers and logistics service providers to obtain new innovative ideas of how to become more sustainable. The certification organization Green Freight Europe (GFE) wants to develop a database for these types of experiences in order to encourage its members to generate sustainable initiatives.

Method: In support of this plan, we interviewed several logistics service providers and shippers and conducted a brief survey among GFE members.

Results: Sustainability forms one of the goals for all interviewed companies mainly based on cost reduction but followed closely as a tool to attract new customers. At the moment, the information obtained to keep updated on sustainability comes mainly from truck producers and not from information from best cases from other logistics service providers.

Conclusions: We have found that there is a willingness to submit best cases, but also a fear that the submitter will miss his competitive advantage by telling others about his innovations.

Key words: sustainability; green logistics; green freight Europe.

INTRODUCTION

Sustainability plays an important role in the mission of organizations [McDonough, Braungart 2002, Maloni, Brown 2006]. Sustainability also has become an integral part of the mission of both logistics service providers and shippers [Uitenboogaart et al. 2010, Ploos van Amstel 2008, Pieters et al 2013]. However shippers do not consider sustainability to be a prime aspect of when choosing logistics service provider. A recent study shows that price got the highest index score of 100%, followed closely by reliability - 94 % and sustainability only with - 45 % [Van der Meulen, Kindt 2010]. Using this index, it is understandable that shippers take into account the first two criteria. Sustainability is a question of minor importance when looking for a suitable logistics service provider as well as for sustainable solutions in the transport sector. This image also emerges from the interviews we have conducted with logistic managers of nine companies. These companies were five logistics providers, the three shippers and one private carrier. They all linked sustainability directly to cost reduction with continued reliability. We also found that the interviewed companies had no fixed standards

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for the integration of sustainability into concrete operational projects. Companies, but also governments and other stakeholders e.g. non-governmental organisations (WHO, OESO, Greenpeace etc.), each have a different vision of what sustainability is and how it actually materializes. In fact, sustainability is a "wicked problem" [Dentoni et al. 2012] to which no uniform approach can be applied.

We formulated a hypothesis that both shippers and carriers could use experiences of other companies. These experiences could improve their sustainable performance or could gain inspiration for new sustainable alternatives in creating sustainable solutions and initiatives in the field of sustainable physical distribution. The question was how shippers and carriers want to obtain these experiences of other companies; as described in best cases or worst cases, during company visits, in seminars, or by do's and don'ts. In principle, the industry can bring such experiences together in order to obtain new insight. The transport industry often focuses on the development of infrastructure, dedicated public policy or alternative fuels when working out new strategies in the field of sustainability [Piecyk, McKinnon, 2010]. However business experiences and scenario techniques can broaden the scope of possible sustainable solutions. Scenarios, specifically with regard to the impact of sustainability on the physical distribution market, are developed by using the Delphi method [Von der Gracht, Darkow, 2010].

The tactic of best and worst cases is often used to develop a planning scenario [Schwartz, 1998]. Regarding planning scenario specific to the logistics market little research has been done so far. Usually a holistic approach to the supply chain as a whole is chosen [Von der Gracht, Darkow 2010]. The scenarios that Deutsche Post AG in 2012 drafted for the future of the postal services industry are a good example of such a holistic approach. Sustainable logistics as a specific, independent theme in these scenarios was not presented. Curiously, the same organization in 2010 presented its vision on sustainable logistics but this was not any further elaborated. In 2012 Green Freight Europe (GFE) was established to unite shippers and carriers in order to promote sustainable logistics. GFE is planning collaboration between GFE Members, manufacturers, knowledge partners and other external stakeholders to develop test protocols, review strategies and verify the performance of management and operational practices, networks, vehicles, technologies and equipment that have the potential to reduce greenhouse gases from freight transport. GFE has the ambition to establish credible performance criteria and review test data to ensure that such practices, vehicles, equipment and technologies will help fleets improve their efficiency and reduce emissions. The aim is to create a pan-European standard similar to the program of SmartWay Partnership in the USA [website GFE]. The 100th GFE member was welcomed on March 27th, 2013. The goal is to have 250 company members at the end of 2013 [website GFE].

Starting 2014, GFE would like to create a database filled with experiences of members with successful projects to assist other GFE members in setting up suitable projects to make transport more sustainable [GFE 2012]. This should aid members to gain inspiration for building innovative approach to sustainable logistics of their own. What form should these experiences have in order to help GFE members make the best use of such a database?

METHODOLOGY

To gain insight into this question we talked to five logistics service providers, a private carrier and three shippers. All nine companies describe themselves as active pioneers in the field of sustainable transportation. Three of them (two shippers and a logistics service provider) are members of GFE and participate in the Lean and Green program; five companies (one private carrier and four logistics service providers) are participants of the Lean and Green program. One shipper is not involved in any of these programs, but does proudly mention on its website that its logistics service provider is a participant of the Lean and Green program. From these interviews we obtained an idea of how these interviewees did learn from the experience of others, and what they wanted to share with others. Based on this, we prepared a questionnaire which was distributed during the first open day of the GFE members in Heddesheim (FRG) on July 3rd, 2013. Twenty-two of the 70 members that were present in Heddesheim, filled in this questionnaire. Because respondents were not asked to indicate their organizations to which they belonged and the total number of GFE members already exceeded 100, no general conclusions can be drawn from the results of the questionnaire. On the other hand, the information obtained from both the questionnaire and the interviews may give us a good insight of the direction GFE should take when developing a database of best cases. This best case database may help GFE members in turning their individual experiences into specific case studies which can inspire other GFE members [Eisenhardt 1989, Eisenhardt, Graebner 2007, Yin 2009].

THE INTERVIEWS

The interviews were conducted at the location of each company, in an informal form in order to exchange opinions. Sustainability issues were discussed at six organisations with a person who had a good understanding of all aspects of sustainability in transport. At one shipper (number 2) we talked to all seven stakeholders within the organization. We wanted to know more about the following aspects:

1. How did the company position itself in the field of sustainable logistics?
2. What experiences it had in setting up projects regarding sustainability?
3. How do they obtain knowledge in the area of sustainable transportation?

Ad 1) All interviewees named sustainability as one of the goals of the organization. All respondents saw sustainability in the context of corporate social responsibility [Maloni, Brown 2006], but two respondents (shipper 2 and 3) mentioned sustainability in connection with the continuation of the organization. Obviously there is a wide variety of ideas among respondents as to what sustainability actually is and how it could be addressed best. This confirmed the view that sustainability is a "wicked problem" [Dentoni et al. 2012].

Logistics service providers 1: Our employees think differently about sustainability. It varies from specialist to specialist. For example, the planners have less to do with sustainability as the sellers. The sellers consider sustainability to be important.

Shippers make a choice for sustainable performance primarily based on cost reduction, they don't consider it a goal in general. This view was also confirmed by all carriers we interviewed. This is in compliance with the findings of Van der Meulen and Kindt [2010].

Logistics service providers 2: Internally no one gets excited by greener transport which at the same time is 100,000 euro more expensive.

Logistics service providers 4: People often think and expect that cheaper transport and sustainability go together. Cost increase even by 5% due to a sustainable solution is not acceptable for the customer.

Despite these opinions there are also signs that organizations want to be sustainable rather on account of other reasons as purely financial reasons.

Logistics service providers 1: The measures in the field of sustainable performance that we take don't directly influence the process of recruiting new customers, but it ultimately has a positive impact on our commercial activities. Sustainability is just embedded in our organization. We distinguish ourselves from competitors by being the leader in this field. Because of this we are often one of the first to try a new sustainable initiative. We also have an edge in knowledge and experience.

Ad 2) In terms of experience with setting up projects for making transport more sustainable, it is striking that the shipper takes the initiative. Hereby those solutions come forward that are tailored to the needs of this specific shipper. Logistics service providers also have their own ideas, but they reach only a small number of their customers. For example, logistics service providers 1 launched a program that allows the shipper to compensate CO2 emission with a small surcharge per trip, to accumulate money for planting trees. However, only 50 of the approximately 3000 customers of logistics service providers 1 choose this option. Moreover, they are not the largest customers and make up only 2% of sales.

Shipper 3 participates in a project where the transportation capacity is shared with third parties, even with a competitor. The fact of sharing the capacity with a competitor caused an emotional response with the other two shippers. These two indicated that they prefer not to share a truck with a competitor:

Shipper 1: If we work with a competitor, sharing the same truck, then there is a risk that emotions will prevail. It will probably become a sensitive matter for us.

Shipper 2: Sharing a truck with competitors gives us a cost advantage, but also is profitable for our competitors. Even if we achieve more benefit then our competitors, we would prefer to do nothing to give them a cost advantage.

We could wonder whether the shipper is absolutely sure about not sharing the transportation capacity with competitors. Both the general manager and marketing manager of shipper 2 had the same opinion: never. However, the financial director of shipper 2 indicated that their logistics service provider has shared transportation space with competitors for many years and due to this fact its clients obtained a cost advantage.

Ad 3) The logistics service providers obtain their knowledge on sustainability especially from the truck producer. Hereby, they work together on specific projects that are tailored to the needs of the logistics service provider. All respondents mention Lean and Green as a source of inspiration, but also state that having the Lean and Green Award is not a distinctive aspect anymore.

Shipper 1: Many logistics service providers have already joined Lean and Green. It would amaze me if someone is not a member yet.

Logistics service provider 2: In my eyes there are too many companies that have connection with Lean and Green. Not everyone is as active as they should be and that is 'killing' for the group. The newly introduced Lean and Green stars could give a boost to continue working on improving sustainability in transportation. These stars could distinguish yourself from others.

None of the respondents share experiences with each other. In a transport market where one tries to get the most out of a competitive advantage this is an understandable attitude. The interviewees often talked about the "uniqueness" of their organization and situation and they therefore requires customization. It remains unclear to what extent the experience gained by such a customization project could also be transferred to competitors and customers.

THE QUESTIONNAIRE

The purpose of the questionnaire was to understand what kind of information GFE members want to find on a Best Practices Sharing Platform and in what form this information should be presented.

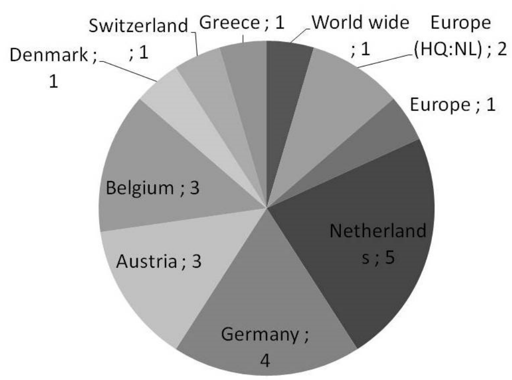

Fig. 1. Responses by country
Rys. 1. Odpowiedzi według krajów

The twenty two respondents originate from different countries of the European Union with a relative large group coming from the Benelux countries (Figure 1). The spread is quite similar to the present composition of the members of GFE. Since we have not asked for the organization of the respondent, we can say nothing about distinction in answers of carriers and shippers. Moreover, we implicitly assumed that they as GFE members want to share information with others because that is one of the objectives of the GFE organization [website GFE].Based on discussions with the Working Group of Sharing Platform GFE we have drawn up a list of themes which could be interesting for GFE members. Respondents could evaluate the themes by using a Likert scale (Table 1).

Table 1. Choices and ratings
Tabela 1. Wybory i ich rating

Choice	Rating
completely unnecessary	0
not really interesting	1
can be interesting	2
important	3
very important	4

The result of evaluation sorted by average score is given in table 2.

Table 2. Average scores by theme
Tabela 2. Średnia ocena według zagadnienia

Theme	Number of respondents	Average score	Standard deviation
1. Innovations	20	3,55	0,51
2. Supply Chain Optimization	21	3,48	0,68
3. Eco driving	22	3,14	0,83
4. Transport collaboration	20	3,05	0,83
5. Vehicles	21	3,00	0,84
6. Verified Technologies	21	3,00	0,77
7. Alternative fuels	22	2,91	0,92
8. Information technology	21	2,90	0,77
9. Legal information	21	2,81	1,03
10. Telematics	20	2,80	1,01
11. Anti-idling	20	2,75	0,79
12. Environmental management systems	21	2,71	0,96
13. Consolidation	18	2,56	0,78
14. Manufacturer information	20	2,40	0,82
15. Material planning	17	1,88	0,86

It was striking that none of the themes was evaluated as 'completely unnecessary'. However, not all 22 respondents gave a rating to each theme. We could give a zero to those themes that were not evaluated, but we have chosen not to do that and to consider just the rated choices. If we would have given these unrated themes a zero, the results would have been slightly different Innovations and Supply Chain Optimization would have switched places. But the order of a theme would not have changed significantly. Therefore we have chosen to take into account only themes that were rated. It is striking that standard deviations of the themes Innovations and Supply Chain Optimization are low and the standard deviations of the other themes are higher. It means that respondents not always agree with each other on the importance of a theme. Apparently, the Working Group of GFE Sharing Platform should offer members a list of more general themes such as Technologies, Transport and Organizational aspects.

The purpose of the GFE Sharing Platform is to share best practices. But a member could also learn a lot from the mistakes of others: worst practices. Again, the respondent could express his preference by using the Likert scale (Table 1). There is a clear result with regard to the best practices: they are seen as a very positive and important tool. In contrast, bad experiences evoke more mixed results. No majority for worst practices as a good instrument: 57% see in no benefit or doubt of their use and 43% recognize the benefits of learning from them. One respondent suggested: *Instead of worst practices we should call it learning from trials/pilots.*

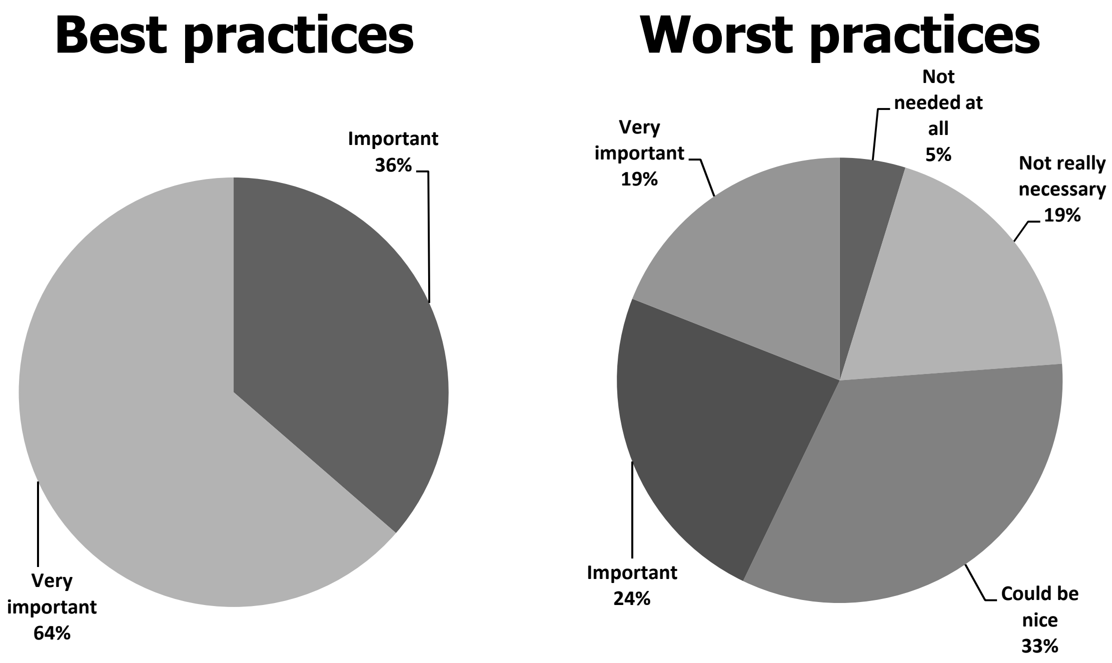

Fig. 2. Best practices versus Worst practices
Rys. 2. Dobre praktyki vs złe praktyki

Table 3. Forms of information by preference
Tabela 3. Formy informacji według preferencji

Theme	Number of respondents	Average score	Standard deviation
1. Case studies	22	3,36	0,66
2. Workshops	22	2,82	1,01
3. Articles	22	2,68	0,95
4. Conferences	22	2,45	0,86
5. Company visits	21	2,19	0,75

Next that we wanted to know in which form GFE members want the information to be presented. We gave respondents a choice between case studies, articles, workshops, company visits and conferences. Here the respondent had the opportunity to use a Likert scale (Table 1). The results are presented in Table 3 in order of preference.

Case studies proved to be most preferable, followed by workshops, articles, conferences and finally company visits as the least attractive. This fact surprised us. We had expected company visits would end up higher and articles would score lower. Perhaps the comment of a respondent explains this choice:

Due to huge distance between partners, workshops, company visits and conferences are difficult to attend.

Finally, we asked what GFE members think of sharing their knowledge and experiences with others members. It clearly appeared that they are willing to share their own knowledge and experiences with other members. Only one respondent expressed his doubt and no one said absolutely no. From two respondents we have received no opinion. The doubter mentioned as a reason:

We may not have best practices yet.

Another respondent expressed his concerns in the following sentence:

Yes and no! Tricky! Some knowledge and experience result in a competitive advantage and should not to be shared!

The same picture appeared from the interviews: fear to lose a competitive advantage by sharing knowledge with competitors. GFE will have to do its best to get that aspect clear: how one can share information without harming the company's competitive interests.

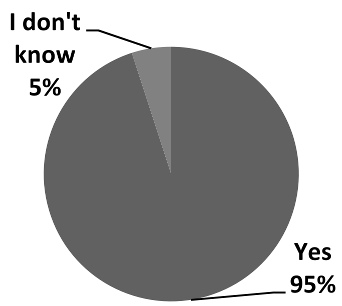

Fig. 3. Willingness to share experiences with others
Rys. 3. Chęć dzielenia się doświadczeniem z innymi

CONCLUSIONS AND RECOMMENDATION

Even though our research was conducted under a small number of respondents, it shows that transport companies want to learn from each other's experiences, but they are also careful in terms of sharing information with competitors. The themes of best practices which are considered to be useful for a GFE database of best practises are very broad. This means that companies have no a clear idea of the direction in which they should go. According to our research, sensitivity towards competition plays always a considerable role when sharing experiences. In a general sense, the need for a creation of a knowledge sharing platform appears to be widespread amongst our respondents. In order to make this GFE platform interesting for sharing information, good examples of cooperation projects regarding sustainability in the form of case studies are best. GFE members want to get new ideas that they might develop in future for themselves. It is a pity that there is a little interest for worst cases because an organization could learn so much from the mistakes of others.

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UCZENIE SIĘ PRZEZ DOŚWIADCZENIE W ZRÓWNOWAŻONEJ PRAKTYCE TRANSPORTOWEJ: GREEN FREIGHT EUROPE ORAZ WDROŻENIE NAJLEPSZYCH ROZWIĄZAŃ

STRESZCZENIE. **Wstęp:** Dla wiele dostarczycieli usług logistycznych oraz przewoźników pojęcie transportu zrównoważonego jest pojęciem całkiem nowym, nawet biorąc pod uwagę, że większość fakt, że większość firm transportowych jest już włączonych w rozwój zrównoważony. Każdy z nich ma też inne doświadczenia w tym zakresie. Obserwując wysiłki i osiągnięcia, wydaje się korzystnie dzielenie się swoimi doświadczeniami, które mogą się przyczynić do wprowadzenia nowych innowacyjnych metod prowadzących do zrównoważonego rozwoju firm. Certyfikowana organizacja Green Freight Europe (GFE) chce stworzyć bazę danych obejmujących różnego rodzaju doświadczenia w celu wspierania swoich członków do bardziej zrównoważonego rozwoju.
Metoda: przeprowadzono wywiady z dostarczycielami usług logistycznych oraz przewoźnikami jak również przeprowadzono krótką ankietę wśród członków GFE.
Wyniki: Rozwój zrównoważony kojarzy się praktycznie wszystkim ankietowanym przedsiębiorstwom z redukcją kosztów, ale również z narzędziem mogącym przyciągnąć nowych klientów. Obecnie otrzymane informacje o podtrzymywaniu praktyk rozwoju zrównoważonego pochodzą głównie od producentów samochodów a nie od dostarczycieli usług logistycznych.
Wnioski: Stwierdzono, że istnieje chęć dzielenia się dobrymi praktykami, ale również obawa, że przekazujący informację straci swoją przewagę konkurencyjną poprzez przekazanie innych informacji o unowocześnieniach.

Słowa kluczowe: rozwój zrównoważony, zielona logistyka, Green Freight Europe

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URL: http://www.logforum.net/vol11/issue1/no7

LERNEN DURCH ERFAHRUNG IN DER ZUKUNFTSFÄHIGEN TRANSPORTPRAXIS: GREEN FREIGHT EUROPE UND DIE EINFÜHRUNG DER BESTEN LÖSUNGEN

ZUSAMMENFASSUNG. Einleitung: Der Begriff des zukunftsfähigen Transportes stellt für viele Logistdienstleister und Frachtführer eine ganz neue Bezeichnung dar, wenn auch die meisten Transportunternehmen in ihrer Betriebspraxis bereits einer nachhaltigen Entwicklung nachgehen. Jede Transportfirma besitzt aber unterschiedliche Erfahrungen in diesem Bereich. Wenn man die betreffenden Bemühungen und Errungenschaften wahrnimmt, scheint der Erfahrungsaustausch durchaus brauchbar zu sein, zumal dies zur Einführung der neuen, zur nachhaltigen Firmenentwicklung führenden Innovationsmethoden beitragen kann. Die zertifizierte Organisation Green Freight Europe (GFE) hat momentan vor, eine verschiedenartige Erfahrungen umfassende Datenbasis zwecks Unterstützung ihrer Mitglieder bei deren nachhaltigen Entwicklung zu erstellen.

Methoden: Es wurden Umfragen bei den Logistikdienstleistern, Frachtführern und bei den GFE-Mitgliedern durchgeführt.

Ergebnisse: Die nachhaltige Entwicklung wird praktisch bei allen interviewten Unternehmen mit Kostenreduzierung assoziert. Sie wird bei ihnen auch als ein brauchbares, neue Kunden anziehendes Werkzeug angesehen. Die gegenwärtig gewonnenen Informationen über die Aufrechterhaltung der Praktiken für die nachhaltige Entwicklung kommen hauptsächlich von Autoherstellern und nicht von den Logistikdienstleistern.

Fazit: Es wurde festgestellt, dass man willig ist, gute Praktiken gegenseitig auszutauschen, wobei auch die Angst besteht, dass der Informationsmitteilende seine Wettbewerbsfähigkeit durch Preisgeben von innovativen Informationen verliert.

Codewörter: nachhaltige Entwicklung, Green-Logistik, Green Freight Europe

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ROUTING PROBLEMS BASED ON HILS SYSTEM PLATFORM

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ABSTRACT. Background: The logistic systems are very complex socio-technical systems. In this paper the proposal of application of the hierarchical multi-layers system platform HILS approach for the solution of the complex vehicle routing problems is presented. The interactive system functional structure was proposed which by intelligent dedicated inter-layers interactions enables the professional solutions of these practical problems. To illustrate these capabilities the complex example of the real-time VRP-SPD-TW routing problem was presented in which upper layers offers the context-related real-time updating network specifications that stimulates the adequate routing parameters and specifications updating for problem solution in optimization layer. At the bottom dispatching control layer the DISCON (Dispatching CONtrol) method from public transport was adopted to logistics applications in which the actual routing is treated as obligatory reference schedule to be stabilized. The intelligence aspects are related among others to HILS based decomposition, context-related trade-offs between routing modifications and corrective dispatching control capabilities e.g. priority or route guidance actions.

Methods: Decomposition of the vehicle routing problem for the HILS layers tasks creating the ILS system hierarchical structure. Dedicated solution method for the VRP-SPD-TW routing problem. The recognition of the control preferences structure by AHP-Entropy methods. DISCON and PIACON multi-criteria interacting control methods.

Results: Original formulation and solution of the vehicle routing problem by system-wide approach with essential practical advantages: consistency, lack of redundancy, essential reduction of dimension, dedicated formulation, multi-criteria approach, exploration of the integration and intelligence features supported by the intelligent PIACON-DISCON methods control activities

Conclusions: The presented proposal creates the professional approach to the solution of the crucial problems in logistics systems with the implementation of modern tools and enabling technologies.

Key words: ILS systems, systems intelligence, vehicle routing problems, multi-criteria dispatching control, system-wide approach, HILS system platform, decomposition of the optimisation problems.

INTRODUCTION

The provision by logistics systems of the high quality on-time and reliable service is a key operational problem which affects both customers (influences their service standards), logistic operators (best use of existing resources) and the city community (potential to mitigate of the negative congestion and environmental problems especially in the central parts of the cities).

There are many papers in scientific literature covering the development of various systems connected with above mentioned problems [Mingyong 2014, Shrestha 2014, Gorodestskii 2011].

The professional HILS (Hierarchical Integrated Intelligent Logistic Systems) platform for development of ILS systems was proposed from the perspective of modern system-wide capabilities supported by new available technologies and professional tools [Adamski 2003, 2011b]. The main functional

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features specifications of HILS includes: practically efficient individual ILS systems solutions, dedicated to high level of complexity, stimulating the system efficiency and productivity (e.g. system-wide activities coherency and understanding system processes/ mechanisms), exploration of system-wide communication and integrated functionalities, flexibility/intelligence, new ILS activity supporting technologies, vehicles/ digital maps platforms. This HILS platform is a crucial step enabling the development of practically efficient ILS systems proposals dedicated to very complex dynamic, stochastic and behavioral interactions existing in logistics processes [Adamski 2011b]. The real time system-wide identification, intelligent diagnosis, estimation and prediction of these interactions, conditioning the efficiency and productivity of the crucial HILS platform integrated functionalities (e.g. management, adaptation, routing/scheduling, surveillance and monitoring and direct control actions). These functionalities are realized in integrated way by the hierarchical multi-layer functional structure and are characterized by different tasks specifications (e.g. decisions time horizons, types of processes representations and optimization problems, reaction times to real time recognized and diagnosed events etc.). This HILS platform is embedded in a nowadays available advanced sensing, information, computer, communication enabling technologies supported by capabilities of vehicle platforms (e.g. vehicle navigation, location, v-v. v-i communication, vehicle-probe etc.). In addition it is supported by professional exploration of integration (co-operative complex systems approach with multi: networks/layers/users/services/ objectives specifications) and intelligence (recognizing, diagnosing and understanding complex interactions and behavioral patterns, decreasing uncertainty, unpredictability, recognizing the abnormal traffic events and opportunities for very efficient actions). [Adamski 2014].

Five Layers HILS in natural way integrate and vertically orders wide spectrum of decision making and optimal control functions that additionally are supported by integrated data, knowledge and tools basis equipped with dedicated DSS and CASD. At the upper layer the logistic strategy is created by multi-criteria approach integrating layers tasks. The management actions concerning the flows of materials, means, information in the areas of supply, production, distribution from the point of view of clients are realized. The typical integrated management activities consists of several stages: Activity Targets Establishing? Demand Estimation and Prognosis? Organization of Available Resources? Multi-criteria Decisions Optimization? General Level of Service Analysis. The general co-operative HILS multi-layers operation may be presented by the following cycle [Adamski 2011b].

1. Coordination and Management layer offers ALIS (Advanced Logistics Information Service) concerning SupNet interactions, essential events (e.g. incidents, critical network elements), network state specifications, global preferences and constraints, and coordination premises.
2. Adaptation layer offers: dynamic network updating: structure (available elements), routes (patterns, nodes/links, specifications), levels of congestion (incidents, available throughput)
3. Optimisation layer solves different types of VRP (Vehicle Routing and Scheduling) problems after robust estimation of the routing problem specifications (e.g. travel times)
4. Supervision and Monitoring layer offers the real-time monitoring of the logistic system environment as well as the monitoring of the crucial system parameters (e.g. operational efficiency of the system resources exploration , system reliability, shortages, costs, demands). The modern multi-media technologies are used for ALIS, visualization, warning and alarm generation purposes. The intelligent supervision diagnoses the abnormal system events recognized by monitoring actions. In consequence wide spectrum of professional anticipative and preventive actions practically on all layers of the proposed system can be realized.
5. Control Layer offers: very important new functional element of the bottom direct control layer concerns the full integration of the tasks of optimisation and intelligent supervision layers with the intelligent adaptive control actions realized by the multi-criteria DISCON and PIACON control methods [Adamski 2005, 2006, 2011a]. The practical proposals of traffic

multi-criteria control capabilities realized in ITS hierarchical multi-layer adaptive, optimisation and direct control structure were presented in [Adamski 2003].

In this context very important new adaptive layer tasks are concerned with existing ITS systems services e.g. vehicle route guidance in the network (e.g. to logistic centres) and automatic incidents detection and management. In this paper the HILS platform implementation for the very complex real-time vehicle routing problems will be presented with exploration of the original multi-criteria dispatching control actions dedicated to these routing problems.

VEHICLE ROUTING PROBLEMS

Vehicle routing problems are well serviced by the functionalities of the HILS platform. To illustrate of HILS application, the VRP-TW (Vehicle Routing Problem with Time Windows) is presented (see Fig.1). In this problem the HILS upper layers interactions offer the strategic context related updated demand and network specifications (i.e. adequate level of service specifications and routing parameters values for routing optimisation layer, supported by intelligent monitoring and supervision layer activity. At the bottom direct control layer the DISCON public transport dispatching control method was adopted to the real-time routing disturbances compensations with optimal routing treated as reference schedule to be stabilized by dispatching control actions. The formal VRP-TW typical routing problem specifications implemented in the optimisation layer are as follows: [Adamski, 2011b].

1. *Network specifications:* $G=(V,L)$ with customers located in the nodes $v \in V$ ($\#V=n$), selected dedicated for demand depots, and available L-links ($\#L=m$) or sub-areas.
2. *Nodes:* $\forall i \in V: \{d_i/p_i, TW_i=[ts_i, te_i], \tau_i, t^a_i\}$ represents respectively: customers demand forward/backward, time-windows, service/arrival times at customer i-th.
3. *Links:* $\forall (i, j) \in L: \{T_{ij} / D_{ij}, C_{ij}, U_{ij}\}$ represents respectively travel times/distances, costs, level of uncertainties
4. Routes specifications: originating/terminating at selected one/multi depots, homogeneous/ heterogeneous depots, available resources and functionalities.
5. Service specifications: (SP1: $\forall i$: must be assigned to exactly one/several routes/vehicles ; SP2: $\forall i$; is visited only ones/several times; SP3: demand all customers are serviced; SP4: type of obligatory LoS (Level of Service) specifications
6. Fleet of vehicles: homogeneous/heterogeneous; vehicle types related capacity
7. Customers: fixed/elastic demand; known delivery/pick-up demands
8. Adopted multi-criteria selected optimazation objectives: total distance /travel time, costs, LoS-measures, sum of lateness at customers, negative environmental impacts.

The typical VRP-TW problem in HILS platform can be formulated as follows: recognition of demand specifications and strategically compatible available dedicated service resources (localization of depots, admissible service areas and modes). Selection of demand related service standards specifications and optimisation specifications for VRP to be solved in optimisation layer. The selection of representative information sources and estimation, prediction and diagnose traffic situations in the selected areas. Generation by adaptive layer representative estimators of the parameters for routing optimisation problem. The formulation of dedicated optimisation problem with selection of types of ADV admissible *decision variables:* for example $x_{ijk} \in \{0,1\}$ binary variables used to assignment of the network arc (i, j) to the route of the k-th vehicle; $z_{ij} \in R_1^+$ demand delivered to customers routed after node "i", $y_{ij} \in R_1^+$ demand pick-up from customers routed up to node "i"

$$\text{(ADV):} \quad \{ x_{ijk} \in \{0,1\}; \quad y_{ij},\ z_{ij} \in R_1^+\}$$

Flow conservation principles for delivery demands and admissible routing flows:

(FCA): $$\sum_{i=1}^{N+1} z_{ij} - \sum_{i=1}^{N+1} z_{ji} = d_j \quad \forall j\neq 1;$$

$$\sum_{i=1}^{N+1} y_{ji} - \sum_{i=1}^{N+1} y_{ij} = p_j \;\; ; \forall j\neq 1;$$

$$y_{ij} + z_{ij} \le cap \sum_{k=1}^{K} x_{ijk}$$

ILS upper layers LoS specifications: all customers must be visited only ones and assigned to exactly one route from finite set of routes/vehicles. Customers Visits Specifications are:

(CVS): $$\sum_{i=1}^{N+1}\sum_{k=1}^{K} x_{ijk} = 1 \quad \forall j\neq 1;$$

$$\sum_{i=1}^{N+1} x_{ijk} - \sum_{i=1}^{N+1} x_{jik} = 0 \qquad \sum_{i=1}^{N+1} x_{ojk} \le 1$$

Operational Specifications: travel times representation, service time windows functionalities, customers visiting times sequence, maximum admissible routes distances/ travel times are:

$$t_{ik}^{a} \in [t_{si}, t_{ei}];$$

(OS): $$t_{ik}^{a} + \tau_i + T_{ij} - M(1 - x_{ijk}) \le t_{jk}^{a};$$

$$\sum_{i=0}^{n}\sum_{j=0}^{n} c_{ij} x_{ijk} \le L$$

The identical fleet of vehicles k=1,..,K specifications $\forall k \in K$: {limited capacity cap_k =cap}. This type of VRP-TW optimization problem may be formulated as follows (see Fig.1):

$$PO_{min} \;\; X, Z \qquad Q = \sum_{k=1}^{K}\sum_{i=1}^{N+1}\sum_{j=1}^{N+1} c_{ij} \cdot x_{ijk}$$

$$| \, | (ADV)(FCA)(CVS)(OS)$$

Testing example was selected from [Mingyong, Erbao, 2010] with HILS selected parameters values and problem specifications: types of problem real-time VRP-SPD-TW with CVS customers visits specifications and one recognized depot in v1.

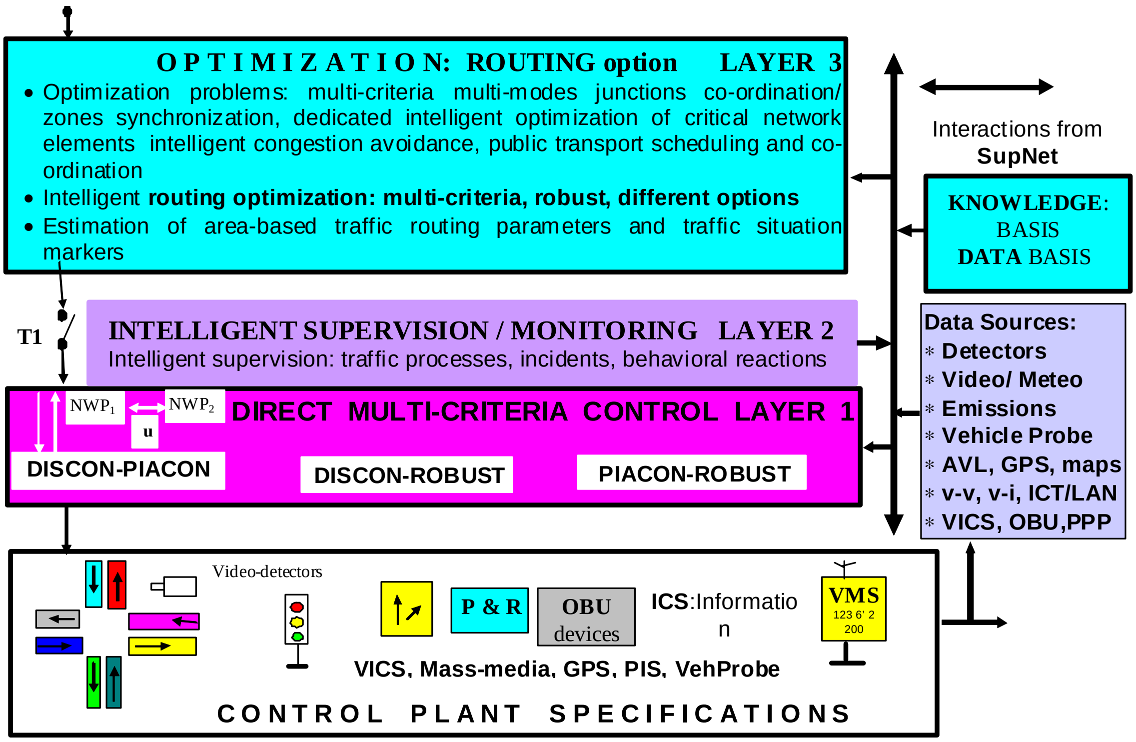

Fig. 1. Illustration of the vehicle routing dedicated HILS bottom layers functional co-operation
Rys. 1. Ilustracja funkcjonalnej kooperacji dolnych warstw HILS dedykowanej dla problemu wyboru tras

Table 1. The results of the numerical VRP-SPD-TW example
Tabela 1. Wyniki optymalizacji VRP-SPD-TW przykładu

<table>
<tr><th>vehicle</th><th>solution</th><th>distance/load</th><th>Optimal routes parameters</th></tr>
<tr><td>k=1</td><td>1-4-6-2-1</td><td>215/8</td><td><table><tr><td>i</td><td>1</td><td>4</td><td>6</td><td>2</td><td>1</td><td>L_1</td></tr><tr><td>k=1</td><td>8</td><td>5.5</td><td>7</td><td>8</td><td>8</td><td>215</td></tr></table></td></tr>
<tr><td>k=2</td><td>1-9-8-3-1</td><td>315/7</td><td><table><tr><td>i</td><td>1</td><td>9</td><td>8</td><td>3</td><td>1</td><td>L_2</td></tr><tr><td>k=2</td><td>7</td><td>7</td><td>6</td><td>5.5</td><td>5.5</td><td>315</td></tr></table></td></tr>
<tr><td>k=3</td><td>1-7-5-1</td><td>265/7</td><td><table><tr><td>i</td><td>1</td><td>7</td><td>5</td><td>1</td><td>L_3</td></tr><tr><td>k=3</td><td>7</td><td>7</td><td>6</td><td>6</td><td>265</td></tr></table></td></tr>
</table>

The suggested problem specifications by adaptive layer are as follows: N=8; K ≤ 5; Cap=8; suggested fleet of homogeneous vehicles; Demand is fixed : d = [2 1.5 4.5 3 1.5 4 2.5 3] / p = [3 1 2 2 3 4 1.5 3]; estimated customers service times: τ=[1 0.5 1 1 1 1.5 1 0.8]; Time windows with starting/ending times: t_s =[6 5 1 4 3 2 4 1.5] / t_e= [7 7 3 7 5 5 6 4]; Costs: matrix $C=C^T$ the data over diagonal represented by vector; C=[40 60 75 90 200 100 160 80; 65 40 100 50 75 110 100;75 100 100 75 75 75;100 50 90 90 150; 100 75 75 100;70 90 75;70 100;100].

The optimal routing proposals from optimization layer are presented in Table1.

Optimal dispatching control for VRP-SPD-TW problem solutions is realized at the bottom direct control layer (see Fig. 1) and is dedicated to compensate off-reference trajectory (determined in optimization layer by routes selection) deviations and essential increasing the robustness of the actual obligatory trajectory. Dispatching control actions dynamically evolving in 2-D (time and space) are integrated in DISCON (DISpatching CONtrol) method [Adamski 1998, 2011a] in an optimal dynamic control strategy resulting from the minimization of some selected measures of service standards e.g. off-reference routing trajectory deviations. Wide spectrum of DISCON control tasks (punctuality, regularity, synchronizing priority control) call for a multi-criteria integrated approach. In the papers [Adamski 1998,2003] the 1-D and 2-D (primal and dual) dynamic control plant representations have been developed and illustrated by a family of single criteria optimal control DISCON solutions of dead-beat, LQ, LQG type. The efficient dispatching multi-criteria priority control mode at traffic signalized intersections was proposed as an option in the PIACON (Polyoptimal Intelligent Adaptive CONtrol) method [Adamski 2006]. The originally different options of the DISCON method were developed and implemented in the public transport [Adamski 2005, 2011a].

In this paper some adaptations of the DISCON method to logistics routing problems are proposed. The operation of logistics vehicles in urban areas is influenced both by traffic conditions (e.g. traffic congestion, traffic events, interactions of drivers with actual traffic situations) as well as by customers demand (e.g. 2-D spatio-temporal demand randomness and behavioral uncertainty). In DISCON real-time dispatching control method these aspects are represented in the control model by disturbances and parameters variation and guaranty of robust features of generated control actions. Nowadays advanced computer, sensors, communication and control technologies create the family of new enabling technologies for advanced control actions. The new capabilities of hierarchical multi-layer ITS-ILS systems concern the system functionalities realized in integrated network-related way on different system layers. More available traffic data sources (e.g. video detectors, lasers, vehicle probes [Leihs, Adamski 2011], VICS vehicle platforms, GPS offer more network-related information enabling to formulate and solve more advanced system layers tasks. In particular, the advanced sensor systems offering high quality 2-D traffic data concerning the individual vehicles (e.g. vehicle type recognition and tracking) that through effective communication media can be gathered remotely and integrated across hierarchical ITS-ILS systems platforms. The monitoring and intelligent surveillance layer tasks are a typical in this area and require dedicated data fusion for intelligent traffic situations diagnosis tools. The advanced multi-criteria traffic control layer fully integrated with monitoring and surveillance layer uses these diagnosis results for generation of adequate structures of preferences in multi-criteria intelligent control (e.g. the traffic situations markers mechanism used in the PIACON method [Adamski 2003]. This allows among others to realize real-time congestion-related multi-criteria control actions and explore the beneficial network-related synergic effects by multi-layer integrated operation. In the logistics systems it may be especially explored in the real-time priority control area by integration of PIACON-DISCON methods. Priority control option in DISCON method is an essential component of the control actions aimed in reduction off-reference trajectory and off-scheduled time window deviations. In DISCON these control options are called respectively; the punctuality and synchronizing dispatching control options dedicated to real-time recognized traffic preference situations. The multi-criteria adaptive priority control providing in real-time offers important advantages: flexibility, efficiency, robust features. Therefore, the robust real-time priority control features of PIACON-DISCON methods will be also explored in the context of logistics vehicles "reference trajectory" robust prediction, estimation and control solutions embedded in multi-layer HILS platform. DISCON control problem: reference trajectory deviations i.e. dynamic propagation off-schedule arrival t^a_{ij} /travel times T_{ij} deviations $x_{ij} = t^a_{ij} - t^{as}_{ij}$ / $z_{ij} = T_{ij} - T^s_{ij} + w_{ij}$ will be represented by punctuality control model and admissible deviations and control actions:

(DCS): $x_{j+1} = x_j + u_j + z_j$;

$$x_j \in [xLB_j, xUB_j] \; ; \quad u_j \in [uLB_j, uUB_j]$$

At this point all DISCON public transport dynamic dispatching control options (deterministic, stochastic, single/multi-criteria, robust, anticipative, priority control) [Adamski 1998, 2003] are available for HILS application. For example LQ/LOG logistic bottom direct HILS control layer dispatching control problems may be formulated as follows:

PO $_{\min}$ u_j

$$J_{T-j} = \|x_T\|^2_{Q_T} + \sum_{k=j}^{T-1} \|x_k\|^2_{Q_k} + \|u_k\|^2_{R_k}$$

$|$(DSC)

where Q_k , R_k are symmetric nonnegative definite weighting matrices, the first and the second term may be regarded as the off-reference trajectory deviations penalties at terminal (T) and all customers points. The last term penalize the weighted sum of squares of control actions.

In addition the vehicle load balance equation and fuel consumption minimizing vehicle routing option can be added to DISCON multi-criteria dispatching control [Adamski 2011b].

For a given time window TW=[a_j,b_j] the reference point of vehicle arrival to j-th customer can be selected for example as aj + TW/3. The logistics' services consist in different routes assigned to different vehicles therefore in the illustrative example of the DISCON LQG control solution we have three routes for three vehicles (see Fig. 2). In Fig. 2-4 the LQG DISCON solutions for the optimal routes selected in the optimisation layer and high quality of the Kalman filter estimations of the system states for selected routes are presented.

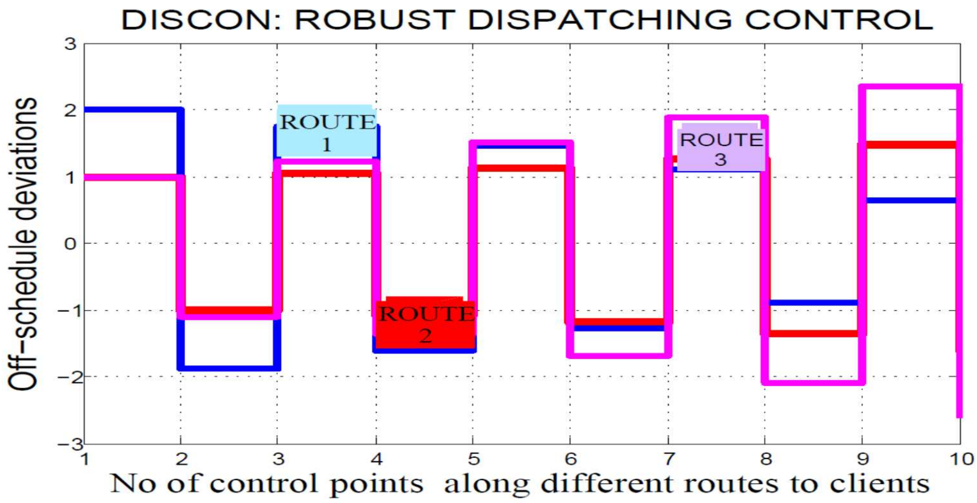

Fig. 2. DISCON off-reference trajectory compensating control actions along the three routes
Rys. 2. DISCON sterowanie kompensujące odchyłki wzdłuż trzech tras od referencyjnej trajektorii

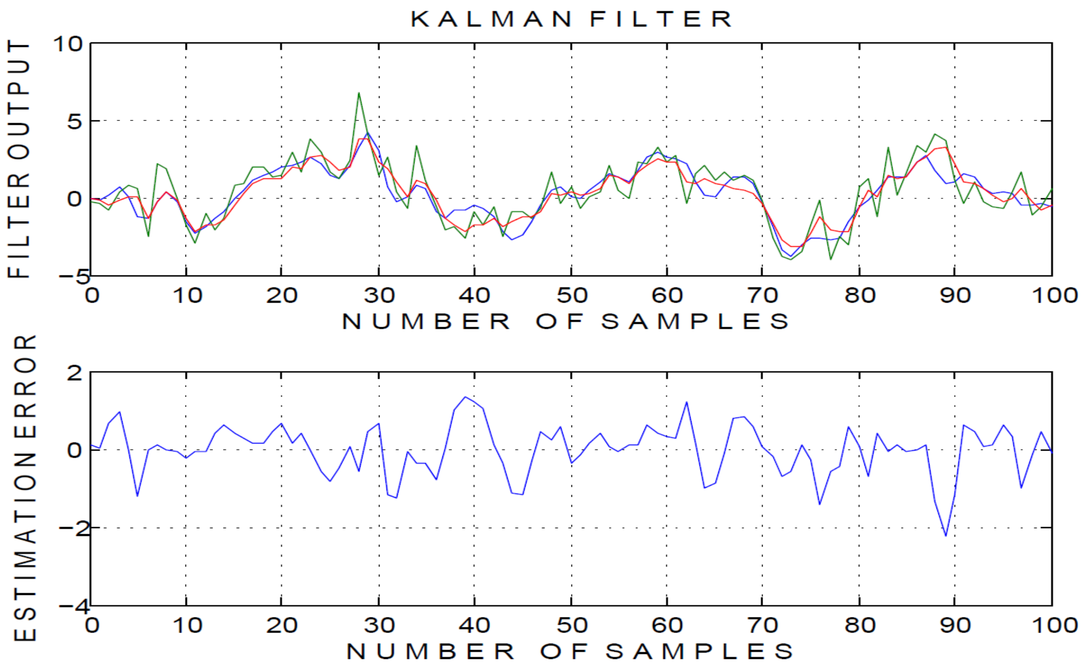

Fig. 3. DISCON: " reference trajectory" LQG dispatching control mode based on Kalman Filter route 1
Rys. 3. DISCON: mod sterowania dyspozytorskiego LQG bazujący na filtrze Kalmana - trasa 1

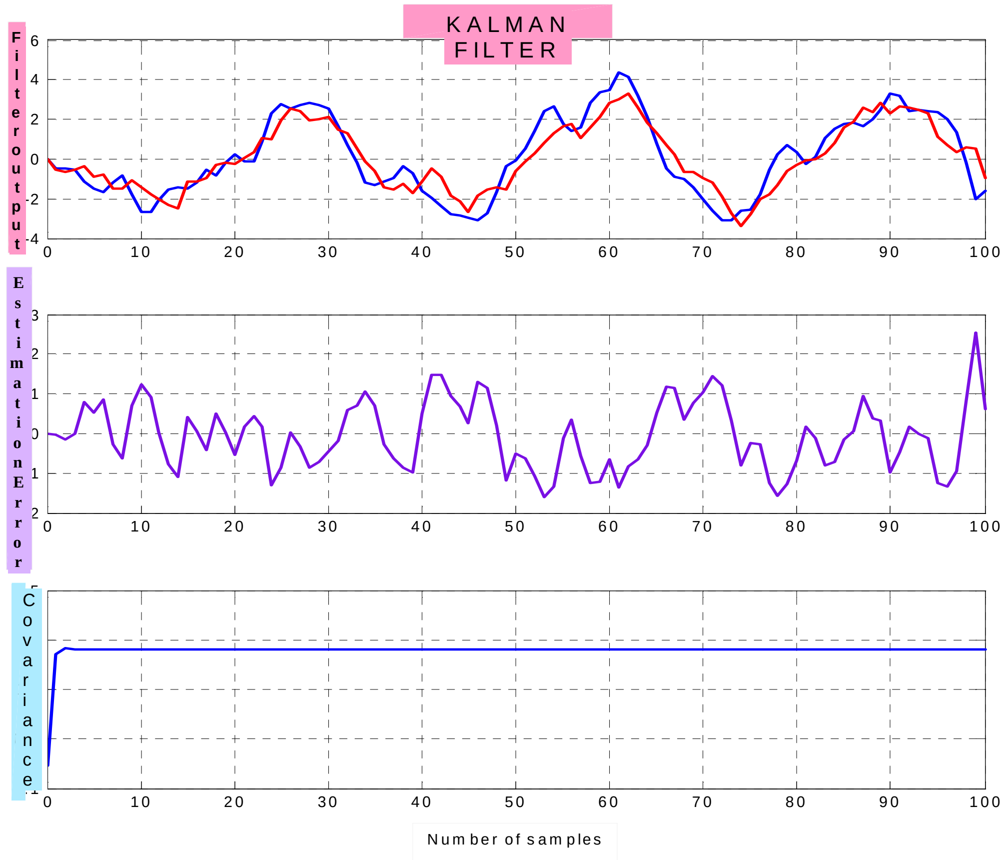

Fig. 4. DISCON: " reference trajectory" LQG dispatching control mode based on Kalman Filter - route 2
Rys. 4. DISCON: mod referencyjnego sterowania dyspozytorskiego LQG bazujący na filtrze Kalmana - trasa 2

ROBUST DISPATCHING CONTROL IN LOGISTICS

Wide spectrum of DISCON control options (punctuality, synchronizing and priority control) call for a multi-criteria integrated approach. Special emphasis is placed on the practical usability of the optimal solutions which are to a high degree determined by their robust features. Practically, distributed control hardware architecture with on-board computers, vehicle location and identification (AVLI) systems and decentralized adaptive control scheme seems to be most promising solution. The efficient dispatching multi-criteria priority control mode at traffic signalized intersections was proposed as an aggregated option of the PIACON-DISCON methods [Adamski 2006a, 2011b]. After the detection of the vehicle arrival to the junction and evaluation of its measure of deviations, the dynamic trade-offs with conflicting individual traffic and public transport demands are established by PIACON and appropriate priority robust control options for DISCON are proposed in terms of "robust reference trajectory" [Adamski 2005].

The special emphasis has been devoted to multi-criteria robustness features of the dispatching control actions. Reference trajectory priority control is similar to offered by DISCON-PIACON [Adamski 2005] interaction for public transport. After the detection of the vehicle arrival to the junction and evaluation of its measure of deviations the dynamic trade-offs with conflicting traffic and robust criteria (expressed in terms of norms of the Hardy spaces H_2 and H_∞.) demands are established by PIACON and appropriate robust local reference priority options called the "local reference trajectory" for DISCON are proposed. In the logistics applications (i.e. single vehicle at single intersection) some simplified approach can be proposed. The supervision and monitoring layer recognize the control preferences structure for PIACON control method but the DISCON dispatching control method can influence the importance of some priority control measure in preference structure dedicated to real-time dispatching control of the logistics vehicle. To reduce along logistics vehicle routes the influence of the dispatching control actions subjectivity and recognize the adequate preference structure of the control criteria in a given traffic situation, the AHP-Entropy method was used and the ranking is realized (at supervision and monitoring layer) according to calculated distance d2 and close–degree to the ideal point. There are eight control performance criteria (C1-C8) to be evaluated: number of stops, delays, capacity, queues, discomfort measures, priorities, dedicated modes, degree of flexibility. These criteria to be evaluated by six traffic situations markers (TSM1-TSM6) [Adamski 2003] representing traffic conditions and operational events such as traffic blockings, operational priorities, network synchronization requirements: free flow, near capacity, over-saturated, priorities, "synchro". The proposed approach consists of 5 steps (see Table 2-3):

A. Standardize the TSM (Traffic Situations Markers) and determine target matrix;
B. Determine the entropy indicator weight λ_e for TSM;
C. Calculate the weights by AHP and combine with λ_e to get comprehensive weight WW;
D. Construct the normalized matrix to determine the ideal point;
E. Calculate the distance d2 and close degree to ideal point to sort control criteria in preference structure.

Table 2. TSM- Traffic Situations Markers based traffic conditions
Tabela 2. Markery Sytuacji Ruchowych dla opisu warunków ruchu

AAHP						**WW**
1.0000 0.5000 0.2000 0.1429 0.5000 1.0000	2.0000 1.0000 0.3333 0.2000 0.5000 1.0000	5.0000 3.0000 1.0000 0.2000 1.0000 0.5000	7.0000 5.0000 5.0000 1.0000 0.3333 0.5000	2.0000 2.0000 1.0000 3.0000 1.0000 1.0000	1.0000 1.0000 2.0000 2.0000 1.0000 1.0000	0.3330 0.2158 0.1473 0.0969 0.0889 0.1181
λmax = 6.4339		CI = 0.02868		CR = 0.02313		
λe =	0.3915	0.1490	0.1985	0.1252	0.0696	0.0663

Table 3. Preference structure
Tabela 3. Struktura preferencji

C -criteria	d2	Ranking	Close-degree	Ranking
C1	0.2814	2	0.3397	1
C2	0.2611	1	0.4376	2
C3	0.2952	3	0.5646	3
C4	0.4048	6	0.6041	6
C5	0.4045	8	0.6530	8
C6	0.3212	7	0.7098	5
C7	0.4013	5	0.7562	4
C8	0.3230	4	0.7909	7

In Fig. 5 the corresponding example of such above preference related delay -capacity mode for PIACON control method generated from supervision and monitoring layer is presented .

Different points from Compromise Set offers different signal plans/ green signals for traffic signal groups therefore DISCON methods preserving compatibility of the general control preference structure can in intelligent way influence the dedicated green signal from the point of view priority control of the logistics vehicle. The robust control measures considered in multi-criteria PIACON control method will verified the DISCON influences.

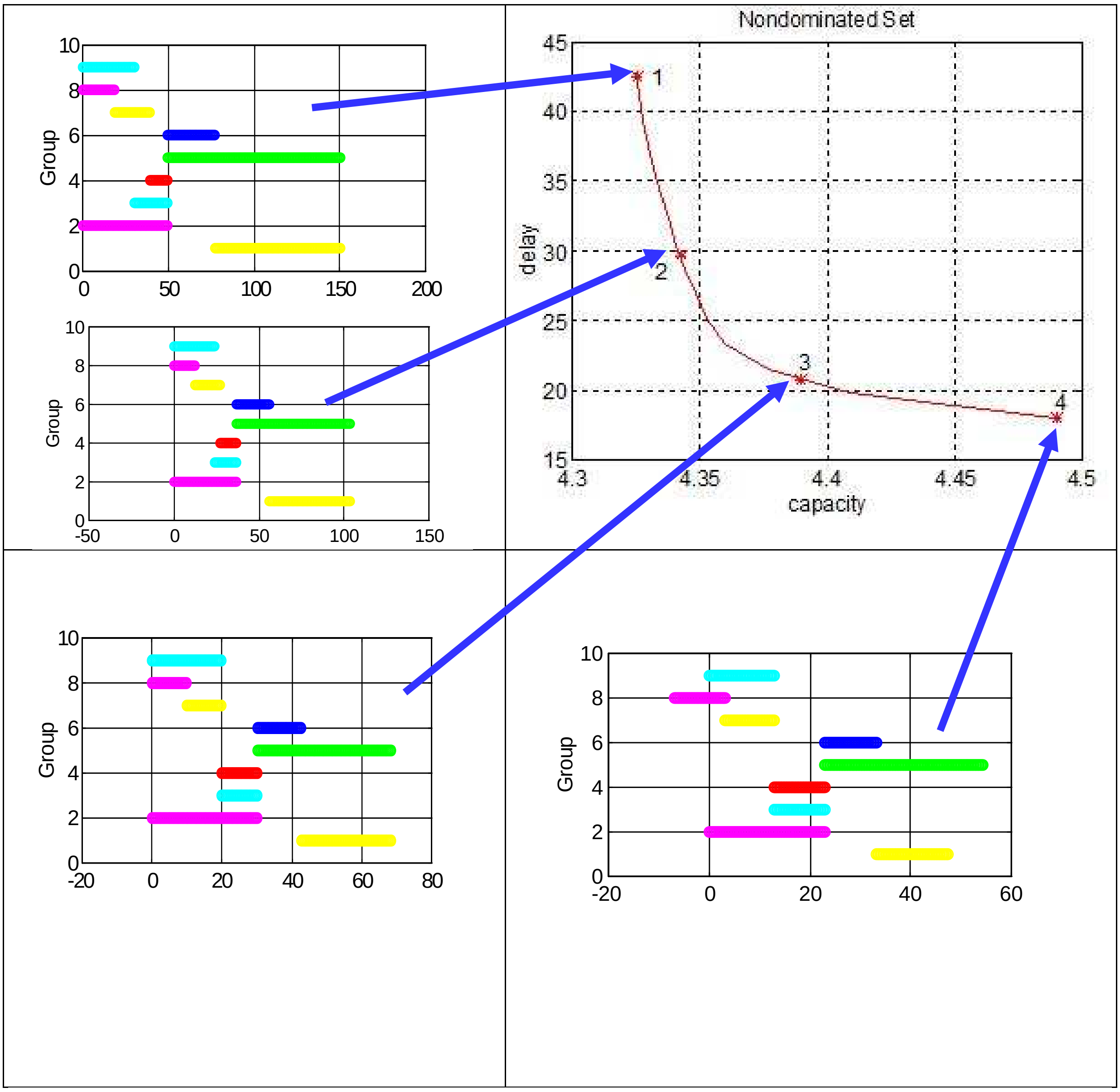

Fig. 5. PIACON capacity-delay trade-offs mode selection based on recognized preference structure
Rys. 5. PIACON wybór zbioru kompromisów przepustowość- straty czasu bazując na rozpoznanej strukturze preferencji

CONCLUSIONS

The ILS systems are good examples of socio-technical very complex systems. In this paper the proposal of the exploration of the system-wide intelligent dedicated interactions of the hierarchical multi-layers HILS platform for the solution of the complex real-time VRP vehicle routing problems was presented. An illustrative example of the real-time VRP-SPD-TW routing problem was solved. In this example the HILS upper layers offer the context-related LoS and network specifications that determine the adequate routing parameters and problem optimization specifications for optimization layer. The HILS platform related new proposal of the multi-layer decomposition of this problem offering very important problem advantages (consistency, lack of redundancy, essential reduction of dimension, dedicated formulation, inter-layer coordination). At the bottom dispatching control layer the DISCON method from public transport was adopted to logistics applications with actual routing treated as obligatory reference schedule to be stabilized by real-time dispatching control actions realized along these routes. The intelligence aspects are related among others to context-related trade-offs between routing modifications and corrective dispatching multi-criteria control capabilities e.g. priority or route guidance actions.

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PROBLEMY WYBORU TRAS BAZUJĄCE NA HILS PLATFORMIE SYSTEMOWEJ

STRESZCZENIE. **Wstęp:** Zastosowano hierarchiczną wielowarstwową platformę systemową HILS do rozwiązywania złożonych problemów wyboru tras dla pojazdów logistycznych.

Metody: Dekompozycja problemu wyboru tras na zadania warstw systemowych tworzących hierarchiczną strukturę ILS systemu. Dedykowana metoda rozwiązania problemu wyboru tras dla problemu VRP-SPD-TW . Metody rozpoznawania struktury preferencji sterowania wielokryterialnego AHP - Entropia. DISCON i PIACON metody optymalnego sterowania dyspozytorskiego i ruchu indywidualnego jedno/wielokryterialne.

Wyniki: Sformułowano i rozwiązano oryginalny problem wyboru tras przy pomocy podejścia systemowego oferującego istotne zalety praktyczne, redukcja wymiarowości i redundancji, systemowe wielo-kryterialne podejście, eksploracja cech integracji i inteligencji wspomaganej inteligentnymi działaniami sterującymi.

Wnioski: Proponowane podejście stanowi profesjonalne rozwiązanie kluczowych problemów spotykanych w systemach logistycznych z wykorzystaniem nowoczesnych narzędzi i technologii umożliwiających.

Słowa kluczowe: ILS systemy, inteligencja systemowa, problemy wyboru tras, sterowanie dyspozytorskie, podejście systemowe, systemowe struktury hierarchiczne, HILS platforma systemowa, dekompozycja problemów optymalizacji

PROBLEME DER ROUTENAUSWAHL GESTÜTZT AUF DIE HILS-SYSTEMPLATTFORM

ZUSAMMENFASSUNG. Einleitung: Für die Lösung von komplizierten Problemen bei der Routenauswahl für Logistik-Transportfahrzeuge hat man eine hierarchische Hils-Mehrsichten-Systemplattform in Anspruch genommen.
Methoden: Es wurde eine Dekomposition des Problems der Routenauswahl bis auf die Aufgaben der einzelnen Systemschichten, die eine hierarchische Struktur des Hils-Systems bilden, vorgenommen. Die weiteren angewendeten Methoden: dedizierte Methode für die Lösung des Problems der Routenauswahl für das VRP-SPD-TW-Problem, die Methoden für die Erkennung der Präferenzstruktur der AHP-Entropie-Mehrkriterien-Steuerung, ferner die Mehtoden von DISCON und PIACON für eine optimale Dispositionssteuerung und für die Ein/Mehrkriterien-Steuerung des Individualverkehrs.
Ergebnisse: Es wurde ein Konzept ausgearbeitet und ein kompliziertes Problem der Routenauswahl durch ein systemhaftes, praktische Vorteile bietendes Herangehen gelöst. Die anderen Vorteile des Konzeptes sind: Reduktion der Dimensionalität und der Redundanz, das systemhafte Mehrkriterien-Herangehen an die Problemlösung, Exploration von Merkamlen der Integration und der durch intelligente Steuerungsaktivitäten unterstützten Intelligenz.
Fazit: Das vorgeschlagene Herangehen stellt eine professionelle Lösung der schlüsselhaften, in Logistiksystemen auftretenden Probleme unter Anwendung von modernen Tools und brauchbaren Technologien dar.

Codewörter: ILS-Systeme, System-Intelligenz, Probleme der Routenauswahl, dispositorische Steuerung, systemhaftes Herangehen, hierarchische Systemstrukturen, HILS-Systemplattform, Dekomposition von Optimierungsproblemen

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GATHERING KNOWLEDGE ABOUT DISRUPTIONS IN MATERIAL FLOW IN NETWORK SUPPLY CHAIN

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ABSTRACT. Background: The article aims at presenting a study into disruptions in a network supply chain of metallurgic products. The research was carried out in the years 2011-2013. Network supply chains include key chain links for building the resistance. These chain links affect material flows of the whole supply chain through silencing disruptions. Those predisposed to form a strategy strengthening the resistance of the whole network supply chain are organizations fulfilling the assumptions of flagship enterprise.

Material and methods: The research is carried out in two stages: the stage of identification of disruptions (risk factors) and the stage of identification of strengthening disruptions zones. The authors carried out simulation experiments based on three models built in the management system dynamics technique (VensimDSS). The proposed methodology required constructing original tools for measuring disruptions and zones strengthening the disruptions in the form of cards for measuring disruptions.

Results: The value added is grouping of disruptions in risk factors distinguished in terms of the frequency of the occurrence of disruptions and their results. The authors proposed and defined the notion of zones of strengthening disruptions. The zones are formed from sets of factors strengthening disruptions with similar influence on disruptions.

Conclusions: The IT system composed of a module for identification of disruptions in material flows and a simulation model is a proposal dedicated to organizations controlling material flows in a network supply chain in the conditions of disruptions.

Key words: gathering knowledge, flagship enterprise, network supply chain, disruptions.

INTRODUCTION

The first stage of knowledge management is knowledge acquisition in the organization and in its environment [Probst, Raub, Romhardt 2002, Salmador, Florín 2012]. Information turns into knowledge when it is interpreted and related to a context by its holder. Knowledge management in supply chains refers to a wide spectrum of issues, including the manner of decision making in particular organizations, gaining and processing knowledge about customers, etc. Relatively little attention is devoted in the research to factors causing deviations from the planned material flows. Gathering knowledge about disruptions is an essential task of the flagship enterprise whose part is to silence disruptions so that they will not transfer to the subsequent supply chains. The flagship enterprise controls material processes in supply chains, coordinates tasks performed by participants of the network and, having knowledge on disruptions in the entire supply chain, stands a chance to strengthen its resistance.

The paper presents the idea of gathering knowledge in order to strengthen the resistance of a network supply chain.

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The first part of the paper indicates approaches to measurement the disruptions in a supply chain which have been presented for the past years in the literature. The first part was closed with the expression of the research hypotheses. The second part indicated the author's idea and the resulting methodology of gathering knowledge within the range of disruptions in material flows, referring to contemporary solutions in this field. The worked out methodology was applied in a network supply chain of metallurgic products.

NETWORK STRUCTURE OF SUPPLY CHAIN - FLAGSHIP ENTERPRISE

The complexity of the relations in contemporary supply chains results from dynamic changes in the environment as well as variable recipients' needs. Because of the fact that contemporary supply chains are characterized with a complex structure on each stage of creating the value added, in this paper they will be defined as "network supply chains". Between the entities functioning in the supply chain, the network of connections and relationships is established. The strength of the positive relations represents the level of integration (consistency). Integration (consistency) is one of the constitutive elements of the supply chain which depend on the quality of relationships between the entities constituting the supply chain as well as the size of the established system [Awasthi, Grzybowska 2014].

Creating network relations is especially justified in extremely innovative sectors and in those industries where products are diversified according to the recipients' needs [Brzóska 2013; Chan, Wang, Luong, Chan 2009]. Harryson, Dudkowski, Stern [2008] point out that not only the number of network relations but also the variability of their forms constitute the basis which provides the foundation for organizations to develop new ideas and skills using their key competences and resources.

When defining the role of each link in the network it is worth looking at the graph theory. Determining the centrality of the node according to the degrees of tops (numbers of relations built on the entry and the exit by a given organization) often also means the assessment of the popularity or influentiality of nodes. The centrality according to the degrees of tops is useful for determining which nodes are the key ones from the point of view of spreading information or affecting the nodes situated in the immediate vicinity. Another indicator of the role of a node in a network is mediation. Mediation shows which nodes are the most important from the perspective of communication between nodes. Large mediation nodes are potential points of loss of cohesion of the network. Lin, Yang and Arga [2009] notice that the position of a node in the relational sense means authority essential for exerting efficient influence on other participants of the network. Taking into account the social networks theory in characterizing the network it can be noticed that the social status of the node reflects its authority in the form of one-sidedly directed emotional ties - respect, liking, recognition [Czakon 2012]. Hagedoorn, Roijakkers, Van Kranenburg [2006] remark that the centrality and the popularity of nodes in a network creates a potential for exerting influence on other members of the network. The central link in the network, fulfilling the above-mentioned conditions, is defined in the paper as the flagship enterprise.

During the life of a flagship enterprise networks have features which predispose them to create new relationships. Consequently, these nodes more often than others decide about adding new nodes to the network. The phenomenon of preferential addition of results when creating a network in which a small number of nodes has a very high degree of networkness. The remaining nodes of such a network have a considerably lower degree of networkness. Preferential adding usually results in the phenomenon of small worlds (cliques).

When referring these features of the flagship enterprise to the supply chain it can be noticed that these organizations are not only partners of their suppliers and recipients but simultaneously they widen relations on a given stage of the supply chain creating network relations. A coordination of material flows is a basic task of the flagship enterprise. The coordination is based on three storage payments: effort of participants in the given system, the synergy of their action and the general aim [Grzybowska 2012]. Coordination in the supply chain is one of the barriers of their integration alongside the lack of trust, the lack of understanding the regulations, inappropriate IT systems and differences in the indicated objectives [Grzybowska, Kovács 2014]. Flagship enterprises in the network, understood in this manner, have an essential influence on the amplification of the resistance of a supply chain.

Sheffi [2005] notices that every type of disruptions requires other activities so, depending on key risk factors, the way of building the resistance will be different. Consequently, the first step in the research into the resistance of a supply chain is to identify disruptions and factors amplifying them. Deviations in the anticipated and real level of customer service is the most important measure showing the results of disruptions in material flows.

Sheffi [2005], while investigating ways in which enterprises can respond to strong disruptions and conduct activities reducing threats connected with disruptions, claimed that:

- Reduction of bottlenecks connected with disruptions occurs through monitoring, early-warning systems (an increase in the sensitivity of a supply chain), a quick reaction to the change of needs, collaboration and redundancy
- Operating flexibility is increased through standardization of parts, facilitating their replaceability (product modularity, product designing from the logistic perspective), the postponed production strategy or mass customization of products (multi-variantness) in response to changes of needs which are difficult to forecast, management of relations with customers and suppliers.

Taking into account these requirements the authors proposed an original methodology of gathering knowledge for the needs of strengthening the resistance of a network supply chain. Two research questions, which became the basis of the put forward hypotheses, were as follows:

Research question 1. What is the influence of disruptions in a network supply chain of metallurgic products on deviations in material flows.
H1. Disruptions affect an increase in the frequency of deviations in material flows

Research question 2. What is the influence of factors strengthening the disruption on disruptions in a network supply chain of metallurgic products
H2. Factors defining the zones of strengthening disruptions intensify disruptions in material flows.

THE CONCEPT OF GATHERING KNOWLEDGE ABOUT DISRUPTIONS IN MATERIAL FLOW IN A NETWORK SUPPLY CHAIN

Problems indicated by managers, occurring as a result of including subcontractors into the structure of flows induced to channel the research in such a way as to allow working out tools permitting identification and assessment of disruptions as well as an analysis of decision-making variants connected with compensation of disruptions, through considering two options depending on the frequency of the appearing disruptions [Machado et al 2007; Chopra et al 2007]:

- flexibility allowing compensation of disruptions via designed mechanisms (e.g. the flexibility of resources, the supplies surplus, the redundancy of subcontractors, suppliers, logistic co-operators),
- adaptability involving a change of procedures or network structures

In the research the authors used secondary data gathered for analysing a network supply chain of metallurgic products concerning formation of supplies as well as initial data in the area of the identification of disruptions and assessment of their influence on material flows.

Gathering the initial data was conducted by means of the diary method. The measurement tool was a questionnaire called the "the disruption measurement card". The questionnaire contained both closed as open questions. The research conducted by means of disruption measurement card aim at:

- determining which disruptions are not caught by the IT systems supporting material flows in the investigated organizations,
- limitation of potential disrupting factors, selected on the basis of the literature research, to the ones essential for the investigated supply chain.

Disruption measurement cards were made available in three research objects which are different stages of the supply chain of metallurgic products. The cards were filled every day for 12 months by workers of different organizational units. The obtained data were converted in the Statistica software.

The process of the analysis of disruptions is a multi-staged one [Blackhurst, Craighead, Elkins, Handfield 2005]. At the first stage the authors suggested using the cause and effect analysis for identifying the relationship between disruptions and deviations. Thanks to this, this stage of research was conducted according to the following steps [Kramarz 2013]:

- identifying deviations in material flows,
- indicating the relationship: a deviation in material flows - a result of the disruption (organizational results, e.g.: difficulty in functioning of the process, lack of workers, equipments, lack of materials, lack of information, financial results, including costs connected with extraordinary transport, costs of lost sales),
- identifying the place where the disrupting factor occurs (the base enterprise, the supplier, the subcontractor, transport processes),
- identifying factors strengthening the disruption
- assessment of the total of losses connected with the appearance of the deviation.

The classification of disruptions is based on the system approach which allows dividing disruptions according to the following phases: entry, inside the system, which involves processes of transformation and exit. The cause and effect analysis allows sorting out the investigated variables in the following sets: deviations in material flows, factors causing disruptions, chain links of the supply chain generating disruptions, factors strengthening disruptions. Thanks to such an approach it is possible to assess the power of their influence on deviations in the realized processes. The set of factors causing disruptions was categorised into endogenous factors connected with the characterization of the order, with the characterization of the base enterprise and with the characterization of the partner, and exogenous actors connected with the environment of the process of order completion.

At this stage research the authors:

- conducted pilot studies which confirmed the thesis that current IT tools were not sufficient for strengthening the resistance of network supply chains
- identified the most frequent deviations in material flows and their results for organizations in a network supply chain of metallurgic products
- defined risks factors distinguished in respect of similar frequencies of the occurrence of disruptions
- defined zones of strengthening of disruptions.

Factors strengthening disruptions as well as risk factors were distinguished by means of the factor analysis.

In the disruption measurement card factors causing disruptions were left in the form of an open question, allowing workers who filled the questionnaire every day to name freely the event which caused deviations in material flows. It was a conscious approach to the manner of measurement which aimed at catching all possible events, and not only those which were known to the author of the questionnaire while creating it. The mentioned disruptions were characterized descriptively in respect of the reasons of occurrence and the results, the subject responsible for the occurrence of a disruption, and they were assessed according to the power of the influence on the organization according to the organizational and financial criterion. The manner of rating the power of the influence of disruptive factors was provided in the table. Factors strengthening disruptions in material flows were also assessed every day. Respondents marked if a given event took place on that day and, if the they rated (in the event of a positive response) what power of influence it had on disruptions in material flows.

DISRUPTIONS AND ZONES OF STRENGTHENING DISRUPTIONS IN A NETWORK SUPPLY CHAIN OF METALLURGIC PRODUCTS

The carried out literature and pilot research allowed selecting 32 factors causing disruptions in material flows in a network supply chain of metallurgic products. The initial analysis of the relevance of the relationship between selected variables, showed correlations between certain variables, therefore the authors decided to carry out the factor analysis in order to connect strongly correlated variables, and consequently reduce the number of variables. Risk factors distinguished in this way were analysed in respect of the factual justification of connecting definite variables in a given risk factor. As a result of the carried out analysis the authors selected 6 risk factors significantly diversified in respect of the frequency of occurrence of disruptions.

- Factor 1 refers to the organization of production and logistic processes, disruptions are generated by wastage ('muda' according to Lean),
- Factor 2 refers to supplies, disruptions are generated by suppliers,
- Factor 3 involves disruptions arisen at the stage of the realization of logistic processes between the base enterprise and the customer,
- Factor 4 involves disruptions generated by the subcontractor,
- Factor 5 involves disruptions generated by the supplier in the area of the reliability of supplies,
- Factor 6 involves disruptions generated by the base enterprise in the area of order realization including monitoring and processing of orders.

The distinguished risk factors not only represent significantly the variability of disruptions in respect of the frequency of their occurrence but also have their essential reason. The division of the factors is compatible with the phasic (system) perspective in logistics so it involves suppliers, the base enterprise, logistic enterprises, customers. The authors distinguished two types of risk factors within the base enterprise itself. The first risk factor expresses disruptions resulting from bad organization of work. Variables forming this factor refer to wastage factors in an organization (muda), well-known from the literature. The sixth risk factor referring to the risk generated by the base enterprise refers to events happening as a result of the maladjustment of the supply base of the organization and inspection procedures of the quality inspection to the real requirements of material flows. Similarly, disruptions generated by the supplier in respect of the frequency constituted two risk factors. The second risk factor comprises events connected with completeness, quality or lack of supply, and the fifth risk factor contains events associated with the time of delivery realization.

At the stage of identification of disruptions in material flows in s network supply chain the authors also distinguished key deviations (as results of disruptions):

- Unpunctual order realization O1,
- Incomplete order realization O2,
- Unrealized order O3,
- Deviations from the determined stock levels O4,
- Extraordinary transport O5.

The correlation analysis showed that the increase in the frequency of disruptions generated by suppliers is accompanied by an increase in the frequency of unpunctual orders and extraordinary transports. However, the growth of factors from the wastage group (muda) is accompanied by an increases in the frequency of deviations from the determined stock levels. The growth of disruptions generated by the subcontractor causes an increase in the frequency of deviations from the determined stock levels.

The canonical analysis, where deviations in material flows were the dependent variable and risk factors were the independent variable, confirmed the influence of the frequency of disruptions on deviations (the canonical correlation coefficient R^2=0,74 at the relevance level p=0,0042). Consequently, hypothesis 1 was confirmed.

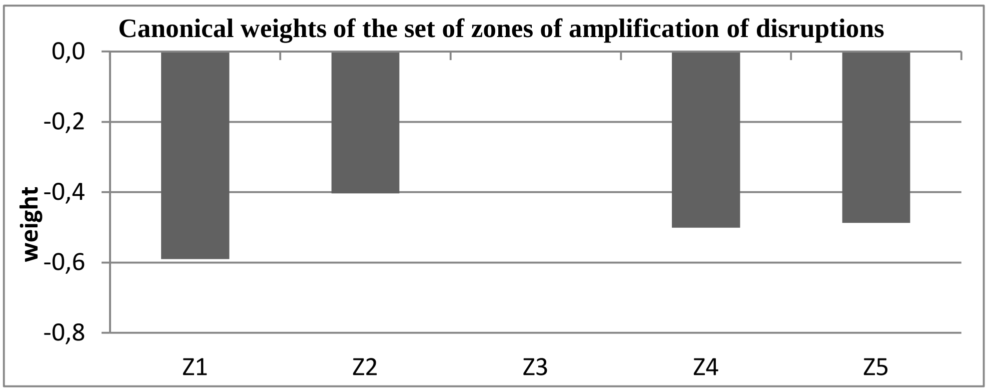
Disruption in material flows can become stronger through the influence of other factors which in the literature are defined as factors of amplification of disruptions. The assessment of factors of amplification of disruptions was carried out on a research sample of 54 enterprises of a network supply chain of metallurgic products. Particular zones were selected on the basis of the factor analysis. Taking into account the findings of the literature research (finished with the selection of factors of amplification of disruptions) and also the findings of the empirical research carried out in earlier stages (including especially separating risk factors in respect of frequency) zones of amplification of disruptions were indicated.

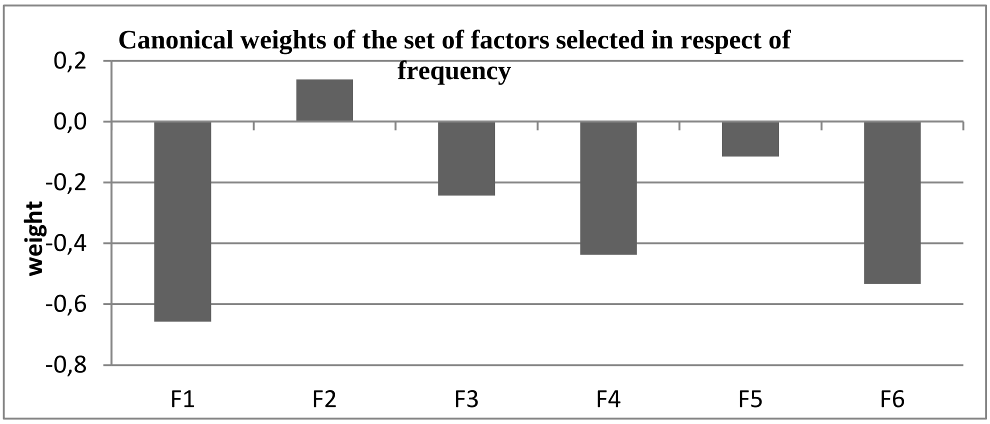
The factor analysis was carried out in two steps. At the first step the authors singled out 12 groups of factors which were represented by 20 factors of amplification of disruptions and 97% explained the variability of the examined phenomenon. Not all groups were characterized with a significant representation of factors of amplification of disruptions. At the second step the authors distinguished 5 zones of amplification of disruptions. The description of zones of amplification of disruptions was presented in Table 1. The distinguished 5 zones is represented altogether by 17 factors of amplification of disruptions:
Zone 1 - Zone of amplification of disruptions in the microenvironment of the base enterprise in the suppliers? environment
Zone 2 - Zone of amplification of disruptions in material flows on the line of communication between the nodes of the network supply chain
Zone 3 - Zone of amplification of disruptions in the area of the market
Zone 4 - Zone of amplification of disruptions resulting from limitations of capacity
Zone 5 - Zone of amplification of disruption in the area of the macro-environment of the network supply chain.

The factors mentioned in zones of amplification of disruptions in 93% explain the variability of factors of amplification of disruptions. The content-related analysis of factors of amplification of disruptions representing particular zones of amplification of disruptions allows acceptance of the division received by means of the factor analysis. he authors indicated a possibility of dividing the factors of amplification of disruptions into homogeneous, in respect of the effect on the frequency of disruptions presented in risk factors, groups defined with zones of amplification of disruptions.

The analysis of the influence of factors strengthening disruptions on the frequency of disruptions expressed in risk factors was effected by means of the canonical analysis, where the components of the independent variable were zones strengthening disruptions, and the dependent variable was represented by risks factors separated in respect of frequency. The obtained configuration of components of the dependent and the independent variable (fig. 1), which significantly explains the influence of zones of amplification of the disruption on risks factors distinguished in respect of frequency, took the canonical correlation coefficient R=0.699 at the relevance level p=0.0054.

Zones 1,2,4 and 5 strongly and favourably amplify the risk factors distinguished in respect of frequency, whereas they exert the strongest influence on the growth of the frequency of disruptions connected with wastage in the base enterprise and connected with unpunctuality of deliveries generated by the supplier. In the obtained configuration only the second risk factor (disruptions generated by suppliers, including defective or incomplete delivery) has a negative and very low canonical coefficient. Consequently, it can be noticed, first of all, an essential influence of zones strengthening disruptions on the punctuality of processes realized by the supplier and on the organizations of processes in the base enterprise. The findings of this part of the research allow adopting Hypothesis 2. At the same time, the obtained findings in the area of testing both of the research hypotheses became the basis for constructing a simulation model which is a module of an IT tool.





Source: The authors' study

Fig. 1. Results of the canonical analysis
Rys. 1. Rezultat analizy kanonicznej

CONCLUSIONS

The network structure of the supply chain enlarges the flexibility through the redundance of production and logistic resources. Flexibility, however, increases the resistance of the entire supply chain on disruptions

In such structures it is extremely essential to gather knowledge on disruptions. The proposed methodology of measuring disruptions including identification of disruptions, indication of the risk factors and zones of amplification of disruptions aims at adjustment of the designed IT tool which allows knowledge gathering under the specificity of a given industry.

The modules designed in the tool, i.e. the modules for tracking disruptions and for tracking real material flows, compatible with the ERP system, allow undertaking activities to correct the size and the frequency of deliveries and the volume of buffer reserves according to the developed real-time strategies of amplification of the resistance.

The system also allows recording deviations in the past periods and making a list of historic data. These provide the basis for estimating the trends connected with disruptions and referring them to the cooperators' attributes.

The system takes into account the stochastic aspect of cooperation. Through historic analyses it is in a position to assess the variability of demand and deliveries on the part of cooperators as well as the sizes and the reasons of deviations and use this knowledge for material flow management.

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GROMADZENIE WIEDZY O ZAKŁÓCENIACH W PRZEPŁYWACH MATERIAŁOWYCH W SIECIOWYM ŁAŃCUCHU DOSTAW

STRESZCZENIE. Wstęp: Artykuł ma na celu prezentację badań nad strategiami wzmacniania odporności w sieciowym łańcuchu dostaw wyrobów hutniczych. Badania przeprowadzono w latach 2011-2013. W sieciowych łańcuchach dostaw istnieją ogniwa kluczowe dla budowania odporności. Ogniwa te oddziałują na przepływy materiałowe całego łańcucha poprzez wytłumianie zakłóceń. Predysponowane do kształtowania strategii wzmacniającej odporność całego sieciowego łańcucha dostaw są przedsiębiorstwa flagowe. Prowadzone badania miały na celu wskazanie metodyki gromadzenia wiedzy pozwalającej przedsiębiorstwom flagowym wzmacniać odporność sieciowego łańcucha dostaw.

Metody: Wzmacnianie odporności w sieciowych łańcuchach dostaw wymaga opisu struktury sieciowego łańcucha dostaw, charakterystyki przedsiębiorstw sterujących przepływami a także zdefiniowania czynników ryzyka i stref wzmacniania zakłóceń. Uwzględniając te wymagania zaproponowano oryginalną metodykę gromadzenia wiedzy dla potrzeb wzmacniania odporności sieciowego łańcucha dostaw. Definiowanie czynników ryzyka oraz stref wzmacniania zakłóceń a także charakterystyka sieci według wyodrębnionych atrybutów są rekomendowanymi przez autorów etapami budowy modelu wspomagania decyzji strategicznych materiałowego punktu rozdziału w zakresie wzmacniania odporności łańcucha dostaw. Badania obejmują zarówno wskazanie wpływu struktury łańcucha dostaw na zakłócenia oraz strategii i roli materiałowego punktu rozdziału w wygładzaniu zakłóceń, jak i wytypowanie zbioru czynników zakłócających, przeprowadzenie analizy przyczynowo skutkowej obejmującej zakłócenia i skutki zakłóceń z perspektywy poszczególnych ogniw łańcucha dostaw oraz wskazanie potencjalnych czynników wzmacniających zakłócenia.

Wyniki: Wartością dodaną, wzbogacającą teorię zarządzania jest zgrupowanie zakłóceń w czynnikach ryzyka wyodrębnionych pod względem częstotliwości występowania zakłóceń oraz ich skutków. Ponadto zaproponowano i zdefiniowano pojęcie stref wzmacniania zakłóceń. Strefy ukształtowane są ze zbiorów czynników wzmacniających zakłócenia mających podobny wpływ na zakłócenia.

Wnioski: Proponowane podejście gromadzenia wiedzy pozwalającej na modelowanie przepływów materiałowych i budowę strategii wzmacniania odporności sieciowego łańcucha dostaw zostało zweryfikowane w wybranej organizacji spieniającej założenia przedsiębiorstwa flagowego sieciowego łańcucha dostaw wyrobów hutniczych.

Słowa kluczowe: przedsiębiorstwo flagowe, gromadzenie wiedzy, zakłócenia, sieciowy łańcuch dostaw

SAMMELN VON WISSEN ÜBER STÖRUNGEN IM MATERIALFLUSS INNERHALB EINER NETZWERK-LIEFERKETTE

ZUSAMMENFASSUNG. Einleitung: Der Artikel bezweckt eine Präsentation von Forschungen über die Strategien der Stärkung von Beständigkeit innerhalb der Netzwerk-Lieferkette für Hüttenerzeugnisse. Die Forschungen wurden in den Jahren 2011-2013 durchgeführt. Innerhalb der Netzwerk-Lieferketten bestehen Glieder, die schlüsselhaft und ausschlaggebend für den Aufbau derer Beständigkeit sind. Die einzelnen Glieder können die Materialflüsse der ganzen Lieferkette durch die Eindämmung von Störungen beeinflussen. Für die Ausgestaltung der Strategien, die die Beständigkeit der ganzen Netzwerk-Lieferkette zu stärken vermögen, sind am meisten die Flaggunternehmen prädistiniert. Die durchgeführten Forschungen hatten zum Ziel, eine Methodik für das Sammeln von Wissen zu ermitteln, die den Flaggunternehmen erlaubt, die Beständigkeit der Netzwerk-Lieferkette zu stärken.

Methoden: Die Stärkung der Beständigkeit in den Netzwerk-Lieferketten bedarf einer Beschreibung von Struktur der Netzwerk-Lieferkette, ferner einer Charakteristik der die Materialflüsse steuernden Unternehmen und einer Definierung von Risikofaktoren und Zonen für die Stärkung von Störungen. Unter Berücksichtigung dieser Anforderungen hat man eine originelle Methodik für das Sammeln von Wissen zwecks der Stärkung der Beständigkeit der Netzwerk-Lieferkette vorgeschlagen.

Die Definierung von Risikofaktoren und Zonen für die Stärkung von Störungen sowie die Chrakteristik eines Netzwerkes nach den ausgewählten Attributen machen die durch die Autoren rekommendierten Etappen des Aufbaus eines Modells für die Unterstützung strategischer Entscheidungen im Bereich der Stärkung der Beständigkeit der Lieferkette aus. Die Forschungen umfassen die Festlegung der durch die Struktur der Lieferkette bedingten Beeinflussung der Störungen sowie die Ermittlung der Strategie und Rolle der Material-Verteilungsstelle bei der Ausglättung der Störungen. Sie lassen darüber hinaus die störenden Einflu?faktoren erkennen und erlauben die Ursache-Wirkungs-Analyse durchzuführen, die die Störungen und ihre Auswirkungen aus der Perspektive der einzelnen Kettenglieder erfasst und auf die potenziellen, die Störungen stärkenden Einflußfaktoren hinweist.

Ergebnisse: Die Wertschöpfung, die die Management-Theorie bereichert, besteht in der Gruppierung der Störungen innerhalb der Risikofaktoren, die hinsichtlich der Intensität des Auftretens der Störungen und ihrer Auswirkungen ermittelt werden. Anschlie?end hat man den Begriff für die die Störungen stärkenden Zonen vorgeschlagen und definiert. Die Zonen werden aus den Mengen der die Störungen stärkenden und sie ähnlicherweise beeinflussenden Faktoren ermittelt.
Fazit: Das vorgeschlagene Herangehen an das Sammeln von Wissen, welches das Modellieren der Materialflüsse und den Aufbau einer Strategie für die Stärkung der Beständigkeit der Netzwerk-Lieferkette erlaubt, wurde in einer ausgewählten, die Anforderungen des Flaggunternehmens erfüllenden Organisation der Netzwerk-Lieferkette für Hüttenerzeugnisse verifiziert.

Codewörter: Flaggunternehmen, Sammeln von Wissen, Störungen, Netzwerk-Lieferkette

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INTER-ORGANIZATIONAL PROXIMITY IN THE CONTEXT OF LOGISTICS – RESEARCH CHALLENGES

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ABSTRACT. Background: One of major areas of modern research econnected with management issues covers inter-organizational networks (including supply chains) and cooperation processes aimed at improvement of the effectiveness of their performance to be found in such networks. The logistics is the main factor responsible for effectiveness of the supply chain. A possible and a quite new direction of research in the area of the performance of processes of the inter-organizational cooperation is the proximity hypothesis that is considered in five dimensions (geographical, organizational, social, cognitive, and institutional). However, according to many authors, there is a lack of research on supply chains conducted from the logistics point of view. The proximity hypothesis in this area of research can be seen as a kind of novum. Therefore, this paper presents the proximity concept from the perspective of the management science, the overview of prior research covering the inter-organizational proximity with supply chain from the logistics point of view as well as the possible future directions of the empirical efforts.

Methods: The aim of this paper is to present previous theoretical and empirical results of research covering inter-organizational proximity in logistics and to show current and up-to-date research challenges in this area. The method of the critical analysis of literature is used to realize the goal constructed this way.

Results: Knowledge about the influence of the inter-organizational proximity on the performance of supply chains is rather limited, and the research conducted so far, is rather fragmentary and not free of limitations of the conceptual and methodological nature. Additional rationales for further research in this area include knowledge and cognitive gaps indentified in this paper. According to authors the aim of future empirical research should be as follows: (1) unification and update of used conceptual and methodological approaches in research on the proximity in supply chains, (2) testing of theoretical hypotheses with attention paid to importance of the proximity for supply chains taking into account the significant heterogeneity of this form of inter-organizational cooperation, and (3) recognizing the role of the inter-organizational proximity for the practice of supply chain management and for the realization of the integration function of the logistics.

Conclusions: There is a shortage of scientific research (both in the theoretical and empirical dimension) explaining the importance of the proximity hypothesis for the performance of supply chains. Additionally, there are interesting gaps in existing scientific output, connecting the logistics output (effectiveness and performance of supply chains) and economic geography (the proximity hypothesis). Closing these gaps should increase our understanding of the supply chains performance and, therefore, this will be the area of further research of authors.

Key words: inter-organizational proximity, supply chain, logistics.

INTRODUCTION

The effective supply chains in modern economy, where the logistics is the main factor of their performance [Harrison, van Hoek 2010], are tools to be used while creating a competitive advantage [Sołtysik, Świerczek 2009, Witkowski 2010, Ciesielski 2011]. The significance of supply chains for organizations is explained by the increasing importance of the inter-organization cooperation [Klimas 2014] and changing the level of the market competition from the inter-organizational one to the competition among supply chains [Li et al. 2006]. Therefore, it should be obvious, that

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functioning of supply chains is one of current areas of scientific research [Sołtysik, Świerczek 2009]. The proximity hypothesis is one of possible directions of the scientific exploration [Czakon 2010] and its application to supply chains can contribute to better understanding of the mechanism of their functioning and achieving a higher level of performance (meaning of the supply chains performance determined by the inter-organizational proximity lies outside the scope of this paper. This issue will be developed in subsequent publications of authors). The concentration on the proximity in the context of supply chains seems to be justified, taking into account the fact that it is called "a decisive factor of the competitive advantage" of supply chains [Hall, Jacobs 2010] and its dimensions are thought to be "fundamental dimensions" of the supply chain management [Carbone, Blanquart 2013].

The shortage of the scientific literature connecting the proximity with supply chains [Klimas, Twaróg 2013] was the reason for undertaking the considerations in this topic. The aim of this paper is to present previous theoretical and empirical works about proximity in the logistics, as well as pointing the most promising research challenges in this area.

The paper consists of the introduction, three main chapters and conclusions. The first main part gives some general ideas of proximity from the perspective of management sciences. The second part concentrates on the logistics area. It presents the previous empirical research connecting the topic of the proximity with supply chains. The third part shows possible directions of future research in the area of logistics covering implications of the inter-organizational proximity. The last part contains the conclusions of considerations made previously.

PROXIMITY IN THE LIGHT OF MANAGEMENT SCIENCES - DEFINITION AND MEANING

The inter-organizational proximity is understood as "consistency in attributes of organisations cooperating with each other" [Boschma, Frenken 2010] and is considered with reference to "physical space, psychological and social relations, cultural values or institutional conditions of actions" [Czakon, 2010]. From such a point of view, proximity is a multidimensional category, covering five separate (from an analytical point of view) dimensions [Boschma 2005]: geographical, cognitive, institutional, social and organizational ones. The five-dimensional approach, proposed by Boschma [2005], is the most often cited one, but it is not the only existing model of the proximity structure [Knoben and Oerlemans 2006; Klimas 2014]. A different point of view is presented by Rallet and Torre [1999], Petruzzelli, Albino and Carbonara [2007], De Oliveira et al. [2011], Carbone and Blanquart [2013], or by Kebir and Torre [2013]. The proximity hypothesis assumes that the closer the organizations are in particular dimensions, the more effective their cooperation will be [Boschma 2005, Rallet, Torre 1999]. The changes in the level of the performance of cooperation resulting from changing the proximity level among organizations are explained by an increase in work productivity, generating a comparative cost advantage as well as improvement of effectiveness of innovation processes [Czakon, 2010]. Looking for more detailed explanations of the significance of proximity for effectiveness of modern organizations, it is possible to conclude that this proximity is used as a variable that is used to help better understand such processes as: knowledge management, innovation management, inter-organizational cooperation as well as inter-organisational networking (Table 1).

Assuming the strategic management perspective, it seems that areas of identifiable meaning of the proximity concentrate on processes that are key factors of the competitive advantage in globalized and knowledge-based economy [Klimas, 2014]. From such a point of view, proximity can help improve market positions of modern companies.

Table 1. Directions of considerations on proximity from a point of view of management sciences
Tabela 1. Kierunki rozważań nad bliskością na gruncie nauk o zarządzaniu

Conceptual area of considerations	**Variables explained by inter-organizational proximity**
knowledge management	absorption of knowledge [Mattes 2012], access to knowledge [Harorimana, Harebamungu 2013], diffusion of knowledge [Dangelico, Garavelli, Petruzzelli 2010], transfer of knowledge [Herrmann et al. 2012], coordination of knowledge processes [Capaldo & Petruzzelli 2014], **creation of knowledge [Petruzzelli, Albino, Carbonara 2007], exchange of knowledge [Broekel, Boschma 2012],** mutual learning [Harorimana, Harebamungu 2013], **absorptive capabilities [Hall & Jacobs 2010]**
Innovativeness and innovation management	effectiveness of innovation activities [Broekel, Boschma 2012**], product innovations [Letaifa, Rabeau 2013], transfer of technology [Huyghe et al. 2014]**
inter-organizational cooperation	effectiveness of inter-organizational relations [Huykghe et al. 2014], **intensity of cooperation [Cunningham, Werker 2012], coordination of cooperation [Kechidi, Talbot 2010],** establishment of cooperation [Mattes 2012], effectiveness of cooperation [Rodríguez-Cohard, Parras 2011]
networking	strength of ties [Jones, Search 2009], effectiveness of knowledge network [Broekel, Boschma 2012], network structure [Broekel, Hartog, 2011], symmetry and power of ties [Jones, Search 2009]

The implications confirmed by scientific research are in bold font, the others are only of theoretical nature.

Source: own work

Concluding, the proximity concept attracted researchers' (of management area) interest relatively late, i.e. at the beginning of the twenty first century. Additionally at the beginning, some attention was paid to processes of inter-organizational cooperation, including network cooperation. After that, research started to be connected closely with processes of knowledge management and innovation management discussed with reference to various types of inter-organizational cooperation, i.e. clusters [Canda, Vázques 2005], industry and technology districts [Petruzzelli, Albino, Carbonara 2007] and innovation networks [Broekel, Boschma 2012; Klimas 2014]. According to many authors there is a shortage of research conducted in the supply chains context, taking into consideration the synthesis of logistics and proximity points of view.

PREVIOUS EMPIRICAL WORKS IN THE AREA OF INTER-ORGANIZATIONAL PROXIMITY IN THE CONTEXT OF LOGISTICS

The concept of proximity is quite new regarding the area of logistics understood as the art of modeling flows of goods and information [Szołtysek, 2012]. To be more detailed, first papers connecting multidimensional inter-organizational proximity with logistics were published approximately 10 years after the topic had started to be interesting for researchers in the area of the management. Novelty of this topic is the reason why scientific literature in this area is scarce, fragmentary and mainly of the conceptual nature. The existing empirical studies are mainly of exploratory nature and (rather) were conducted qualitatively in the form of a case study only (table 2).

From the logistics point of view, the key benefits of proximity can be indentified in regard to the concept of supply chains. Firstly, according to the scientific literature, in case of entities functioning as links in a supply chain, proximity enables to improve the processes of the coordination of the inter-organizational cooperation, to intensify mutual learning and to improve innovation processes [Hall, Jacobs, 2010]. Secondly, much emphasis is put on the importance of the proximity for the integration of supply chains [Klimas, Twaróg 2013] and efficient management of these chains [De Oliveira et al. 2011]. Positive implications of optimization of the proximity of entities within supply chains are multidimensional (e.g. costs, social, time, quality related ones) and depend on the considered dimension of the inter-organizational proximity (table 3).

Table 2. The review of studies connecting inter-organizational proximity with supply chains
Tabela 2. Przegląd badań wiążących bliskość międzyorganizacyjną z łańcuchami dostaw

Authors	**Topic of research**	**Methodological approach**	**Dimensions of proximity**	**Issues**
Hall and Jacobs [2010]	links of a global supply chain	qualitative – case study	organizational, institutional, cognitive, social and geographical	meaning of dimensions of proximity, consequences of their insufficient or excessive level
Kechidi and Talbot [2010]	Airbus and network of its subcontractors	qualitative – case study	organizational, institutional and geographical	dimensions of proximity as reasons of conflicts and motives for common actions
De Oliveira et al. [2011]	members of Supply Chain Council	quantitative – descriptive statistics and structural equation modeling	digital	meaning for the cooperation within supply chains (direct effect) and the performance of the organizations (indirect effect)
Carbone and Blanquart [2013]	links of green supply chains	qualitative – 7 case studies	organizational, institutional and geographical	typology of cooperation practices with regard to types of proximity and types of environmental practices
Galli and Brunori [2013]	short (lean) supply chains	qualitative – 19 case studies	social and geographical	criterion of identification of lean supply chains, importance for the balanced development of sustainable products provided by the supply chain
Klimas [2014]	links of supply chains organized as networks of innova-tions	qualitative and quantitative – analysis of interviews, descriptive statistics and regression analysis	organizational	meaning for network cooperation and organizational innovation

Source: own study

Table 3. Dimensions of proximity and functioning of supply chains
Tabela 3. Wymiary bliskości, a funkcjonowanie łańcuchów dostaw

Dimension of proximity	**Foundation of proximity**	**Importance for integrations and functioning of supply chains**
geographical	spatial and time distance of entities	bigger possibilities of direct contacts, lower transport costs, quicker access to resources
organizational	organizational similarity and membership to inter-organizational networks	easier cooperation (including communications) due to common and shared approaches to management, philosophy of activity, organizational culture, organizational structure, and strategic orientation, and vision of the future (including convergence of goals). The similarities in the above mentioned aspects can be a source of mutual understanding and inter-organizational trust, as well as of reduction of the risk of opportunistic behaviors
social	interpersonal relationships connecting workers of members of particular supply chain	an increase in effectiveness of communication (utilization of both formal and informal communication channels) and limitation of risks of opportunistic behaviors (e.g. by relationships of friendship, sympathy, family, common values and standards)
cognitive	similarity of mental models and of cognitive processes, homogeneity and heterogeneity of knowledge databases, technologies applied anddomain of activity	synchronization of manufacturing processes based on common technological processess, production and quality standards applied, an increase in communication performance through use of understandable jargon and technological slang and affiliation to the same group of the practice (e.g. community of practice)
institutional	institutional environment (including culutural issues) of members of supply chain	possibility of easier and more flexible cooperation as the members of supply chain work under similar law framework (same book-keeping rules, labor law, WHS standards) or cultural conditions (lack of cultural differences and conflicts hampering the cooperation)

Source: own study

Concluding, the meaning of proximity in the context of logistics results from the fact that the proximity in question can be a factor that can explain [Hall & Jacobs, 2010] both gaining new competences by members of supply chains and effective management along with coordination of complex and collective activities and logistic processes to be found in the supply chain. Based on the above and assuming that logistics is an activity of coordination of flows of goods and information within the supply chain [Harrison, van Hoek 2010], which leads to improvement of its effectiveness.

RESEARCH CHALLENGES IN THE AREA OF INTER-ORGANIZATIONAL PROXIMITY IN THE CONTEXT OF LOGISTICS

Based on significant and interesting theoretical and empirical works regarding the influence of the proximity on the performance of the inter-organizational cooperation (see table 1), it can be concluded that the proximity hypothesis is believed to perform the role of a significant determinant of performance of contemporary supply chains. However, according to authors, there is a deficiency of research restricting the empirical perspective to functioning of supply chains. The authors propose the following three directions of research.

First direction

Many of existing postulates pointing out the influence of proximity on the cooperation processes are only of theoretical nature and therefore need to be verified empirically (see variables that are not bold font in table 1).

Second direction

Prior scientific works linking the proximity hypothesis with activity of supply chains are quite inconsistent regarding the theoretical assumptions adopted (e.g. lack of coherence and high level of ambiguities in the field of number and types of proximity dimensions). Additionally, in many cases the conceptual [e.g. De Oliveir et al. 2011] or measurement [e.g. Hall Jacobson 2010] assumptions adopted during research on proximity within supply chains do not agree with the recent knowledge in the area of the inter-organizational proximity (see remarks in table 4).

Table 4. Shortcomings in previous research linking the proximity with supply chains
Tabela 4. Mankamenty w dotychczasowych pracach badawczych nad bliskością w łańcuchach dostaw

Authors	**Topic of research**	**Dimensions of proximity**	**Remarks referring to conceptualization and operationalization**
Hall and Jacobs [2010]	links of global supply chain	organizational, institutional, cognitive, social and geographical	narrow approach to organizational dimension of proximity covering only to the method of the control during the cooperation
Kechidi and Talbot [2010]	Airbus and network of its subcontractors	organizational, institutional and geographical	organizational dimension of proximity perceived as a type of institutional proximity; narrow approach to institutional dimension of proximity including only cultural aspects; only three dimensions of proximity were taken into consideration
De Oliveira et al. [2011]	members of Supply Chain Council	digital	digital proximity as a type of the organizational dimension of proximity; only one dimension of proximity was taken into consideration
Carbone and Blanquart [2013]	links of green supply chains	organizational, institutional and geographical	narrow approach to institutional dimension of proximity including only cultural aspects; organizational cultures included to institutional dimension of proximity instead of to organizational proximity; only three dimensions of proximity were taken into consideration
Galli and Brunori [2013]	short (lean) supply chains	social and geographical	geographical proximity limited to spatial distance while the time and infrastructure issues remain outside the consideration; only two dimensions of proximity were taken into consideration
Klimas [2014]	links of supply chains organized as networks of innovations	organizational	only one dimension of proximity was taken into consideration

Source: own study

Third direction

The previous empirical works should be described as fragmentary and there is a possibility to point few important research gaps. The recommended directions of future research on proximity in the context of the inter-organizational cooperation should be as follows: dynamics of proximity, relationships and interdependencies among dimensions of proximity, nature and the scope of implications of proximity for cooperation and networking cooperation [Klimas, 2014]. Additionally, research gaps are also experienced in relation to cooperation within the supply chain. In particular, some attention is paid to the need of further research that would broaden knowledge of the essence as well as types of management of supply chains through consideration of the significance of proximity dimensions [Li et al. 2006] or comparative research on significance of proximity for the performance of different types of supply chains that are diversified by means of their criterion of proximity in particular dimensions [Kechidi, Talbot, 2010]. Additionally, due to the lack of this type of research, it seems to be justified to focus future research efforts on recognizing the importance of proximity in different types of supply chains, in supply chains functioning in various economic areas, or in supply chains of different geographical locations. It is worth mentioning that at present such topics as significance of proximity and its individual dimensions for realization and the flow of the integration function of the logistics [Szołtysek, 2011] in organizations of the supply chains status, are out of scope of the research.

CONCLUSIONS

Based on scientific literature, there is a lack of scientific research (theoretical and empirical ones) narrowing the considerations on the significance of the hypothesis of the proximity for performance of functioning of supply chains. The researchers of the proximity point out that the inter-organizational proximity is one of fundaments of the inter-organizational cooperation and its importance for the logistics has not been explained entirely and needs further research [Nikkanen, 2005]. According to authors, regarding the existing scientific literature connecting the logistics area (functioning of supply chains), strategic management (effectiveness of inter-organizational cooperation) and economic geography (the hypothesis of the proximity) there are interesting cognitive gaps. Closing the gaps in question should lead to better understanding and improvement of performance of supply chains, which will be subject to further research of authors.

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BLISKOŚĆ MIĘDZYORGANIZACYJNA W KONTEKŚCIE LOGISTYKI - WYZWANIA BADAWCZE

STRESZCZENIE. **Wstęp:** Jednym z głównych obszarów badań współczesnej nauki o zarządzaniu są sieci międzyorganizacyjne (w tym łańcuchy dostaw) oraz zachodzące w ich ramach procesy współdziałania zmierzające do poprawy sprawności ich funkcjonowania. Podstawowym czynnikiem sprawności łańcucha dostaw jest logistyka. Możliwym i stosunkowo nowym kierunkiem badań w obszarze sprawności procesów współdziałania międzyorganizacyjnego jest hipoteza bliskości rozpatrywana w pięciu wymiarach (geograficznym, organizacyjnym, społecznym, poznawczym oraz instytucjonalnym). W opinii autorów brakuje jednak badań prowadzonych w kontekście łańcuchów dostaw przyjmujących logistyczny punkt widzenia. W tym obszarze hipoteza bliskości wciąż stanowi swoiste novum. Dlatego też, w artykule przybliżono koncepcję bliskości z perspektywy nauk o zarządzaniu, przedstawiono przegląd dotychczasowych badań wiążących bliskość międzyorganizacyjną z łańcuchami dostaw z punktu widzenia logistyki oraz nakreślono możliwe kierunki dalszych badań.

Metody: Celem niniejszego artykułu jest przedstawienie dotychczasowego dorobku teoretycznego oraz empirycznego nad bliskością międzyorganizacyjną w logistyce ze wskazaniem aktualnych wyzwań badawczych w tym obszarze. Dla realizacji tak skonstruowanego celu wykorzystano metodę krytycznej analizy literatury.

Wyniki: Stan wiedzy dotyczący znaczenia bliskości międzyorganizacyjnej dla sprawnego funkcjonowania łańcuchów dostaw jest dość skromny, a dotychczasowe badania empiryczne są fragmentaryczne i nie są wolne od ograniczeń koncepcyjno-metodycznych. Dodatkowym uzasadnieniem potrzeby dalszej i głębszej eksploracji naukowej są zidentyfikowane w artykule luki badawcze. Zdaniem autorów przyszłe badania empiryczne powinny służyć: (1) ujednoliceniu oraz aktualizacji wykorzystywanych podejść koncepcyjno-metodycznych w badaniach nad bliskością w łańcuchach dostaw, (2) testowaniu postulatów teoretycznych wskazujących na znaczenie bliskości dla funkcjonowania łańcuchów dostaw z uwzględnieniem znaczącej heterogeniczności tej formy współdziałania międzyorganizacyjnego, a także (3) rozpoznaniu roli bliskości międzyorganizacyjnej dla praktyk zarządzania łańcuchami dostaw oraz dla realizacji integracyjnej funkcji logistyki.

Wnioski: W literaturze widoczny jest deficyt badań naukowych (teoretycznych oraz empirycznych) zawężających rozważania nad znaczeniem hipotezy bliskości do sprawności funkcjonowania łańcuchów dostaw. Co więcej, w istniejącym dorobku naukowym łączącym dorobek logistyki (sprawność łańcuchów dostaw) oraz geografii ekonomicznej (hipoteza bliskości) występują interesujące luki poznawcze, których zapełnienie powinno przyczynić się do głębszego zrozumienia sprawności łańcuchów dostaw - co będzie przedmiotem dalszych badań autorów.

Słowa kluczowe: bliskość międzyorganizacyjna, łańcuch dostaw, logistyka

INTERORGANISATIONALE NÄHE IM KONTEXT DER LOGISTIK - FORSCHUNGSHERAUSFORDERUNGEN

ZUSAMMENFASSUNG. Einleitung: Einer der Schwerpunkte von Forschungen innerhalb der gegenwärtigen Managementlehre sind interorganisationale Netzwerke (darunter Lieferketten) und die sich in ihren Rahmen vollziehenden Zusammenwirkungsprozesse, die auf die Verbesserung deren Funktionalität hinzielen. Ein grundlegender Einflu?faktor für die Funktionalität einer Lieferkette ist die Logistik. Eine mögliche und relativ neue Forschungsausrichtung bei der Erfassung von Proze?leistung innerhalb der interorganisationalen Zusammenwirkung stellt die Hypothese der Nähe, die in fünf Ausmassen (im geographischen, organisatorischen, sozialen, erkundlichen und institutionalen Ausma?) betrachtet wird, dar. Nach Ansicht der Autoren bleiben jedoch die in der Anbetracht der Lieferketten und unter dem logistischen Gesichtspunkt durchgeführten Forschungen aus. Auf diesem Gebiet erscheint die Hypothese der Nähe immer noch als einzigartiges Novum. Daher hat man im Artikel das Konzept der Nähe aus der Perspektive der Managementlehre projiziert und die Übersicht über die bisherigen Forschungen, die unter dem logistischen Gesischtspunkt die interorganisationale Nähe mit den Lieferketten verbinden, dargestellt. Ferner wurde auch die mögliche Ausrichtung von weiteren Forschungen kontouriert.
Methoden: Das Ziel des vorliegenden Artikels ist es, die bisherigen, theoretischen und empirischen Errungenschaften im Bereich der interorganisationalen Nähe mit dem Hinweis auf die aktuellen Forschungsherausforderungen auf diesem Gebiet darzubieten. Für die Ausführung des so abgezeichneten Zieles hat man die Methode für kritische Auswertung der Gegenstandsliteratur in Anspruch genommen.
Ergebnisse: Der Wissensstand zur Bedeutung der interorganisationalen Nähe für die einwandfreie Funktionalität der Lieferketten ist ziemlich bescheiden bemessen, und die bisherigen empirischen Forschungen sind fragmentarisch und auch nicht ganz frei von konzepionell-methodologischen Einschränkungen. Eine zusätzliche Begründung für den Bedarf einer weiteren und vertieften, wissenschaftlichen Erforschung stellen die von den Autoren identifizierten Forschungslücken dar. Nach Ansicht der Autoren sollen die zukünftigen empirischen Forschungen den folgenden Zielsetzungen dienen: (1) der Vereinheitlichung und Aktualisierung der konzepionell-methodologischen Herangehen an die Erforschung der Nähe innerhalb der Lieferketten, (2) der Überprüfung der theoretischen Postulate, die auf die Bedeutung der Nähe für die Funktionalität der Lieferketten unter Berücksichtigung einer wesentlichen Heterogenität dieser Form des interorganisationalen Zusammenwirkens hinweisen sowie (3) der Erkenntnis der Rolle der interorganisationalen Nähe für das praktische Management von Lieferketten sowie für die Ausübung der Integrationsfunktion der Logistik.
Fazit: In der Gegenstandsliteratur ist ein Mangel von sowohl theoretischen, als auch empirischen Forschungen, die die Erkundungen über die Bedeutung der Hypothese der Nähe für die Funktionalität der Lieferkette einengen würden, erkenntlich. Darüber hinaus treten im wissenschaftlichen, die Leistung der Logistik (Funktinalität der Lieferketten) und die Leistung der Wirtschaftsgeographie (Hypothese der Nähe) verbindenden Erwerb interessante Erkundungslücken auf, die möglichst schnell geschlossen werden sollen, was zu einem besseren Verständnis der Funktionalitätsfrage innerhalb der Lieferketten beitragen und auch zum Gegenstand der weiterhin von den Autoren zu betätigenden, betreffenden Forschungen werden sollte.

Codewörter: interorganisationale Nähe, Lieferkette, Logistik

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STRATEGIC VEHICLE FLEET MANAGEMENT - THE COMPOSITION 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 second 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 companies' fleets of vehicles. It means deciding on the number of vehicles in a fleet (the fleet sizing problem - FS) and types of vehicles in a fleet (the fleet composition problem - FC). The essence of both problems lies in balancing transportation supply and demand taking into account different demand types to be fulfilled and different vehicle types that can be put into a fleet. Vehicles, which can substitute each other while fulfilling different demand types. In the paper an original mathematical model (an optimization method) allowing for the FS/FC 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 some best fitted (optimal) fleet size / composition matching company's transportation requirements. An optimal fleet size / composition allows for a significantly higher fleet utilization (10-15% higher) than any other, including random fleet structure. Moreover, any changes in the optimal fleet size / composition, even small ones, result in a lower utilization of vehicles (lower by a few percent).

Conclusions: The presented in this paper analysis, on the one hand, is consistent with a widespread opinion that the number of vehicle types in a fleet should be limited. In the other words it means that the versatility / interchangeability of vehicles is very important. On the other hand, the analysis proves that even small changes in a fleet size / fleet composition can result in an important changes of the fleet effectiveness (measured for example by the utilization ratio).

Key words: management, optimization, fleet, transport, sizing, composition.

"Is your fleet the right size?" - David Kirby

INTRODUCTION

The decision of how many vehicles keep in a company's fleet to fulfil varying with time transportation requirements is called a fleet sizing (FS) problem [Gould, 1969]. Whereas, in case of a fleet composition (FC) problem types of vehicles should be defined as well [Etezadi and Beasley, 1983].

The most crucial factor influencing the FS/FC problems is a demand for transportation services. Its level, seasonal changes, trend, but also its character resulting in particular types of transportation requirements to be fulfilled. In practice, there can be observed not only seasonal changes of the demand but also more short-term fluctuations as monthly or even daily changes. In many economy branches transportation requirements increase significantly (even by 30%) at the end of every month, usually in a last week or a third decade

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of a month (phenomenon so-called "the third decade syndrome").

The demand can also be of different types according to specific features of loads, distances, routes or locations of destination points / customers, their orders and many others. For example resulting in:

- transportation of commodities that require or not special treatment (e.g. general freights v. dangerous goods, loose materials, temperature controlled environment shipments),
- transportation of heavy and/or oversized loads,
- local, regional, domestic or international shipments (short- and long-distance haulage),
- urban, suburban or rural deliveries,
- less than truck-load (LTL) or full truck-load (FTL) shipments.

The demand for transportation services can be defined by a number of kilometers, ton-kilometers, tones, cubic-meters, pallets, liters or any other measure of loads to be transported /transports to be done within a given time period.

As a result, different (universal, specialized or special) types of vehicles of different load capacity (small, light, medium, heavy or even very heavy trucks) are necessary to transport particular types of loads. However, the range of load types being within transportation capabilities of particular types of vehicles is limited. It depends on both, the interrelationship of vehicle and load features and vehicle maximum productivity that can be split among particular demand types.

All the mentioned above features of the demand (level and seasonal changes of particular demand types) can lead to an oversized fleet or to an unmet demand (transportation requirements not fulfilled by vehicles in a fleet), or even both at the same time. The unmet demand usually cannot be backordered and has to be outsourced or lost. Moreover, some long-term changes of the demand can force fleet size changes (increases or reductions).

There are also very important economic aspects of the FS/FC problems. In contrast to using outside transportation resources (buying transportation services in the market from common carriers), an in-house transportation solution results not only in variable, but, what is very important, in fixed costs as well. The fixed costs have to be bore even though particular vehicles in a fleet do not work (are not utilized) at a particular time period. These are the costs of unused resources - downtime, empty movements, and underutilized vehicles' loading capacity and/or productivity e.g. mileage (due to seasonal or other changes of the transportation demand). On the other hand, a company operating their own fleet of vehicles has to cover costs of all kilometers travelled (loaded and empty ones).

What can reduce level of the unmet demand or too high fixed costs and at the same time increase utilization ratio of an in-house fleet is the right interchangeability/versatility of vehicles in a fleet. The interchangeability /versatility means ability of particular vehicles to serve particular demand types.

THE METHOD FOR SOLVING THE FC PROBLEM

There exist many methods for solving the FS/FC problems using different computational /optimization techniques. One can distinguish methods based on: Linear Programing (including one of the very first FS solution procedures proposed in the year 1954 by Dantzig and Fulkerson [Dantzig and Fulkerson 1954]; Non-Linear Programing [Hall, Sriskandarajah and Genesharajah 2001]; Dynamic Programming [Fagerholt 1999]; Queuing Theory [Parikh 1977, Zak, Redmer and Sawicki 2008]; Simulation [Koo, Jang and Suh 2005, Petering 2011]; Network / Graph Theory [Beaujon and Turnquist 1991, Wu, Hartman and Wilson 2005], and Inventory management techniques [Du and Hall 1997] as well. The separate and large group of methods constitute those combining the FS/FC problems with the Vehicle Routing Problem - VRP. As a result, the FS/FC problems, which are strategic in nature, are treated more as tactic-operational ones. This group of methods usually includes heuristic [Ball, Golden, Assad and Bodin 1983, Golden, Assad, Levy and Gheysens 1984, Renaud and Boctor 2002] and metaheuristic ones [Yepes and Medina 2006, Osman and Salhi 1996, Gendreau, Laporte, Musaraganyi and Taillard 1999].

Majority of the FS/FC solution methods balances supply and demand for transportation services. They adjust supply of transportation capabilities of a fleet to the demand for transportation services to be delivered. The supply is defined by a number of vehicles in a fleet and their capacity (e.g. tonnage or the Gross Vehicle Weight Rating - GVWR) and productivity (e.g. a maximum annul mileage). When considering the FC problem different types of vehicles serving different types of transportation demand are taken into account as well. The general aim of balancing supply and demand is to fulfil all the demand while minimizing overall costs or maximizing utilization ratio of a fleet.

The general drawback of the mentioned above solution methods is that they do not take into account an interchangeability of vehicles when serving different types of transportation demand. Usually a necessary numbers of vehicles in a fleet to serve particular demand types are calculated separately. While in practice vehicles of particular types are utilized to fulfill interchangeably different demand types, with lower or higher effectiveness and under some limitations of course. When it is not taken into account it can result in an oversized fleet.

The question arises how to balance transportation supply and demand assuming that particular vehicle types can serve particular demand types interchangeably? What will be the distribution of vehicles' productivity between particular types of demand?

The point is to assess the most probable number of kilometers that vehicle of a given type will travel carrying loads (serving demand) of a given type. Let assume that a vehicle of a particular type, having the maximum productivity of 100 kilometers per given period of time / analysis, can serve for example three types of demand (1, 2 and 3) requiring the following number of kilometers to be covered: 100, 200 and 300 per period of analysis (600 kilometers in total). The probability that the vehicle will be engaged in carrying loads of the type 3 (the demand 3) is three times higher than the probability of carrying loads of the type 1, since the overall workload to be done associated with the demand type 3 is 300 kilometers, whereas for the demand type 1 it is 100 kilometers only. Based on this assumption, the maximum productivity of the vehicle can be most probably divided between the three demand types as follows: 17 kilometers traveled carrying loads of type 1 (it comes from 100 kilometers multiplied by 1/6 that is 100 kilometers being the total quantity of kilometers associated with the demand type 1 divided by 600 kilometers being the total number of kilometers to be covered within the period of analysis), 33 kilometers traveled carrying loads of type 2, and the rest that is 50 kilometers traveled carrying loads of type 3. But if there in the fleet are too many vehicles that can serve, for example, demand number 3, let assume 10 vehicles of the same type as the analyzed one, it means that each one of them can travel 30 kilometers only when serving demand type 3 (300 kilometers divided by 10 vehicles), not 50! And they are underutilized.

As a result a generic formula for calculating the number of vehicles of particular types j (j = 1, 2, 3, …, J) in a fleet, the number that maximizes utilization ratio of a fleet and allows for fulfilling the whole transportation demand divided into I types (i = 1, 2, 3, …, I) can be written as follows:

$$K_P(l_j) = \sum_{i=1}^{I}\left[Min\left\{1, \frac{P_i}{\sum_{j=1}^{J}\left(W_j \cdot l_j \cdot zW_{ij} \cdot \frac{P_i}{\sum_{i=1}^{I}\left(P_i \cdot zW_{ij}\right)}\right)}\right\} \cdot \frac{P_i}{\sum_{i=1}^{I} P_i}\right]$$

under the condition:

$$\sum_{j=1}^{J}\left(W_j \cdot l_j\right) \geq \sum_{i=1}^{I} P_i$$

where:

$K_P(l_j)$ - average utilization ratio of a fleet composed of vehicles of particular types j in the quantity of l_j vehicles of particular types j [-],

l_j - number of vehicles of particular types j in a fleet, including 0 that allows for fleet composition adjustments as well - DECISION VARIABLES [-],

P_i - demand for transportation services of a type i per period of analysis; i = 1, 2, 3, …, I [kilometers - km, tones - t, ton-kilometers - tkm, pallets - p, m^3, liters - l, routes - r, …/… e.g. one year],

W_j - average, real productivity of one vehicle of a type j per period of analysis, expressed in the same units of measurement as the demand [km, t, tkm, p, m^3, l, r, …/…],

zW_{ij} - productivity range of particular vehicle types j in relation to demand types i denoting what types of demand can serve given type of vehicles; $zW_{ij} \in \{0, 1\}$ - binary value or $zW_{ij} \in \langle 0, 1\rangle$ [-],

Min{…}- minimum value of elements of a set.

THE CASE STUDY – SOLVING THE FC PROBLEM IN POLISH CIRCUMSTANCES

Let's consider a domestic transportation company operating in Poland. The company exploiting a fleet composed of 14 types of vehicles and serving 5 types of transportation demand (carrying 5 types of loads).

As for the demand types i, there are the following ones:

- i = 1: long-haul - regular loads - an average number of customers per one route 3 - an average weight of a load per one route 18t - an average number of cargo units per one route 30 pallets - an average length of one route 715 km - the total annual number of kilometers 2 000 000,
- i = 2: short-haul - regular loads - an average number of customers per one route 3 - an average weight of a load per one route 13.5t - an average number of cargo units per one route 27 pallets - an average length of one route 235 km - the total annual number of kilometers 900 000,
- i = 3: short-haul - temperature controlled loads - an average number of customers per one route 4 - an average weight of a load per one route 12t - an average number of cargo units per one route 12 pallets - an average length of one route 270 km - the total annual number of kilometers 1 100 000,
- i = 4: urban distribution - regular loads - an average number of customers per one route 6 - an average weight of a load per one route 6t - an average number of cargo units per one route 12 pallets - an average length of one route 135 km - the total annual number of kilometers 800 000,
- i = 5: urban distribution - regular and temperature controlled loads - an average number of customers per one route 4 - an average weight of a load per one route 6t - an average number of cargo units per one route 8 pallets - an average length of one route 185 km - the total annual number of kilometers 700 000.

As for the vehicle types j, there are the following ones:

- j = 1, 2, 3 and 4: tractors with semi-trailers - full tilt (curtain sided) - load capacity of 20, 24 and 26 tones / 33 pallets - maximum annual mileage 50 to 80 000 km - emission standard EURO3, 4 and 5 - age 3 to 10 years,
- j = 5: trucks - closed body - load capacity of 6 tones / 12 pallets - maximum annual mileage 82 000 km - emission standard EURO5 - age 1 year,
- j = 6,7 and 8: trucks - full tilt - load capacity of 8 and 10 tones / 14 and 16 pallets - maximum annual mileage 42 to 71 000 km - emission standard EURO3 and 5 - age 4 to 12 years,
- j = 9 and 10: trucks - isolated - load capacity of 14 tones / 18 and 20 pallets - maximum annual mileage 66 to 79 000 km - emission standard EURO4 and 5 - age 3 to 6 years,
- j = 11: trucks - refrigerated - load capacity of 16 tones / 18 pallets - maximum annual mileage 55 000 km - emission standard EURO3 - age 8 years,
- j = 12 and 13: vans - closed body - load capacity of 1.5 and 2 tones / 2 and 6 pallets - maximum annual mileage 59 to 69 000 km - emission standard EURO4 and 5 - age 1 to 5 years,

– j = 14: vans - isolated - load capacity of 2 tones / 4 pallets - maximum annual mileage 67 000 km - emission standard EURO5 - age 2 years.

An optimal fleet composition balancing described above transportation supply and demand has been constructed maximizing the average, weighted utilization ratio $K_P(l_j)$ (taking into account a maximum annual mileage) of vehicles in the fleet under the constraint that the numbers lj of vehicles of particular types j will be high enough to fully satisfy the transportation demand of all types i.

In the analysis the limited ability of particular vehicle types to serve particular demand types has been taken into account. In details the maximum annual mileage of vehicles of particular types has been divided between the 5 demand types taking into account the matching of vehicles (their load capacities) to particular demand types (an average weight of loads and number of cargo units per one route) - see Table 1. For example, tractors with semi-trailers - full tilt (the vehicle types j = 1, 2, 3 and 4), irrespectively of their load capacity (20, 24 or 26 tones / 33 pallets), are suitable to serve the long-haul - regular load shipments (the demand type i=1), characterized by an average weight of a load of 18t /30 pallets per one route being 715-kilometer long on average and, however, with the less efficiency, the short-haul - regular load shipments (the demand type i=2), characterized by an average weight of a load of 13.5t / 27 pallets per one route being 235-kilometer long on average. And, they are not suitable to serve the short-haul - temperature controlled load shipments and the urban distribution as well (the demand types i = 3, 4 and 5).

Using the proposed above mathematical model of the FS/FC problem, the above described data and a professional solver for the MS Excel the problem has been solved. The results are presented in Table 2.

Table 1. Ability of particular vehicle types to serve particular demand types
Tabela 1. Możliwości obsługi danego rodzaju popytu przez dany rodzaj pojazdu

Vehicle type *j*	**Demand type *i***				
	1	**2**	**3**	**4**	**5**
1	√	√			
2	√	√			
3	√	√			
4	√	√			
5				√	√
6		√		√	√
7				√	√
8	√	√		√	√
9		√	√	√	√
10		√	√	√	√
11			√		√
12				√	
13				√	
14				√	√

Source: author's research

Table 2. Selected solutions of the analyzed FC problem
Tabela 2. Wybrane rozwiązania analizowanego problemu kompozycji taboru

Vehicle type *j*	**Number of vehicles of type *j* in the fleet – l_j**		
	Smooth solution	**Random solution**	**Optimal solution**
1	6	8	15
2	6	10	0
3	6	3	11
4	6	2	17
5	6	9	0
6	6	8	0
7	6	11	0
8	6	2	0
9	6	9	0
10	6	3	0
11	6	7	32
12	6	8	0
13	6	1	0
14	6	2	13
Total fleet size	**84**	**83**	**88**
Utilization ratio – $K_p(l_j)$	**87%**	**86%**	**100%**

Source: author's research

As it is shown in Table 2 the optimal solution is significantly better than the smooth and the random ones. To assure a comparability of the solutions it was assumed that the value of the LHS of the constraint can exceed the value of the RHS by no more than 1% in all the solutions. As a result the total size of the fleet is similar in all the selected solutions (in fact, it is the highest in the optimal solution, and from this point of view the worst one, however, the best fitted). The utilization ratio for the optimal solution turned out to be the best one, assuring the very high fleet utilization that is always the most economical. Of course the presented calculations are based on some assumptions and are significant simplification of the reality. However, one can expect that even though the real life utilization of a fleet will be lower than calculated, it will be lower for all the solutions (possible fleet compositions) to the same degree (a methodological error). So, the optimal solution should still denote a fleet composition assuring its best utilization.

It is also worthwhile to notice that based on the optimal solution the fleet is composed of 5 vehicle types only. The low number of vehicle types in a fleet, the easier to manage it.

The carried out sensitivity analysis revealed that any changes in the optimal composition of the analyzed fleet decreases its utilization. For example random changes of the number of vehicles of particular types by only 1 vehicle (increased number of vehicles of a one type, and at the same time decreased number of vehicles of another type, kipping the fleet size constant and the demand satisfaction constraint fulfilled) result in the decrease of the utilization ratio by 0.5%. If the number of the exchanged vehicles is 5 the utilization ratio decreases by 4.5%.

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CONCLUSIONS

The FS/FC decisions concerning types and number of vehicles in a fleet, as well as MoB decision problem, belong to the group of the strategic fleet management problems. These decisions as any other strategic ones concern relatively long-term planning and effects they cause are postponed in time. It means that to asses if the FS/FC decisions made were correct or wrong is possible after a relatively long time (half a year to one year or even more). Moreover, such decisions are usually crucial and their results that are noticeable outside a company have an economical character (e.g. investments). That is the cause why it is very important to make this type of decisions not only intuitively, but first of all based on comprehensive and correct analysis. The presented in this paper analysis, on the one hand, is consistent with a widespread opinion that the number of vehicle types in a fleet should be limited (the lower, the better). It the other words it means that the versatility/ interchangeability of vehicles is very important. On the other hand, the analysis proves that even small changes in a fleet size/ fleet composition can result in an important changes of the fleet effectiveness (measured for example by the utilization ratio).

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STRATEGICZNE ZARZĄDZANIE TABOREM SAMOCHODOWYM - PROBLEM KOMPOZYCJI

STRESZCZENIE. **Wstęp:** Floty pojazdów stanowią podstawowy środek produkcji w transporcie. Prawidłowe zarządzanie nimi jest zatem kluczowe dla wszystkich firm realizujących przewozy. Niniejszy artykuł jest drugim z serii trzech, jakie autor chce poświęcić tematyce strategicznego zarządzania taborem samochodowym.
Metody: W artykule omówiono sposoby kształtowania flot samochodowych przedsiębiorstw. To znaczy ustalenia liczby (problem liczebności - FS) i rodzajów pojazdów (problem kompozycji - FC) we flocie. Istota obu problemów leży w równoważeniu podaży i popytu na przewozy z uwzględnieniem różnych rodzajów popytu, jakie trzeba zaspokoić, oraz różnych rodzajów pojazdów, jakie mogą znaleźć się we flocie wraz z wzajemną zastępowalnością owych pojazdów przy zaspokajaniu poszczególnych rodzajów popytu. W artykule zaproponowano autorską, matematyczną metodę (model optymalizacyjny) pozwalającą na prowadzenie analiz typu FS/FC.
Rezultaty: W artykule zaprezentowano zastosowanie opracowanej metody na rzeczywistym przykładzie problemu decyzyjnego w warunkach polskich oraz uzyskane rezultaty. Rezultaty te pokazały, że istnieje pewne, najlepsze (optymalne) dopasowanie struktury floty do potrzeb przewozowych. Rozwiązanie pozwalające na wykorzystanie taboru w stopniu istotnie wyższym (10-15%), niż w przypadku innych, w tym losowych, rozwiązań. A zmiana owego optymalnego rozwiązania, nawet w niewielkim stopniu, powoduje pogorszenie wykorzystania taboru o kilka procent.
Wnioski: Prezentowana w pracy analiza jest z jednej strony zgodna popularną opinią, iż ilość typów samochodów we flocie powinna być ograniczona. Oznacza to, że uniwersalność i możliwość zmian w liczbie samochodów ma bardzo duże znaczenie. Z drugiej strony, prezentowana analiza potwierdza stwierdzenie, że nawet małe zmiany w wielkości floty i jej składzie mogą powodować istotne zmiany efektywności całej floty (mierzone na przykład, jako procent użytkowania).

Słowa kluczowe: zarządzanie, optymalizacja, flota, transport, liczebność, kompozycja.

STRATEGISCHES FAHRZEUGFLOTTENMANAGEMENT - DAS PROBLEM DER FLOTTENZUSAMMENSETZUNG

ZUSAMMENFASSUNG. Einleitung: Fahrzeugflotten und Fuhrparks stellen das Rückgrat der Verkehrsproduktion dar. Ein angemessenes Flottenmanagement ist für alle Gesellschaften und Firmen mit Transportaufgaben von großem Belang. Der vorliegende Artikel ist der zweite von dreien, die der Autor dem strategischen Fahrzeugflottenmanagement widmet.
Methoden: Dieser Artikel beschreibt Möglichkeiten für Unternehmen ihre Fahrzeugflotte zusammenzusetzen. Dies beinhaltet sowohl die Beantwortung der Frage nach der Flottengröße (the fleet sizing problem - FS) und der Zusammensetzung der Fahrzeugflotte (the fleet composition problem - FC). Der Kern beider Probleme liegt dabei darin, Angebot und Nachfrage nach Transportdienstleistungen so auszubalancieren, dass der Typ der Fahrzeugnachfrage auf Basis verschiedener Fahrzeugtypen einer Flotten bedient werden kann. Verschiedene Fahrzeugtypen können dabei substituierend eingesetzt werden. Im vorliegenden Artikel wird dabei ein ursprünglich mathematisches Modell (Optimierungsmethode) zur FS/FC-Analyse vorgestellt.
Ergebnisse: Es werden die Umsetzung und Ergebnisse einer Anwendung der vorgestellten Optimierungsmethode im Rahmen eines Feldversuchs in Polen präsentiert. Die Lösung zeigt, dass es eine optimale Flottengröße und -zusammensetzung gibt um die Transportnachfrage eines Unternehmens zu bedienen. Die Verwendung einer optimalen Flottengröße und -zusammensetzung erlaubt eine spürbar höhere (10- 15%) Auslastung der Fahrzeugflotte im Vergleich zu anderen, auch zufällig gewählten, Strategien zur Flottenzusammensetzung. Weiterhin kann gezeigt werden, dass bereits kleine Veränderungen in der FS/FC-Struktur zu merklichen (mehrere Prozent) Auslastungsveränderungen der Gesamtflotte führen.
Fazit: Einerseits, die präsentierte Analyse stimmt mit der öffentliche Meinung, die die Anzahl der Arten von Autos in der Flotte begrenzt werden sollte. Dies bedeutet, dass die Universalität und die Möglichkeit von Veränderungen in der Anzahl von Fahrzeugen von große Bedeutung ist. Andererseits bestätigt diese Analyse die Feststellung, dass auch kleine Änderungen in der Größe der Flotte und der Zusammensetzung können wesentliche Veränderungen in der Effizienz der gesamten Flotten verursachen.

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

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E-COMMERCE INFLUENCE ON CHANGES IN LOGISTICS PROCESSES

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ABSTRACT. Background: The aim of this publication is to address the changes in retail trade, which have a direct influence on the development of e-commerce which in turn causes modifications to logistics chain management strategies and methods of flow control.

Materials: The article has been written on the basis of an analysis of subject literature together with determining the influence of e-commerce to changes in logistics processes. The publications included in this study have been selected in order to present the subject of e-commerce development as well as evaluate changes in methods of flow control. The analysis has been prepared based on the author's experience and available reports and publications.

Results: As a result of the conducted analysis, an assessment of the proficiency level of the changes in logistics processes on the local and international market as well as of the trends for these changes has been made.

Conclusions: With the development of e-commerce, a new logistics chain management strategy began to appear, which covered both the process of handling the online and offline sales channel. Therefore, it can be concluded that properly adapted flow control methods will be the means for achieving the goal. Tasks will include: streamlining flow processes, improving the efficiency of logistic processes as well as adjusting them to market requirements.

Key words: e-commerce, online sales, logistics.

INTRODUCTION

Online shopping is becoming more and more popular especially in Europe, the Americas and Asia. Although the share of such purchases in the whole of commerce is still marginal, we are observing both diversified and constantly high dynamics of this sector.

E-commerce sales of goods and services grew by 16.3% to 363.1 billion euros in 2013, according to the latest statistics. This amount includes sales in the European Union, which equaled to 318.1 billion euros, representing 87.6% of the Old Continent's total turnover and represents an increase year-on-year by 15%. This data was included in a report prepared by the E-commerce Europe association [Harrington 2014].

E-commerce is becoming more and more demanding in terms of innovative business models and consumer expectations. The logistics needs of this market are diverse due to the increasing variety of products (e.g. books, clothing, household appliances, building materials) of different value, weight and size. Customers increasingly expect to receive information in real time and value simplified and free returns of goods as well as flexible delivery options [Kawa 2014].

E-COMMERCE IN POLAND AND WORLDWIDE

E-commerce - Poland set against Europe

According to the "eCommerce Poland 2013" report, Polish e-commerce is one of the

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fastest growing in Europe. The growth rate is 20-25% per year [Jarosz 2013]. Similar results were published by Ecommerce Europe, stating that the Polish e-commerce market increased by 24% in Poland compared to 2012.

E-commerce in Poland is growing fastest among Central European countries - results were published in a report by Central Europe B2C Ecommerce [Zarzycka 2014].

In 2013, its value amounted to approx. 25 billion PLN. According to estimates, in two years it is to reach approx. 40 billion PLN. The share of e-commerce in the total trade in Poland is approx. 4%, however, this is much less than in developed countries, such as the United Kingdom, Germany, or Norway.

Over 30% of Poles declare that they shop online. This is more than in Spain and Italy. Poles choose online shopping mainly due to the following:

- lower price (71%),
- home delivery (70%),
- convenience (61%),
- and saving time (50%).

However, according to TNS Poland data:

- 43% shop several times a year,
- 25% several times a month,
- 19% once a month,
- 8% once a year or less,
- 4% at least once a week,
- 1% cannot define.

Delivering a package to the customer is one of the key processes in e-commerce. Interestingly enough, according to studies conducted by the ARC Rynek i Opinia Research Institute at the request of Poczta Polska (the Polish Post) the price of the transport service is not a priority criterion (34% of respondents). What is more important is punctuality (41%), but also no damages (22%) or losses (20%). Moreover, research shows that a guaranteed delivery date is much more important to customers - 65% of respondents than a mere declaration - 25%. Only 10% of respondents prefer dedicated forms such as delivery on a specified day and time. However, e-commerce clients do not want to wait for the purchased product more than 3 days. A confirmation of delivery (19%), package tracking (17%), shipping insurance (15%) and confirmation of delivery (14%) are also essential [Kawa 2014].

The e-commerce market in Central Europe is growing faster than the one in the US. In 2013, it grew by 19% and reached 75.9 billion euros. According to forecasts, the market will grow by 23% compared to 2013 and reach 93.3 billion euros. In terms of growth dynamics, Poland is the leader of the region. The value of the domestic market increased by 24%. However, this did not affect average online expenses, Poles spent an average of 422 euros online last year, while the European average was 1402 euros, whereas the average in Central Europe - 2617 euros.

Germany is definitely the largest market in the region. Here, e-commerce turnover amounts to 65.7% of the entire Central European market. Internet availability in Germany is very high - 85%, and the German web user population is 69.9 million. As the younger generation of Germans, open to new trends, enters into adult life familiarized with the Internet, their market is moving away from traditional models of stationary and mail-order sales, becoming a true e-commerce potentate. This trend is confirmed by a 22% increase in value of the German e-commerce market [Zarzycka 2014].

Till now, it has generally been a one-way tendency - we could observe openings of stores from the offline world - online. In 2014, an opposite trend was - as can be seen from the observation of more than half of respondents (56 per cent), e-stores will also develop in a stationary manner, like in the form of collection points or openings of traditional locations, increasingly operating as showrooms [Berezowski 2014].

Currently, we are also dealing with the first generation of the so-called "digital generation" - people who were born and have grown up in an Internet environment. This generation expects a wide experience related to electronic channels such as: social media, electronic banking or online shopping.

The status of e-commerce in Europe and worldwide

The development of Polish e-commerce does not differ much from the global one. According to the Goldman Sachs / JP Morgan data, global e-commerce sales growth amounts to approx. 19% per annum. In Europe, this trend is similar. In 2013, the value of European e-commerce was equal to 370 billion euros. In the coming years, a 20% increase is expected, while in 2016 the turnover of e-entrepreneurs is anticipated to reach 625 billion euros.

The proficiency level and popularity of e-commerce is very diverse in EU member states. In 2013, once again, the biggest online sales were recorded in the UK (107.1 billion euros), Germany (63.4 billion) and France (51.1 billion). Total sales in these countries amounted to 221.6 billion euros, which accounted for 61% of total sales in Europe and 69% in the European Union [Harrington 2014]. The UK market is the largest in Europe - the total turnover is equal to 96.2 billion euros. Germany (50 billion) and France (45 billion) together are at the same level. In comparison, in 2012, the e-commerce turnover in the US amounted to up to 226 billion USD [Jongen and Weening 2013].

According to the European Commission, e-commerce is the main driver of economic growth and increased employment in the whole of the European Union. E-commerce in Europe, directly and indirectly, provides employment to 2 million people. It is estimated that there is a total of approx. 550 thousand e-businesses and 3.5 billion packages are sent annually. A great interest of various EU bodies in e-commerce accounts for the fact that it is noteworthy. The EU is seeking to develop best practices for e-commerce, in particular in the context of logistics. For example, the EU Communication Commission indicates that the supply of goods purchased over the Internet is one of the five most important priorities in the development of e-commerce. This is confirmed by the European Council and the European Parliament. In connection with the adoption of the Green Paper by the EU, a broad agreement has appeared between all stakeholders, both in terms of emerging issues and attempts to find common solutions [Kawa 2014].

Logistics operators, e-retailers and consumer organizations are participating in an open discussion and are undertaking more and more new initiatives in order to innovatively and constructively influence the development of solutions dedicated to this sector of the economy, and thus better meet the expectations of their customers.

Although direct commerce on the Internet is one of the pillars of the European economy, large differences in the development of this field between the mature markets of Western and Northern Europe and the developing Central Eastern Europe are noticeable:

- Western Europe (United Kingdom, Ireland, France, Benelux) has sales at the level of 177.7 billion euros, which represents 49% of the total turnover in Europe.
- Central Europe (Germany, Austria, Switzerland and Poland) ended last year with sales amounting to 93.2 billion euros (25.7% of total sales in Europe) and came in second among the regions of the Old Continent. Of course, Germany had the greatest influence here - being the second largest market in Europe.
- Southern countries (Spain, Italy, Portugal, Greece and Turkey) strengthened their third position with sales equal to 40.8 billion euros, constituting 11.2% of total European e-commerce.
- The so-called North (Scandinavia, Baltics and Iceland) took fourth place (32 billion euros, 8.8% of the European e-market).
- Eastern Europe (remaining countries with Russia in the lead) closed the list with total sales of 19.3 billion euros, constituting 5.3% of the European market (interestingly enough, these figures represent an increase year-on-year as high as 47.4%) [Harrington 2014].

E-commerce worldwide

Ecommerce Europe has also published the first results of the global version of their report. Its goal was to compare the European e-market with other regions of the world. In 2013, the undisputed global leader was the Asia-Pacific region (mainly due to China). With total e-sales at the level of 406.1 billion euros (+16.7% year-on-year), this area left Europe (363.1 billion euros, +16.3%) and

North America (333.5 billion euros, +6.0%) behind. The Middle East and North Africa experienced the most dynamic growth of e-sales - up to 32.6% to 11.9 billion euros. Latin America brings up the rear with a result of 37.9 billion euros in sales (a 24.6% increase) [Harrington 2014].

The "Big Data" database resources will also certainly influence further development of e-commerce, and thus the design of supply chains. Global data is growing at a breathtaking pace - 500 million emails were recorded daily in 2013. Companies with digital profiles, such as Amazon or Wal-Mart, have effectively been using large databases for a long time in order to understand their clients. When using databases, choices and analysis can be made on the basis of something that can be measured. Challenges in the management field, including planning and supply chain design with all its primary and secondary processes, require an in-depth analysis and recognizing regularities and recurrences among data, which can then be applied to properly adapted and implemented strategies and business solutions. The amount of data which can be generated from various sources (omni-channel) also contributes directly to the fact that retailers with online and offline sales channels analyze data from social media in order to act flexibly and quickly and make conversions in their supply chains at the right time. They then focus on areas that are best diagnosed and measurable, but, on the other hand, allowing for maximum use of existing infrastructure.

E-COMMERCE IN THE LOGISTICS CONTEXT

Evolution in logistics

Globalization processes, a dynamic development of information technology with increasing competition have caused significant changes in the activities of economic entities. One of the many important factors to achieve this goal is the swiftness of operations as well as process effectiveness and efficiency, in turn imposing cooperation coordination, which takes on the supply chain form [Skowron-Grabowska 2010]. Since the twenties, parallel processes of management techniques development can be observed together with their adaptation to the needs of supply chain control as well as creating and borrowing general concepts, such as process management, cost accounting, and a new angle of looking at risk management.

The Supply-Chain Council (SCC) watches over the creation and development of Supply-chain Operations Reference (SCOR) models and Design Chain Operations Reference (DCOR) models. Thanks to the SCOR process reference model, companies can quickly determine and compare the performance of standard supply chain processes against best practices in other companies in the SCC. With this model, manufacturers, suppliers, distributors and retailers have the opportunity of assessing the efficiency of their supply chains and identifying and measuring specific operational processes [Ciesielski 2009].

Today, the latest model of supply chain management is DCOR, referred to as a multi-diagnostic tool for managing supply chain design. According to its authors, the DCOR model allows to find answers to the question on how to design a supply chain from the original supplier to the final customer, through a network of manufacturers, suppliers and distributors in order to ensure that customers are satisfied with the quality, price and completeness [Wieczerzycki 2012]. Certainly, everyone operating on the e-commerce market, be it local or global, especially companies from sectors experiencing the largest sales growth year-on-year, asks themselves this same question. The supply chain strategy is influenced by demand, supply and competition in the industry, therefore, the question remains whether current supply chain strategies are developing just as rapidly as the entire e-commerce industry?

Logistics can be understood as one of following:

- logistics is an area of economic knowledge about the flow of goods and information in the economy,
- logistics is a concept of flow inventory management based on an integrated approach,

– logistics covers processes of the physical flow of material goods - raw materials, resources, semi-finished and finished products as well as related information, occurring in real time in enterprises and between them [Ciesielski 2009].

However, in every case, material flows, which have to be known and skillfully managed, are the common element which combines different logistics approaches that have to be known and skillfully managed. This signifies that the means for delivering such a purpose are flow control methods.

The importance of methods of controlling the flow of goods in modern economy also results from tasks which logistics is faced with, among which the most important are:

– improving the processes of material goods flow, so that subsequent participants of economic processes can smoothly carry out their basic functions;
– improving flow efficiency, which means the need to reduce costs associated with the movement and storage of goods;
– subordinating logistics processes to the requirements of customers.

However, the implementation of these tasks without the knowledge of the methods applied is not possible and logistics targets remain mere postulates. Nevertheless, finding and applying appropriate methods of effective flow control is not a simple matter. Among other things, this is due to the fact that the flow process is complicated, it encompasses a very large number of different tasks, warehouse management, inventory control, consolidation, maintenance, packaging, marking, coding and transport. Therefore, in diverse situations and areas of logistics, a variety of methods and techniques can be used in order to achieve this target.

E-commerce logistics varies from traditional logistics, online orders are characterized by a small number of products ordered and a large number of packages. Errors are common in such a model, therefore, extensive automation of processes based on effective management systems of not only the warehouse and its processes, but also of the delivery of packages or potential returns is vital. When choosing a logistics solution, it is necessary to check what systems are in use.

It is, therefore, essential to distinguish logistics as a category which the e-entrepreneur should pay special attention to, and it is also a confirmation of the huge role that logistics plays in online sales. We place the value of logistics processes, meaning all the elements that have shaped today's e-commerce and have direct impact on the company's strategy on par with management and marketing. Automation of chosen logistics processes does not yet fully proceed in direct proportion to the growing importance of e-commerce. Many entrepreneurs associate logistics mainly with transport, however, few of them know that the components of logistics, which are essential for e-commerce, are also all the processes related to warehousing and supply, additional services (labeling, putting together sets, packaging, assembly, etc.), the circulation of documents, payments as well as resource planning.

From a logistics point of view, e-commerce is not just a new distribution channel, it is a change which in a revolutionary way impacts warehousing processes and inventory management. From the point of view of the warehouse or distribution center, the traditional model is based on orders generated by stores, wholesalers, intermediaries. Till now, orders were a response to market demand, being the result of planned and executed sales.

What does e-commerce change then?

Online sales cause an increase in the number of orders while reducing their complexity and value. Therefore, under the current operating structures, logistics services directed at an internet client become a primary challenge. Today, effective customer service of an e-commerce client requires both good organization and appropriate know-how, but also an efficient service process and modern logistics resources, including proper system solutions [E-commerce ... 2014].

Processing of returns

As opposed to traditional commerce, online shopping is inseparably connected to deliveries to the end customer, but also to the return of merchandise and collection from the client. This last part, although not key in the entire supply chain process, is the most difficult and the most expensive. The problem of processing returns and its scale in e-commerce is still hard to define and estimate due to the fact that it is a new market for its participants, everyone involved in the process learns their rights and responsibilities once they enter this sector. Companies do not possess reliable historical data, which would allow them to properly plan the procedure of processing returns and, currently, they partly make use of solutions which to-date where dedicated to the B2B sector.

It can, therefore, be noted that the important procedure of processing product returns is still being neglected by Polish online stores. For many companies, this is one of many major barriers in the development of e-commerce and this problem is particularly visible in the case of textiles. Clothing is the third best selling product category online, right after "home and garden" and "gifts and accessories". Customers could be buying more of these products, if they had a wider range of opportunities of returning goods.

A new EU directive will be of great importance in the field of reverse logistics, it obliges e-traders to cover shipping costs in the event of cancellation by the customer within 14 days. Online stores should, therefore, devote more attention to what product and consumer rights knowledge their employees have and whether they know how to share it. This way, they can help increase customers' trust towards their store as well as towards online shopping in general [Kraska 2013].

Furthermore, according to the guidelines of the Office of Competition and Consumer Protection in Poland (OCCP), the customer will be able to choose any company to pick the item up and transport it to the store. In principle, customers already have such a possibility now, however, only a number of e-stores have adhered to this. This change results from a judgment of the European Court of Justice, which refers to the Consumer Rights Directive of the EU enforcing Consumer Rights "on the protection of consumers in respect to distance contracts", which indicates that in the event of cancellation, the e-store should not only return the value of the goods back to the client, but also the cost of shipment [Kawa 2014].

Variations in the level of orders

The challenge which people responsible for logistics and operations in online stores face are seasonal variations in the level of orders which clearly increase in the fourth quarter of each year. Variations related to the level of online stores' inventories are connected to this, which translates into the need to ensure a sufficiently large warehouse and process (production) efficiency. It is vital to remember that after the period of increased orders, it is not necessary to maintain high maximum employment or increased storage space, but in the first quarter of the new year an increased volume of returns should be expected.

A study of companies from the retail e-commerce industry (Table 1) shows that the high season - with an increased number of orders is respectively in April - June and November - December, the second period being related to the peak holiday season, of course. The volume of orders in high season periods (Christmas) increases by approx. 50% compared to other months and certainly requires increased process efficiency and warehouse space from manufacturers, logistics operators and distributors. Greater volume of orders in the fourth quarter of the year also translates into an increased volume of returns right at the beginning of the following year.

Currently, when the e-commerce market in Poland is dynamically changing and growing month-to-month, planning on the basis of historical data is quite difficult and estimates may be subject to considerable error. Therefore, until this industry reaches a certain maturity, demand should be closely monitored, that is the relationship between price and quantity which consumers are willing and able to pay at a given time.

With such a new and dynamic industry, with limited availability of historical data used in planning, the issue of direct and open cooperation between manufacturers, distributors, logistics operators and couriers is very important. Therefore, information given at the right time and the right place is key, as then a quick and efficient reaction to emerging changes is possible. On the basis of the above, it can also be assumed that target logistics processes and system solutions dedicated to the e-commerce industry must be flexible, accurate and fast. For most participants of this part of the market, everything is new and requires a certain adaptation of the currently used solutions or creating entirely new ones. Each active participant of this supply chain, e-stores, logistics operators, couriers build their own competencies, look for the best and most effective solutions to meet the growing amount of assortment, item quantity, seasonality versus time pressure and shopping habits of Generation Y or the following ones, for who shopping on the Internet will be an absolute standard and way of life.

Table 1. Seasonality of e-commerce in the retail industry (selected industries)
Tabela 1. Sezonowość e-commerce w branży Retail (wybrane branże)

Month	1	2	3	4	5	6	7	8	9	10	11	12
	The percentage of the number of orders each month											
retail – industry 1	7%	8%	9%	9%	8%	10%	6%	6%	8%	8%	13%	8%
retail – industry 1	6%	6%	8%	8%	8%	10%	6%	6%	8%	8%	14%	12%
retail – industry 2	9%	8%	5%	11%	9%	8%	7%	7%	5%	7%	11%	12%

SUMMARY

With the development of e-logistics, there are new opportunities of optimizing the logistics chain, which more and more innovative companies notice. Thanks to increasingly new models of cooperation, such as dropshipping (IT and clothing industries), there is a low-threshold of entering e-commerce. Today, a small entrepreneur with a good idea for a business does not have to stock up his warehouse without knowing the market where he wants to try out his luck. However, the scale and development of his business certainly affects and will affect the logistics of the supplier or manufacturer. Therefore, it can be concluded that the role of logistics and its great importance in e-commerce can currently be argued in many ways.

Global e-sales are growing at a very high pace, currently constituting 4 percent of total global sales. Although the infrastructure for e-commerce in developing countries is less advanced in comparison to developed countries, it is precisely these countries which, in perspective, can possibly have the biggest sales growth. As a result, over the next five or more years, the face of e-commerce will largely change and in turn change the perception of logistics.

By 2017, the highest growth in the e-commerce sector will be recorded in Indonesia, China, India and Mexico. The US and the UK can also expect a strong increase. Large chains and stores have problems with expansion plans for they are facing a dilemma - whether to invest in developing countries with less developed infrastructure, in which the return on investment will come no earlier than after several years, or focus on mature markets with good infrastructure, but strong competition [Meyer 2013].

Currently, we are observing changes on the Polish market which had their counterpart in Western Europe as early as 2002. This is primarily connected to market segmentation, where small e-businesses now represent more than 90 percent of all e-stores in Poland. Furthermore, according to estimates from PMR Research analysts, the value of the Polish e-commerce market amounts to almost 24 billion PLN, meaning 5.7 billion euros, and at the end of 2014 it is expected to reach a value of over 27 billion PLN [PMR 2014]. Forecasts for this market are promising and talk about a doubling of its value in five years.

We can, therefore, conclude that regardless of the promising figures, consumer expectations in the context of integrating online and offline sales will continually grow, and that logistics solutions, which are currently in place, still do not always meet the requirements of management processes of tens of thousands of products of various sizes with a relatively small number of pieces on the order, or processes of complaints via e-stores or returns of goods purchased online, in a traditional store. Meeting these requirements is already influencing changes in the design of logistics solutions dedicated to this sector as well as process management, which currently represents a major challenge for distributors and logistics operators on the local and global market. Over the next months, the local market and Polish entrepreneurs will be faced with a challenge to match Western Europe in the development of e-commerce and, at the same time, begin to keep up with this development on every level. Certainly, last year's and current investments in new logistics warehouses located in Poland and dedicated to the service of e-commerce (Amazon, Inditex and, in the future, Merlin's new logistics warehouse) will have an effect on this.

The dynamic development of the e-commerce sector may contribute to the fact that traditional, stationary stores will have to remodel their existing way of functioning and adapt to the changing buying habits of modern consumers. Maybe they will need to become showrooms or places where customers can meet experts, receive full information about a product, service, or get advice on what to choose. This kind of business model will also have an impact on the change in the management of the supply chain in the current B2B sales channel and the introduction of innovation, which can be connected to a change in stereotypes and a violation of existing paradigms [Brdulak 2012].

In digital space, experience and knowledge are a battleground for competing brands. Experience is a set of key methods that determine success along with the possibility of being a pioneer in applying innovative solutions. Therefore, the key question when developing supply chain strategies may be - which strategies should we apply in order to deliver products and services to those customer groups that we want to provide services to? And what is important - which method should we use to develop this strategy? [Gattorna 2013]. In today's rapidly changing market conditions, the choice of the supply chain strategy is crucial, because if we choose the right one, we will then be able to act faster than the competition and, at the same time, be able to predict buying behaviours of consumers on the borderline between the product and the market.

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WPŁYW E-COMMERCE NA ZMIANY W PROCESACH LOGISTYCZNYCH

STRESZCZENIE. **Wstęp:** Tematem publikacji jest opracowanie tematyki zmian zachodzących w handlu detalicznym wpływających bezpośrednio na rozwoju handlu internetowego co przekłada się na zamiany w strategii zarządzania łańcuchem logistycznym i metod sterowania przepływami.
Materiały: Artykuł został opracowany na podstawie analizy literatury przedmiotu wraz z określeniem wpływu handlu internetowego na zmiany w procesach logistycznych. Publikacje ujęte w opracowaniu zostały wyselekcjonowane w celu przedstawienia tematyki rozwoju handlu internetowego oraz oceny zmian w metodach sterowania przepływami. Analiza została opracowana w oparciu o doświadczenie autora oraz dostępne raporty i publikacje.
Wyniki: W wyniku przeprowadzonej analizy dokonano oceny poziomu zaawansowania zmian zachodzących w procesach logistycznych na rynku lokalnym i międzynarodowym oraz trendy tych zmian.
Wnioski: Z rozwojem handlu internetowego pojawiała się nowa strategia zarządzania łańcuchem logistycznym, obejmująca swym zasięgiem zarówno proces obsługi kanału sprzedaży online jak i offline. Wnioskować zatem można, że środkiem służącym do realizacji celu będą właściwie dostosowane metody sterowania przepływami do zadań których będzie należało: usprawnienie procesów przepływu, poprawa efektywności oraz podporządkowanie procesów logistycznych wymaganiom rynku..

Słowa kluczowe: e-commerce, sprzedaż online, logistyka

DER EINFLUSS DES ELEKTRONISCHEN HANDELS AUF DIE VERÄNDERUNGEN IN LOGISTISCHEN PROZESSEN

ZUSAMMENFASSUNG. Einleitung: Zum Thema der vorliegenden Veröffentlichung wurde eine Projizierung der sich im Einzelhandel vollziehenden Veränderungen, die die Entwicklung des Internet-Handel direkt beeinflussen, was demzufolge sich auf die Veränderungen innerhalb der Strategie für Management der Logistik-Kette sowie der Methoden für die Steuerung von Materialflüssen auswirkt.
Material: Der Beitrag wurde auf Grund einer Analyse der Gegenstandsliteratur samt der Ermittlung des Einflusses des Internet-Handels auf die sich in logistischen Prozessen vollziehenden Veränderungen ausgearbeitet. Die betreffenden, in der Abhandlung erfassten Veröffentlichungen wurden zwecks der Darstellung der Entwicklungsfrage innerhalb des Internet-Handels sowie zwecks der Beurteilung der Veränderungen innerhalb der Methoden für die Steuerung von Materialflüssen ausgewählt. Die Analyse wurde in Anlehnung an die eigene Erfahrung des Verfassers sowie an die vorhandenen Berichte und Veröffentlichungen zu diesem Thema vorgenommen.

Ergebnisse: In Folge der durchgeführten Analyse hat man eine Beurteilung des Niveaus in Bezug auf den Fortschritt der sich in logistischen Prozessen vollziehenden Veränderungen auf dem Binnen- und internationalen Markt sowie einen Hinweis auf die Trends dieser Veränderungen zustande gebracht.
Fazit: Parallel zur Entwicklung des Internet-Handels tauchte eine neue Strategie für Management der Logistik-Kette, die sowohl den Prozess des online-, als auch des offline-Verkaufs umfasst, auf. Man kann also ein Fazit ziehen, dass die zweckmäßig angepassten Methoden für die Steuerung der Materialflüsse die richtigen Mittel für die Ausführung der Aufgabenstellung in diesem Bereich sind. Zu solchen Aufgaben gehören wie folgt: Vervollkommnung der Materialfluss-Prozesse, Verbesserung der Effektivität und die Anpassung logistischer Prozesse an die Herausforderungen des Marktes.

Codewörter: elekronischer Handel (E-Handel), online-Verkauf, Logistik

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COLLABORATION AND COMMUNICATION IN A NETWORKED ECONOMY

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ABSTRACT. **Background:** The networked economy is a result of the increasing specialization and productivity. The blurring of company boundaries enables potential for new competitive advantages. However, along with the growing networked economy, the complexity also increases.

Methods: With their current study the German logistics association sheds a light on the most important trends of the networked and complex economy and the strategies of logistics and supply chain management (SCM) coping with them.

Results and conclusions: This paper focuses on the collaboration of actors in logistics and supply chain management and the communication required for being successful. Furthermore, going beyond the study, the role of collaboration for innovation in logistics and SCM is considered, that has been neglected in literature so far. Finally, the paper concludes with a discussion reflecting the current state of collaboration in the context of its potential.

Key words: collaboration, communication, network, logistics strategies, innovation.

INTRODUCTION: A NETWORKED ECONOMY: BREAK-UP OF FIRM BOUNDARIES

Basically, economies deal with goods and resources satisfying needs [Picot et al., 2012; Picot/Reichwald/Wigand, 2008]. As a precondition goods and resources are typically rare and require the basic mechanisms of division of labor (specialization) and trade or trade-off, respectively. Thus, nowadays individuals are responsible for a small part of the overall tasks in an economy consisting of jobs, departments, firms, sectors and nations, and increase herewith productivity. Obviously, the productivity coming from the division of labor and the trade/trade-off are inter-dependent on all levels of the economy. Shortcomings in these mechanisms are defined as the problems of organization and are caused by a lack of information. Therefore, on the one side, the so-called coordination problem is based on missing information, and the so-called motivation-problem, on the other side, results from conflicts of interests and information asymmetries. The most important task for overall productivity in an economy is, thus, finding an adequate form of organization that optimizes productivity by reducing the coordination and motivation problems, and aims at fulfilling as much needs as possible.

Concerning logistics systems collaboration (the words "collaboration" and "cooperation" are used synonymously in this article) is of growing importance due to the increasing specialization [Pfohl, 2015; Pfohl, 2010]. Fig.1 shows that both, on the input-, as well as on the output-side of logistics systems, firm boundaries are blurring. On the side of the input the decision of make or buy defines the degree of the individual firm´s specialization.

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While in the make-case the own specialization and resources are exploited, in the buy-case the specialization of either vertical or horizontal partners is used. Thus, entering a vertical cooperation, a firm uses the complementary specialization of suppliers and, therefore the specialization of upstream value-chain partners. A horizontal cooperation makes use of the specialization of other firms within the same stage of value creation and is set up e.g. in order to level firm-capacities. Regarding the output-side of the logistics system, customer service is provided. Herein, competition takes place horizontally between firms at the same stage of value creation, as well as vertically, between whole supply chains focusing the final customer. Due to the increasing importance of cooperation along and between supply chains formations are possible where firms acting as partners and competitors simultaneously. This situation combining cooperation and competition at the same time is termed with the synthetic word "co-opetition" [Brandenburger, 1996].

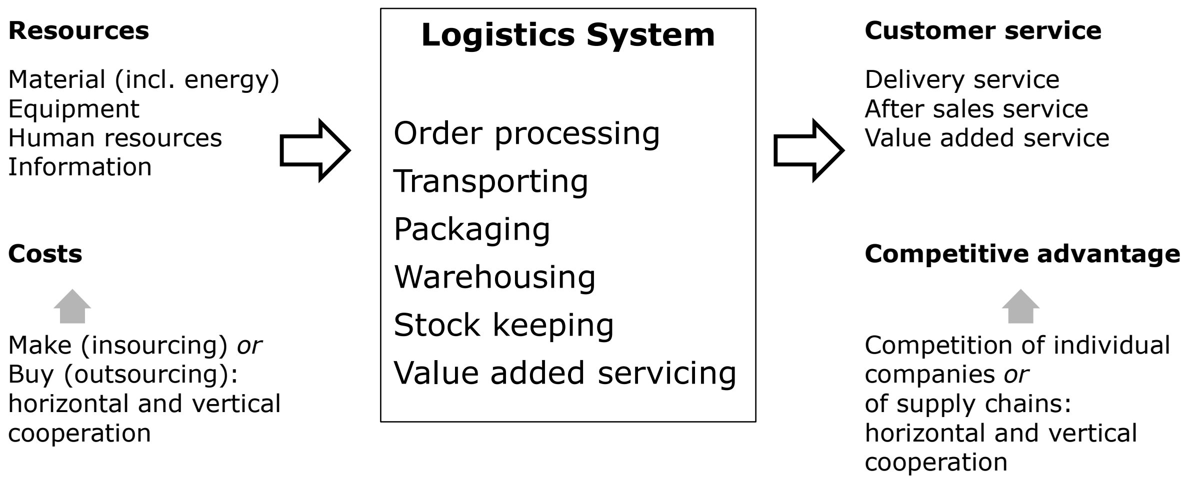


Fig. 1. "Co-opetition" in a networked economy
Rys. 1. Konkurencja w usieciowionej gospodarce

In the light of the above, the question is raised, which trends can be identified concerning cooperation in the context of logistics and, thus, which strategies are implemented and intended by practitioners. Answering this question firstly, a short introduction in the relational-view [c.f. Dyer/Singh, 1998], explaining competitive advantages through cooperation is given, before the current study of Handfield et al. [2013] is introduced and discussed regarding the management of cooperation in the area of logistics and supply chain management (SCM). The study comprises a comprehensive literature review in the first step and ensures herewith an extensive theoretical foundation. Afterwards experts are interviewed and a broad survey has been set up and analyzed. Based on this research methodology this article stresses the trends regarding cooperation activities and the role of information and communication technologies used in this context. Furthermore, according to the importance of cooperation for innovation, innovation in logistics and SCM should be considered, having been neglected so far [Pfohl, 2007]. According to Handfield et al. [2013] finding that innovation is one of the most important drivers for collaboration in order to meet increasing customer expectations, this article discusses the role of collaboration for innovation in more detail and gives, finally, an overall conclusion on the importance of collaboration reflecting the current state.

COMPETITIVE ADVANTAGES THROUGH COOPERATION: INTRODUCING THE RELATIONAL VIEW

Explaining the realization of competitive advantages through collaboration in strategic management theoretically, Dyer/Singh [1998] develops the relational view. Coming from a resource-based perspective of strategic management, highlighting tangible and intangible resources a firm is able to exploit, the relational view [c.f. Dyer/Singh, 1998] states four mechanisms for achieving competitive advantages in inter-organizational relationships. Thus, for realizing competitive advantages through cooperation partners have to:

- invest in relation specific assets (e.g. common investments in infrastructure; processes or machinery tailored to partners),
- set up knowledge-sharing routines (e.g. mechanisms for inter-organizational knowledge transfer and patterns for interactions),
- have complementary resources and capabilities (e.g. capabilities that can be combined for offering a new value-creating service, that are available within the specific cooperation solely, and therefore creating incentives for staying within the cooperation) and
- implement effective governance that reduces transaction costs by formal or informal agreements (e.g. creating incentives for cooperation).

These mechanisms make relationships rare and make them difficult to imitate for others. Furthermore, Dyer/Singh [1998] state relation specific aspects functioning as imitation barriers. The inter-organizational asset interconnectedness strengthens the degree of specialization within the relationship and, therefore, the productivity. The partner scarcity refers to the limited number of potential partners that discriminates collaboration late-comers. Furthermore, the resource indivisibility strengthens the relationship because advantages depend on the combination of resources and capabilities and create a path-dependency preventing imitation. And, finally, the institutional environment enables informal and social complexity (e.g. by cultural characteristics) improving the relationship, and being a barrier for imitation, as well.

The relational view is used in chapter 6 of this article for the interpretation of the current state of cooperation in logistics and supply chain management and shows potential for creating competitive advantage. In the following the current state of cooperation in the field of logistics and supply chain management and implemented and intended strategies are discussed using the study of Handfield et al. [2013]. The study founds on an extensive literature review and broad data collection and analysis, introduced firstly, before being discussed concerning the contents.

STUDY ON TRENDS AND STRATEGIES IN LOGISTICS AND SCM: METHODOLOGY AND SAMPLE CHARACTERISTICS

The German logistics association "Bundesvereinigung Logistik" (BVL) analyzes current trends in logistics regularly, for more than twenty years by now. While the economy is getting more and more internationalized and connected, the study has been aligned and partners from all over the world have been integrated. In the current study "Embracing Global Logistics Complexity to Drive Market Advantage" research partners from the United States, Brazil, Russia, The Netherlands, Belgium and China participated and supported the data collection assuring an international perspective. The overall research methodology of the current study comprises four stages [Handfield et al., 2013].

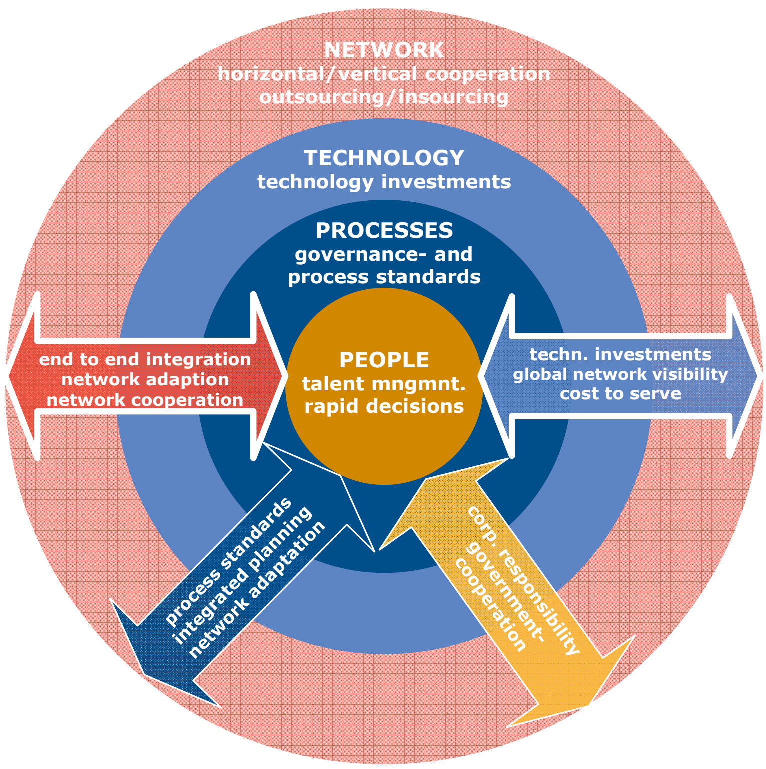
In the first stage, the literature review and content analysis-stage, more than 200 reports from consultants and research institutes have been analyzed. Key topics regarding trends and strategies have been identified and used for a broader content analysis in more than thousand research articles in German, English and Chinese databases. In doing so the pre-existing list of keywords had been evaluated and adapted.

In the second stage, the executive interview-stage, this work has been used preparing structured interviews with 62 logistics and/or supply chain managers from logistics service providers, retail and industry in Germany, the UK, French, the USA, China, Brazil and Russia. The interviews had been documented and coded for extracting the main topics of strategies and trends. These topics were used for developing the final questionnaire.

In the third stage, the survey-stage, the online-questionnaire, available in English, German, Portuguese, Chinese and Russian, had been launched. With the support of the international research partner organizations the questionnaire was spread internationally.

During the final stage, the data analysis and report-stage, 1,757 questionnaires have been analyzed (645 full-answered) for documenting the main findings. Considering global sales and number of employees, small, middle and large companies are represented in the study. While participants from industry are having the largest proportion (two-thirds), nearly one-third of the participants are logistics service providers and about ten per cent are from retail.

Dealing with the trends like, e.g. increasing customer expectations, networked economies, cost pressure, globalization and a lack of qualified managers and employees the study of Handfield et al. [2013] identified "people", "processes", "technology" and "network" as the four key strategies and integrated them in a model for logistics strategies (see Fig. 2). The networked economy in this model gives a framework for addressing all other logistics strategies. This article first and foremost concentrates on the network and technology strategies.



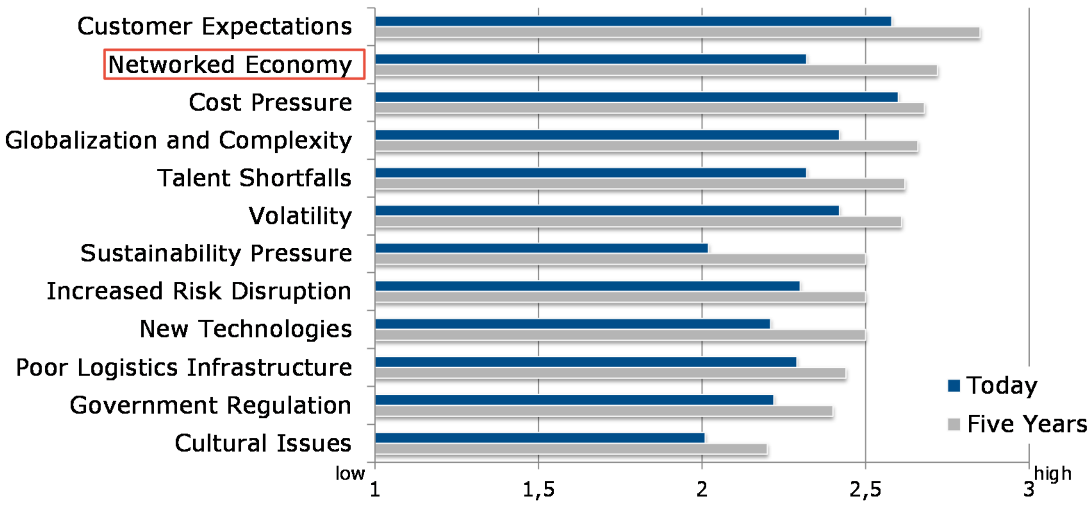
Source: Handfield et al. [2013] adapted

Fig. 2. A model of logistics strategies
Rys. 2. Model strategii logistycznych

In the following the study results concerning collaboration activities are discussed using the introduced data-sample considering the key strategies and trends identified.

RESULTS OF THE STUDY: MANAGING COLLABORATION USING INFORMATION AND COMMUNICATION TECHNOLOGIES

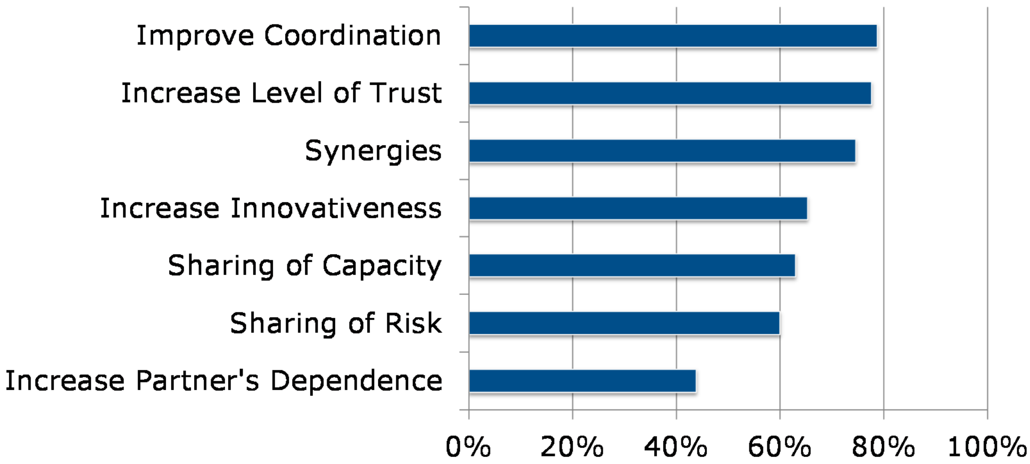
First and foremost a main finding of the study from Handfield et al. [2013] is, that the networked economy is, besides customer expectations, cost pressure, globalization/ complexity and the shortfall of talents, one of the main trends of logistics and supply chain management today and in the future (see Fig. 3). Considering the growing importance of the main trends identified, the networked economy shows, compared with the other trends, the highest increase in the next five years. Overall, the respondents rate the networked economy as second important in the future, directly following the customer expectations.



Source: Handfield et al. 2013 adapted

Fig. 3. Importance of logistics trends
Rys. 3 Istotność trendów logistycznych

Specifically, in the following it will be discussed, what the networked economy means in practical terms and how the current state of implementation can be characterized. Namely, firms tend to build cohesive and integrated sets of network-relationships on identified synergies to create new capabilities and innovative solutions. The most important reasons for collaboration are: improved coordination, increasing trust, synergies and improved innovation (see Fig. 4). For the management of the networked supply chain there are different approaches integrated depending on the direction of the material flow. Thus, the agreement with the statement "we have power and control the relationship" decreases from the logistics service providers (LSPs), to tier-one suppliers, LSPs´ subcontractors, tier-two suppliers, immediate customers, LSPs´ customers and indirect customers, finally. Contrarily, the agreement with the statement "we exchange information and cooperate" decreases upstream.



Source: Handfield et al. 2013 adapted

Fig. 4. Percentage of respondents rating reasons for "collaboration" as important
Rys. 4. Udział procentowy respondentów akceptujących daną przyczynę współpracy jako ważną

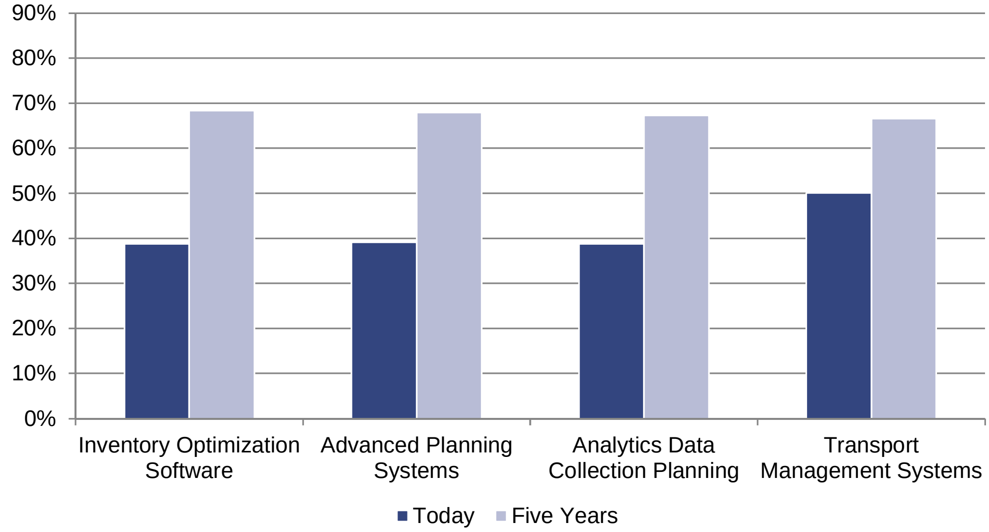
The study shows that, already today, the firms exchange different kinds of information with their partners. Transportation schedules and demand forecasts are most important and will increase within five years, as well. The exchange of inventory data, production data and data about planned promotions are also expected as important and will also increase in the next five years. The study also shows, picking out the top-performing companies (companies within the uppermost quarter considering reliability, number of complaints and cost savings) that these firms are more willing to exchange R&D-data with a small number of strategic partners because founding on trust.

Realizing an end-to-end integration increasing transparency by an improved demand sensing is also shown to be important. An improved demand sensing allows an increased timeframe and thus, the mapping of volatility and the reduction of the forecast error ratio, as well. Risk reduction strategies are, apart from close inter- and intra-organizational coordination and business continuity plans, multiple sourcing and buffer inventory strategies and, also, the reduction of transport distances by local sourcing.

One of the strategies companies pursuing for many years by now is globally outsourcing of activities. However, along with the increasing complexity a growing number of companies are questioning these outsourcing strategies in comparison with near-shoring. Considering the outsourcing of activities, reverse logistics and transportation are most relevant: about 60 per cent of the respondents agree with transportation completely outsourced and approximately the same proportion agrees with partially or completely outsourced reverse logistics. Contrarily respondents disagree with outsourced inventory management and assembly. Thus, organizations are seeking to retain control of these activities. Respondents indicate that most of the outsourcing activities will stay constant in five years.

Another aspect regarded with the study is the growing importance of government collaboration. Respondents state that government collaboration focuses on the development of industry standards, education, infrastructure and trade policy. The importance considering these aspects will even increase in the next five years, following the answers of the respondents.

The study also sheds a light on the current and planned technology investments. Due to the fact, that companies have recognized the importance of real time data regarding events, customer demands and capacities, investments in technologies increase that are able to collect and analyze data (see Fig. 5). Regarding the networked economy, these technologies will play major roles within logistics and supply chain collaboration. In this context the study also highlights the potential of big data analysis, regard as relevant in the near future.



Source: Handfield et al., 2013

Fig. 5. Technology Investments
Rys. 5. Inwestycje technologiczne

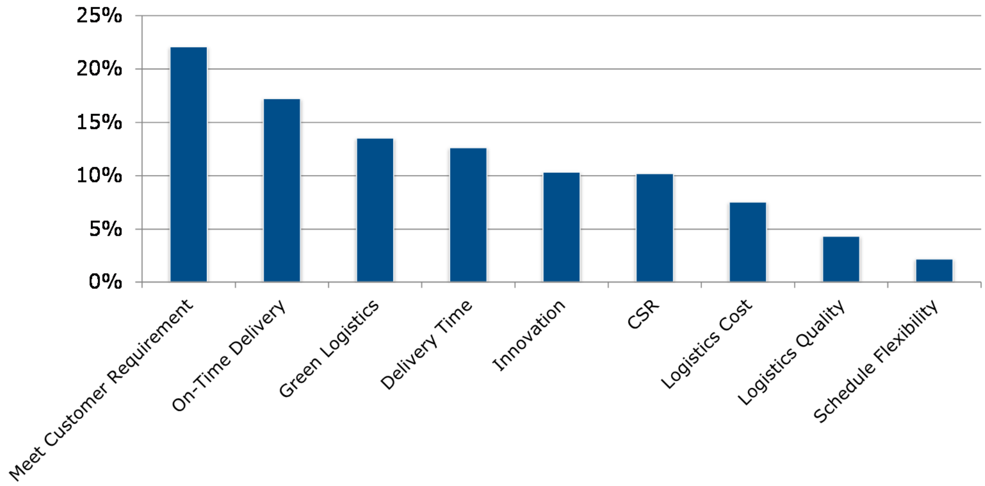
THE ROLE OF COLLABORATION FOR INNOVATION

As already shown, Handfield et al [2013] point out innovation as one of the most important drivers for innovation. Fig. 6 shows, that the importance of innovation as a logistics objective increases. Accordingly, the modularization of logistics and reduction of logistics costs are not the only buying criteria, and focus is shifting to the development of services that are able to fulfill customer needs and create new ones by innovation [European Logistics Association/Arthur D. Little, 2007]. Therefore, collaboration is gaining importance for innovative logistics and supply chain management strategies.

Langley/Capgemini [2013] consider with the Logistics Outsourcing Study 2013 the aspect of supply chain innovation. Herein they show that shippers and 3PLs are relatively aligned on the top drivers for innovation. Trusting relationships, operational excellence and talented people are rated as most important for driving innovation. Going further, both shippers and 3PLs agree on gainsharing investments as the top funding source for innovation. A perceptual gap is identified asking for the largest source of innovation. Both think of themselves as the main source of innovation, followed by the other party as second important source of innovation, respectively [see Fig.7; see also European Logistics Association/Arthur D. Little, 2007; Pfohl, 2007].

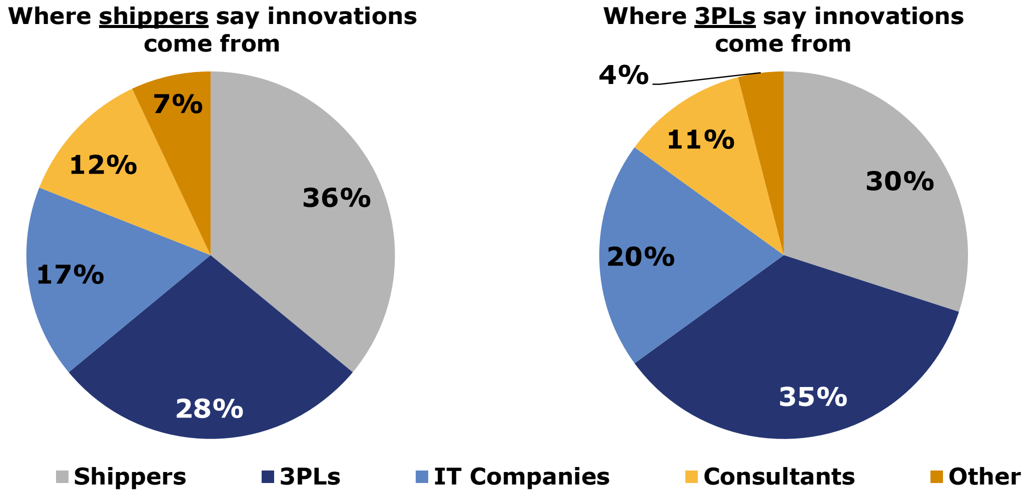
Langley/Capgemini [2013] conclude that fundamental changes in the relationships are necessary for innovation. Furthermore, these relationships are facilitated by leveraging organizational drivers like structure, relationship governance, advanced IT and data analysis. With the 2014 study the authors are able to show that relationships have improved and collaboration has increased

[Langley/Capgemini, 2014]. They find that shippers and shippers and 3PLs both increased interest in collaboration - even with competitors - in order to achieve logistics costs and service improvements. Accordingly, the study of European Logistics Association/Arthur D. Little [2007] shows that top innovators amongst shippers involve their suppliers when looking for innovation ideas (see Fig. 8). Furthermore, this study also shows that top innovators at logistics service providers pursue innovation in cooperation with their shippers to get good results. Shippers estimated that EBIT margins could increase by 4,4% if innovation management is optimized. Top innovators amongst the logistics service providers even estimated an increase of 8,5%.



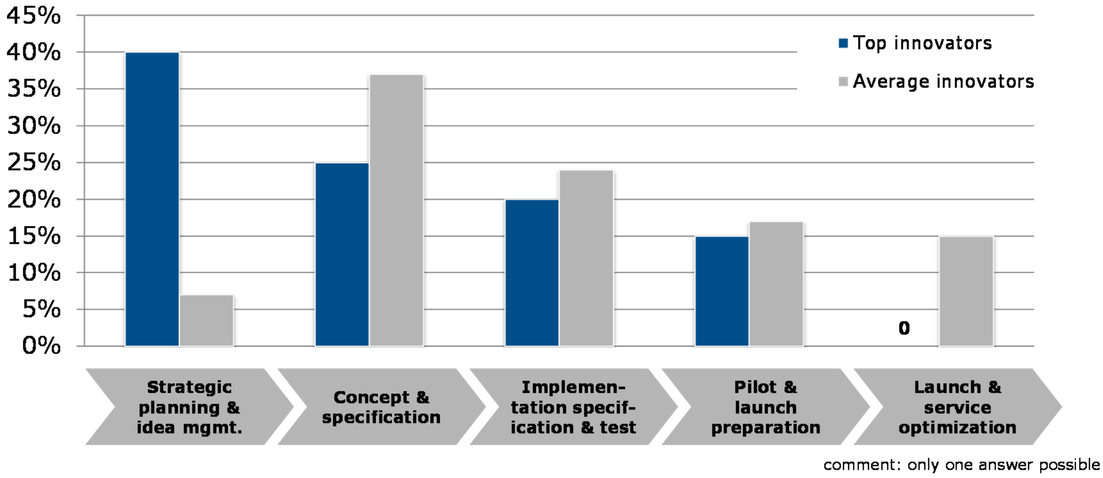
Source: Handfield et al., 2013

Fig. 6. Percentage of logistics objectives ranked number one
Rys. 6. Udział procentowy celów logistycznych uznawanych za najważniejsze



Source: Langley/Capgemini 2013

Fig. 7. Perceptual gap: largest source for innovation
Rys. 7. Różnice w odbiorze źródła innowacji



Source: European Logistics Association/Arthur D. Little, 2007

Fig. 8. Start of Involvement of Logistics Service Providers in the Innovation Process of Shippers
Rys. 8. Fazy włącznia usługodawców logistycznych w innowacyjny proces nadawców

DISCUSSION

The study of Handfield et al. [2013] shows, that companies have already recognized the increasing importance of collaboration. In the following the results of the study considering the mechanisms for creating competitive advantages (Dyer/Singh, 1998) are discussed in order to determine the potential already exploited by companies, today.

First, the study highlights that firms tend to build cohesive and integrated relationships focusing on synergies and improved supply chain coordination. Thus, firms are beginning to leverage complementary resources and capabilities and therefore, one of the mechanisms for competitive advantages. Second, another point that has been shown with the study is the governance of collaboration. Dyer/Singh [1998] claim for an effective governance of the collaboration. Even if the effectiveness is not evaluated with the analysis of the current state, it can be seen that there is a clear direction of the power to control the collaboration. Probably further research has to show which directions or form of power is able to realize effective governance in terms of the relational view. Third, the increasing willingness to exchange information can be seen as a precondition for the development of knowledge sharing routines aiming at exchanging, combining and further developing the knowledge of partners. Here can also be, fourth, found approaches for relation specific assets, when looking at the IT-infrastructure. To sum up, the study shows linkages to the four mechanisms for value creation stated by Dyer/Singh [1998] with the relational view. For realizing competitive advantages through collaboration in a connected economy is important to organize these mechanisms specifically. Thus, for sustainable competitive advantages companies should consider the barriers for imitation and make the relationship mechanisms difficult to imitate for others. In doing so, it can be assumed, that competitive advantages can be realized and protected both on a firm level and on a supply chain level, as well.

Furthermore, this article shows the importance of collaboration for innovation. Due to the fact, that besides cost reduction and modularization, the development of new services regarding customer´s needs and creating new ones is gaining importance, collaboration in logistics and SCM for innovation reasons increases. It is shown that top-performers integrate their partners at early stages of innovation processes and are therefore able to develop and realize mechanisms of relational advantages.

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WSPÓŁPRACA I KOMUNIKACJA W USIECIOWIONEJ GOSPODARCE

STRESZCZENIE. **Wstęp:** Usieciowiona gospodarka jest wynikiem wzrastającej specjalizacji oraz produktywności. Zacieranie się granic przedsiębiorstw umożliwia uzyskiwanie nowych form przewagi konkurencyjnej. Jednak, wraz ze wzrostem usieciowanej gospodarki, wzrasta również jej złożoność.
Metody: Prezentowana praca przybliża najważniejsze trendy usieciowionej i kompleksowej gospodarki, jak również odpowiadające na nie strategie logistyki i zarządzania łańcuchami dostaw.
Wyniki i wnioski: Praca skupia się na współpracy aktorów w obrębie zarządzania logistyką i łańcuchem dostaw oraz komunikacją niezbędną do osiągnięcia sukcesu. Wychodząc dalej, została omówiona rola współpracy zakresie innowacji w logistyce oraz zarządzaniu łańcuchem dostaw, która - jak dotąd - jest stosunkowo słabo opisana w literaturze fachowej. Zaprezentowano również wnioski wraz z dyskusją na temat obecnego stanu współpracy w kontekście jej potencjalnych możliwości.

Słowa kluczowe: współpraca, komunikacja, strategie logistyczne, innowacja

KOOPERATION UND KOMMUNIKATION IN EINER VERNETZTEN WIRTSCHAFT

ZUSAMMENFASSUNG. Einleitung: Die vernetzte Wirtschaft ist ein Ergebnis zunehmender Spezialisierung und Produktivität. Das Verwischen von Unternehmensgrenzen ermöglicht dabei Potenzial zur Erzielung von Wettbewerbsvorteilen. Allerdings geht mit der zunehmenden Verflechtung der Wirtschaft auch eine Zunahme der Komplexität einher.

Methoden: Mit ihrer aktuellen Studie betrachtet die Bundesvereinigung Logistik die wichtigsten Trends der vernetzten und komplexen Wirtschaft und die Strategien im Bereich der Logistik und des Supply Chain Managements (SCM), mit diesen Trends umzugehen.
Ergebnisse und Fazit: Der vorliegende Beitrag fokussiert die Kooperation von Akteuren in der Logistik und im SCM und die für den Erfolg dringend notwendige Kommunikation. Weiterhin geht der Beitrag über diese Studie hinaus und zeigt die Rolle der Zusammenarbeit für Innovationen in der Logistik und im SCM auf, einem in der Literatur bisher vernachlässigten Bereich. In einer abschließenden Diskussion wird der aktuelle Stand der überbetrieblichen Zusammenarbeit im Zusammenhang mit dessen Potenzial reflektiert.

Codewörter: Kooperation, Kommunikation, Logistik-Strategien, Innovation

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APPLICATION OF AN ELECTRONIC BULLETIN BOARD, AS A MECHANISM OF COORDINATION OF ACTIONS IN COMPLEX SYSTEMS - REFERENCE MODEL

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ABSTRACT. **Background:** In her previous research, the author of this publication indicates that coordination is a dependent variable which has a great driving force and is a very unstable factor. This results in the fact that all of the actions connected with coordination have an impact on other factors of cooperation as well as the integration of the enterprises in the structures of a supply chain type structure.

Material and methods: The article has been divided into two basic parts. The first part regards the reference models in complex systems (supply chain systems). They can constitute a starting point for the modelling of target processes in the built supply chain structure. The second part presents template process models (Reference Models) for selected action coordination mechanisms during enterprise cooperation. The aim of the article is the presentation the model an Electronic Bulletin Board (EBB), as a mechanism of coordination of actions in complex systems.

Results: The article was prepared on the basis of literature from the researched area. The material was also prepared on the basis of interviews with practitioners. They have allowed for the preparation of template process models (Reference Models) for selected action coordination methods in the supply chain.

Conclusions: The result of the work is a prepared model as well as its description in the use of IDEF0. The presented model is a demonstrative model. The proposed reference model makes it possible to define the parameters of a selected mechanism of coordination of actions, and forms a basis for affecting the progression of the process through an analysis of values of identified parameters. The parameterization of elements constitutes the foundation for the monitoring of the process via 1) unambiguous identification of the object of monitoring and 2) analysis of different variants of the progression of the process.

Key words: Coordination of Actions, Reference Model, Complex Systems, Electronic Bulletin Board.

INTRODUCTION

The idea of supply chain management is interpreted not only in the context of logistics but also in the framework of integration and synchronization. Regardless of how the essence of the concept is understood, its distinguishing feature is process orientation, i.e. approaching the supply chain's decisions, actions and flows as processes [Witkowski 2003, Supply Chain Council 2009]. Lambert, Cooper and Pagh mention that to some SCM is seen as the management of relationships both between corporate functions and across companies [Lambert et al. 1998]. The supply chain management is a decision process that not only integrates all of its participants, but also helps to coordinate the basic flows: products/services, information and funds [Sitek, Wikarek 2014].

Modelling always begins with the so-called mental model. Mental models can be found in a variety of disciplines within the humanities. Mental models were first introduced in the field of simulation modelling by Forrester [Forrester 1972]. The historical foundations of

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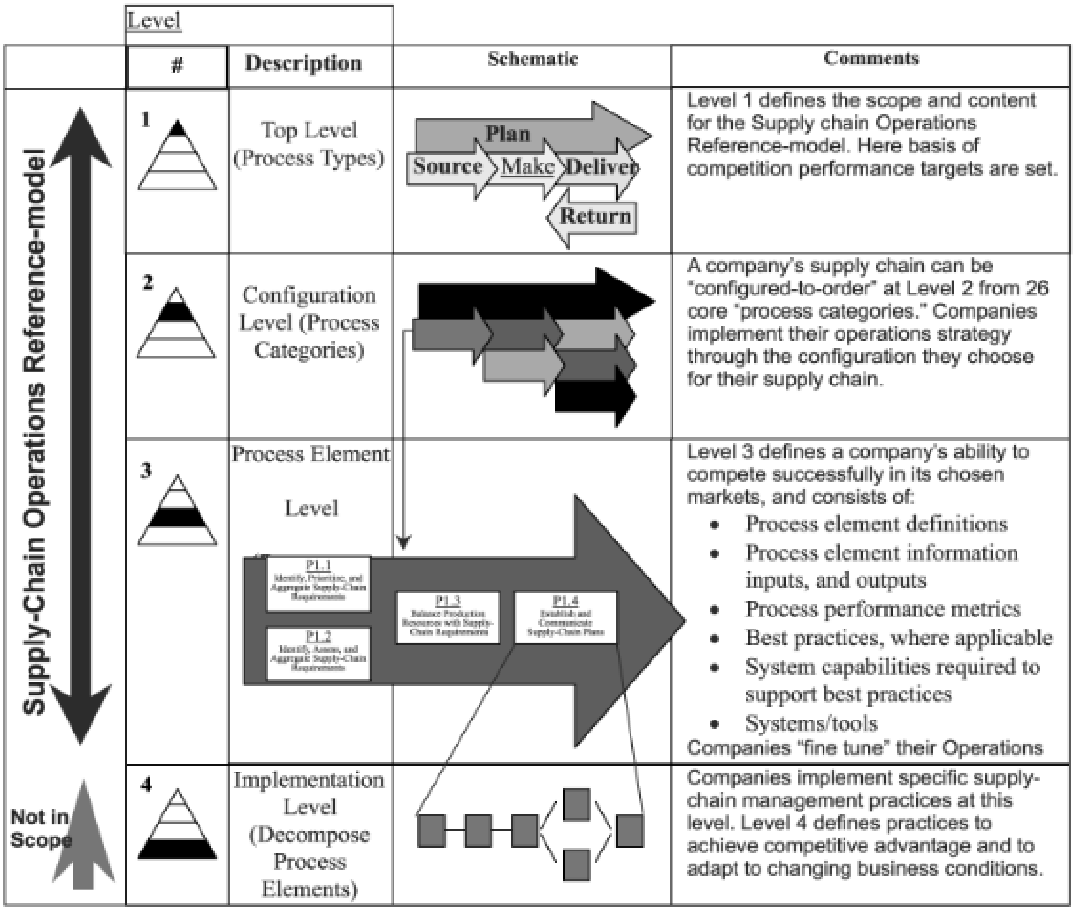
modeling formalism were developed in the USA [Chen 1995], and they resulted in the creation of the family of IDEF methods. Until now, over 70 modeling languages have been developed. However, this large variety makes language selection process difficult (Pawlewski). IDEF0 is a method designed to model the decisions, actions, and activities of an organization or system [Grzybowska, Kovács 2014].

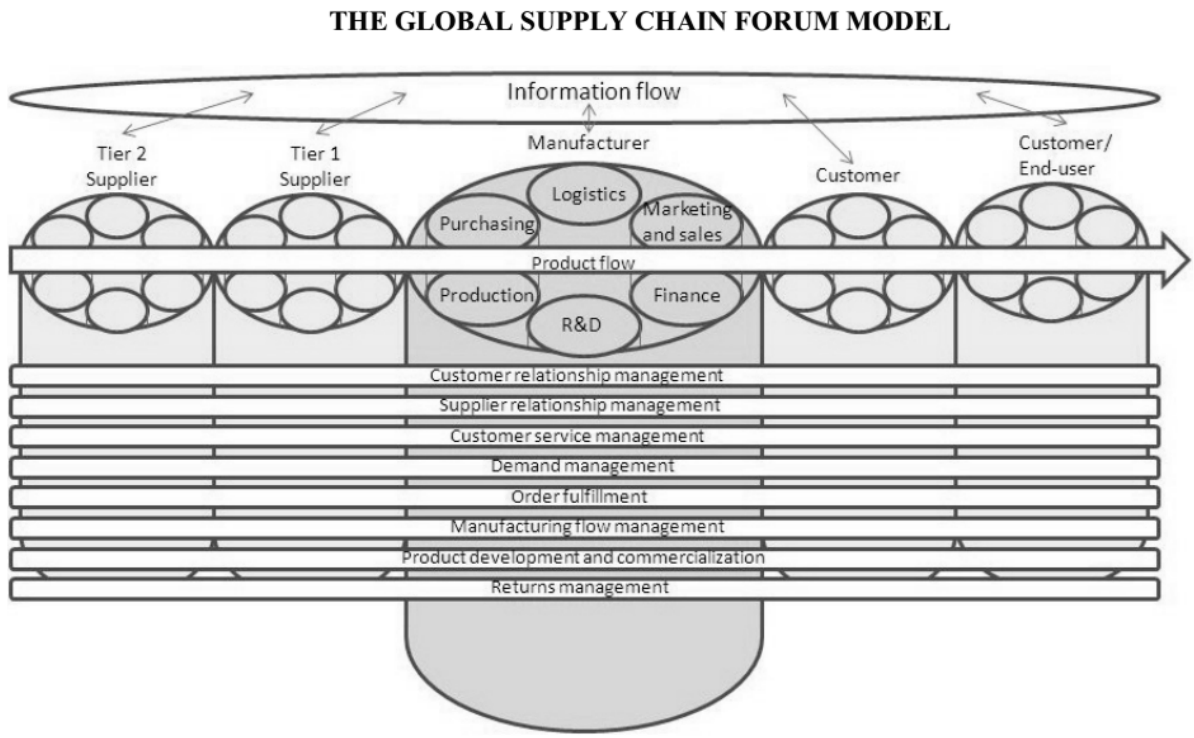
The most commonly cited reference models are:

- The Supply Chain Operations Reference (SCOR) model, developed by the Supply Chain Council (SCC) and AMR Research in 1996 is the most commonly cited SCM framework [Lockamy, McCormack 2004]. The SCOR model "provides a unique framework that links business processes, metrics, best practices and technology features into a unified structure to support communication among supply chain partners and to improve the effectiveness of supply chain management and related supply chain improvement activities" [Supply Chain Council, 2009].
- The Global Supply Chain Forum model, the second most popular framework is developed by the Global Supply Chain Forum (GSCF) [Lambert et al. 1998], at Ohio State University's Supply Chain Management Institute (SCMI). Supply chain management is the management of relationships in the network of organizations, from end customers through original suppliers, using key cross-functional business processes to create value for customers and other stakeholders [Naslund, Williamson 2010]. According to the GSCF framework, when all proper coordination mechanisms are in place across the various functions, the result will be an efficient and effective supply chain.



Source: Lockamy and McCormack, 2004

Fig. 1. Supply-Chain Operations Reference Model (version 4,0)
Rys. 1. Model referencyjny Supply-Chain Operations (wersja 4,0)



Source: http://scm-institute.org/Our-Relationship-Based-Business-Model.htm

Fig. 2. The Global Supply Chain Forum Model
Rys. 2. Model Global Supply Chain Forum

The author in the article "Coordination in the Supply Chain - an Indication of Logistic Management", presented activity coordination techniques that are applied by the enterprises. Fifty enterprises, unrelated to each other in their business activities took part in the conducted research. The respondents had the possibility of indicating more than one answer. The application of three coordination techniques was most often noted: coordination (28% indication), the application of six or seven techniques (4% each) was least common. 16% of the research respondents apply eight of the ten coordination techniques [Grzybowska, 2013].

These studies inspired to work on the problem of coordination. The aim of the article is the presentation the model an Electronic Bulletin Board (EBB), as a mechanism of coordination of actions in complex systems.

THE ELECTRONIC BULLETIN BOARD - A MECHANISM OF COORDINATION OF ACTIONS

Coordination terms and models have been developed in different fields to coordinate the interaction among components and objects, and are nowadays used to model and analyze organizations too [Boella, van der Torre 2006]. When the word coordination was first recorded in 1605, it meant "orderly combination" [Barnhart Dictionary of Etymology, 1988].

The coordination mechanism has a form of interactions among differentiated (in terms of form, targets, intentions, the manner of organization, etc.) and independent entities. Following Kotarbiński, the coordination of actions is understood in terms of agreement. Based on the literature and interviews with practitioners [Toktas-Palut, Ülengin, 2011; Natarajan, 2003; Simatupang, Wright, Sridharan, 2002; Redmiles, van der Hoek, Al-Ani, Hildenbrand, Quirk, Sarma, Silva Filho, de Souza, Trainer, 2007], it is possible to distinguish several mechanisms/means/forms of coordination of actions that can be employed in the phase of initiating cooperation on an order, and during cooperation and execution of the order. The discussed mechanism is most typically employed during agreements in the phase of initiating cooperation.

One method of activity coordination is self-coordination, understood as the voluntary cooperation of units- as during an open market fair. "The possibility of coordination through voluntary cooperation is based on the fundamental truth, although often negated - that both parties to the transaction gain a benefit from it, under the condition that this is a transaction that is voluntary and conscious from both sides" [Friedman 1993]. One of the methods of the voluntary cooperation of entities is the Open Method of Coordination - OMC. The open method of coordination is based on:

- the mutual identification of aims to be achieved in a complex, multi-agent system,
- the joint establishment of means aimed at the achievement of goals (in the form of statistics, indicators and guidelines),
- analyses, which entail the comparison of system element activities and the ex-change of good practices.

The coordination mechanism with the use of the Electronic Bulletin Board is a modified form of the classic form of coordination - contracting. Coordination with the use of an Electronic Bulletin Board is applied when the order has a very well defined sub-order or sub-task structure. As a result, the order can be structured into its simpler sub-tasks.

The structuring of the order entails its decomposition into a series of sub-orders in order to separate the structure of the order. This is a strictly indicated system resulting from the combining of sub-orders of the entire order. Structuring enables:

- the creation of a complete overview of the entire order and its aim,
- the division of the order into smaller sub-orders, which can be given for completion to sub-contractors,
- the indication of borderline conditions for the planning, steering and supervision over the completion of the order,
- the indication of all of the resources necessary to complete the order,
- the enabling of the current review of the costs of the order,
- the establishment of the control points of the order,
- placing the efficiency gauges in order.

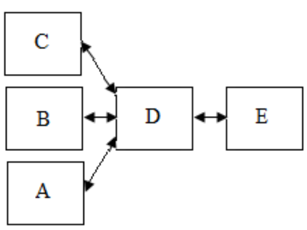
THE ELECTRONIC BULLETIN BOARD - REFERENCE MODEL

The Electronic Bulletin Board is a general term applicable to the technological/IT solution. The solution can refer to the electronic platform, logistics platform and integration platform. It can also apply to different forms of bidding/auction, shopping or group web portals (systems). Finally, the name "Electronic Bulletin Board" can be applied to solutions designed for the exchange of information, dedicated to the needs of industrial clusters which are characterized by quick adaptability to the changing needs of the market and diverse requirements through cooperation and application of new technologies. The Electronic Bulletin Board is consistent with new trends in technology. The core idea behind EBB is to coordinate multiple collaborating enterprises concurrently in the phase of initiating cooperation. The duration of coordination activities in this phase is usually set by the initiator of cooperation. The proposed reference model concerning the coordination of actions using the Electronic Bulletin Board does not take into account detailed terms of cooperation within the network, e.g. trust between partners, sharing of information and knowledge, organizational compatibility, etc.

It must also be emphasized that the presented reference model should be understood as a course of actions. Its referential nature carries an additional benefit, namely high flexibility of the model ensuring the applicability of general schemes to specific conditions in a given organization. The reference model was created using IDEF0 methodology modified specifically for the purposes of the model.

The model has been divided into two areas ("pools"), principal (client) and agent (supplier, subcontractor). Between the two pools there is the Electronic Bulletin Board represented in the form of a common (shared) block (Fig. 3) containing data and information available to all users. It is also possible to identify a narrow group of users. The model also contains elements in the form of cubes which refer to actions or activities implemented within the framework of a process relating to the coordination of actions. The cubes feature a unique combination of letters and characters ("alphanumeric index") which make it possible to quickly find them and accurately identify actions. The index note localizes functions (process/action/activity) in a complex hierarchical diagram structure. The cubes are interconnected by arrows. The arrows are objects of mutual relations between functions (cubes) which define information and illustrate relationships existing between actions.

The coordination with the use of the Electronic Bulletin Board is maintaining the coordination and supervision of all of the works, even those at the lowest level of complexity, by the main ordering party. In such a case, when a sub-contractor is found for some sub-order, the scope of the works of this sub-order is decomposed into sub-sub-orders by the main sub-contractor. One can observe a repeating action (most often repeated multiple times) of the same instruction (schedule of activities) in the loop.



Source: own study

Fig. 3. Concentrated nature
Rys. 3. Skoncentrowany charakter

In such a layout, cell D, who is the main ordering party, has the most advantageous position, having the full coordination of the activities and control over the completion of the order (Fig. 3).

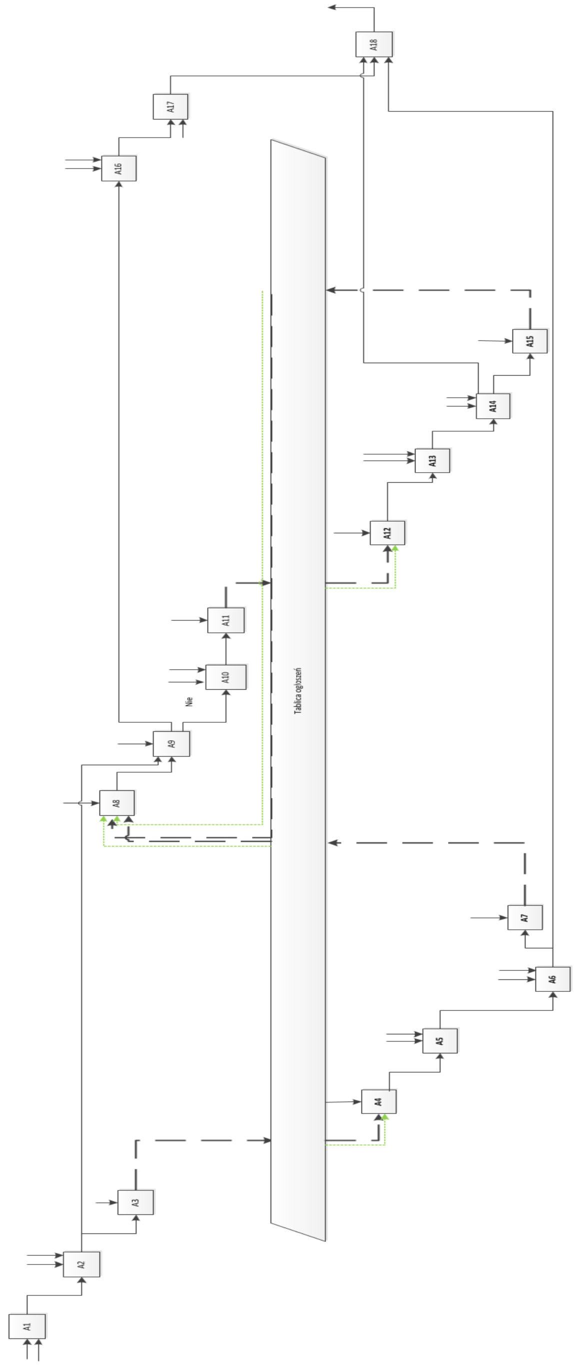
The structuring of the order entails its decomposition into a series of sub-orders in order to separate the structure of the order. This is a strictly indicated system resulting from the combining of sub-orders of the entire order. Structuring enables:

- the creation of a complete overview of the entire order and its aim,
- the division of the order into smaller sub-orders, which can be given for completion to sub-contractors,
- the indication of borderline conditions for the planning, steering and supervision over the completion of the order,
- the indication of all of the resources necessary to complete the order,
- the enabling of the current review of the costs of the order,
- the establishment of the control points of the order,
- placing the efficiency gauges in order.

The proposed reference model provides replies to the following questions:

- What actions (and in what order) should be executed?
- What information is necessary for the execution of actions?
- What effects are to be expected?
- What methods of analysis can be employed for the execution of actions?

The proposed reference model identifies relationships between business partners. It fills the gap with respect to the formalization of mechanisms applied for the coordination of actions, and forms a foundation for the development of a suitable simulation model.



Source: own study

Fig. 4. The electronic bulletin board - concentrated coordination of actions
Rys. 4. Elektroniczna tablica ogłoszeń - skoncentrowane koordynowanie działań

Table 1. Identification of actions - the electronic bulletin board - focused coordination of actions
Tabela 1. Identyfikacja działań - elektroniczna tablica ogłoszeń - skoncentrowane koordynowanie działań

ID	Name of the activity
A1	Commencing works of the request from the client
A2	Decomposition of the request into tasks, with consideration of a chosen criterion
A3	Adding the tasks to the information board
A4	Reading the tasks allocated on the board
A5	Evaluating the possibilities and profitability of the allocated task
A6	Making a decision about the possibility and profitability of performance of the task
A7	Putting the answer on the board
A8	Reading all records - collecting offers and answers with a resignation
A9	Verification of compliance of tasks with offers
A10	Making a decision about the possibility to obtain the lacking resources through decomposing the tasks
A11	Terminating the works
A12	Decomposition of the tasks into sub-tasks
A13	Adding the sub-tasks to the information board
A14	Reading the allocated sub-tasks
A15	Evaluating the possibility of performance and probability of the allocated sub-task
A16	Making a decision about the possibility and profitability of performance of the sub-task
A17	Putting the answer on the board
A18	Choosing an optimal composition of offers
A19	Allocating the tasks to subcontractors – request
A20	Confirming the commencement of works over the request

Source: own study

CONCLUSIONS

The methodology of reference modelling is used for the representation of complex systems and interactions existing between their constituent elements. Reference models are designed for the presentation of concepts of operation of different elements (objects), and illustrate their actions (processes). Reference models make it possible to build a complex system structure and select suitable tools that will support the automation of actions (processes) described by the models. Last but not least, reference modelling allows the development of structural and methodological frameworks that prove useful for the optimization of complex systems.

Consequently, the next step in exploring the coordination of actions using the Electronic Bulletin Board will be the development of a simulation model. The model will serve as an analytical tool for the purpose of monitoring the probability of accomplishment of goals set by users of the Electronic Bulletin Board functioning in a complex system. The simulation modelling apparatus will be employed as a tool for analyzing parameters connected to the mechanism of coordination of actions between participants of complex systems, taking into account randomly occurring temporal and personal limitations.

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ZASTOSOWANIE ELEKTRONICZNEJ TABLICY OGŁOSZEŃ, JAKO MECHANIZM KOORDYNACJI DZIAŁAŃ W SYSTEMACH ZŁOŻONYCH - MODEL REFERENCYJNY

STRESZCZENIE. **Wstęp:** Autorka we wcześniejszych badaniach wskazuje, że koordynacja działań jest zmienną zależną, która ma wpływ na siłę napędową i jest czynnikiem bardzo niestabilnym. Wynika to z faktu, że wszystkie czynności związanych z koordynacją działań wpływają na inne czynniki współpracy oraz integracji przedsiębiorstw w strukturach typu łańcuch dostaw.

Metody: Artykuł został podzielony na dwie zasadnicze części. Pierwsza część odnosi się do wybranego mechanizmu koordynacji działań tj. koordynacji działań przy wykorzystaniu elektronicznej tablicy ogłoszeń. Część druga pracy zawiera model referencyjny omawianego mechanizmu. Model ten może stanowić punkt wyjścia do modelowania procesów docelowych w zbudowanej strukturze łańcucha dostaw.
Rezultaty: Artykuł został przygotowany na podstawie literatury z badanego obszaru. Przygotowano również materiał na podstawie wywiadów z praktykami. Informacje zaczerpnięte od praktyków, podbudowane literaturą pozwalają na przygotowanie modeli procesów (modele referencyjne) dla wybranych metod koordynacji działań w łańcuchu dostaw.
Wnioski: Wynikiem pracy jest model referencyjny, rozumiany jako sposób postępowania, (została zastosowana zmodyfikowana metodologia IDEF0) oraz jego opis. Prezentowany model ma charakter poglądowy. Proponowany model odniesienia umożliwia określenie parametrów wybranego mechanizmu koordynacji działań i tworzy podstawę do analizy wartości wskazanych parametrów. Parametryzacja elementów stanowi podstawę do monitorowania procesu przez 1) jednoznaczną identyfikację obiektu monitorowania i 2) analizę różnych wariantów postępu procesu.

Słowa kluczowe: koordynacja działań, model referencyjny, system złożony, elektroniczna tablica ogłoszeń

DIE ANWENDUNG VON ELEKTRONISCHER VERKÜNDUNGS-TAFEL ALS MECHANISMUS FÜR DIE KOORDINIERUNG VON AKTIVITÄTEN IN KOMPLEXEN SYSTEMEN - EIN REFERENZ-MODELL

ZUSAMMENFASSUNG. Einleitung: Die Autorin weist in ihren früheren Forschungen darauf hin, dass die Koordinierung von Aktivitäten eine abhängige Variable ist, die die Antriebskraft beeinflusst und als ein sehr unstabiler Faktor anzusehen ist. Dies resultiert aus der Tatsache, laut deren alle mit der Koordination verbundenen Aktivitäten andere Faktoren der Zusammenarbeit und der Integration von Unternehmen innerhalb der lieferkettenmäßigen Strukturen mit beieinflussen.
Methoden: Der Artikel wurde in zwei Hauptteile aufgeteilt. Der erste Teil bezieht sich auf den ausgewählten Mechanismus der Koordinierung von Aktivitäten, d.h. der Koordinierung von Handlungen unter Anwendung einer elektronischen Verkündungstafel. Der andere Teil umfasst das Referenzmodell des besagten Mechanismus. Das Modell kann als Ausgangspunkt für Modellierung von Zielprozessen in einer aufgebauten Struktur einer Lieferkette bestehen.
Ergebnisse: Dem Artikel liegt die Fachliteratur aus dem betreffenden Bereich zugrunde. Das Material hat man auch mithilfe von Interviews mit Praktikern ermittelt. Die von den Praktikern gewonnenen, mit der Fachliteratur untermauerten Informationen erlauben es, die Prozeßmodelle (Referenzmodelle) für die ausgewählten Methoden der Koordinierung der Aktivitäten innerhalb von Lieferketten zu erstellen.
Fazit: Als Arbeitsergebnis gelten das als eine bestimmte Vorgehensweise aufgefasste Referenzmodell (dabei wurde die modifizierte IDEF0-Methodologie angewendet), sowie dessen Beschreibung. Das dargestellte Modell besitzt einen Anschauungscharakter. Das vorgeschlagene Referenzmodell ermöglicht die Bestimmung von Parametern des ausgewählten Mechanismus für die Koordinierung der Handlungen und schafft somit eine Grundlage für die Analyse von Werten der genannten Parameter. Die Parametrisierung der Elemente ist die Voraussetzung eines effizienten Prozeß-Monitorings, realiziert durch: 1) eine eindeutige Identifizierung des wahrgenommenen Objektes und durch: 2) die Analyse unterschiedlicher Varianten des Prozeßablaufes.

Codewörter: Koordinierung von Aktivitäten, Referenzmodell, komplexes System, elektronische Verkündungstafel

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RANKING OF INTEGRATION FACTORS WITHIN SUPPLY CHAINS OF FORWARD AND BACKWARD TYPES - RECOMMENDATIONS FROM RESEARCHES

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ABSTRACT. **Background:** Integration trends are one of main determinants of the development of modern logistics. After the period of interest focused mainly on supply chains realizing one-way flows only, at present there is a time for supply chains characterized by two-way flows, realizing at the same time both forward and backward flows. The possibility of various configurations of such chains requires identification of integration factors and determination of their influence on the results of the whole supply chain. Experiences of the science as well as the practice of supply chains show the urgent need of learning of reasons of the integration within supply chains of the two-way type.

Material and methods: The researches on modeling and simulation of integration processes within supply chains of forward and backward type were carried out in the environment of iGrafx Process 2013 for Six Sigma. The empirical material obtained in these researches was put to the statistical analysis by the used of Minitab 17. The identification of the significance of differences was made with the help of analysis of variance ANOVA. Additionally the analysis of differences in form of absolute averages was made. The following measures are main ones for the evaluation of the integration of a supply chain of forward and backward types: cashflow, profitability, service level.

Results: 8 192 simulation experiments were made for 6 integration factors: accessibility of recycled materials, production planning, stock management, integration of transport, unification of packing materials and optimization of the material flow. Based on the analysis of the significance and values of differences, the results of the influence of each integration factor on global results of supply chains of forward and backward type were obtained. They were used to prepare the ranking of integration factors. The main factors, forming the integration shape of two-way supply chains were: stock management, production planning and accessibility of recycled materials.

Conclusions: The integration offers new possibilities therefore it is the promising option of actions. In complicated and complex logistic reality, it is more and more difficult to function, in economic sense, without starting and tightening close cooperation. Sometimes it is even not possible at all. The growing popularity of two-way supply chains opens the dimensions of the possible cooperation. However, both science and the practice need the reliable quantitative information covering the conscious creation of the integration in supply chains. Such tool could be a ranking, recommended in this paper, of integration factors from the perspective of three measures of evaluation of global level of functioning of the supply chain.

Key words: ranking of integration factors, modeling and simulation of the supply chain, measure of the supply chain.

INTRODUCTION

The integration solutions, due to the possible opportunities, are the objects of interest both for science and practice already for a long time [SCOR 2010]. The identification of pro-integration factors, learning the strength and the direction of their influence within the defined configurations of supply chains as well as the creation of the system of evaluation of the integration level

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[Aryee, Naim, Lalwani 2008; Lummus, Vokurka, Krumwiede 2008, Dobrzyński 2009] are the basic problems, still waiting to be solved. These solutions are awaited both by the science and by the practice. The present world suffers from the shortage of resources, and tries to rationalize the use of them [Mousumi 2010]. The actions covering the use of recycled materials change the paradigms of thinking and in a natural way bring companies closer in various dimensions - integration relationships. The supply chains of forward and backward type (two-way) are the intensively developing area of the logistics [Cardoso, Ana Paula, Barbosa-Povoa, Relvas 2013; Jonrinaldi, Zhang 2013], which needs to be researched in more detailed way. It is worth to make a scientific research of the integration phenomenon in the context of the paradigm of the sustainable development (eco-logistics) to be able to use offered effects in an intended way [Zaman, Goschin 2010].

RESEARCH PROCEDURE - REVIEW OF LITERATURE

The essence of the research project was a comprehensive identification of both internal and external factors, which influence on the shape of the integration of supply chains of forward and backward type. The plan of the research projects consisted of the following tasks:
- identification of potential integration factors based on the review of the literature,
- selection (listing, comparison and choice) of integration factors based on questionnaire researches conducted in companies,
- elaborating, based on theoretical and practical researches, the integration levels (A, B, C, where A means the highest one) within each of the factors - defined characteristics of actions,
- identification of methods of measurement and evaluation of the integration level based on the review of the literature,
- elaborating, based on theoretical and practical researches, indicators of the evaluation of the integration level of two-way supply chains,
- determination of the direction and the strength of the influence of integration factors with the help of modeling and simulation procedure.

The topic of integration factors is covered among others in the following works:
- evaluation of the influence of integration factors on the efficiency of the production planning [Malak, Adamczak, Domański, Cyplik 2013],
- pointing the most essential integration factors as well as the actions undertaken to build closer relationships with cooperation partners within supply chains [Kupczyk, Pruska, Hadaś, Cyplik 2014],
- presentation of similarities and differences in actions undertaken to increase the integrations in two-way supply chains [Kupczyk, Hadaś, Cyplik, Pruska 2014].

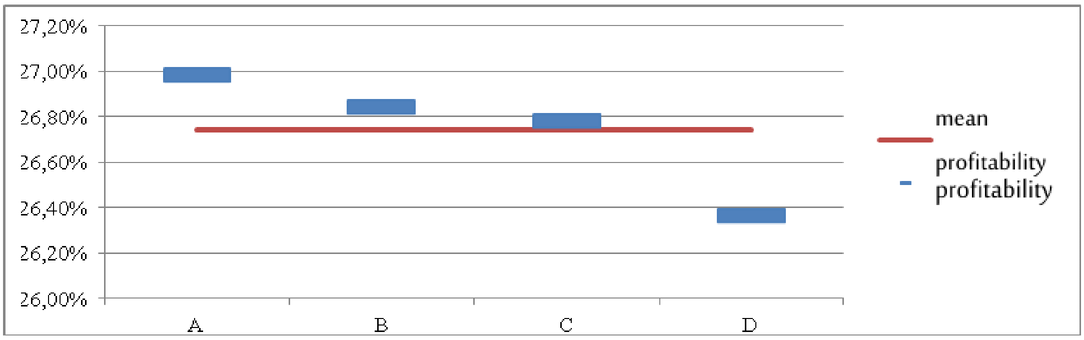
The topics of indicators and the evaluation system were the subjects of among others following works:
- system of measurement of the integration level of a supply chain of forward and backward type, together with the describing of the rule of the evaluation as well as the guidelines for the transformation of the chain in order to increase its efficiency [Hadaś, Cyplik, Adamczak 2014],
- the system of measurement of the integration level of sustainable supply chain together with its methodology and guidelines of its application [Cyplik, Hadaś, Adamczak, Domański, Kupczyk, Pruska 2014].

The idea of present researches has its source in previous scientific works of authors [Adamczak, Domański, Cyplik, Pruska 2013]. The results of previous introducing researches were already presented in the paper [Domański, Adamczak, Hentschel 2015]. The present article gives the whole results of researches of authors.

ANALYSIS OF THE INFLUENCE OF INTEGRATION FACTORS

Introduction to analysis

Based on the results of the conducted simulations within the model of the supply chain of forward and backward type, the authors observed various influence of individual integration factors on the defined operational indicators (cashflow, profitability, service level). Such observation can be used to build a ranking of integration factors that means to indicate which factor influences in the biggest way on given operational indicators. Authors based their conclusions on the analysis of variance between values of given indicator on each of integration level of each factor and a global mean of this indicator (calculated for all integration levels). The example of such situation is presented on Figure 1.



Source: own study

Fig. 1. Comparison of the profitability of supply chain at various integration levels for the factor Production planning
Rys. 1. Porównanie rentowności łańcucha dostaw na różnych poziomach integracji czynnika Planowanie produkcji

Taking into account the number of integration factors (6), the number of integration levels for each of factors (4) and the number of replications (2), which were implemented in the researches, the differences were calculated for the total number of 8 192 cases. They created the database for the use of building the ranking of integration factors. Firstly, it was decided to conduct the analysis of significance of individual differences to eliminate observations without differences from statistical point of view. Authors assumed that the bigger change of the integration level within considered factor induces bigger change (difference) of an indicator of a supply chain, the more significant this integration factor is. The ranking of integration factors was prepared in two variants: based on the influence on each of defined indicators and on the mean value of the influence. The detailed analysis were made and presented in subsequent parts of this work.

Analysis of the significance of differences

The aim of the analysis of the significance of differences is to determine whether the values of the definite indicator for the given factor at separate integration levels are significantly different comparing to the mean value of this indicator from statistical point of view. Authors assumed, that if there are no significant differences between values at individual integration levels, it means that these values are not significantly different from the global mean value of this indicator. The following hypotheses were stated:
H0: Values of differences of definite indicator from its mean value for each integration level are the same,
H1: Values of differences of definite indicator from its mean value for each integration level are not the same.

The verification of stated hypotheses was conducted by the use of ANOVA analysis of variance. The significance level α=0,05 was assumed. The example of the report of ANOVA analysis of variance obtained by the use of Minitab 17 is presented below (the example prepared for the analysis of the profitability for the factor: Production planning).

```
Analysis of Variance

Source              DF   Adj SS    Adj MS  F-Value  P-Value
Planning level       3  0,04345  0,014483    44,26    0,000
Error             8188  2,67944  0,000327
Total             8191  2,72289
```

Table 1. Values of P-Value indicator
Tabela 1. Wartości wskaźnika P-Value

Factor	P-Value		
	Cashflow	Profitability	Service level
Accessibility of recycled material	0,000	0,000	0,000
Production planning	0,000	0,000	0,000
Stock management	0,000	0,000	0,000
Transport integration	0,846	0,000	0,992
Unification of packaging	0,998	0,645	0,932
Optimization of material flows	0,001	0,000	0,003

Source: own study

The ANOVA analysis was made for six distinguished integration factors separately for each of indicators. Therefore, 18 analyses were obtained. The P-values for them were presented in Table 1.

According to assumptions of ANOVA analysis, if the value of P-value indicator is bigger than assumed significance level, there are no reasons to reject the null hypothesis. The grey color was used in the table 1 for these values, which do not allow to state, that at given integration levels the values of definite indicator are different comparing to its global mean value.

Analysis of values of differences

The second step of realized analysis was to determine differences between mean values at definite integration level of each factor and a global mean value of this indicator. The values of differences for three indicators of supply chains are presented in tables 2-4. The values, which are not significantly different from global mean from statistical point of view, are marked by the used of grey color.

Table 2. Values of differences of indicator Cashflow from its mean value
Tabela 2. Wartości różnicy miary cashflow od jej wartości średniej

Integration level	Accessibility of recycled material	Production planning	Stock management	Transport integration	Unification of packaging	Optimization of material flows
A	- 55 883,00 zł	382 092,00 zł	704 694,00 zł	10 063,00 zł	2 239,00 zł	38 763,00 zł
B	- 30 041,00 zł	- 54 645,00 zł	286 791,00 zł	1 740,00 zł	- 115,00 zł	23 365,00 zł
C	- 16,00 zł	- 84 207,00 zł	56 956,00 zł	- 2 661,00 zł	- 507,00 zł	- 23 020,00 zł
D	85 940,00 zł	- 243 240,00 zł	-1 048 441,00 zł	- 9 142,00 zł	- 1 617,00 zł	- 39 108,00 zł
Mean absolute difference	**42 970,00 zł**	**191 046,00 zł**	**524 220,50 zł**	**5 901,50 zł**	**1 119,50 zł**	**31 064,00 zł**

Source: own study

Table 3. Values of differences of indicator Profitability from its mean value
Tabela 3. Wartości różnicy miary rentowność od jej wartości średniej

Integration level	Accessibility of recycled material	Production planning	Stock management	Transport integration	Unification of packaging	Optimization of material flows
A	1,35%	0,24%	0,61%	0,25%	0,03%	0,44%
B	0,92%	0,10%	0,57%	0,05%	0,02%	0,18%
C	-0,57%	0,04%	0,33%	-0,07%	-0,02%	-0,24%
D	-1,70%	-0,38%	-1,51%	-0,23%	-0,03%	-0,38%
Mean absolute difference	**1,14%**	**0,19%**	**0,76%**	**0,15%**	**0,03%**	**0,31%**

Source: own study

Table 4. Values of differences of indicator Service level from its mean value
Tabela 4. Wartości różnicy miary poziom obsługi klienta od jej wartości średniej

Integration level	Accessibility of recycled material	Production planning	Stock management	Transport integration	Unification of packaging	Optimization of material flows
A	0,94%	8,41%	3,97%	0,04%	0,08%	0,42%
B	0,92%	-1,12%	2,51%	0,00%	0,00%	0,01%
C	-0,90%	-1,58%	-1,92%	-0,01%	-0,04%	-0,08%
D	-0,96%	-5,71%	-4,56%	-0,03%	-0,04%	-0,35%
Mean absolute difference	**0,93%**	**4,21%**	**3,24%**	**0,02%**	**0,04%**	**0,22%**

Source: own study

The mean absolute difference is given at the bottom of each of tables 2-4. It is a value calculated as an arithmetic mean of absolute differences at each integration level. It indicates how much the indicator, calculated as a mean value, is different at each of integration level comparing to the mean value, but it does not indicate whether this difference is positive or negative.

Ranking of integration factors

The mean absolute values, presented above, were used to prepare the ranking of integration factors. The ratio of mean absolute value to mean global value of a given indicator was calculated to prepare a standardization of results.

The following mean values of indicators for supply chains were used in above mentioned calculation: cashflow = 2 585 527,86 PLN, profitability = 26,74%, service level = 89,06%. The results for all integration factors are presented in the table 5.

Table 5. The ratio of mean absolute value to mean global value of indicators for supply chains
Tabela 5. Stosunek średnich różnic bezwzględnych do wartości średnich miar łańcucha dostaw

Indicator	Accessibility of recycled material	Production planning	Stock management	Transport integration	Unification of packaging	Optimization of material flows
Cashflow	1,66%	7,39%	20,28%	0,23%	0,04%	1,20%
Profitability	4,24%	0,71%	2,82%	0,56%	0,09%	1,16%
Service level	1,04%	4,72%	3,64%	0,02%	0,04%	0,24%

Source: own study

Based on the table 5, the ranking of integration factors were prepared according to the rule: the highest percent ratio of absolute mean difference to global mean value means the highest (1) place in the ranking. The ranking list was presented in the table 6.

The ranking of integration factors was prepared in three perspectives related to separate indicators of the supply chain. The place in the ranking was not assigned in the situation when the ANOVA analysis shows no statistical significance between differences for the given pair (indicator and factor). There is also a possibility to prepare an alternative version of the ranking of integration factors according to average influence of the factor on three defined indicators of the supply chain. The ranking list prepared in this way is presented in the table 7.

Table 6. The ranking of integration factors
Tabela 6. Ranking czynników integracji

Indicator	Accessibility of recycled material	Production planning	Stock management	Transport integration	Unification of packaging	Optimization of material flows
Cashflow	3	2	1	-	-	4
Profitability	1	4	2	5	-	3
Service level	3	1	2	-	-	4

Source: own study

Table 7. Average influence of integration factors on the indicators of supply chains
Tabela 7. Średni wpływ czynników integracji na miary łańcucha dostaw

Indicator	Accessibility of recycled material	Production planning	Stock management	Transport integration	Unification of packaging	Optimization of material flows
Cashflow	1,66%	7,39%	20,28%	0,23%	0,04%	1,20%
Profitability	4,24%	0,71%	2,82%	0,56%	0,09%	1,16%
Service level	1,04%	4,72%	3,64%	0,02%	0,04%	0,24%
average influence	**2,32%**	**4,27%**	**8,91%**	**0,27%**	**0,06%**	**0,87%**
ranking position	**3**	**2**	**1**	**-**	**-**	**4**

Source: own study

The place in the ranking was not assigned in the situation when the influence was not statistically significant, similarly as in the first version of the ranking. The advantage of this version is the precise determination of the position in the ranking. However it is obtained by the lost of transparency of the perspective of the evaluation in relation to each of the indicator separately.

CONCLUSIONS

Resuming the results of the hierarchization of integration factors in supply chains of forward and backward type, it can be noted the creation of the following triad: stock management, production planning and accessibility of recycled materials. These characteristics and in this sequence build the first basic line of integration factors in supply chains. The less important integration factor is only the optimization of material flows. Other factors (transport management and unification of packages) have no statistically significant influence on the results of the supply chain. These results confirm still actual significance of factors of stock management and production planning - more typical for on-way supply chains and the factor of accessibility of recycled material - typical for two-way supply chains. The final results of the researches enter into the transformation of the supply chain into the eco-chain.

Authors made the identification and selection of integration factors in two-way supply chains. The next step was the evaluation of each factor regarding the strength (value of the indicator) and direction (sign of the indicator) of the interaction. Knowing these relationships, it is possible to create fruitful cooperation within supply chains in rational and conscious way. Very complicated conditions of functioning are typical for the area of researches, chosen by authors. They are not directly susceptible on the transfer of standard solutions. Despite of that, authors took the challenge to explain the influence of integration factors on the results of supply chains in a quantitative way. The previous researches, known to authors, in this area were only of qualitative nature (integration models). Authors hope that obtained results will be useful for other researchers and managers, operating in areas connecting with supply chains as well as they will inspire to further researches in this area.

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RANKING CZYNNIKÓW INTEGRACJI W ŁAŃCUCHACH LOGISTYCZNYCH TYPU FORWARD I BACKWARD – REKOMENDACJE Z BADAŃ

STRESZCZENIE. **Wstęp:** Trendy integracyjne są jedną z głównych determinant rozwoju współczesnej logistyki. Obecnie po fazie zainteresowania łańcuchami dostaw realizującymi jedynie przepływy jednokierunkowe, nadeszła era łańcuchów dwukierunkowych typu forward i backward, realizujących jednocześnie przepływy w przód i w tył. Możliwość różnorodnej konfiguracji ogniw w takich łańcuchach dostaw wymaga zidentyfikowania czynników integracji oraz ustalenia ich stopnia oddziaływania na wyniki łańcucha dostaw. Doświadczenia nauki i praktyki łańcuchów dostaw zwracają uwagę na pilną potrzebę poznania uwarunkowań integracji w łańcuchach działających dwukierunkowo.
Metody: Prace związane z modelowaniem i realizacją eksperymentów symulacyjnych zjawiska integracji w łańcuchach logistycznych typu forward i backward przeprowadzono w środowisku iGrafx Process 2013 for Six Sigma. Uzyskany w ich trakcie materiał empiryczny poddano następnie obróbce statystycznej w pakiecie Minitab 17. Identyfikacja istotności różnic wyników została dokonana w oparciu o analizę wariancji ANOVA. Dopełnieniem analizy wariancji jest analiza wartości różnic w postaci średnich bezwzględnych. Podstawę oceny integracji łańcucha dostaw typu forward i backward stanowią następujące miary: cashflow, rentowność i poziom obsługi klienta.
Wyniki: Przeprowadzono 8 192 eksperymenty symulacyjne dla 6 czynników integracji: dostępność surowca wtórnego, planowanie produkcji, zarządzanie zapasami, integracja działań transportowych, unifikacja opakowań i optymalizacja przepływu materiałowego. W oparciu o wyniki analiz istotności i wartości różnic otrzymano wyniki wpływu danego czynnika integracji na wyniki globalne łańcucha dostaw typu forward i backward. Posłużyły one do stworzenia rankingu czynników integracji. Głównymi czynnikami kształtującymi postać integracji łańcuchów dwukierunkowych są w kolejności: zarządzanie zapasami, planowanie produkcji oraz dostępność surowców wtórnych.
Wnioski: Integracja oferuje nowe możliwości stąd jest to obiecująca opcja działania. W skomplikowanych i złożonych realiach logistycznych coraz trudniej ekonomicznie funkcjonować bez podejmowania form bliższej współpracy i zacieśniania tych więzi, czasami jest to wręcz niemożliwe. Rosnąca popularność łańcuchów dwukierunkowych otwiera nowe wymiary możliwości współpracy. Jednak nauce i praktyce potrzeba wiarygodnych informacji ilościowych na temat świadomego kreowania zjawiska integracji w łańcuchach logistycznych. Takie narzędzie może stanowić rekomendowana w artykule lista (ranking) czynników integracji w perspektywie trzech miar oceny globalnego stopnia funkcjonowania łańcucha dostaw.

Słowa kluczowe: ranking czynników integracji, modelowanie i symulacja łańcucha dostaw, miary łańcucha dostaw.

RANKING VON INTEGRATIONSFAKTOREN IN DEN LIEFERKETTEN VOM TYP FORWARD UND BACKWARD - DIE FORSCHUNGSGESTÜTZTEN EMPFEHLUNGEN

ZUSAMMENFASSUNG. Einleitung: Die Integrationstrends stellen heutzutage einen der wesentlichsten Einflussfaktoren der modernen Logistik dar. Nach einer Phase, in welcher das Interesse an den auf die nur in eine Richtung strömenden Materialflüsse orientierten Lieferketten bestand, kam die Zeit für die Zwei-Richtungen-Lieferketten vom Typ forward und backward, die die Materialflüsse vorwärts- und rückwärtssteuern können. Die Möglichkeit unterschiedlicher Konfiguration der Glieder innerhalb solcher Ketten bedarf einer Identifizierung von Intergrationsfaktoren und Festlegung deren Beeinflussung von Ergebnissen der Lieferkette. Die Erfahrungen aus Forschung und Praxis bezüglich der Lieferketten weisen auf die akute Notwendigkeit der Ermittlung von Voraussetzungen für die Integration innerhalb der in zwei Richtungen wirkenden Lieferketten hin.

Methoden: Die Forschungsarbeiten, die mit Modellierung und Ausführung von Simulationsexperimenten in Bezug auf Integrationserscheinungen innerhalb der Lieferketten vom Typ forward und backward verbunden waren, wurden im Medium iGrafx Process 2013 for Six Sigma durchgeführt. Das dadurch gewonnene, empirische Material wurde ferner einer statistischen Bearbeitung im Paket Minitab 17 unterzogen. Die Identifizierung der Relevanz von Ergebnis-Differenzen kam mithilfe der Varianz-Analyse ANOVA zustande. Die Vervollkommnung der Varianz-Analyse wird durch die Analyse von Differenzen-Werten in Form von absoluten Mittelwerten erreicht. Als Grundlagen für die Bewertung der Integration der Lieferkette vom Typ forward und backward bestehen folgende Maßstäbe: cashflow, Renatabilität und Niveau des Kundenservices.
Ergebnisse: Es wurden 8192 Simulationsexperimente für 6 Integrationsfaktoren, d.h.: Verfügbarkeit von Sekundärstoffen, Produktionsplanung, Lagerbestandsführung, Integration von Transportaktivitäten, Vereinheitlichung von Verpackungen und Opimimierung des Materialflusses, durchgeführt. Gestützt auf die Ergebnisse der Analyse der Relevanz und der Differenzen-Werte ermittelte man den Wert des Einflusses eines Integrationsfaktors auf das Gesamtergebnis der Lieferkette vom Typ forward und backward. Als solche wurden sie für die Aufstellung eines Rankings der betreffenden Integrationsfaktoren in Anspruch genommen. Demzufolge sind: Lagerbestandsführung, Produktionsplanung und Verfügbarkeit von Sekundärstoffen die wichtigsten Faktoren, die die Integration der Zwei-Richtungen-Lieferketten ausgestalten.
Fazit: Die Integration bietet neue Möglichkeiten und daher stellt sie eine vielversprechende Wirkungsoption dar. In der komplizierten und komplexen, logistischen Wirklichkeit fällt es immer schwieriger, ohne Inanspruchnahme der Formen einer engeren Zusammenarbeit und kooperativer Anbindungen wirtschaftlich zu handeln, manchmal ist dies gar nicht möglich. Die wachsende Popularität der Zwei-Richtungen-Lieferketten eröffnet neue Räume für die effektive Betätigung einer Zusammenarbeit in diesem Bereich. Die Wissenschaft und die Praxis bedürfen jedoch glaubwürdiger quantitativer Daten hinsichtlich der bewusstvollen Ausgestaltung der Erscheinung der Integration innerhalb der Logistikketten. Als solch ein Tool dazu kann die im vorliegenden Beitrag empfohlene Auflistung (Ranking) der Integrationsfaktoren in Form von den 3 Maßstäben für die Bewertung des Gesamt-Wirkungsgrades bei Funktionsausübung einer Lieferkette angesehen werden.

Codewörter: Ranking von Integrationsfaktoren, Modellierung und Simulation der Lieferkette, Maßstäbe der Lieferkette.

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DIVISION OF ENVIRONMENTALLY SUSTAINABLE SOLUTIONS IN WAREHOUSE MANAGEMENT AND EXAMPLE METHODS OF THEIR EVALUATION

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ABSTRACT. **Background:** Environmentally sustainable solutions are entering the domain of logistics. More and more frequently do we hear of sustainable or "green" warehouses, although the scale and scope of implementations in specific investments is not incomparable, and the adjective "green" is added rather for marketing, not utility-related, purposes. Furthermore, it is difficult to confront implemented solutions differently than with the use of evaluations dedicated to broadly-understood sustainable buildings. In order to identify the solutions, it is necessary to prepare a key for their division first. Identification, classification, popularisation and, in the long-run, implementation of sustainable solutions in warehouse management requires them to be organised.
Methods: On the basis of available information, chiefly primary and secondary sources, but also legal documentation developed in countries with high environmental awareness, materials which allow indicating the structure of division of sustainable solutions have been collected. The division has been prepared by means of analysing solutions, creating homogenous groups, and their further unification. The comparison of evaluations given to sustainable solutions has been prepared on the basis of information made available by certifying institutions.
Results: Sustainable solutions have been divided into groups, although the division is not disjoint. Three basic groups of solutions (reducing harmful emissions, reducing consumption of resources, increasing ecological value of facilities) have been distinguished. One is homogenous, the other two are divided into further subgroups.
Conclusions: Division of sustainable solutions and specification of particular groups are a basis for identification, qualification, popularisation and, in the long term, implementation of sustainable solutions for warehouse management, consequently leading to lower emission of greenhouse gases and resource consumption, and, in the long-run, to a "green" warehouse.

Key words: sustainability, sustainable warehouse, green warehouse, sustainable solutions.

INTRODUCTION

Environmentally sustainable buildings (hereinafter: sustainable buildings) also include warehouse facilities. Broadly promoted trend for "green" buildings is entering the domain of logistics.

A sustainable warehouse, understood as a "set of organisational and technological solutions whose aim is to efficiently execute warehouse processes, with the highest social standards met, with the lowest possible environmental impact and taking financial effectiveness into account" [Żuchowski 2014], should be "equipped" with sustainable solutions. Organisational and technological solutions mentioned above might be described as "environmental technologies", defined back in 1995 as [Shrivastava 1995] "production equipment, methods and procedures, product designs, and product delivery mechanisms that conserve energy and natural resources, minimize environmental load of human activities, and protect the natural

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environment". In order to identify the solutions, it is necessary to prepare a key for their division first. Identification, classification and, last but not least, implementation of sustainable solutions requires them to be organised.

The basic motives of the use of sustainable technologies should be classified concern for the conditions of life of future generations and economic benefits. Two distinct themes can go hand in hand - there is nothing to prevent that to reconcile them. "When my employer began ramping up its sustainability initiatives, I thought we'd be faced with a lot of tough choices between economy or eco-friendliness," says logistics engineer Dr. Rajiv Saxena. "But as we've progressed, I've been pleasantly surprised to discover that much of good logistics engineering is not only compatible with greener business practices, it's actually synonymous with it." [Underwood 2008].

DIVISION OF SUSTAINABLE SOLUTIONS

One of broader divisions of widely-understood environmental technologies was presented in the 2007 Energy Independence and Security Act of the Congress of the United States of America [110th Congress Public Law 140] and it includes the following activities:

1. reducing the use of energy, water and natural resources,
2. improving the quality of internal environment (working conditions), including reducing the level of internal contaminations, improving thermal comfort and quality of lighting, and level of noise, influencing the health and productivity of users,
3. reducing negative impact on the environment, especially caused by air and water pollution or waste generation, throughout a building's lifecycle (A building's lifecycle mainly comprises the following stages: construction (including the design), use, upgrade (renovation, adaptation etc.) and final demolition),
4. increasing the use of environment-friendly materials, particularly the ones which are non-toxic, renewable and recycled,
5. increasing the possibility to reuse and recycle,
6. integrating systems in buildings,
7. reducing environmental impact and transport energy consumption, related both to building location and its development.
8. taking a building's influence on human health and natural environment into account, including:
   - increasing the effectiveness of employees,
   - influence of materials and processes carried out in the building throughout its lifecycle.

The definition of a "green building" developed by the US Environmental Protection Agency included a list of architectural factors influencing natural environment, presented in Table 1. To a considerable degree, these factors are compliant with, or even synthesize, the definition provided in the Energy Independence and Security Act.

Table 1. List of buildings' factors influencing natural environment
Tabela 1. Zestawienie czynników wpływu budynków na środowisko naturalne

Construction site factors	Consumption	Environmental factors	Effects
Location Project Construction Operation Maintenance / conservation Renovation Demolition	Energy Water Materials Natural resources	Waste Air pollution Water pollution Internal environment pollution Heat islands Rain water	Impact on human health Degradation of natural environment Loss of resources

Source: Environmental Protection Agency 2014

Beneficial impact of the above factors on the environment may assume several forms, therefore in terms of effects of their application in buildings, sustainable solutions may be divided into three basic groups:

- solutions reducing harmful emissions, both to natural and internal environment,
- solutions reducing the consumption of resources, also by supplying them from alternative sources,
- solutions increasing ecological value of a facility

The first group of technologies includes technologies reducing negative impact on warehouse micro- and macroenvironment by limiting emissions of harmful substances. It is also applied to noise. Emissions may be limited directly (e.g. by reducing the volume of waste or minimising the emission of exhaust fumes) or indirectly, by using biodegradable or recycled resources.

The second group of solutions is related to consumption - minimising the absorption of resources, directly by using alternative sources available in the vicinity of a warehouse, and employing more effective or cost-saving solutions.

The third group of sustainable solutions is related to the use of possessed resources, but not with the aim to produce alternative energy, but to maximise positive impact of a warehouse facility on natural environment. Properly maintained biologically active areas, preservation of existing fauna and flora to a possible degree or minimisation of landscape "interruptions" may serve as examples.

Suggested division of sustainable technologies together with factors they may influence has been presented in Table 2.

Table 2. List of buildings' factors influencing natural environment
Tabela 2. Zestawienie czynników wpływu budynków na środowisko naturalne

Sustainable solutions		Factors / solutions
Reducing harmful emissions	Directly	Waste Toxins, exhaust fumes Noise Wastewater / grey water Heat / Cold
	Indirectly	Construction materials Usable materials Spare parts
Reducing the consumption of resources	Minimisation	Heating Lighting Running water / Irrigation Electricity Fuels Materials (e.g. packaging)
	Alternative sources	Water Heating Lighting Electricity Environment-friendly external sources
Increasing ecological value of a facility / complex, integration with natural environment		Biologically active areas Preservation of natural fauna and flora Care about landscape

Source: Own study

The division is not disjoint - certain solutions may belong to both groups, such as thermal insulation, which may be qualified as a solution allowing the reduction of energy consumption, as well as the reduction of excessive heat generation / emission. The reduction of harmful emissions may be directly ensured by minimising energy consumption for example by using devices with low energy intensity. This, in turn, may be qualified as belonging to the group of solutions reducing resource consumption.

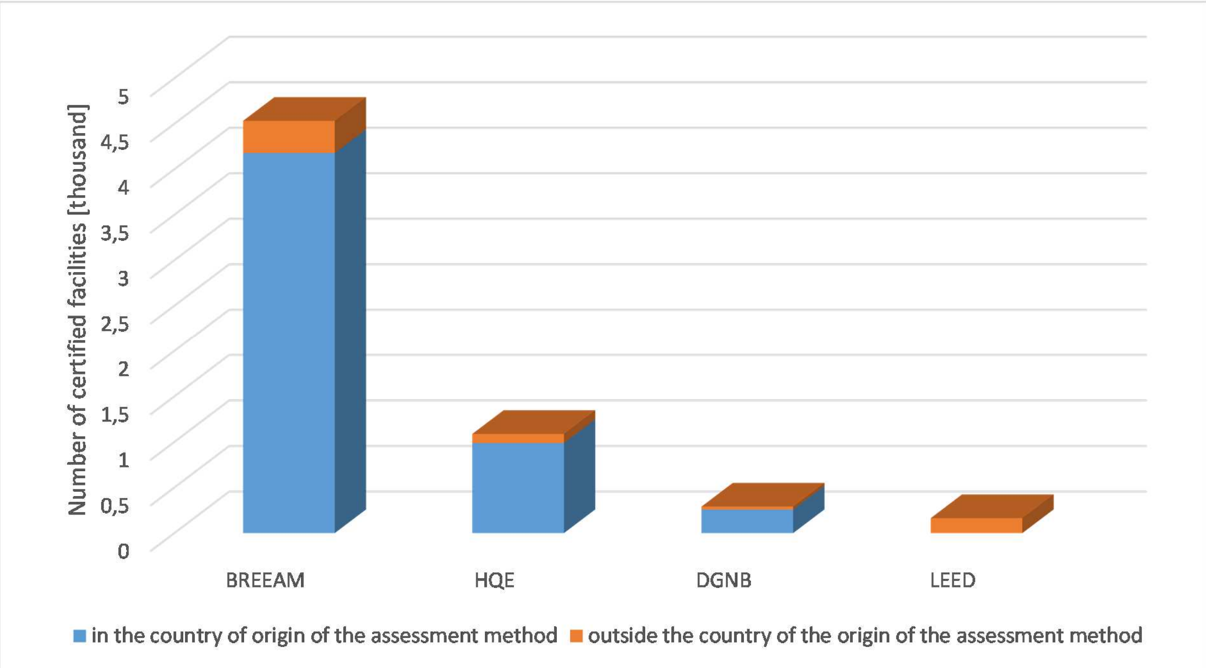
METHODS OF EVALUATING ENVIRONMENTALLY SUSTAINABLE WAREHOUSE FACILITIES

Sustainable facilities require the possibility of verification. The purpose of developing methods of evaluating sustainable buildings was transparent comparison and differentiation of buildings aspiring to be called "sustainable". Increasing promotion of evaluations results in the stimulation of demand for sustainable buildings and for enabling potential owners or users of evaluated buildings to make conscious decisions. Promotion of sustainable buildings' evaluation finally leads to the reduction of their negative impact on natural environment [Rouach 2013].

No dedicated system for evaluating sustainable warehouses has been implemented so far. General building evaluation systems, however, allow evaluating specialised facilities, including warehouses. Among four certification methodologies applied most frequently in Europe there are (certification system's country of origin provided in brackets):

a. Building Research Establishment Environmental Assessment Methodology BREEAM (United Kingdom),
b. Haute Qualité Environnementale HQE (France),
c. Deutsche Gesellschaft für Nachhaltiges Bauen - DGNB (Germany),
d. Leadership in Energy and Environmental Design LEED (USA).

A number of certificates granted in Europe is presented in Figure 1. The fact that a vast majority of certificates by a given system has been issued in a methodology's country of origin, although they go beyond local legal regulations, is interesting. LEED, originating in the USA, but successfully employed in Europe (second largest number of certified facilities outside the certification system's country of origin), is an example here.



Source: RICS 2012

Fig. 1. Number of certified European facilities divided into certification methodologies
Rys. 1. Ilość certyfikowanych europejskich obiektów w podziale na metodologie certyfikacji

Table 3. Comparison of basic parametres of systems evaluating sustainable buildings
Tabela 3. Porównanie podstawowych paramentów systemów oceny zrównoważonych obiektów

Parametre	**Evaluation system**			
	BREEAM	**LEED**	**DGNB**	**HQE**
Evaluated aspects				
Construction, materials	X	X		X
Management	X			X
Internal environment	X	X	X	X
Land development	X	X	X	
Water usage	X	X	x	
Water and waste	X			x
Innovations	X	X		
Energy usage	X	X		
Processes	x			
Economic effectiveness			X	
Evaluated buildings				
New	X	X	X	X
Expanded	X	X		
Existing/used	X	X	X	X
Redecorated	X	X	X	X
Shell & Core *	X	X		
Facility evaluation schemes				
Office	X	X	X	
Commercial	X	X	X	
Industrial	X		X	
Of special purpose	X		X	
School				X
Other	X	X		X
Number of levels of positive evaluations	**5**	**4**	**3**	**4**
Warehouse evaluation	**X**	**X**	**X**	**X**

* A building with finished common areas and unfinished office, commercial, production and warehouse space etc.

Source: RICS 2012

The comparison of basic parametres of systems evaluating the sustainability of buildings is presented in Table 3.

Each of the described systems for evaluating sustainable buildings allows warehouse evaluation. With regard to the evaluation of energy usage, however, BREEAM and LEED seem most suitable.

SUMMARY

Literature lacks studies which organise results of implementing sustainable solutions in warehouse facilities. In general, however, green buildings prove their advantage over "classic" ones, which leads directly to a conclusion that warehouses as sustainable buildings will show their supremacy in terms of financial savings, working conditions, "green" added value and, last but not least, benefits to environment and to an entrepreneur - a typical win-win situation.

On the basis of available information developed in countries with high environmental awareness, materials have been collected with the purpose of preparing a structure of a division of sustainable solutions in terms of warehouse management. The division has been prepared by means of analysing solutions, creating homogenous groups, and their further unification.

Finally, sustainable solutions have been divided into three groups, although the division is not disjoint. Three basic groups include solutions which reduce harmful emissions (directly and indirectly), reduce the consumption of resources (by minimising consumption or using alternative energy sources) and increasing ecological value of facilities.

Division of sustainable solutions and specification of particular groups form a basis for identification, qualification, popularisation and, in the long term, implementation of sustainable solutions for warehouse management, consequently leading to lower emission of greenhouse gases and consumption of resources, and, in the long-run, to a "green" warehouse.

Specialists in logistics have a task to identify, study and promote sustainable solutions which allow achieving results achieved by sustainable buildings, but also to trigger a domino effect, initiating further research, which would specify achieved results in more detail or extend their scope to other fields of management.

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PODZIAŁ ZRÓWNOWAŻONYCH POD WZGLĘDEM ŚRODOWISKOWYM ROZWIĄZAŃ W GOSPODARCE MAGAZYNOWEJ ORAZ PRZYKŁADOWE METODY ICH OCENY

STRESZCZENIE. **Wstęp:** Zrównoważone pod względem środowiskowym rozwiązania wkraczają na grunt logistyki. Coraz częściej słyszymy o zrównoważonych czy "zielonych" magazynach, choć skala i zakres wdrożeń w poszczególnych inwestycjach nie jest nieporównywalny, a miano "zielony" jest nadawane raczej pod względem relacji marketingowych, niż utylitarnym. Trudno jest też implementowane rozwiązania konfrontować, poza stosowaniem ocen dedykowanych ogólnie pojętym zrównoważonym budynkom. W celu identyfikacji rozwiązań uprzednio konieczne jest przygotowanie klucza ich podziału. Identyfikacja, klasyfikacja, popularyzacja i ostatecznie implementacja zrównoważonych rozwiązań w zakresie gospodarki magazynowej wymaga ich systematyzacji.
Metody: Na podstawie dostępnych informacji, przede wszystkim źródeł pierwotnych i wtórnych, ale także dokumentacji prawnej, rozwijanej w krajach o znacznej świadomości środowiskowej, zebrane zostały materiały w celu przygotowaniu struktury podziału zrównoważonych rozwiązań. Podział został przygotowany poprzez analizę rozwiązań, tworzenie homogenicznych grup, a następnie ich ujednolicenie. Porównanie ocen zrównoważonych rozwiązań zostało przygotowane na podstawie informacji udostępnianych przez instytucje certyfikujące.
Wyniki: Zrównoważone rozwiązania zostały podzielone na grupy, choć podział nie jest rozłączny. Wyszczególnione zostały trzy podstawowe grupy rozwiązań (redukujące niekorzystne emisje, redukujące konsumpcję zasobów, zwiększające ekologiczne walory obiektów), jedna homogeniczna, dwie podzielone na dalsze podgrupy.
Wnioski: Podział zrównoważonych rozwiązań i specyfikacja poszczególnych grup są podstawą do identyfikacji, kwalifikacji i popularyzacji, a w dłuższej perspektywie implementacji zrównoważonych rozwiązań w zakresie gospodarki magazynowej, w rezultacie prowadząc do redukcji emisji gazów cieplarnianych i konsumpcji zasobów, a docelowo do "zielonego" magazynu.

Słowa kluczowe: zrównoważony rozwój, zrównoważany magazyn, zielony magazyn, zrównoważone rozwiązania

UNTERTEILUNG DER NACHHALTIGEN, ÖKOLOGISCHEN LÖSUNGEN IN DER LAGERWIRTSCHAFT UND IHRE BEISPIELHAFTEN BEWERTUNGSMETHODEN

ZUSAMMENFASSUNG. Einleitung: Nachhaltige Lösungen finden Eingang in die Logistik. Immer häufiger hört man von nachhaltigen bzw. "grünen" Lagern, obwohl die Skala und der Umfang der Implementierungen bei den einzelnen Investitionen unvergleichbar sind und die Bezeichnung "grün" eher im Hinblick auf Marketing- als auf utilitäre Zwecke vergeben wird. Es ist auch schwierig, die implementierten Lösungen gegenseitig zu konfrontieren - ausgenommen die Anwendung von Bewertungen, die generell für die nachhaltigen Lager-Gebäude gelten. Zur Identifizierung der Lösungen ist es notwendig, vorher einen Unterteilungsschlüssel zu erarbeiten. Die Identifizierung, Klassifizierung, Popularisierung und schließlich Implementierung von nachhaltigen Lösungen in der Lagerwirtschaft erfordern deren Systematisierung.

Methoden: Aufgrund verfügbarer Informationen, insbesondere Primär- und Sekundärquellen, sowie der in den Ländern mit hohem Umweltbewusstsein entwickelten Rechtsakten, wurden Materialien zur Vorbereitung der Unterteilungsstruktur von nachhaltigen Lösungen zusammengestellt. Die Unterteilung wurde durch die Auswertung von Lösungen, die Bildung von homogenen Gruppen und ihre darauffolgende Vereinheitlichung vorbereitet. Der Vergleich von Bewertungen der nachhaltigen Lösungen wurde aufgrund von Informationen bereitgestellt, die von den Zertifizierungsstellen zur Verfügung gestellt wurden.

Ergebnisse: Die nachhaltigen Lösungen wurden in Gruppen unterteilt, obwohl die Unterteilung nicht disjunktiv ist. Aufgeführt wurden drei grundlegende Lösungsgruppen (Verminderung der schädlichen Emissionen, Verminderung des Ressourcenverbrauchs, Verbesserung der Umweltschutzvorteile der Lager-Gebäude), wovon eine homogen ist und zwei in weitere Gruppen unterteilt sind.

Fazit: Die Unterteilung der nachhaltigen Lösungen und Spezifikation von einzelnen Gruppen sind eine Grundlage für die Identifizierung, Qualifizierung sowie Popularisierung, und in einer längeren Perspektive, für die Implementierung von nachhaltigen Lösungen in der Lagerwirtschaft, was zur Reduktion der Emission von Treibhausgasen, ferner zur Reduktion des Ressourcenverbrauchs und im Endergebnis zum "grünen" Lager führt.

Codewörter: nachhaltige Entwicklung, nachhaltiges Lager, "grünes" Lager, nachhaltige Lösungen

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FUZZY DECISION-MAKING APPROACH IN GEOMETRIC PROGRAMMING FOR A SINGLE ITEM EOQ MODEL

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ABSTRACT. **Background and methods**: Fuzzy decision-making approach is allowed in geometric programming for a single item EOQ model with dynamic ordering cost and demand-dependent unit cost. The setup cost varies with the quantity produced/purchased and the modification of objective function with storage area in the presence of imprecisely estimated parameters are investigated. It incorporates all concepts of a fuzzy arithmetic approach, the quantity ordered, and demand per unit compares both fuzzy geometric programming technique and other models for linear membership functions.

Results and conclusions: Investigation of the properties of an optimal solution allows developing an algorithm whose validity is illustrated through an example problem and the results discussed. Sensitivity analysis of the optimal solution is also studied with respect to changes in different parameter values.

Key words: fuzzy, GPP, Setup cost, EOQ, Single item.

INTRODUCTION

In the classic economic production quantity (EPQ) models, the square root formula for the economic order quantity (EOQ) was used in the inventory literature for a pretty long time. Ever since its introduction in the second decade of the past century, the EOQ model has been the subject of extensive investigations and extensions by academicians. Although the EOQ formula has been widely used and accepted by many industries, some practitioners have questioned its practical application. For several years, classical EOQ problems with different variations were solved by many researchers and therefore the research on the inventory problems with EOQ formula has become a hot issue in enterprises and academia.

Taha [1976], Urgeletti Tinnarelli [1983] initially proposed an EOQ model that deals with different variations of formula. But various Paradigmatic changes in science and mathematics concern the concept of uncertainty. In Science, this change has been manifested by a gradual transition from the traditional view, which insists that uncertainty is undesirable and should be avoided by all possible means. According to the traditional view, science should strive for certainty in all its manifestations; hence uncertainty is regarded as unscientific. According to the modern view, uncertainty is considered essential to science; it is not any an unavoidable plague but has; in fact, a great utility. But to tackle non-random uncertainty no other mathematics was developed other than fuzzy set theory and showed the intention to accommodate uncertainty in the presence of random variables. From literature survey, the

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EOQ model in inventory systems, where uncertainty for single item is tackled from the traditional probability theory is assessed by a crisp value. But practical situations, precise value of the total cost are seldom achieved as they may be vague and imprecise to certain extent. Thus in inventory system, the decision maker may allow some flexibility in the parameter values in order to tackle the uncertainties which always fit the real situations.

Following Zadeh [1965], significant contributions in this direction have been applied in many fields including production related areas. Sommer [1981] applied fuzzy dynamic programming to an inventory and production scheduling problem in which the management cuisses to fulfill a contract for providing a product and then withdraw from the market. Kacprzyk et al. [1982] introduced the determination of optimal of firms from a global view point of top management in a fuzzy environment with fuzzy constraints improved on reappointments and a fuzzy goal for preferable inventory levels to be attained. Park [1987] examined the EOQ formula in the fuzzy set theoretic perspective associating the fuzziness with the cost data. Here, inventory costs were represented by trapezoidal fuzzy numbers (TrFN) and the EOQ model was transformed to a fuzzy optimization problem.

Recently, for a single product with demand related to unit price Cheng [1989] has solved the EOQ model by geometric programming method. His treatments are fully analytical and much computational efforts were needed there to get the optimal solution. But Roy et al. [1995, 1997] have considered the space constraint with the objective goal in fuzzy environment and attacked the fuzzy optimization problem directly using either fuzzy non-linear or fuzzy geometric programming technique similarly Lee et al. [1998] and Vujosevic et al. [17] have applied fuzzy arithmetic approach in EOQ model without constraints. Tripathy et al. [2009, 2011, 2011a] also investigated fuzzy EOQ models where demand is deterministic and unit cost of production is a function of both process reliability and demand. Tripathy et al. [2008] developed the fuzzy model by imposing entropy cost to modify the traditional EOQ model with stock dependent demand where pre- and post deterioration discounts are allowed.

Table 1. Summary of the related research
Tabela 1. Podsumowanie pokrewnych badań

Authors	Demand	Setup cost	Holding cost	Unit cost of production	Constraint	Planning horizon	Structure of the Model	Model class
Vujosevic et al. (1996)	Constant	Constant	$\frac{\tilde{c}_h c_p Q}{2\times 100}$	Constant	No	Finite	Fuzzy	Defuzzification
Tripathy et al. (2009)	Constant	Constant	$\frac{Hr^2q^2}{2\lambda}$	Reliability and demand	Reliability	Infinite	Fuzzy	NLP
Tripathy et al. (2011)	Constant	Constant	$\frac{H\lambda q^2}{2r^2}$	Reliability and demand	Reliability	Infinite	Fuzzy	NLP
Tripathy et al. (2011)	Constant	Constant	$\frac{Hq^2}{2r^2\lambda}$	Reliability and demand	Reliability	Infinite	Fuzzy	NLP
Roy et al. (1995)	Constant	Variable	$\frac{1}{2}C_1q$	No	Space	Infinite	Fuzzy	NLP
Roy et al. (1997)	Constant	Variable	$\frac{1}{2}C_1q$	Demand	Space	Infinite	Fuzzy	NLP, GPP
Present paper (2014)	Constant	Variable	$\frac{1}{2\times 100}C_1KD^{-\beta}q$	Demand	Space	Infinite	Fuzzy	GPP

In this paper a single item EOQ model is developed where unit price varies inversely with demand and setup cost increases with the increase of production. In company or industry, total expenditure for production and storage area are normally limited but imprecise, uncertain, non-specificity, inconsistency vagueness and flexible. These are defined within some ranges. However, the non stochastic and ill formed inventory models can be realistically represented in the fuzzy environment. The problem is reduced to a fuzzy optimization problem associating fuzziness with the storage area and total expenditure. The optimum order quantity is evaluated by fuzzy geometric programming (FGP) method and the results are obtained for linear membership functions. The model is illustrated with numerical example and with the variation in tolerance limits for both shortage area and total expenditure. A sensitivity analysis is presented. The numerical results for fuzzy and crisp models are compared.

The remainder of this paper is organized as follows. In section 2, assumptions and notations are provided for the development of the model and the mathematical formulation is developed. In section 3, mathematical analysis of fuzzy geometric programming (FGPP) is formulated. The solution of the FGPP inventory is derived in section 4. The numerical example is presented to illustrate the development of the model in section 5. The sensitivity analysis is carried out in section 6 to observe the changes in the optimal solution. Finally section 7 deals with the summary and the concluding remarks.

MATHEMATICAL MODEL

A single item inventory model with demand dependent unit price and variable setup cost under storage constraint is formulated as

$$\text{Min } C\ (D,q) = C_{03}q^{\nu-1}D + KD^{1-\beta} + \frac{1}{2\times 100}C_1 KD^{-\beta}q$$
$$\text{s.t.}\quad Aq \leq B$$
$$\forall \quad D, q > 0 \qquad (1)$$

where
q = number of order quantity,
D = demand per unit time
C_1 = holding cost per item per unit time.
C_3 = setup cost = C03 q^{ν},
(C_{03} (> 0) and ν (0< ν < 1) are constants)
P = unit production cost = $KD^{-\beta}$, K (> 0) and β (> 1) are constants.
Here lead time is zero, no back order is permitted and replenishment rate is infinite. A and B are nonnegative real numbers, B is the space constraint goal. The above model in a fuzzy environment is

$$\widetilde{Min}\ C\ (D,q) = C_{03}q^{\nu-1}D + KD^{1-\beta} + \frac{1}{2\times 100}C_1 KD^{-\beta}q$$
$$\text{s.t.}\quad Aq \leq \tilde{B}$$
$$\forall \quad D, q > 0 \qquad (2)$$

(A wavy bar (~) represents fuzzification of the parameters).

MATHEMATICAL ANALYSIS OF FUZZY GEOMETRIC PROGRAMMING (FGP)

A fuzzy non linear programming problem with fuzzy resources and objective are defined as

$$\widetilde{Min}\ g_0(x)$$
$$\text{s.t. } g_i(x) \leq \tilde{b}_i \quad i=1, 2, 3, \ldots\ldots m.$$

In fuzzy set theory, the fuzzy objective and fuzzy resources are obtained by their membership functions, which may be linear or nonlinear. Here μ_0 and μ_i (i = 1, 2 ...., m) are assumed to be non increasing continuous linear membership functions for objective and resources respectively such as

$$\mu_i\,(g_i(x)) = \begin{cases} 1 \quad if\ g_i(x) < b_i, \\ 1 - \frac{g_i(x)-b_i}{P_i}\ if\ b_i \leq g_i(x) \leq b_i + P_i, \\ 0\ if\ g_i > b_i + P_i, \end{cases}$$
i = 0, 1, 2,...., m.

In this formulation, the fuzzy objective goal is b_0 and its corresponding tolerance is P_0 and for the fuzzy constraints, the goals are b_i's and their corresponding tolerances are P_i's (i = 1, 2, ..., m). To solve the equation (3), the max - min operator of Bellman et al. [1970] and the approach of Zimmermann [1976] are implemented.

The membership function of the decision set, μ_D (x), is

$\mu_D(x) = \min\{\mu_0(x), \mu_1(x), ..., \mu_m(x)\}, \forall x \in X$

The min operator is used here to model the intersection of the fuzzy sets of objective and constraints. Since the decision maker wants to have a crisp decision proposal, the maximizing decision will correspond to the value of x, x_{max} that has the highest degree of membership in the decision set.

$\mu_D(x_{max}) = \max_{x\geq 0}[\min\{\mu_0(x), \mu_1(x), \ldots, \mu_m(x)\}]$.

It is equivalent to solving the following crisp non linear programming problem.

$$\begin{aligned}&\text{Max } \alpha\\ &\text{s.t. } \mu_0(x) \geq \alpha\\ &\mu_i(x) \geq \alpha \ (i = 1, 2, \ldots, m) \qquad (4)\\ &\forall x \geq 0, \alpha \in (0, 1)\end{aligned}$$

If the objective function and the constraints, $g_0(x)$ and $g_i(x)$ (i = 1, 2, ...m) are of posynomial form, then the equation (3) reduces to a fuzzy geometric programming (FGP) problem. Proceeding as before, the expression (4) is obtained in an alternative farm as

$$\text{Min } \alpha^{-1}$$

$$\text{s.t. } \frac{g_i(x)}{b_i+P_i} + \frac{P_i}{b_i+P_i} \qquad (5)$$

$\forall \quad x \geq 0, \alpha \in (0, 1)$,

where $x = (x_1, x_2 \ldots x_n)^T$

Now the equation (5) is solved by the usual crisp geometric programming problem.

SOLUTION OF THE PROPOSED (FGP) INVENTORY MODEL

From Equation (2), it is obtained as per Equation (5)

Min α^{-1}

s.t.

$$B_1 D q^{\nu-1} + B_2 D^{1-\beta} + B_3 D^{-\beta} q + B_4 \alpha \leq 1$$

$$B_5 q + B_6 \alpha \leq 1$$

$$\forall \quad D, q > 0, \alpha \in (0, 1) \qquad (6)$$

where

$$B_1 = \frac{C_{03}}{(C_0+P_0)},\ B_2 = \frac{K}{(C_0+P_0)}$$

$$B_3 = \frac{C_1 K}{2\times 100(C_0+P_0)},\ B_4 = \frac{P_0}{C_0+P_0}$$

$$B_5 = \frac{A}{(B+P)},\ B_6 = \frac{P}{B+P}$$

The dual of Equation (6) is given by

$$\text{Max } d(\lambda) = \left(\frac{1}{\lambda_0}\right)^{\lambda_0}\left(\frac{B_1}{\lambda_1}\right)^{\lambda_1}\left(\frac{B_2}{\lambda_2}\right)^{\lambda_2}\left(\frac{B_3}{\lambda_3}\right)^{\lambda_3}\left(\frac{B_4}{\lambda_4}\right)^{\lambda_4} \times \left(\sum_{i=1}^{4}\lambda_i\right)^{\sum_{i=1}^{4}\lambda_1}\left(\frac{B_5}{\lambda_5}\right)^{\lambda_5}\left(\frac{B_6}{\lambda_6}\right)^{\lambda_6}\left(\sum_{i=5}^{6}\lambda_i\right)^{\sum_{i=5}^{6}\lambda_i} \qquad (7)$$

where, $\lambda_0 = 1$

$-\lambda_0 + \lambda_4 + \lambda_6 = 0$

$\lambda_1 + (1-\beta)\lambda_2 + (-\beta)\lambda_3 = 0$

$(\nu - 1)\lambda_1 + \lambda_3 + \lambda_5 = 0$

Let $\lambda_1 = t_1$, $\lambda_3 = t_2$, $\lambda_4 = t_3$, solving the above equations,

$\lambda_2 = (\beta t_2 - t_1) / (1 - \beta)$

$\lambda_5 = (1 - \nu) t_1 - t_2$

$\lambda_6 = 1 - t_3$, and then, the above dual expression becomes

$$\text{Max } d(t_1, t_2, t_3) = \left(\frac{B_1}{t_1}\right)^{t_1}\left(\frac{B_2(1-\beta)}{(\beta t_2 - t_1)}\right)^{(\beta t_2 - t_1)/(1-\beta)}\left(\frac{B_3}{t_2}\right)^{t_2}\left(\frac{B_4}{t_3}\right)^{t_3} \left(\frac{B_5}{((1-\nu)t_1 - t_2)}\right)^{(1-\nu)t_1-t_2}\left(\frac{B_6}{1-t_3}\right)^{1-t_3}\left(t_1 + \frac{\beta t_2 - t_1}{1-\beta} + t_2 + t_3\right)^{t_1+\frac{\beta t_2-t_1}{1-\beta}+t_2+t_3} \times (1+(1-\nu)t_1 - t_2 - t_3)^{1+(1-\nu)t_1-t_2-t_3} \qquad (8)$$

Solving the equations $\frac{\partial d}{\partial t_1} = 0, \frac{\partial d}{\partial t_2} = 0, \frac{\partial d}{\partial t_3} = 0$, t_1^*, t_2^*, t_3^* are evaluated and here λ_0^*,

λ_1^*, λ_2^*, λ_3^*, λ_4^*, λ_5^*, λ_6^* are also determined Therefore, optimum values are

$$q^* = \frac{\lambda_5^*}{B_5^*}(\lambda_5^* + \lambda_6^*)^{-1}, D^* = \left(\frac{\lambda_2^*}{B_2^*}(\lambda_1^* + \lambda_2^* + \lambda_3^* + \lambda_4^*)^{-1}\right)^{\frac{1}{1-\beta}}, \quad \alpha^* = \frac{\lambda_4^*}{B_4^*}(\lambda_1^* + \lambda_2^* + \lambda_3^* + \lambda_4^*)^{-1}$$ and

$$C^*(D^*, q^*) = C_{03}\, q^{*\nu-1} D^* + K D^{*1-\beta} + \frac{1}{2\times 100} C_1\, K D^{*-\beta} q^*$$

So, by FGP technique, the optimal values of q, D and α the corresponding minimum cost are evaluated for the known values of other parameters.

NUMERICAL EXAMPLE

For a particular EOQ problem, let C_{03} = Rs. 200, K = 100, C_1 = Rs. 100, ν = 0.5, β = 1.5, A = 10 units, B = 50 units, C_0 = Rs. 2000 and $P_0 = 20$ and P=15 units. For these values the optimal value of productions batch quantity q*, optimal demand rate D*, minimum average total cost C* (D*, q*) and Aq* obtained by FGP are given in Table 2.

After 66 iterations Table 2 reveals the optimal replenishment policy for single item with demand dependent unit cost and dynamic setup cost. In this table the optimal numerical results of fuzzy model are compared with the results of crisp model. The optimum replenishment quantity q^* and Aq^* are both -6.56% and 12.93% more than that of fuzzy and crisp models of Roy et al. [1981] respectively, the optimum quantity demand D^* is 9.70 but 9.81 and 9.21 for comparing models, hence 5.34% more from the crisp model and -1.06% less from the other fuzzy model. The minimum total average cost $C^*(D^*, q^*)$ is 48.62 but 49.60 and 53.93 comparing models, hence -10.67% and -9.85% less from crisp and other fuzzy model respectively.

Table 2. Optimal values for the proposed inventory model
Tabela 2. Optymalne wartości dla proponowanego modelu zapasów

Model	Method	Iteration	q^*	D^*	$C^*(D^*, q^*)$	α^*	Aq^*
Fuzzy model	FGP	66	5.646723	9.702505	48.623	0.56885	56.46723
Fuzzy model, Roy et al. (1997)	FGP	-	6.043	9.8068	53.9328	0.3043	60.43
% Change	-	-	-6.5576	-1.0635	-9.8452	86.9372	-6.5576
Crisp Model, Roy et al. (1997)	NLP	-	5	9.21	54.43	1	50
% Change	-	-	12.93446	5.34750	-10.6687	-43.115	12.93446

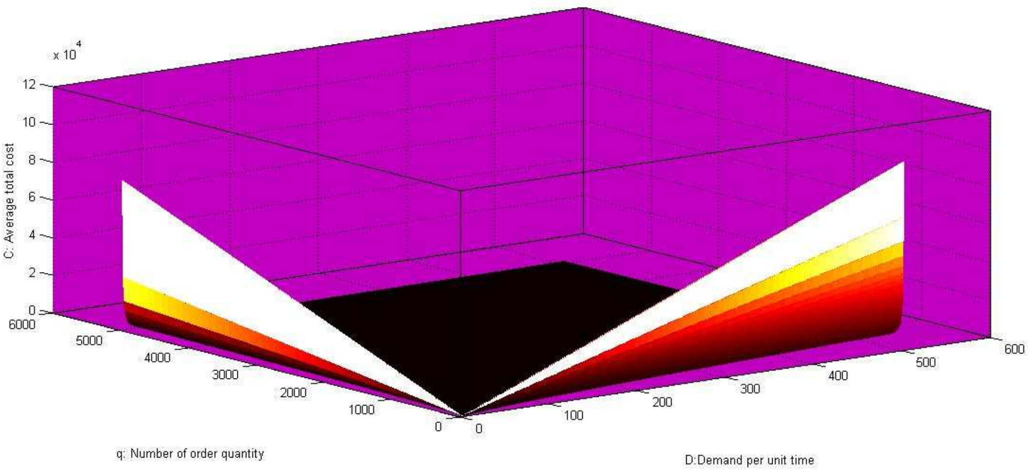

Fig. 1. Mesh plot of Demand per unit time, number of order quantity q and average total cost C
Rys. 1. Wykres popytu w jednostce czasu, liczby zamówień wielkości q i średniego kosztu C

It permits the better use of present fuzzy model as compared to the crisp model and other fuzzy model. The results are justified and agree with the present model. It indicates the consistency of the fuzzy space of EOQ model from other models. Fig. 3 depicts the mesh plot of demand per unit time D, number of order quantity q and average total cost C (D, q).

SENSITIVITY ANALYSIS

Now the effect of changes in the system parameters on the optimal values of q, D, C (D, q) and Aq when only one parameter changes and others remain unchanged the computational results are described in Tables 3 and 4. As a result α^*, q^*,D^*, $C^*(D^*,q^*)$ and Aq^* are less sensitive to the parameters P_0 and P. Following Dutta et al. [1993] and Hamacher et al. [1978] it is observed that the effect of tolerance in the said EOQ model with the earlier numerical values and construct Tables 3 and 4 for the degrees of violation $T_0(=(1-\alpha)P_0)$ and T(=(1-α)P) for two constraints given by equation (6) .

From Table 3, it is seen that: (i) For higher tolerances of P_0, the value of α_{max} does not achieve 1, (ii) For higher acceptable variations P_0, the optimal solutions remain invariant and the optimal solutions are very close to the solutions (q^* =5.646723, $D^* = 9.702505$, $C^*(D^*,q^*) = 48.62299$ and $Aq^* = 56.46723$) of fuzzy model and (q^* =5, $D^* = 9.308755$, $C^*(D^*,q^*) = 49.60392$ and $Aq^* = 50$) of the crisp model without tolerance ($\alpha = 1$) respectively.

From Table 4 it is shown that: (i) For different values of P, degrees of violations T_0 and T are never zero, i.e. different optimal solutions are obtained. (ii) As P increases from 16, the minimum average cost $C^*(D^*,q^*)$ decreases, q^* and D^*increase.

Table 3. Sensitivity Analysis on P_0
Tabela 3. Analiza wrażliwości na P_0

P_0	Iteration	α^*	q^*	D^*	T_0	T	$C^*(D^*,q^*)$	Aq^*
25	64	0.648263	5.527604	9.632260	8.793425	5.276055	48.79344	55.27604
50	36	0.802115	5.275082	9.825778	9.89425	2.968275	49.18562	52.75082
100	45	0.895938	5.140674	9.613929	10.4062	1.56093	49.38490	51.40674
150	44	0.936990	5.094514	9.368276	9.4515	0.94515	49.45155	50.94514
200	51	0.952556	5.071165	9.353637	9.4888	0.71166	49.48888	50.71165
1000	54	0.990419	5.014369	9.317855	9.581	0.143715	49.58054	50.14369

Table 4. Sensitivity Analysis on P
Tabela 4. Analiza wrażliwości na P

P	Iteration	α^*	q^*	D^*	T_0	T	$C^*(D^*,q^*)$	Aq^*
16	66	0.571577	5.685475	9.725153	8.56846	6.854768	48.56846	56.85475
20	87	0.581970	5.836061	9.812222	8.3606	8.3606	48.36059	58.36061
23	62	0.589273	5.944672	9.874131	8.21454	9.446721	48.21454	59.44672
36	33	0.616977	6.378881	10.11459	7.66046	13.78883	47.66046	63.78881
38	70	0.620764	6.441093	10.14817	7.58472	14.41097	47.58471	64.41093
40	63	0.624444	6.502223	10.18096	7.51112	15.02224	47.51111	65.02223

CONCLUSIONS

Inventory modelers have so far considered type of setup cost that is fixed or constant. This is rarely seen to occur in the real market. In the opinion of the author, an alternative (and perhaps more realistic) approach is to consider the setup cost as a function quantity produced / purchased may represent the tractable decision making procedure in fuzzy environment. In constraint to Roy et al. [9], the approach in this paper provides solutions better than those obtained by using properties and this paper the real life inventory models for single item in fuzzy environment by FGP technique is investigated. A new mathematical model is developed and numerical example is provided to illustrate the solution procedure. The new modified EOQ model was numerically compared to the traditional EOQ model. Some sensitivity analyses on the tolerance limits have been presented. The results of the fuzzy models are compound with those of crisp model which reveals that fuzzy models obtain better result than the usual crisp models. Finally, the effect of decision space was demonstrated numerically to have an adverse affect on the total average cost per unit. This method is quite general and despite this, this paper has primarily focused on reducing the total average cost with storage constraint. Further research is required to achieve a better trade-off between the constraint and total average cost, thus maximizing market value through greater flexibility/capability in decision parameters to match dynamic ordering cost and demand dependent unit cost and it can be again extended to other similar inventory models including the ones with shortages and deteriorate items.

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ROZMYTE PODEJŚCIE PODEJMOWANIA DECYZJI W PROGRAMOWANIU GEOMETRYCZNYM DLA JEDNOARTYKUŁOWEGO MODELU EOQ

STRESZCZENIE. **Wstęp i metody:** Rozmyte podejmowanie decyzji jest akceptowalną metodą postępowania w programowania geometrycznym dla pojedynczego artykułu w modelu EOQ ze zmiennym kosztem zamówienia oraz jednostkowym kosztem zależnym od popytu. Koszty przezbrojeń zmieniają się wraz z wielkością produkcji/zakupu. Analizie poddano modyfikacje zmiennych funkcji magazynowania w zależności od estymowanych parametrów. Problem ten obejmuje takie zagadnienia jak rozmyte podejście arytmetyczne, wielkość zamówienia, wielkość popytu. Omówiono zarówno metodę rozmytego programowania geometrycznego jak i inne zagadnienie związane z programowaniem liniowym.
Wyniki i wnioski: Analiza właściwości optymalnego rozwiązania pozwoliła na stworzenie algorytmu, którego poprawność przedstawiono na przykładzie liczbowym. Rezultaty zostały poddane dyskusji. Analiza wrażliwości rozwiązania optymalnego została wykonana przy różnych zmianach wartości parametrów.

Słowa kluczowe: rozmyty, GPP, koszty przezbrojenia, EOQ, pojedynczy artykuł.

EINE UNSCHARFE VORGEHENSWEISE BEIM ENTSCHEIDUNGSTREFFEN IM GEOMETRISCHEN PROGRAMMIEREN FÜR EINZELARTIKEL IM EOQ-MODELL

ZUSAMMENFASSUNG. Einleitung und Methoden: Das unscharfe Entscheidungstreffen ist heutzutage eine akzeptable Vorgehensweise beim geometrischen Programmieren für Einzelnartikel im EOQ-Modell mit variablen Bestellungskosten und den von der Nachfrage abhängigen Einzelkosten.Die Umrüstungskosten verändern sich gemäß den Produktions- und Einkaufsgrößen. Einer betreffenden Analyse wurden Modifikationen von variablen Lagerfunktionen in Abhängigkeit von den estimierten Parametern unterzogen. Die Problemstellung umfasst solche Fragestellungen wie unscharfe arithmetische Vorgehensweise und die Bestellungs- und Nachfragegrö?en. Es wurden dabei sowohl die Methode des unscharfen, geometrischen Programmierens, als auch andere mit dem linearen Programmieren zusammenhängende Fragen erörtert.
Ergebnisse und Fazit: Die Anlyse der Vorteile einer opitmalen Lösung erlaubte die Erstellung eines Algorithmus, dessen Richtigkeit anhand eines zahlenmäßigen Beispieles projiziert und nachgewiesen wurde. Die Ergebnisse wurden einer Diskussion unterzogen. Die Analyse der Empfindlichkeit der opitmalen Lösung wurde bei den sich verändernden Parameter-Werten vorgenommen.

Codewörter: uscharf (fuzzy), GPP, Umrüstungskosten, EOQ, Einzelartikel

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VERSATILE LEADERSHIP AS A DETERMINANT OF EMPLOYEE ENGAGEMENT. DHL EXPRESS (POLAND) SP. Z O.O. EXAMPLE

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ABSTRACT. **Background:** The changes which are taking place today, forces companies to ask themselves about the quality of leadership in the organization and whether the existing work in this area supports the success of the company. In the global environment, both social structure and political are changing. Demographic changes irrevocable impact on the market more than ever before. For company it is necessary to introduce new paradigms of leadership to have a chance to succeed in this new environment.

The aim of researches was to recognize methods, which allow to improve the quality of management of transprot companies.

Methods: Researches were conducted based on literature review and questionnaires sent by employees.

Cocnlusions: Leadership agility model seems to be the answer to the question of how to survive in the new world. Concept of leadership agility draws attention to a smooth transition between the different management styles as well as the end of the heroic leadership, (focused on only one leader) and the beginning of the post heroic leadership, where the contribution of the whole team count. In the new environment, a significant part of the company's success will depend on the commitment of its employees, and hence the added value of their work. Model of leadership agility is used in DHL Express daily and build the base for achieving excellent results not only business but also those related to human capital.

Key words: leadership, engagement, manager, challenge, agility.

INTRODUCTION

Literature confirms that in recent years the world has been significantly transformed [Kotler, Caslione 2009, and Christensen 2011]. Contemporaneity is marked by technological change, economic unrest, multiplying transformations, both social and economic. Economic periods are shortened, information is spreading faster than ever before in the history. This noticeable evolution of the world is reflected in the emergence of the new trends that define the world in new dimensions.

Future trends such as:

- digital Natives, who will create a new world [Small, Vorgan, 2008],
- innovation in the cloud, which will be the largest possibility of a change in the history of the universe [Armbrust et al. 2010],
- bio-economy and well-being, which will become the new motors for the economy, will not be primarily facilitating manager's life [Luoma, Vanhanen, Tommila 2011].

THEORETICAL BACKGROUND

Universal access to the knowledge and information, and the fact that the generation born after 2000 does not know a world without

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a free access to the Internet, is causing an increase in the importance of virtual reality. Transformation of the world and the possibility of cooperation on a global scale using the cloud environment, presents some new challenges for persons managing organizations. The virtual world implies a need to adapt to the new trends, as well as to the new pace of these changes. Progressive globalization has a significant impact on the shape of the organization's environment. The concept of a "globalization" has a long genesis, dating back to several decades. In the past, different authors have been using them [e.g. Stonehouse et al. 2000, Scholte 2000, Held et al. 1999, Levitt 1983] The concept of "globalization" appeared for the first time in Germany in 1953 in the newspaper "Frankfurter Allgemeine Zeitung". Once again, the term "globalization" was used in the magazine "The Economist" in 1959. It was expressed in the economic context, related to "an increase in the amount of import cars globalized". Two years later, the concept was found in Webster's dictionary (Webster's Dictionary) of 1961. Today, however, it has a special meaning "(...) globalization, and with it the global competition, concentration of ownership and capital, expansion of cooperation between companies in the world, differently than previously understood policy of investment and innovation, the growing importance of an economy based on intellectual capital , the rapid development of information technology and telecommunications mean that modern company must rise to the challenge and the need to adapt to the new demands of the global market. This makes it necessary to modify the existing management systems and redefine the paradigms that existed in the past. It is the beginning of a kind of race to the future - making the effort to develop global strategies and more flexible organizational structures easily, develop changes in work systems, implementation of e-business, the introduction of elements of management responsibilities, including standards of ethical and environmental responsibility. "So it seems legitimate to redefine the business environment and give definitions of new meanings. In this context, was born the concept of "VUCA world" [Horney et al. 2010, Johansen 2009, Joiner 2006], which is acronym of volatility, uncertainty, complexity, and ambiguity of the enterprise environment. The term sometimes replaces the previously used concept of "global environment" [Malara 2006] and is giving it a different, much broader dimension. Multidimensionality of the reality in which organizations have to exist, invites us to reflect on the optimal model of a leadership, as a leading determinant of employee engagement in these new and complex conditions.

Employee engagement is a factor which directly translates into business performance [Kruse 2012]. Companies face the challenge of providing the greatest added value for shareholders, while maintaining a high level of employee's commitments. Engagement is defined in several ways [Kahn, 1990, Roberts, Davenport 2002, Johnson, Groff, Taing 2009]. The first concept of the use of "employee engagement" was created by Gallup [1985]. Then other research companies [TowersPerrin, HayGroup, IES, DDI] involved issues concerning engagement in the area of research. In parallel, the academic world constructed its own definitions of the term "engagement". W.A. Kahn [1990] described the engagement as "harnessing ego of members of the organization to fulfill its role in the work" [Kahn 1990]. C.R. McCashland [1999] defined it as "emotional outcome for the employee on the basis of the emerging key ingredients jobs" [McCashland 1999]. Another definition says that "(commitment to) the extent to which the individual personally join in helping organizations working better than is necessary to maintain the position" [Smythe 2009]. For this study, the authors have adopted a definition A.M. Saks "the intellectual and emotional commitment to the organization or the amount of effort put in work", as well as the definition of J.K .Harter, F.L .Schmidt and T.L. Hayes [2002], which describes motivation as an individual effort of employees at work [Juchnowicz 2010], satisfaction with the work and enthusiasm towards her [Harter, Schmidt, Hayes, 2002]. Complicated nature of VUCA world and the growing importance of the engagement of employees to the performance of the organization, caused the fact that the personage of a manager and the question about the contemporary model of leadership is coming to the center of scientific inquiry.

A study conducted in 2006 by KornFerry [Falkowski, Nowakowski, 2006] shows that the average Polish manager uses little expressive style of a leadership, while the variation is relatively flat. In 2013 [www.outsourcingportal.pl] Hays company confirmed in its development the trend noted before. The study, performed on a sample, showed that 49% of Polish managers use only one leadership style. This could be a potential threat because the volatility of the economic and social environment forces managers to be more flexible at their daily work, including the area of management teams, as well as other, more innovative approach to problem solving. Researches carried out in recent years indicate that the "leadership agility" is required, to survive in the new world [Horney, Pasman, O'Shea, 2010]. Unfortunately, in the Polish language there is no good equivalent of describing the denotation of "leadership agility". The direct translation would sound "leadership adroitness," which does not seem to give a full sense of the definition, introduced by the creators of this concept B. Joiner and S. Josephs [2006].

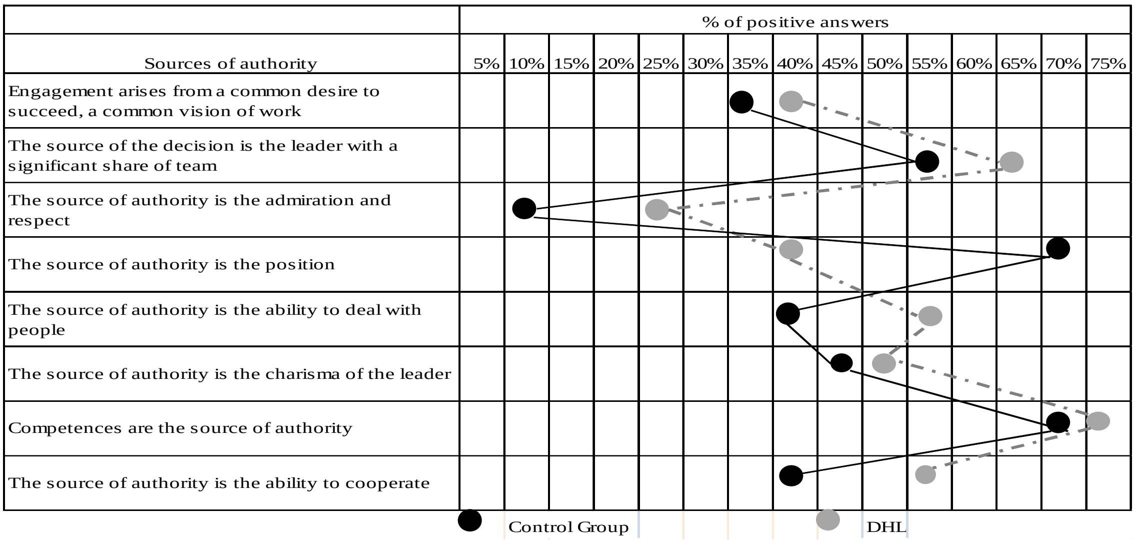
B. Joiner and S. Josephs had understood it as an exact analogy to the organization of "agile" and identify it with the ability to prudent and effective action in a complex, rapidly changing world. L. Iacocca and C. Witney [2007] had supplemented the above definition with the ability to think from the different perspectives and with different mindset. The authors decided to propose their own translation of the term "leadership agility" using the innovative concept of "versatility leadership". It illustrates the subject of a study in a much broader context than the term "flexibility of a leadership", which better fits in the classical theory of a leadership. Authors, transferring the concept of versatility leadership on the polish ground, indicate the key determinants of the style. These include a strong focus on the adoption and providing feedback, consultative nature of decision-making, personal involvement in the team activities, readiness for quick and courageous changes, ability to cooperate, and the skill people's involvement to achieve business objectives. Undoubtedly, such a model of leadership could arise only if organizational culture supports behavior enhancing the versatility of leadership.

DHL EXPRESS (POLAND) SP. Z O.O. EXAMPLE

The transformations taking place in the business models of Polish companies in the last two decades have been mostly creating a hierarchical organizational culture or market-oriented one. Not much has changed in this matter [Heidtman, Wolfhart, 2010]. One of the companies that consciously is working on a change of the organizational culture, and thus the change in leadership paradigm is DHL Express (Poland) Sp. z o.o.. The company is present on the Polish market since 1991. In 2003 the Polish branch of DHL merged with Servisco - national courier service provider. As a result of the merger in 2004, DHL Express (Poland) Sp. z o.o. was founded. Today, DHL Express (Poland) Sp. z o.o employs more than 6 000 employees and couriers, is present in more than 50 locations, and has over 2 300 courier routes. The company operates in the field of courier services, on the market dominated by large international players. The most important trend in courier services is the growing importance of modern technology and the Internet. Business is more often conducted online. Importance of a flexible behavior and a speed to match customer's expectations is growing. Simpler, faster, better is becoming a motto. The policy objective of the company is to provide services in a way that affects the positive perception of the brand - for example, by increasing the level of customer satisfaction and loyalty. To build competitive advantage, the company knowingly uses the available tools in the area of modern human capital management. Since 2008, DHL Express (Poland) Sp. z o.o has been consciously taking steps to balance organizational culture between two areas: "market" and "clan". One element of this change is the conscious shape of a leadership style. Main attributes rely on two pillars: respect and results. Significant emphasis is placed on a close contact with employees through regular meetings aimed at giving and receiving feedback, engaging employees in corporate initiatives, pursuing a transparent policy of employment and remuneration, and fast implementation of changes. Certainly, it can be concluded that the direction of a change in the conduct of the dominant leadership style in the organization is in compliance with, the above-mentioned, versatility of leadership.

Analyzing the data collected during the original surveys to determine the sources of leadership at DHL Express (Poland) Sp. z o.o. and in companies of the control group , it was found that the specificity of human capital management in DHL Express (Poland) Sp. z o.o. is significantly different from that characterizing other companies present on the market. Leading sources of authority in DHL Express (Poland) Sp. z o.o. are shown in Table 1.

Table 1. Sources of authority in DHL and in the control group
Tabela 1. Źródła władzy w DHL i w grupie kontrolnej



Source: own compilation

Table 1 shows the percentage of respondents who agreed with the statements contained in the left column. The collected data show that DHL Express (Poland) Sp. z o.o. essentially creates a better atmosphere to strengthen the leadership versatility (team's motivation stems from the desire to succeed, the source of the decision is the leader with a significant participation of employees, the source of authority is the ability to deal with people, skills and ability to cooperation).

Light of the foregoing authors had inflicted the question whether the development of paradigm of leadership, running in a parallel to the process of a change in organizational culture, results in the increase of employee's engagement. To find the answer to this question, the authors have compiled together the firm's performance in the area of turnover and absenteeism. The choice of these variables has been dictated by the adoption of generally applicable notion that a high absenteeism rate is one of the indicators of the low engagement of employees. And turnover is the final result of progressive deterioration of engagement. Chart 1 shows the dynamics of changes in the turnover and absenteeism in the years 2007 - 2014. It shows that the turnover has decreased significantly since 2008 and remains at a low level. The same regularity applies absenteeism, whose value in 2010 decreased by 1 percentage point and remains low till now.

The authors decided to get a broader picture, to track changes in the engagement index, which is the subject of the annual employee opinion survey. It should be noted that since 2010, the participation of employees in this anonymous survey is more than 90%. Thus, we consider the results as fully representative. Chart 2 illustrates the changes in the index of engagement that have taken place in the years 2007 - 2014. They show clear evidence of the high level of commitment emphasized by a clear boundary point of changes in 2011.

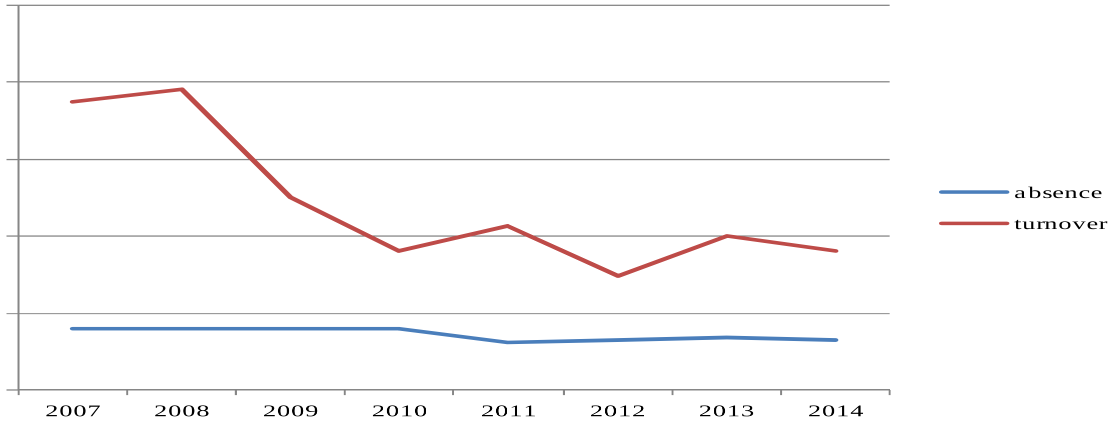


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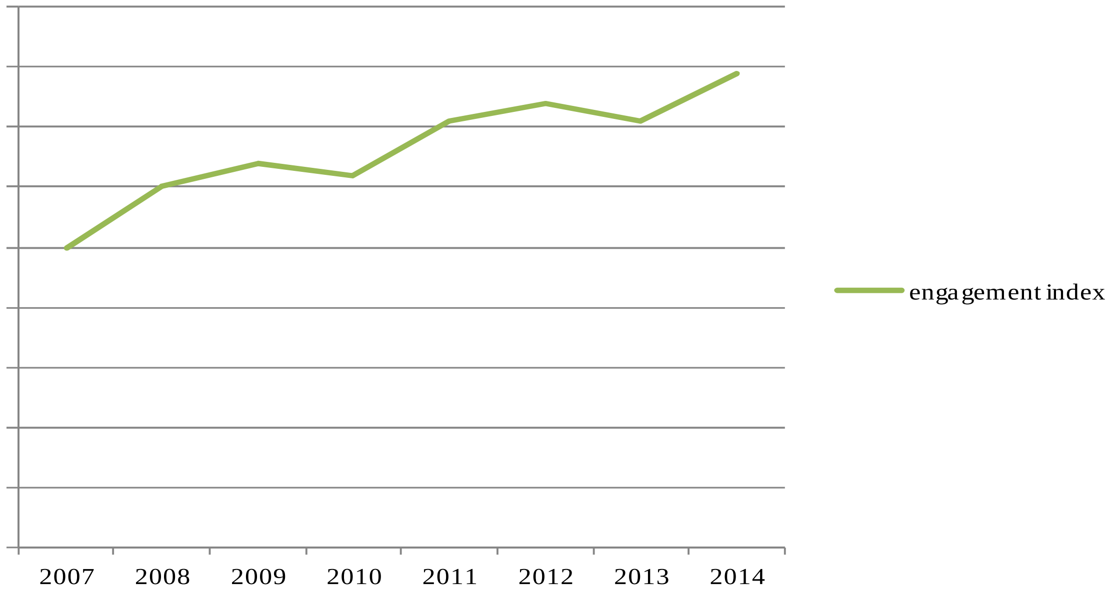
Fig. 1. Dynamics of changes in absenteeism and turnover in the years 2007 to 2014
Rys. 1. Zmiany w absencji i rotacji w latach 2007 -2014



Source: own compilation

Fig. 2. Dynamics of changes in the engagement index in the years 2007 -2014
Rys. 2. Zmiany w indeksie zaangażowania pracowników w latach 2007-2014

CONCLUSIONS

Graphs shown above clearly represent that the focus on versatility leadership (giving feedback, inspiring others to achieve high performance, paying attention to the development of others, focusing on self-improvement, tracking trends, readiness to implement the changes), and at the same time focus on a changing the organizational culture, directly influences the improvement of the main factors determining the efficiency of human capital (absenteeism, turnover) and also, perhaps above all, the engagement of employees. If we look at the market position of the DHL Express (Poland) Sp. z o.o. we can certainly say that over the past years it has been consistently building a type of leadership style that had a desired result in increasing employee engagement, which in turn contributed to strengthening the company on the market and to provided stakeholders with the expected added value.

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WSZECHSTRONNOŚĆ PRZYWÓDCZA DETREMINANTĄ ZAANGAŻOWANIA PRACOWNIKÓW NA PRZYKŁADZIE DHL EXPRESS (POLAND) SP. Z O.O.

STRESZCZENIE. **Wstęp:** Zmiany zachodzące współcześnie wymuszają na przedsiębiorstwach postawienie sobie pytania o jakość przywództwa w organizacji i o to czy dotychczasowe działania w tej dziedzinie wspierają sukces firmy. W otoczeniu globalnym przedsiębiorstw zmienia się zarówno struktura społeczna jak i polityczna a nieodwołalne zmiany demograficzne wpływają na rynek bardziej niż kiedykolwiek wcześniej. Aby firmy miały szanse na odniesienie sukcesu w nowym środowisku niezbędne jest więc wprowadzenie nowych paradygmatów przywódczych.
Celem pracy było rozpoznanie metod pozwalających na istotną poprawę jakości działania przedsiębiorstwa transportowego.
Metody : Badania wykonano na podstawie literaturowej analizy badanego tematu oraz analizy ankiet przesłanych przez pracowników.
Wnioski: Model wszechstronności przywódczej (ang. leadership agility) wydaje się być odpowiedzią na pytanie jak przetrwać w nowym świecie. Koncept leadership agility zwraca uwagę na płynne przechodzenie menadżerów pomiędzy różnymi stylami a także odwrót od przywództwa heroicznego, skupionego na jednej tylko sobie przywódcy na rzecz przywództwa postheroicznego, gdzie liczy się wkład całego zespołu. W nowym środowisku znaczna część sukcesu firmy zależeć będzie od zaangażowania jej pracowników, a co za tym idzie od wartości dodanej jaką wytworzą. DHL Express (Poland) stosuje w codziennej praktyce model wszechstronności przywódczej osiągając dzięki temu nie tylko znakomite wyniki biznesowe ale także te odnoszące się do kapitału ludzkiego.

Słowa kluczowe: przywództwo, zaangażowanie, kierownik, wyzwanie, elastyczność

VIELSEITIGE GESCHÄFTSFÜHRUNG ALS DETERMINANTE FÜR DAS ENGAGEMENT DER MITARBEITER AM BEISPIEL DER DHL EXPRESS GMBH (POLEN)

ZUSAMMENFASSUNG. Einleitung: Die Änderungen, die in der heutigen Zeit vorgehen, zwingen Unternehmen dazu, sich die Frage nach der Qualität der Geschäftsführung zu stellen. Eine andere Frage ist es, ob die bisher unternommenen Aktivitäten in diesem Bereich den Erfolg der Firma unterstützen. In der globalen Umwelt der Unternehmen ändert sich sowohl die soziale als auch politische Struktur. Demographische Änderungen beeinflussen den Markt mehr denn je zuvor. Um in der neuen Umwelt erfolgreich zu bleiben, müssen die Firmen neue Führungsparadigma einführen. Leadership Agility scheint die richtige Antwort auf die Frage zu sein, wie man in der neuen Welt wirtschaftlich überleben kann. Das Ziel der Arbeit war es, die Methoden, die die Qualität der Verkehrsunternehmen verbessern helfen, zu identifizieren.

Methoden: Die Studie wurde auf der Grundlage einer Literaturrecherche und der Auswertung der unter den Empfängern von Verkehrsdiensten durchgeführten Befragungen ausgearbeitet.
Fazit: Das Konzept von Leadership Agility macht auf eine reibungslose Umstellung und Anpassung der Manager an verschiedene Führungsstile sowie auf die Abkehr vom heroischen, nur auf den Geschäftsführer fokussierten Führungsverständnis, eher auf die Zuwendung der postheroischen Geschäftsführung (wo nicht nur die Führungskraft sondern das gesamte Team zählt) aufmerksam. In der neuen Umwelt hängt der Erfolg des Unternehmens im großen Teil von dem Engagement der Mitarbeiter und von der von ihnen erarbeiteten Wertschöpfung ab. Die Firma DHL Express (Poland) nutzt das Leadership Agility-Modell in der täglichen Praxis und bildet dadurch die Voraussetzungen für großartige Ergebnisse nicht nur in Bezug auf Business-Erfolge sondern auch auf das Menschenkapital.

Codewörter: Führung, Engagement, Manager, Herausforderung, Agilität.

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THE ROLE OF THE CONCEPT OF CORPORATE SOCIAL RESPONSIBILITY IN BUILDING RELATIONSHIPS IN THE SUPPLY CHAIN

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ABSTRACT. **Background:** The aim of this article is to determine the importance of the concept of corporate social responsibility in building partnerships in the supply chain.

In the recent period, one could notice that more and more international companies implementing their strategies based on the concept of sustainable development are evaluating and qualifying their suppliers basing on standards of ethics in business.

Methods: This paper analyzed the requirements of the multinationals companies towards their suppliers in implementing elements of the concept of corporate social responsibility.

Results: The results of the analyzes which were presented on practical examples show that buyers define to suppliers, very often detailed, standards for ethical conduct for suppliers (Supplier Conduct Principles, Principles and Standards of Ethical Supply Management Conduct) and guides for their implementation (Supply Chain CSR Deployment guidebook, Purchasing Way, Supplier Sustainability program Manual), organizing programs (Supply Chain Social Responsibility programs), implementing the Supplier Responsibility projects and developing a checklist (Supply Chain CSR Checklist) for self-evaluation of providers.

Conclusions: When observing global trends one could notice that recently more and more suppliers are evaluated in terms of the fulfillment of the principles of sustainable development, guided by the economic aspects (requiring high technical quality, reliability of supply, competitive price, stable financial position, compliance with legal requirements), environmental aspects, as well as social aspects (principles based on the idea of the Global Compact). One could also perceive that many international companies signing contracts with suppliers require them to sign a declaration, obligating them to introduce the concept of corporate social responsibility by applying the principles contained in Statement on Business Practices and in compliance with the requirements of environmental requirements (Supplier Social & Environmental Responsibility Agreement).

Key words: relationships with suppliers, corporate social responsibility, sustainable development of enterprises, supply chain.

INTRODUCTION

Observing global trends one could observe that in recent years more and more suppliers are monitored by their clients for the fulfillment of the principles of sustainable development which are guided by the economic aspects (requiring high technical quality, reliability of supply, price competitiveness, service support), environmental aspects, as well as social aspects (based on the idea of the Global Compact). Increasing number of institutional buyer issue special rules of behavior and ethical standards for suppliers (Supplier Conduct Principles, Principles and Standards of Ethical Supply Management Conduct), guides for CSR implementation (Supply Chain CSR Deployment Guidebook, Purchasing Way, Supplier Sustainability Program Manual),

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organizing programs (Supply Chain Social Responsibility programs), and checklist which are used for self-assessment of contractors (Supply Chain CSR Checklist).

Particular emphasis on environmental and ethical aspects put Japanese companies. They have developed detailed guidelines for suppliers, for example Toshiba, Sharp, Mazda (Green Procurement Guidelines), Canon, Kyocera (Green Procurement Standards), Fujitsu (Green Procurement Directions), Sony (Green Purchasing Standards), NEC (Green Procurement Policies). These standards are imposed on suppliers as clauses included in the contract. They concern with such issues like:

- Compliance with the legal requirements of environmental legislation;
- Providing eco-declaration;
- Delivery of completed environmental management system questionnaires;
- Ensure the safety of products (by introducing formal quality control standards of products and assessment their impact on the environment), as well as systemic oversight processes based on requirements relating to organizational quality management / environment / safety international standards;
- Compliance with the guidelines for describing the procedures for good environmental practices;
- Taking into account EcoDesign approach;
- Introduction of rules of code of ethical conduct [Dashore, Sohani 2013, Rahman et al. 2013, Brones, de Carvalho, de Senzi Zancul 2014].

REQUIREMENTS FOR SUPPLIERS IN THE IMPLEMENTATION OF THE CONCEPT OF CORPORATE SOCIAL RESPONSIBILITY

Increasingly, international companies require their suppliers (materials for production, equipment, office supplies, packaging) detailed evidence of the establishment of environmental targets, documentation of activities related to limiting the consumption of resources, security processes, training employees, reducing environmentally harmful factors (greenhouse gas such as carbon dioxide, noise, vibration, wastewater, solid waste), as well as dissemination of information on the results of activities related to environmental protection. In conducting audits to assess the functioning of the environmental management system vendors frequently pay attention to such elements like:

- Environment culture that is associated with the establishment of environmental policies, identification of environmental aspects and specifying the environmental objectives and programs;
- Compliance with the legal requirements on the protection of the environment;
- Supervision environmental management system by providing the appropriate documentation (procedures / manuals, records) and resources (infrastructure, technology, processes, information systems, relevant qualifications of employees), and the use of environmental indicators (related to energy consumption, raw materials, waste management and pollution);
- Eliminate inconsistencies (against environmental requirements) and waste (the possibility of reducing the consumption of materials / energy / packaging / water), thereby achieving higher efficiency,
- -Electronic workflow within the enterprise and between partners in the supply chain;
- -Awareness of employees in preparedness and response (in the case of emergency like uncontrolled emissions / leaks, fire);
- -Security management and strive to eliminate and / or reduce the risk of environmental hazards;
- Electronic workflow within the enterprise and between partners in the supply chain;
- Establishment of criteria for the qualification and monitoring of suppliers in the field of environmental performance [Hoejmose, Adrien-Kirby 2012, Tate, Ellram, Dooley 2012, Deshmukh, Vasudevan 2014].

One of the attempts to standardize the criteria for auditing suppliers is the initiative taken by the international chemical industry companies such as Akzo Nobel, BASF, Bayer, Evonik Industries, Henkel, Lanxess and Solvay. This initiative is called Together for Sustainability - The Chemical Initiative for Sustainable Supply Chains.

This idea is based on the guidelines of the United Nations Global Compact and the Responsible Care Initiative which is promoted by the International Council of Chemical Associations (ICCA). The aim of the initiative is to develop common criteria for auditing and self-assessment of suppliers. The intention of the members is that the results of the audit conducted by one of members of Together for Sustainability - The Chemical Initiative for Sustainable Supply Chains will be honored by the other partners according to the idea: "An audit for one is an audit for all".

Similarly, the result of self-assessment of suppliers conducted by one of the initiative member will be honored by others. The evaluation criteria during audits and self-assessments include such elements like: The impact on the environment (compliance with applicable standards, waste management, water and energy use, emissions of harmful substances, contamination of soil and groundwater), security management of products and processes, labor rights as well as human rights [Grimm, Hofstetter, Sarkis 201, Rajesh, Ravi 2015].

The framework of periodic assessments of suppliers is conducted by independent organizations. The results of self-assessment reports are placed on a platform operated by EcoVadis [Crespin-Mazet, Dontenwill 2012].

CODES OF ETHICS IN PURCHASING

More and more companies wanting to develop its image as a reliable partner (as customer) publishes purchasing code of ethics, or supplier good practice guides. These codes are liabilities to suppliers in the field of equal treatment of providers (not forcing financial terms), to comply with the conditions of the agreements (in particular with regard to the terms of the technical quality, volume and supply frequency). Many companies in these codes clearly emphasizes that when choosing suppliers is guided by respect for their human rights, financial and tax regulations [Schneider, Wallenburg, 2012, Kumar et al 2014, Chen, Slotnick 2015]. A detailed list of requirements for suppliers in the implementation of the concept of corporate social responsibility is presented in the table 1.

Table 1. Requirements for suppliers in the implementation of the concept of corporate social responsibility
Tabela 1. Zestawienie wymagań w stosunków dostawców w zakresie realizacji koncepcji społecznej odpowiedzialności przedsiębiorstw

Criteria	Specific requirements
Quality assurance of products and processes	Ensuring the safety of products and processes through the implementation of management systems (quality, environment, occupational health and safety, information security, security in the supply chain).
Supplier's capacity	Ensuring adequate infrastructure capacities (research and development, production and maintenance, transportation and warehousing, maintenance, IT equipment). Ensuring a stable legal and financial situation and dissemination of reliable information (such as financial annual reports, issues new shares / bonds, changes in the ownership structure). Ensuring information security (protection of IT systems, preventing the disclosure of information about the company / employees / customers). Implementation of elements of risk management and business continuity system.
Environmental protection	Supervision of hazardous chemicals in the composition of the product. Elimination of harmful substances from production processes through the use of no heavy metals (such as cadmium, mercury, hexavalent chromium, and lead), and hazardous organic compounds (such as asbestos, benzene). Minimizing environmental pollution (water, earth, air). Promoting the reduction of greenhouse gases. Analyzes of life-cycle assessment and the use of eco-labels. Reducing the weight of the product and its packaging.
Criteria	**Specific requirements**

Fair trading	Building relationships with customers and suppliers on the basis of fair partnership (with the principle of win-win). Preventing corruption and bribery. Preventing abuse of privileged position. Do not take trade relations with countries under embargo and the political-economic restrictions. Prevention of unfair competition Respect for intellectual property rights.
Ensuring safe work conditions	Ensuring safe workplaces (sites, equipment staff and equipment). Promoting the health and safety Prevention of occupational accidents and diseases. Appropriate response to accidents and breakdowns.
Respect for human rights	No use of forced labor. Respect for human rights. Child Labor avoidance The prohibition of discrimination (based on race, religion, age, nationality, social or ethnic origin, sexual orientation, gender, political affiliation, disability). Compliance with payroll obligations to employees.

Source: own elaboration

Many international companies signing contracts with suppliers require them to sign a declaration in which obligates the introduction of the concept of corporate social responsibility through application of the principles of good practice contained in Statements on Business Practices and in Supplier Social & Environmental Responsibility Agreements. These statements and agreements are associated with doing business with strict compliance with all applicable laws and ethical standards, not practices to combat corruption and bribery not discriminate against employees, the protection of international human rights and environmental responsibility.

SUPPLIER DEVELOPMENT PROGRAMS AIMED AT THE IMPLEMENTATION OF THE CONCEPT OF CORPORATE SOCIAL RESPONSIBILITY

Many international companies help local suppliers to meet the requirements by offering them support in the form of consulting and training in the implementation of the concept of corporate social responsibility, especially in areas related to environmental management development programs. Green supplier development programs are based on setting goals and formulating and programs for the partners. The implementation of these programs is associated with the use of less environmentally harmful materials and implementation of cleaner technology [Bai, Sarkis 2010, Dou, Zhu, Sarkis 2014]. Suppliers are supported by expertise through training and specialist advice, implementation of joint projects related to the design of new product solutions that use EcoDesign approach. Increasingly, international companies are also offer programs for comprehensive assistance to providers in the implementation of the concept of social responsibility [Goebel et al. 2012, Lu, Lee, Cheng 2012].

Support programs in corporate social responsibility are offered to the suppliers by companies affiliated to the Electronics Industry Citizen Coalition, which includes manufacturers of high-tech products (such as Acer, Apple, Dell, Eastman Kodak, Flextronics, Hewlett-Packard, Hitachi, HTC, IBM, Konica Minolta, Lenovo, Lexmark, LG Electronics, Logitech, Medtronic, Microsoft, Motorola, Philips, Samsung, Sony, Texas Instruments, Toshiba, Xerox).

Development programs in the area of sustainable development efforts are focused on supporting suppliers to

- Increasing the efficiency and effectiveness of processes;
- The improvement of working conditions and improve staff qualifications;
- The reduction of the level of risk in the supply chain risks in order to ensure continuity of processes carried out by the partners;

- Improving the environmental impact;
- Promoting ethical action in relations with stakeholders [Hoejmose, Roehrich, Grosvold 2014].

Companies that are members of the Electronics Industry Citizen Coalition jointly work out standards for suppliers of self-assessment questionnaires, criteria for auditing, or guidelines for codes of ethical conduct (EICC Code of Conduct) [Tate 2012, Wendy 2012,Wendy 2013].

Another project the Electronic Industry Citizenship Coalition, implemented jointly with the Global e-Sustainability Initiative (GeSI- which currently has over 30 members and partners such as Alcatel Lucent, AT & T, Bakrie Telecom, Bell, BlackBerry, BT, Deutsche Telekom, Ericsson, HP, Huawei, KPN, Microsoft, Nokia, Nokia Siemens Networks (NSN), Orange France Telecom Group, Sony Mobile, Sprint, Swisscom, DTC, Tele2, Telecom Italia, Telefonica, Telenet, Telenor Group, Turk Telekomunikasyon, Verizon, VimpelCom, Vodafone, ZTE Corporation.) is an E-TASC (Electronics - Tool For Accountable Supply Chains). E-TASC is an IT solution that allows EICC and GeSI members to analyze data and generate reports relating to the assessment of suppliers in meeting the requirements for labor standards, environmental impact, risk management and ethical codes of conduct [Raj-Reichert 2013]. The results of these reports allow for more precise and individualized supplier development programs in the implementation of the concept of corporate social responsibility.

CONCLUSIONS

To recapitulate the considerations presented in the article, it should be noted that the implementation of the concept of corporate social responsibility contributes to building partnerships in supply chains [Denham 2015] Offered supplier development programs by multinationals corporations contribute significantly to sustainable development of the partners. Successful implementation of these programs allows providers to focus on delivering their strong market position, ensure product safety, eliminating the negative impact on the environment, improve working conditions and to promote ethical conduct in business relations. It can therefore be concluded that the implementation of the concept of sustainable development has significant effects on reducing risks in the supply chain risks and helps to ensure the continuity of processes carried out by the partners and improve their image.

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ROLA KONCEPCJI SPOŁECZNEJ ODPOWIEDZIALNOŚCI PRZEDSIĘBIORSTW W BUDOWANIU RELACJI W ŁAŃCUCHU DOSTAW

STRESZCZENIE. **Wstęp:** Celem artykułu jest określenie znaczenia koncepcji społecznej odpowiedzialności przedsiębiorstw w budowaniu partnerskich relacji w łańcuchu dostaw. W ostatnim okresie można zauważyć, iż coraz więcej przedsiębiorstw międzynarodowych wdrażając swoje strategie oparte na idei zrównoważonego rozwoju ocenia i kwalifikuje swoich dostawców kierując się standardami etyki w prowadzeniu działalności gospodarczej.

Metody: W artykule przeanalizowano wymagania stawiane przez koncerny międzynarodowe swoim dostawcom w zakresie wdrażania elementów koncepcji społecznej odpowiedzialności przedsiębiorstw.

Wyniki: Przedstawione wyniki analiz zaprezentowanych na praktycznych przykładach wskazują, iż przedsiębiorstwa będące nabywcami definiują wobec dostawców często bardzo szczegółowe standardy zachowań etycznych (Supplier Conduct Principles, Principles and Standards of Ethical Supply Management Conduct) oraz przewodniki w zakresie ich wdrażania (Supply Chain CSR Deployment Guidebook, Purchasing Way, Supplier Sustainability Program Manual), organizując programy (Supply Chain Social Responsibility Programs), wdrażając projekty Supplier Responsibility Projects a także opracowując listy kontrolne (Supply Chain CSR Checklist) służące m.in. do samooceny kontrahentów.

Wnioski: Obserwując trendy światowe można wyraźnie dostrzec, iż w ostatnim okresie coraz częściej dostawcy są oceniani pod względem spełnienia zasad zrównoważonego rozwoju, kierują się aspektami ekonomicznymi (wymagając wysokiej jakości technicznej, niezawodności dostaw, konkurencyjności cenowej, stabilnej sytuacji finansowej, przestrzegania wymagań prawnych), aspektami środowiskowymi, a także społecznymi (zasadami opartymi na idei Global Compact). Zauważyć można także, iż wiele międzynarodowych koncernów podpisując umowy z dostawcami zobowiązuje ich do podpisania także oświadczenia, obligującego ich do wprowadzania koncepcji społecznej odpowiedzialności przedsiębiorstw poprzez stosowanie zasad zawartych w klauzulach tzw. praktyk biznesowych (ang. Statement on Business Practices) oraz w klauzulach przestrzegania wymagań środowiskowych (Supplier Social & Environmental Responsibility Agreement).

Słowa kluczowe: relacje z dostawcami, społeczna odpowiedzialność przedsiębiorstw, zrównoważony trwały rozwój przedsiębiorstw, łańcuch dostaw

DIE ROLLE DES KONZEPTES DER SOZIALEN VERANTWORTUNG DER UNTERNEHMEN BEIM AUFBAU VON BEZIEHUNGEN IN DER LIEFERKETTE

ZUSAMMENFASSUNG. Einleitung: Das Ziel dieses Artikels besteht darin, die Bedeutung des Konzepts der sozialen Verantwortung der Unternehmen beim Aufbau von partnerschaftlichen Verhältnissen in der Lieferkette zu bestimmen. In letzter Zeit kann man bemerken, dass immer mehr internationale Unternehmen beim Einführen ihrer Strategien, welche auf der Idee der ausgewogenen Entwicklung basieren, ihre Lieferanten bewerten und sie nach den Ethik-Standards beim Betreiben des Gewerbes einschätzen.
Methoden: In diesem Artikel wurden die Anforderungen der internationalen Konzerne untersucht, welche beim Einführen von Konzeptelementen der sozialen Verantwortung der Unternehmen an ihre Lieferanten gestellt werden.
Ergebnisse: Die Ergebnisse der an Praxisbeispielen dargestellten Analysen zeigen, dass die Unternehmen, welche Erwerber sind, oft sehr detaillierte Standards des ethischen Verhaltens (Supplier Conduct Principles, Principles and Standards of Ethical Supply Management Conduct) und Anleitungen zu deren Einführung (Supply Chain CSR Deployment Guidebook, Purchasing Way, Supplier Sustainability Program Manual) den Lieferanten gegenüber definieren. Sie erstellen Programme (Supply Chain Social Responsibility Programs), führen Projekte (Supplier Responsibility Projects) ein und bereiten Kontrolllisten (Supply Chain CSR Checklist) vor, welche u.a.: zur Selbsteinschätzung der Kontrahenten dienen.
Fazit: Wenn man die globalen Trends beobachtet, kann man deutlich sehen, dass die Lieferanten in letzter Zeit immer öfter in Bezug auf ihre Erfüllung von Grundsätzen der ausgewogenen Entwicklung bewertet werden, sich nach den ökonomischen Aspekten (die hohe technische Qualität, Versorgungssicherheit, wettbewerbsfähige Preise, stabile Finanzlage, die Einhaltung der gesetzlichen Anforderungen), Umwelt- sowie sozialen Aspekten (Prinzipien, die auf der Idee des Global Compact basieren) richten. Man kann auch bemerken, dass viele internationale Unternehmen beim Unterschreiben der Verträge mit Lieferanten von ihnen auch verlangen, dass sie die Erklärung unterzeichnen, welche sie dazu verpflichtet, das Konzept der sozialen Verantwortung der Unternehmen durch die Anwendung der in den Klauseln enthaltenen, so genannten Geschäftspraktiken (Statement on Business Practices) und die Einhaltung der Umweltschutz-Anforderungen (Supplier Social & Environmental Responsibility Agreement) effektiv einzuführen.

Codewörter: Beziehungen mit Lieferanten, soziale Verantwortung der Unternehmen, ausgewogene, dauerhafte Entwicklung der Unternehmen, Lieferkette

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DISTRIBUTIVE TRADE'S SIGNIFICANCE IN NATIONAL ECONOMY

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ABSTRACT. **Background:** The paper analyzes a significance of distributive trade in contemporary national economies of select European countries (10) from the point of view of employment, gross value-added creation, supply chain establishment, and international expansion. A cause for the paper is a dissatisfactory level of economic development of certain transitional countries on one side and the high distributive trade shares (especially in the number of employees and in the GDP) on the other side.

Methods: Distributive trade's significance for a country is analyzed entirely and segmental. The data collected by Eurostat and Deloitte are analyzed and depicted graphically via usual statistical methods (relative numbers, indices and shares, tabulation and graphical depictions).

Results: The results of the research conducted should confirm a thesis on distributive trade's significance based on its shares in the economic structure; however, as an integrator in the value-creating chains, distributive trade has different significance for certain national economies, for the large-sized companies and groups (especially the retailing ones) are also expanded internationally, along with their supply chains.

Conclusions: Distributive trade does not have an equal significance for the economic development in all countries. Equally, all the divisions within distributive trade do not have equal significance for the overall country's economy, as well as for a launch of its economic development. Nevertheless, it should be necessary to analyze concentration and internationalization in detail for the sake of an evaluation of distributive trade's significance as an integrator in value-creating chains. In that respect, some transitional countries observed do lag behind.

Key words: distributive trade, wholesale trade, retail trade, number of employees, supply chains.

INTRODUCTION

The paper primarily defines and analyzes distributive trade both from a point of view of an activity (division) and from a point of view of its organizational and cooperative forms, based upon accessible literature, as well as upon the Eurostat definitions and classifications. Especially emphasized is the significance of retail trade in contemporary processes of business concentration and internationalization. Subsequently analyzed are various approaches to the importance of distributive trade in an economic structure, i.e., in distributional channels and the entire supply chains, as well as in the integration and initiation of other activities.

For select countries (Austria, Finland, FRG, Italy, the Netherlands, Croatia, Hungary, Slovakia, Czech Republic and Poland), the significance of distributive trade is primarily analyzed from a point of view of its share in the number of enterprises, number of employees, and in the gross value-added, and the importance of retail trade and wholesale trade within a national economy and within an international distribution is subsequently separately analyzed.

The paper's aim is to signify the importance of distributive trade for the economic

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development of a country, as well as a necessity to select the new indices to evaluate this significance.

DISTRIBUTIVE TRADE AND ITS MANIFESTATIONS

The topic of our analysis is distributive trade as an economic activity performed by its incumbents-the companies and their cooperative forms.

According to the Statistical Classification of Economic Activities in the European Community [Eurostat 2008], distributive trade incorporates wholesale and retail trade (i.e., a sale without transformation) of any type of merchandise and the rendition of ancillary services while selling the merchandise. Thus, the overall distributive trade (Section G-Wholesale and Retail Trade: Repair of Motor Vehicles and Motorcycles) is comprised as follows:

- Division 45 (wholesale and retail trade and repair of motor vehicles and motorcycles);
- Division 46 (wholesale trade except motor vehicles and motorcycles);
- Division 47 (retail trade except motor vehicles and motorcycles).

The paper will also use the term "wholesaling" for wholesale trade, while the term "retailing" will also be used for the retail trade.

Nowadays, the characteristics of their purchasers are significant for a distinction between the wholesale and retail trade [Statistical Classification 2008]. In wholesale, the purchasers are the receivers who utilize a merchandise for further economic activities, while it pertains to the servicing of an end consumer or of an end user as a purchaser in the retail trade [cf. Lerchenmüller 2003].

Distributive trade is carried out by economic entities, i.e., by companies, in the activities specified in Divisions 45, 46, and 47.

The topic of our consideration are all the organizational forms of distributive trade; however, in a general sense, a term "enterprise" will be used, as an organizational unit for the production of goods and services enjoying certain degree of autonomy in decision-making, especially in the investment of current funds [Statistics Explained: Glossary, Eurostat 2015]. In that sense, the term "retailer" and "wholesaler" will be used for the enterprises in the domain of wholesaling and retailing.

Large-sized enterprises, companies, i.e., the groups thereof, are formed in the processes of concentration. In that sense, the so-called "retail chains" are especially important within distributive trade.

A retail chain is a company doing its business with many jointly owned retail units and usually has a centralized decision-making for a definition and implementation of its strategy. Some retail chains are the divisions of larger corporations or holdings [Levy, Weitz, 2012].

As it is known, retail and wholesale activities are intertwined within a retail chain. Namely, a tendency to vertically integrate retailing and wholesaling is connected to with the development of a concentration process. Furthermore, the large-sized retailers are also connected with the producers (both on a domestic and on an international market), predominantly based on trademarks (as well as on other cooperation forms). A special business concept of Supply Chain Management (SCM) is being developed, so that the entire supply chains become competitive. In that respect, the phrase of a "retail supply chain" may be used when a large-sized retailer (retail chain) dominates a supply chain.

Therefore, a supply chain is a value-creating chain. As each product or service has a value-creating chain of its own, the retailers and wholesalers are actually the integrators of various value-creating chains. In that sense, the gross value-added indices especially important for each economic activity [Statistics Explained: Glossary, Eurostat 2015].

In certain fields, e.g., in the grocery sector, the greatest power is exercised by the retail supply chains [Dujak 2012], whereas producers dominate the supply chains in certain domains.

VIEWPOINTS ON THE SIGNIFICANCE OF DISTRIBUTION CHANNELS AND DISTRIBUTIVE TRADE

The distributive trade significance is mostly seen in its functions, performed more successfully and efficaciously than other participants in distribution channels, i.e., in the overall supply chains.

Distribution Channel Significance

In modern conditions, the importance of distribution channels for an economy especially emanates from system development and channel integration. E.g., the vertical marketing systems in the US presently cover 70 to 80% of merchandise market for the end consumers [Kotler and Keller 2006].

Additionally, vertical marketing systems are also especially significant from the point of view of a country's foreign trade exchange, since the possibilities and necessities to develop the entire supply chains are immediately created by the entrance of large-sized retail chains in the country, irrespective of which producers will become the members thereof. This means that a new competition in retailing is also emergent through the development of vertical marketing systems, for the vertical marketing systems may launch a production of their own and detour the producers present heretofore (even the major ones) [Kotler, Keller 2006].

In that way, the importance of a distribution channel for a national economy is actually reflected in the activities of its business entities (disregarding whether they are merchants or producers or other services) on whatever market, domestic or a foreign one.

The Importance of Wholesaling

It has been known that wholesaling is important in a national economy due to the performance of its functions, especially because of a decrease in the number of contacts, quantitative and assortment regrouping, and a surmount of spatial and temporal differences when exchanging the merchandise among a distribution channel participants. While aggrandizing both the retailers and producers, the wholesalers lose the positions they have occupied heretofore, but they also find their new functions connected to the execution of marketing and logistic tasks.

The wholesalers are important when they are more efficacious than other distribution channel participants when performing their functions [Kotler et al. 2003; Kotler, Keller 2006].

It is especially significant that the wholesalers continue to develop their services for the retailers. Additionally, they have also been developed in the sense of their business globalization, being confronted with a slow-paced growth on domestic markets [Kotler et al. 2006].

The Importance of Retailing

As well as the wholesalers, the retailers are important in an economy due to their performance of functions [Levy, Weitz 2012].

It is known that a retailer activity is also significant for the level of population's living standard. Namely, the retailers bear responsibility for an encounter of consumers' individual demand with an enormous quantity of merchandise supplies. Hereby, one may also emphasize the significance of retailing due to its influence exerted on a consumer's lifestyle [Dunne, Lush 2008].

Retailing is especially important because of both a design and spatial deployment of stores and because of distant sale (e.g., online retailing). It works not only in the function of population supply on locations in a proximity to the consumers but also in the function of satisfaction of consumers' needs and desires from a closer and/or a more remote environment (e.g., while attracting rural population to the municipal or suburban malls, attracting the shopping tourists, by Internet sale, and the like). Equally important are the stationary stores' working hours, for the retail trade is a tertiary activity. It thus also pertains to a consumer timesaving enabled while purchasing in a mall. It is especially visible in the countries wherein retailing has not been on a necessary level, as it was the case in Bulgaria [Dunne, Lush 2008].

Generally, one may cite Wal-Mart (the world's largest retailer headquartered in the US) contribution to the American economy as an example of retail's contribution to the economic development. Namely, in 2004, Wal-Mart annually increased its discretion income by ca. 1% due to its low prices, having thus provided a great contribution to the US economy. Specifically, with an "Every Day Low Prices" (EDLP) concept, Wal-Mart was successful in its contribution to a low inflation. [Dunne Lush 2008]. This topic is covered also in the literature quoted heretofore.

In any case, retailing in a national economy is important especially for its being one of the most represented activities according to the number of employees and its contribution to the GDP (Fernie et al., 2003, p. 1). In the US, approximately 8.1% of GDP was realized by retailing in 2007 [Dunne, Lush 2008].

Traditionally, retailing is "local." Nowadays, however, retailing is considered a "global industry," though most companies still have a local preponderance. Thus, 95% of companies in the US have a single store, and less than 1% has more than 100 stores [Dunne, Lush 2008].

A special retail's significance is in the fact that the retail chains are expanded internationally and globally and dramatic changes occur in the contemporary concentration and internationalization processes [Wortmann 2003].

A retail concentration is significant, for only large-sized retail companies, groupings, or corporate establishments may deploy the attainments of a modern technical-technological progress and realize a satisfactory development through its market expansion, as it is known [Segetlija 2012].

SELECT INDEX ANALYSIS

The importance of distributive trade (especially that of a retail one) is analyzed by various indices (cf. Knežević, 2011, pp. 429 - 440; Segetlija, 2012, pp. 56f). This paper has primarily analyzed the following shares of distributive trade (and its divisions) as the indices of distributive trade significance in contemporary conditions in select countries: (a) in the overall number of employees; (b) in the overall number of enterprises; (c) in the gross value-added.

Subsequently, analyzed is the importance of modern retailing based upon the following indices:

(a) retailing turnover share in GDP with regard to the economic development level;
(b) significance of global retailers in select countries with regard to their size and share in the overall revenues of the Top 250 Global Retailers.

Table 1 depicts the shares of the overall number of employees in distributive trade (and its divisions) in the overall number of employees in select European countries.

It can be seen in Table 1 that a share of the number of employees in distributive trade differs per countries and that distributive trade is an especially significant activity according to the index. The largest shares in the number of employees in retailing are those in the Netherlands and Croatia, although their economic development levels are unequal (Fig. 1).

Therefore, distributive trade records outstanding shares in the number of employees even in some less developed countries (e.g., in the Republic of Croatia), for these countries have developed disproportionally [Segetlija, 2010].

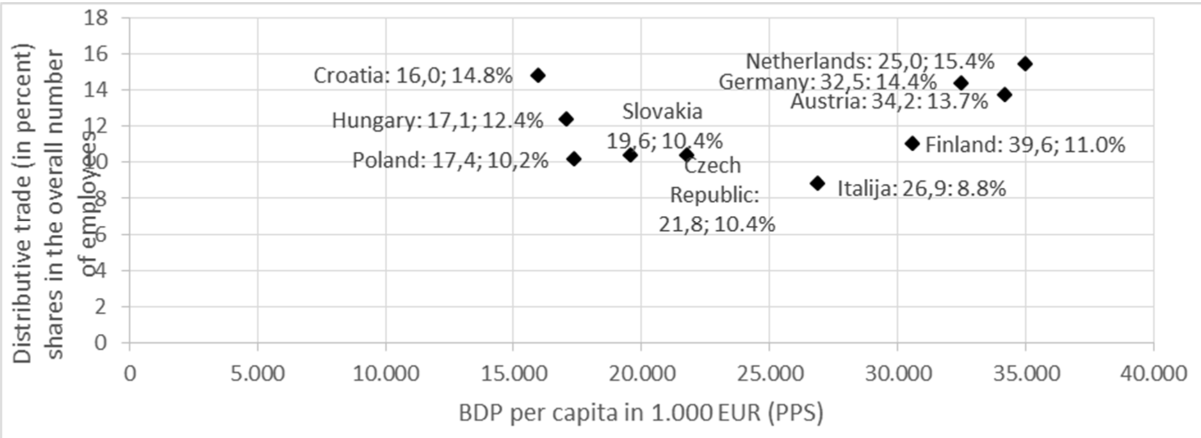
Table 2 depicts the shares of the overall number of distributive trade enterprises in the overall number of enterprises in business economy in the countries observed.

Table 1. Distributive trade shares in the overall number of employees in select countries in 2012
Tabela 1. Udział poszczególnych rodzajów handlu w ogólnej liczbie zatrudnionych w wybranych krajach w 2012

Ordinal	Country	Total number of employees in thousands*	Share on employment in percent			
			45	46	47	G
1.	Austria	4,183.7	1.7	4.4	7.6	13.7
2.	Finland	2,483.2	1.5	3.4	6.1	11.0
3.	Germany	39,126.5	1.8	4.6	7.9	14.3
4.	Italy	8,424.2	1.0	3.2	4.6	8.8
5.	Netherlands	22,898.7	1.4	5,5	8.5	15.4
6.	Slovakia	2,329.0	0.8	4.3	5.3	10.4
7.	Czech Republic	4,890.0	1.2	4.3	4.9	10.4
8.	Poland	15,589.7	1.0	3.7	5.6	10.2
9.	Hungary	3,877.9	1.5	4.1	6.9	12.4
10.	Croatia	1,445.9	1.3	5.1	8.5	14.8

* Resident population concept, total employment, annual averages

Source: Eurostat 2015.



Source: Eurostat 2015.

Fig. 1. Distributive trade share (in percent) in the overall number of employees and BDP per capita in € (PPS) 2012.
Rys. 1. Udział poszczególnych rodzajów handlu w ogólnej liczbie zatrudnionych oraz PKB w € w wybranych krajach w 2012

Table 2. Distributive trade shares in the overall number of enterprises in select countries in 2011
Tabela 2. Udział poszczególnych rodzajów handlu w ogólnej liczbie zatrudnionych w wybranych krajach w 2011

Ordinal	Country	Total number of enterprises*	Share on number of enterprises in percent			
			45	46	47	G
1.	Austria	304,272	3.2	8.1	13.3	24.6
2.	Finland	225,913	4.2	6.8	9.7	20.7
3.	Germany	2,158,094	4.7	6.9	15.4	27.2
4.	Italy	3,843,454	3.1	10.6	16.8	30.5
5.	Netherlands	803,873	3.4	9.1	11.9	24.3
6.	Slovakia	414,905	2.2	13.3	15.1	30.6
7.	Czech Republic	1,004,565	3.3	7.7	13.6	24.5
8.	Poland	1,523,418	5.5	7.6	21.4	34.5
9.	Hungary	550,259	3.6	6.3	15.9	25.7
10.	Croatia	153,687	3.5	11.6	12.1	27.2

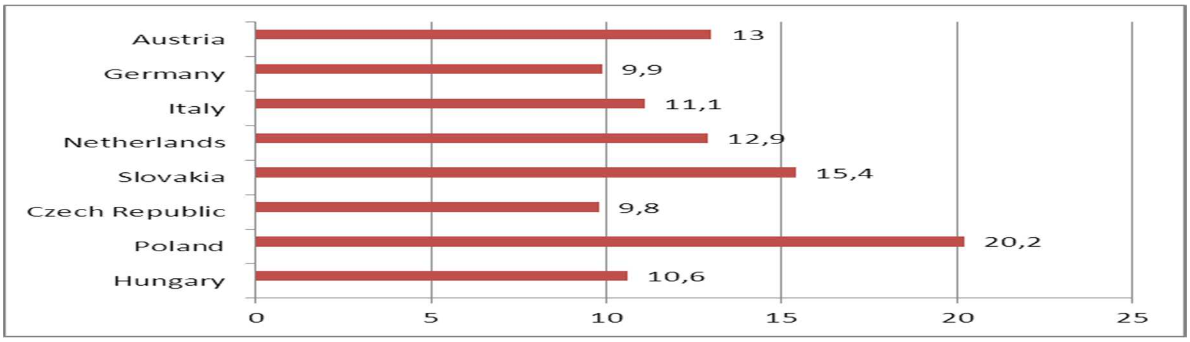
* Total business economy, repair of computers, personal and household goods, except financial and insurance activities.

Source: Eurostat 2015.

Various distribution structures in certain countries are not a reflection of the economic development level. One may especially observe that the shares of retailing in the overall number of employees in transitional countries do not lag behind the shares in the economically and market-developed countries.

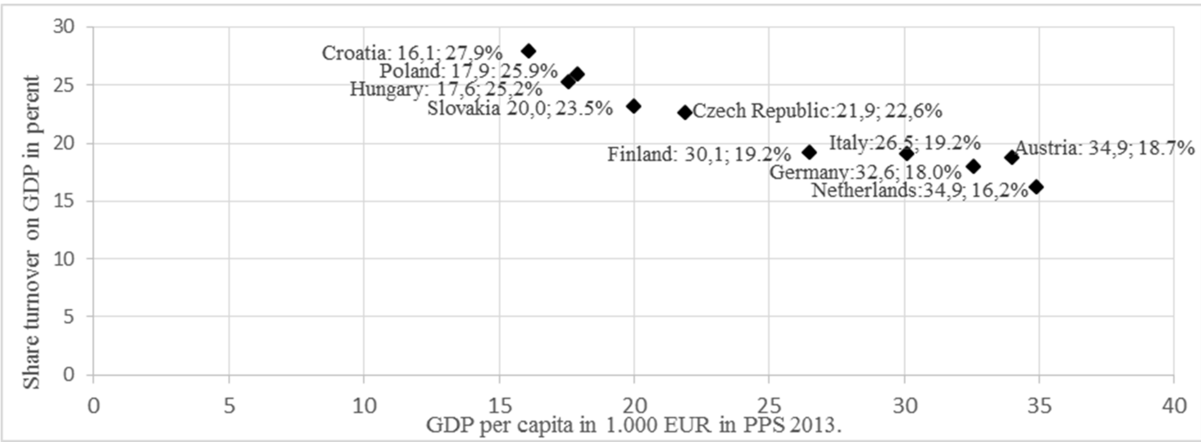
Fig. 2 depicts the distributive trade shares in the gross value-added in select countries in 2011. It is interesting to note that Poland has recorded the highest distributive trade share in the gross value-added (GDP) of all the NACE activities (NACE is a statistical classification of economic activities in the European Community (in French: Nomenclature statistique des activités économiques dans la Communauté européenne). NACE is a European industry standard classification system consisting of a 6-digit code).

As to evaluate the significance of retailing in the national economies of select countries, Fig. 3 depicts the shares of retail turnover in the GDP, with regard to the per capita GDP amount (in PPS).



Source: Eurostat, 2015.

Fig. 2. Distributive trade shares in the gross value-added (in percent) in all NACE activities in select countries in 2011
Rys. 2. Udział gałęzi handle w wartości dodanej brutto (w procentach) w obrębie wszystkich działań NACE w wybranych krajach w 2011



Source: Eurostat, 2015.

Fig. 3. Retail trade turnover share in GDP (in percent) and GDP per capita in select countries in 2013
Rys. 3. Udział handle detalicznej w PKB (w procentach) w wybranych krajach w 2013

Fig. 3 circumstantiates that the countries with a low level of per capita GDP realized have higher shares of retail turnover in the GDP. This disproportion might have been accomplished due to the consumption wherefore a value had not been created but credited. Retailing in those countries has a great significance because of high shares in the number of employees and in the number of enterprises, but it stimulates other activities (as a supply chain integrator) insufficiently.

The importance of retailing with regard to a possibility of its international expansion and supply chain management, thus also pertaining to the stimulation of other companies to create the GDP, may be assessed concerning the numbers and shares of large-sized retailers. Table 3 depicts major data for an evaluation of importance of retailers headquartered in the European countries belonging to 250 of the largest retailers globally.

Table 3 excludes the retailers from Slovakia, Czech Republic, Poland and Hungary, for their retailers have not reached a size necessary to enter among 250 largest retailers.

Table 3. The importance of largest retailers of select European countries in 2013
Tabela 3. Ważność największych detalistów w wybranych krajach europejskich w 2013

Ordinal	Country	Number of companies	Number of single country operators	Average retail revenue* (US$ mill.)	Share of Top 250 revenue (in percent)
1.	Austria	2	0	7,632	0,4
2.	Finland	2	0	11,005	0,5
3.	Germany	17	1	27,060	10,6
4.	Italy	5	1	9,219	2,0
5.	Netherlands	4	1	35,045	3,2
6.	Croatia	1	0	4,011	0,1
7.	Europe	90	20	18,840	38,9
8.	Top 250	250	87	17.418	100,0

Source: Global Powers of Retailing 2015, Deloitte 2015

CONCLUSIONS

Even in contemporary conditions, distributive trade has a great importance for the economy, but all the divisions thereof do not have an equal importance. Equally, the significance of distributive trade, measured by the shares in the number of employees, in the number of enterprises, and in the gross value-added, has different preponderance for different countries. A mere level of economic activity of a country but also an economic policy in a given period is decisive for the importance of distributive trade in that sense.

Due to the progressed concentration processes, business internationalization, and the establishment of large-sized companies that for the supply chains of their own, a significance of distributive trade should be analyzed according to the business results achieved by the large-sized retailers and wholesalers in an international perspective as well. In that sense, the transitional countries observed lag behind.

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ZNACZENIE HANDLU HURTOWEGO I DETALICZNEGO DLA GOSPODARKI NARODOWEJ

STRESZCZENIE. **Wstęp:** W pracy zaprezentowana analizę handlu hurtowego i detalicznego we współczesnych gospodarkach narodowych wybranych krajów europejskich (10) z punktu widzenia zatrudnienia, tworzenie wartości dodanej brutto, tworzenia łańcucha dostaw oraz międzynarodowej ekspansji. Powodem rozpoczęcia prac był z jednej strony niezadowalający poziom rozwoju ekonomicznego niektórych państw, będących w okresie transformacji, z drugiej zaś strony duży udział tego handlu w gospodarce (szczególnie pod względem liczby zatrudnionych osób oraz udziału w tworzeniu PKB).

Metody: Przeanalizowano znaczenie handlu detalicznego i hurtowego dla kraju w ujęciu całkowitym i częściowym. Dane pozyskane z Eurostat I Deloitte'a zostały poddane analizie statystycznej I zaprezentowane graficznie (wartości względne, wskaźniki i udziały, wykresy).

Wyniki: Otrzymane wyniki pracy powinny potwierdzać tezę o istotności omawianego handlu w oparciu na udział w strukturze ekonomicznej, jednak jak integrator w łańcuchach tworzących wartość, handel ten ma różne znaczenie w różnych krajach oraz w zależności od wielkości przedsiębiorstw lub ich grup (szczególnie w przypadku handlu detalicznego), ze względu na ich zasięg międzynarodowy.
Wnioski: Poddany analizie handel ma różne znaczenie dla rozwoju ekonomicznego w poszczególnych krajach. Poszczególne rodzaje handlu mają różne znaczenie w różnych krajach dla gospodarki narodowej jak również dla rozwoju gospodarczego. Niemniej jednak należałoby przeanalizować koncentrację i internacjonalizację handlu detalicznego w celu określenie bezpieczeństwo rozwoju znaczenia badanego handlu, jako integratora łańcuchów tworzących wartość dodaną. Pod tym względem pominięto niektóre kraje będące w okresie transformacji..

Słowa kluczowe: handel detaliczny, handel hurtowy, liczba zatrudnionych, łańcuch dostaw

DIE BEDEUTUNG DES GROß- UND KLEINHANDELS FÜR DIE VOLKSWIRTSCHAFT

ZUSAMMENFASSUNG. Einleitung: In der vorliegenden Arbeit wurde die Analyse des Groß- und Kleinhandels in den gegenwärtigen Volkswirtschaften ausgewählter europäischer Länder (10) hinsichtlich der Anzahl der Erwerbstätigen, der Wertschöpfung in Brutto, der Bildung von Lieferketten und der internationalen Expansion dargestellt. Die Ursache der betreffenden Erforschung waren von einer Seite das unzufriedenstellende Niveau der wirtschaftlichen Entwicklung mancher, in der Transformationsphase befindlicher Länder, von der anderen Seite aber ein relativ hoher Anteil des betreffenden Handels in der Wirtschaft (insbesondere in Hinsicht auf die Anzahl der Erwerbstätigen und auf dessen Beteiligung am Bruttoinlandsprodukt).
Methoden: Es wurde die Bedeutung des Groß- und Kleinhandels für das betreffende Inland in der teilweisen und holistischen Betrachtung analysiert. Die von Eurostat und Deloitte gewonennen Daten wurden einer statistischen Analyse unterzogen und grafisch (Relativwerte, Kennziffern und Anteilwerte, Diagramme) projiziert.
Ergebnisse: Die ermittelten Forschungsergebnisse sollen die These über die Relevanz der betreffenden Handelskateogorien in Bezug auf deren Anteilnahme an der Wirtschaftsstruktur bestätigen, allerdings haben die Kategorien des Handels als Integratoren der wertschöpfenden Lieferketten in verschiedenen Ländern unterschiedliche Bedeutung, und dies in Abhängigkeit von der Größe eines Unternehmens oder einer Unternehmensgruppe (besonders im Falle des Kleinhandels), bedingt durch das internationale Ausmaß deren Betätigung.
Fazit: Die anlysierten Handelskategorien spielen unterschiedliche Rolle bei der wirtschaftlichen Entwicklung der einzelnen Länder. Die betreffenden Handelszweige haben unterschiedliche Bedeutung für die Volkswirtschaft und die wirtschaftliche Entwicklung der betrachteten Länder. Nicht desto weniger sollte man Konzentrierung und Internationalisierung des Kleinhandels als Integrator der wertschöpfenden Lieferketten zwecks der Bestimmung der Bedeutung dieses Handelszweiges in Angriff nehmen. In dieser Hinsicht hat man jedoch manche, in der Transformationsphase befindliche Länder außer Acht gelassen..

Codewörter: Kleinhandel, Großhandel, Anzahl der Erwerbstätigen, Lieferkette

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SUPPLY CHAIN COLLABORATION AND COST SAVING AS A RESULT OF RETURNS HANDLING PROGRAMMES IN RETAIL CORPORATIONS IN POLAND

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ABSTRACT. **Background:** The objective is to define on the basis of the literature as well as to test empirically the main factors that affect the cost saving of many retail chains, resulting from deliberate and conscious policies as well as organized activities in the area of product returns management.

Methods: Based on a survey developed for the study, standardized interviews were conducted with representatives of trade corporations in the apparel industry in Poland. The data collected were analysed statistically.

Results: The results of the statistical analysis showed that the analysed factors had a significant impact on cost saving. A company's ability to cooperate in the supply chain, limited for the purposes of the study to the distributor - retailer relationship, is relevant to the cost savings resulting from the policies of retail corporations in the area of reverse logistics. The integration of IT systems with suppliers and customers also influences the level of cost saving, as does collaboration within a team.

Conclusions: To date, studies in this field have not been conducted in Poland. A particularly important element seems to be the relationship between cooperation in the supply chain and the possible savings which this can generate. This study contributes to the growing trend of research into reverse logistics and emphasizes the role of retailers and cooperation in the supply chain.

Key words: returns handling, supply chain collaboration, clothing industry, cost savings.

INTRODUCTION TO REVERSE LOGISTICS

Reverse logistics is an issue well-known to sales managers. In retail chains there are sometimes deliveries which do not comply with orders, the shelf stock may be too large, sales forecasts may turn out to be too optimistic, or an unprofitable outlet in a certain location is closed down, which means that any unsold goods have to be transferred to other shops. Returns can also be a connected with errors in orders, errors in quantity, double shipments, incomplete shipments, problems in transport, or inter-warehouse transfers [Rogers, Tibben-Lembke 1999]. Reverse logistics applies not only to FMCG goods, but also to seasonal goods and goods which are susceptible to fashion. The clothing industry is an example of the latter.

At the beginning of the supply chain there are suppliers of fabrics and accessories. Other links are designers, who prepare collections. In manufacturing plants, after consultations with designers, production plans are developed and orders are made of the raw materials necessary for production. Then the sales departments send batches of clothes to subsequent links, the distributors and shops.

Typically, designers and the teams responsible for preparing collections and

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marketing prepare and bring to market two collections of clothing every year: spring-summer (March-August) and autumn-winter (August-October). Visible fluctuations in sales are associated with the periods of end-of season sales and pre-holiday periods, when sales tend to grow. In the fashion industry it is important to predict the preferences and tastes of customers. Collections which are designed according to current fashion trends guarantee high sales.

Selling a new collection of clothes is inevitably accompanied by uncertainty. It is therefore important that the distributor and shops exchange information regarding the level of sales as well as each product category. Sharing information and systematic analyses allow them to modify the sales policy, manage inventory and plan promotional campaigns.

The level of product returns from the point of view of cooperation between the different actors in the supply chain is affected by factors such as new product development, sales forecasts, promotional campaigns, purchasing policy, production, trading conditions and product life cycle [Bernon, Cullen, and Gorst, 2008]. In the clothing industry it is important to adjust the inventories of seasonal products between warehouses and stores, as well as the unsold goods that a retailer (distributor) is entitled to return as the spring/summer and autumn/winter seasons change.

From the point of view of the consumer, in turn, manufacturers' guarantees and the possibility of making a complaint are important. Increasingly, the sales of products depend on these factors. Especially in the case of catalogue and online sales, but also in traditional stores, it often happens that customers buy a few items on the assumption that after trying them on at home they will return some of them to the shop.

Today, shopping has also become a way of life, where the sensation of pleasure experienced while walking around the shops is the main goal. Thus, customers spend a lot of time searching for appropriate clothing that will highlight their personality, prestige, or their membership of the particular social group with which they identify. Clothes should be an expression of certain beliefs, opinions, and tastes; and emotions often outweigh usefulness. Liberal product returns policies implemented by shops allow indecisive customers to alter their decisions and return or exchange goods for up to one month after purchase. In this industry goods are rarely returned because of product damage or defects. On the other hand, retail chains sometimes get so called end-of-life products. An example of this can be the action of a chain of underwear shops, which in return for bringing worn garments offered discounts on a new collection.

All the aspects related to the movement of goods in a direction opposite to that which managers would wish for require more attention. Apart from the fact that the whole process requires ordering and formalising, it is also worth considering whether a conscious policy of retail chains in respect of returns management leads to savings. To this end, an empirical study has been conducted.

LITERATURE REVIEW AND RESEARCH CONCEPT

An overview of research reports in the field of reverse logistics in foreign logistics journals led to identifying the key variables for the study of potential savings as well as their operational definitions. Based on the literature, the factors, together with the statements that describe them, which may be relevant for explaining any savings resulting from a deliberate and conscious returns management policy conducted by retail chains in the clothing industry were determined. These include: collaboration in the supply chain; the experience and competence of sellers; and the degree of computerization in handling returns.

In the analysis of the experience and competence of sellers the following statements were used: experienced and knowledgeable staff; competent management; skilled consultants and trainers; support from senior executives; team collaboration; a sufficient number of employees [Ho, 2012].

Collaboration in the supply chain is described by the following indicators: the accuracy of the information which is exchanged; joint access to databases; using inventory data available online; access to information from warehouses; trust between partners; long-term contracts; well-defined objectives, scope and responsibilities within any cooperation; joint arrangements for planning and forecasting; jointly agreed performance indicators; sharing risks and benefits with partners [Olorunniwo, Li 2010].

The degree of computerization of returns handling can be described by the following statements: passing information to all units of the company; prompt handling of returns procedures; effective planning of returns; effective handling of returns operations on a daily basis; the system is integrated with suppliers and recipients [Olorunniwo, Li 2010].

Savings as a theoretical construct are presented in the form of the following statements: we save a lot because of our returns operations; our returns policy improves our cost position relative to competitors; our reverse logistics programme results in considerable savings; our methods of dealing with returns incur lower costs associated with environmental protection [Jack, Powers, Skinner, 2010].

RESEARCH SAMPLE

A questionnaire was designed based on the literature and interviews with the personnel of retail chains. Data were collected by students of Domestic and International Logistics at Poznań University of Economics. Out of 117 questionnaires 12 were excluded for formal reasons, leaving a total of 105 interviews to be included in the analysis. Quantitative research was conducted on a sample of retail chains operating in the clothing industry in Poland based on a directory of retailers. Taking into account the objectives of the study, standardised interviews were conducted with senior management staff representing the analysed retail chains. The research tool was a standardised interview questionnaire. The study was conducted in March and April 2013 on a sample of store managers of clothing industry.

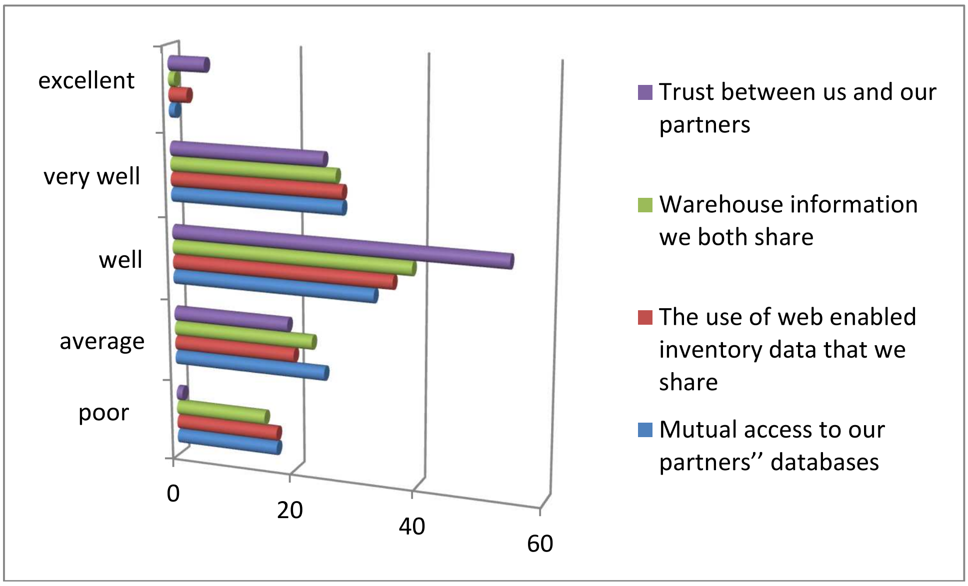
RESULTS, ANALYSIS AND DISCUSSION

To date, studies relating to the factors which affect the savings resulting from a returns management policy have not been conducted in Poland. The aim of this study is to test the correlation of the individual questions and the dependent variable - savings, understood as a potential for improving financial results. Thus, the correlation of individual questions (independent variables) and the dependent variable (the savings construct) was analysed A particularly important element seems to be the relationship between cooperation in the supply chain and any possible savings resulting from deliberate and organized activities (a deliberate policy of a retail chain) in the area of reverse logistics.

Collaboration in the supply chain was assessed in terms of the flow of information and practical cooperation, which is reflected in the choice of indicators describing joint planning in the field of logistics. The choice of such a set of indicators was dictated by the fact that information on stock levels and prior agreements between the supplier and the recipient at managerial level are crucial for effective cooperation between the various links in the supply chain: the supplier and the recipient and the logistics operator.

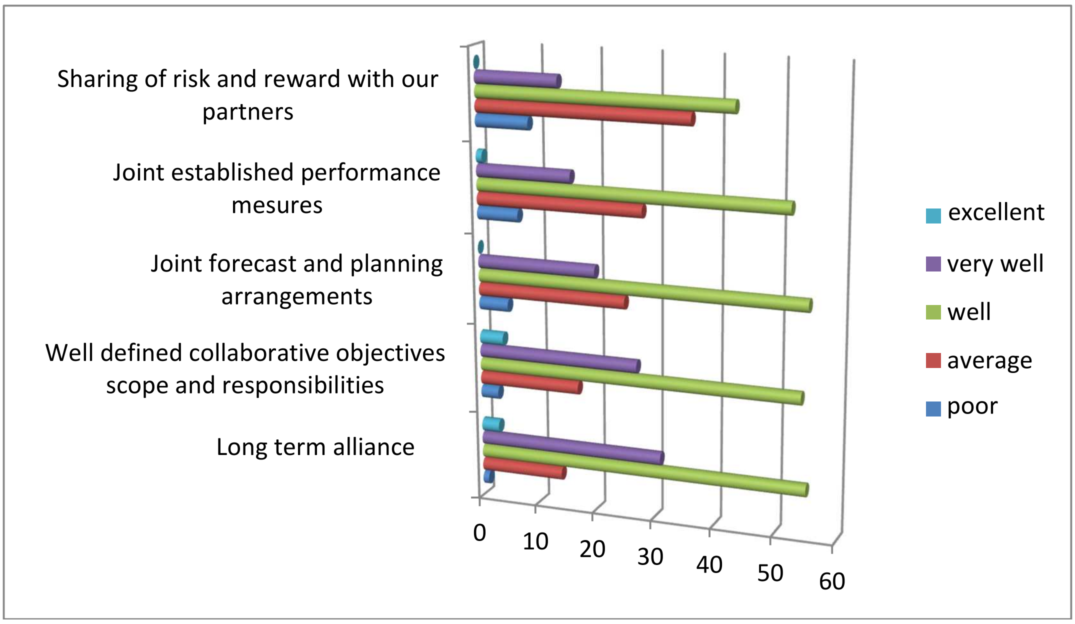
The results of the study (fig.1) indicate that the area of information exchange and the related area of trust are rated by employees as "well" with a tendency towards "Very well" (between 60 and 80% of indications) for all the predefined indicators. The sales personnel particularly highly evaluated the accuracy of the information exchanged and trust between partners.

Joint forecasting and planning, well-defined goals and scope of cooperation, joint performance indicators and the sharing of risks and benefits with partners as indicators measuring operational cooperation were generally evaluated as "Good" (over 50% of indications in each case). However, the assessment of this type of collaboration with partners in part tended towards "Very good" (in the case of long-term contracts and well-defined objectives, scope and responsibilities), whereas the remaining three areas showed a tendency towards "Average" (fig.2).



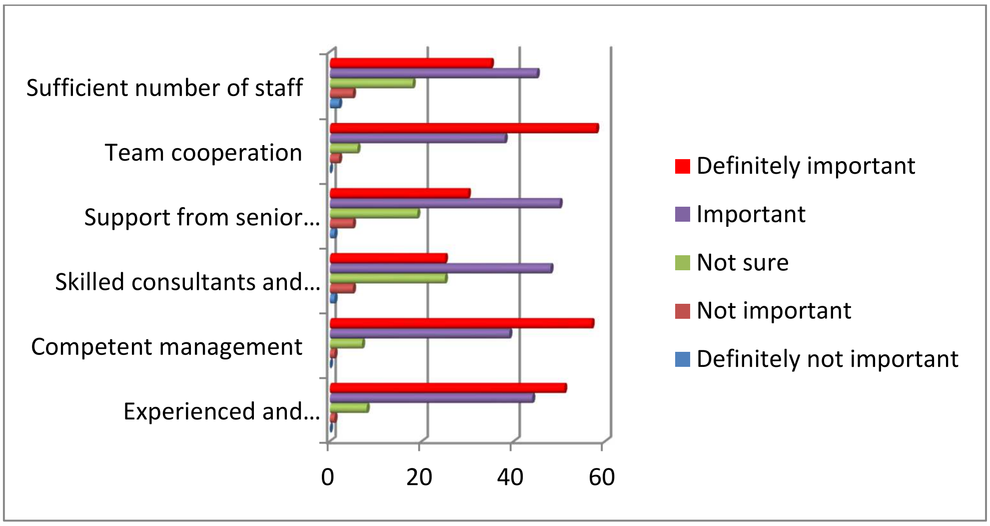
Source: findings of empirical research

Fig. 1. Assessment of information flow in the supply chain
Rys. 1. Ocena przepływów informacji w obrębie łańcucha dostaw



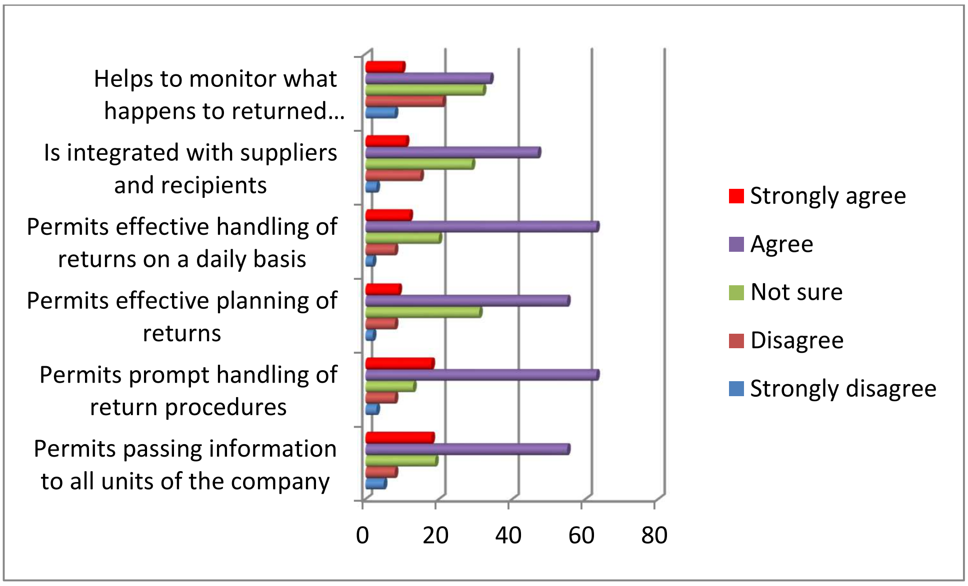
Source: findings of empirical research

Fig. 2. Practical cooperation between the retailer, the logistics operator and suppliers
Rys. 2. Praktyczna współpraca pomiędzy sprzedażą detaliczną, operatorem logistycznym a dostawcami



Source: findings of empirical research

Fig. 3. The importance of experience and competences in terms of handling returns from the managerial perspective
Rys. 3. Istotność doświadczenia i kompetencji odnośnie obsługi zwrotów z punktu widzenia zarządzającego



Source: findings of empirical research

Fig. 4. Assessment of the IT system used by a retail chain
Rys. 4. Ocena systemu IT stosowanego w łańcuchu detalicznym

Managers asked about the importance of experience and competences in the field of reverse logistics (fig.3) generally agree that management and staff who are competent and experienced in handling returns are "Definitely important" (more than 50% of responses). Some respondents had doubts about the importance of training and support from the executive level (the "Not sure" option had 19 indications, with a total of 80 "Important" and "Definitely important" answers). A clear majority declared that cooperation in a team is "Definitely important" (58 responses). Few of the respondents believed that the listed features do not matter at all (less than 5 responses for each statement).

As could be expected, the respondents rated highly the importance of IT systems in the studied companies regarding reverse logistics (fig.4). For each of the statements the answers "Agree" and "Strongly agree" accounted for between 44 and 81 responses. The greatest number of positive responses was recorded for the statements "The IT system used in our company permits effective handling of returns on a daily basis" and "permits prompt handling of return procedures." They were indicated by 75 and 81 respondents respectively.

As many as 72% of positive answers were chosen for the statement that the system "permits passing information to all units of the company" (fig. 4). Although there were 19 "Not sure" answers in this category, probably resulting from the ignorance of employees, in general the findings indicate that a large percentage of firms are integrated into IT systems not only within the chain but also with suppliers and recipients (58 positive responses). In the opinion of managers, computer systems make it possible to monitor what happens to returned goods (44 positive responses, 32 respondents did not have an opinion, and 21 did not agree), and to effectively plan returns (64 positive responses, 31 people did not have an opinion, and 8 disagreed).

The savings that can be achieved through pro-active measures in the area of reverse logistics. In this case, a construct was used as a measuring tool, which consists of the four statements presented in Table 1.

A measure of the reliability of a construct is Cronbach's alpha, which determines the consistency of the items included in a given scale. In other words, it determines to what extent the items included in a given factor are similar to one another, and whether they relate to the same phenomenon - the same theoretical construct. A value for the alpha coefficient above 0.7 indicates that the scale is correct and confirms the correct construction of an indicator. A number of statisticians accept that the measure for the reliability of a Cronbach's alpha scale based on the correlation values between items should generally be above 0.6.

Table 1. Savings
Tabela 1. Oszczędności

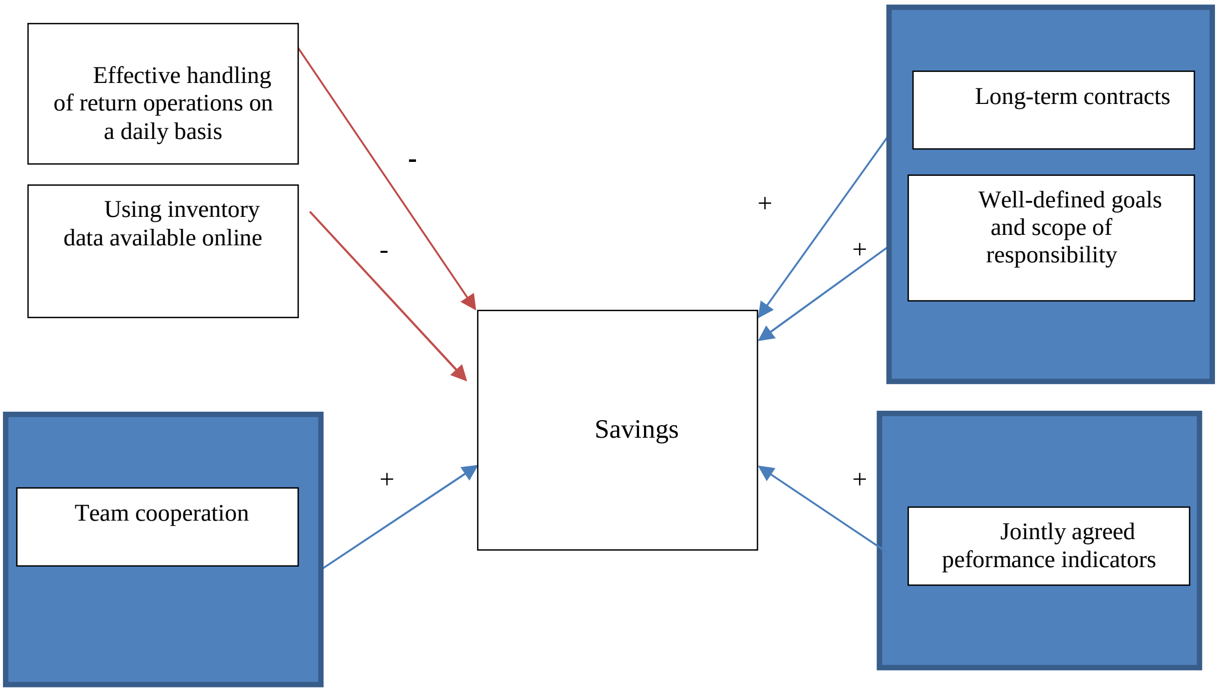
	Statements	Median	Average
Savings (Jack et al., 2010) 1 – strongly disagree 5 – strongly agree Cronbach's alpha 0.67	1. We save a lot because of our returns operations	3	3.2
	2. Our returns policy improves our cost position relative to competitors	3	3.3
	3. Our reverse logistics programme results in considerable savings	3	3.2
	4. Our returns handling methods incur lower costs relating to environmental protection	3	3.3

Source: findings of empirical research

Based on the empirical data collected, correlations were tested between savings (construct) and collaboration in the supply chain, the experience of workers in handling returns as well as the IT system used for returns procedures. The collected data were analysed using Spearman's correlation, followed by a multiple regression analysis, and on this basis the following conclusions were formulated.

The results of the statistical analyses show that the analysed factors have a significant impact on savings. A company's ability to cooperate in the supply chain, limited for the purposes of this study to the supplier - retailer relationship, affects savings resulting from the policies of retail companies in the area of reverse logistics. Not all the statements describing collaboration in the supply chain were empirically confirmed as determinants of savings. Well-defined goals and the scope of responsibility, long-term contracts as well as jointly agreed performance indicators are important for the level of savings. Also, team cooperation plays an important role with regard to the savings achieved as a result of a returns management policy

Using the forward stepwise regression method, a model was obtained, explained at the level of R^2=0.95. The results, presented graphically in Figure 5, are as follows: Using inventory data available online β= -0.49, p=0.0002. Effective handling of returns operations on a daily basis β = -0.35, p=0.16; Team cooperation β = 0.37, p=0.007. Long-term contracts β = 0.73, p=0.002. Well-defined goals and scope of responsibility β = 0.28, p=0.045. Jointly agreed performance indicators β = 0.38, p=0.00.



Source: findings of empirical research

Fig. 5. The factors determining potential savings with regard to reverse logistics
Rys. 5. Czynniki kształtujące potencjalne oszczędności w odniesieniu do logistyki zwrotów

The actual process of handling returns is not monitored, nor is it included in analyses, though possible because (as the data obtained show) there is sufficient computerization and information exchange with suppliers and logistics operators. A manifestation of the opportunism of suppliers is selling as many goods (disposing of the goods) to retailers as possible and leaving all matters relating to excess stock and selling products at a reduced price in the hands of retailers. Despite the fact that, as the collected data show, the process is measurable and controllable, there is no willingness to cooperate in the supply chain and share the benefits.

Effective handling of return operations on a daily basis (β= -0.35, p=0.16) causes an increase in costs related to these procedures. A returns handling programme involves processes and activities specified by individual companies, including inventory control, processing, sorting and making decisions [Rogers, Tibben-Lembke 2001; Stock, Mulki 2009; Blumberg 2004]. The implementation of a procedure for returning goods to the supplier, which generates considerable costs, is a burden for the entire logistics system.

Using inventory data available online β = -0.49, p=0.0002 is a variable that is negatively correlated with the variable of savings resulting from a returns management policy. A possible explanation for this can be the fact that inventory management in the clothing industry involves transferring goods between warehouses and shops, which increases the cost of operations related to transport and storage.

Long-term contracts, well-defined goals and scope of responsibility, as well as jointly agreed performance indicators are variables that are positively correlated with savings in reverse logistics. Such an understanding of cooperation in the supply chain is conducive to achieving long-term benefits by all the parties involved.

Team cooperation is very important in the work of sales personnel, as confirmed by the results obtained. Teamwork, particularly shift work, is based on good communication between employees. Effective transfer of information about customers, goods, transactions and returns creates opportunities for additional savings. However, it must be noted that some of the assumed dependencies were not confirmed and thus have no connection with the dependent variable.

Jointly agreed performance indicators are mostly the aftermath of a long-term contract and regular cooperation. Performance indicators make it possible to monitor results and progress based on interim analyses. Similarly, jointly defined goals and scope of responsibility help to avoid ambiguous situations, unnecessary delays and wrong decisions; thus streamlining returns processes and generating no additional costs.

IT systems, even if their standard is comparable with Western models, are not sufficiently used by senior management, thus their impact on savings was not ascertained. Performing multidimensional analyses and sales monitoring are the basis for effective decisions, and the integration of systems, in addition to its obvious advantages in operational activities, may also provide a basis for planning as well as developing sales policies and sales strategies for both individual stores and the entire chain. The qualifications of advisors and trainers were not included in the analysis as an explanatory variable. Training related to a company's returns policy, whether a liberal or a restrictive one, is rarely provided, as reflected in explorative research.

LIMITATIONS

This analysis included only selected variables and including other significant variables in the model would certainly enhance the explanatory value and provide a more complete picture of the phenomenon.

Future studies could include additional dimensions which were not included in this project. Returns management is a complex issue and even the factors which are generally accepted in the literature and which were taken into account in this study are not able to fully explain this phenomenon.

The sample was restricted to clothing retail chains in two Polish provinces, which limits any inference from the study to the whole population.

Methodologically, the study was based not on hard data but on a questionnaire survey and the analysis is heavily based on the perceptions of the respondents.

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WSPÓŁPRACA W OBRĘBIE ŁAŃCUCHA DOSTAW ORAZ OSZCZĘDNOŚCI WYNIKAJĄCE Z ROZWIĄZAŃ LOGISTYKI ZWROTÓW I DZIAŁALNOŚCI DETALICZNEJ W POLSCE

STRESZCZENIE. **Wstęp**: Celem jest zdefiniowanie na podstawie literatury oraz test empiryczny głównych czynników, które mają wpływ na osiągane przez sieci detaliczne oszczędności wynikające z celowej i świadomej polityki oraz zorganizowanego działania w zakresie zarządzania zwrotami produktów.
Metody: Na podstawie opracowanej ankiety, przeprowadzono wywiady standaryzowane z przedstawicielami korporacji handlowych w branży odzieżowej na terenie wielkopolski i Ziemi Lubuskiej. Zebrane dane poddano analizie statystycznej.
Wyniki: Wyniki analizy statystycznej pokazują, że na oszczędności istotnie wpływają analizowane czynniki. Zdolności firmy w zakresie współpracy w łańcuchu dostaw zredukowanej w badaniach do relacji dystrybutor – detalista mają znaczenie dla oszczędności wynikających z polityki korporacji handlowej w zakresie logistyki zwrotów. Integracja systemu IT z dostawcami i odbiorcami ma znaczenie dla poziomu oszczędności. Także dla osiąganych oszczędności z tytułu realizowanej polityki w zakresie zarządzania zwrotami ma współpraca zespołu.
Wnioski: Studia w omawianym zakresie nie były dotąd przeprowadzane w Polsce. Szczególnie istotne wydają się zależności między współpracą w łańcuchu dostaw a możliwymi do osiągnięcia oszczędnościami z tego tytułu. Przeprowadzone studium wnosi wkład w rozwijający się nurt badań nad logistyką zwrotów i podkreśla rolę detalistów oraz współpracy w łańcuchu dostaw.

Słowa kluczowe: logistyka zwrotów, współpraca w łańcuchu dostaw, przemysł odzieżowy, oszczędności.

KOOPERATION INNERHALB EINER LIEFERKETTE UND DIE AUS DER RETOUREN- UND KLEINHANDELLOGISTIK RESULTIERENDEN EINSPARUNGEN

ZUSAMMENFASSUNG. Einleitung: Das Ziel der Arbeit ist es, gestützt auf die Fachliteratur und einen empirischen Test, die Hauptfaktoren zu definieren, die die von Kleinhandel-Netzen erzielenden Einsparungen beeinflussen, die demzufolge auf gezielte und bewusste Politik sowie auf eine gut organisierte Vorgehensweise im Bereich des Retouren-Managements zurückzuführen sind.
Methoden: Anhand eines ausgearbeiteten Umfrage-Bogens wurden standardisierte Umfragen mit Vertretern von Handelseinrichtungen innerhalb der Bekleidungsbranche in Großpolen und im Lebuser Land durchgeführt. Die gewonnenen Daten wurden einer statistischen Analyse unterzogen.

Ergebnisse: Die Resultate der statistischen Analyse zeigen auf, dass die Einsparungen im wesentlichen Ausmasse von den analysierten Faktoren beeinflusst werden. Die Bereitschaft der Firma zur Kooperation innerhalb einer Lieferkette, die in der vorliegenden Studie auf die Relation Verteiler (Distributor) - Kleinhändler reduziert wurde, üben einen Einfluss auf die Einsparungen aus, die aus der Politik der Handelskörperschaft im Bereich des Retouren-Managements und der Retouren-Logistik resultieren. Eine gezielte Integration des IT-Systems mit den Lieferanten und Abnehmern hat eine Bedeutung in Bezug auf das Niveau der Einsparungen. Nicht ohne Bedeutung für die zu erzielenden Einsparungen infolge einer optimal betriebenen Politik im Bereich des Retouren-Managements bleibt auch das Team-Work.
Fazit: Die betreffenden Studien wurden bisher in Polen nicht durchgeführt. Die Abhängigkeiten zwischen der Kooperation innerhalb einer Lieferkette und den erzielbaren, daraus resultierenden Einsparungen scheinen hier besonders relevant zu sein. Die durchgeführte Studie trägt daher Interessantes zur sich entwickelnden Forschung über die Retouren-Logistik bei und weist auf die Rolle der Kleinhändler und den Belang der Kooperation in der Lieferkette hin.

Codewörter: Retouren-Logistik, Kooperation in der Lieferkette, Bekleidungsindustrie, Einsparungen

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THE CORRELATION ANALYSIS OF ALERT NOTIFICATIONS IN THE RASFF TO FOOD FROM THE NON-EEA COUNTRIES AND FROM THE EEA COUNTRIES

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ABSTRACT. **Background:** The RASFF (Rapid Alert System for Food and Feed) is used to quickly mutual information of member countries of the European Economic Area (EEA) on risks in food. A similar trend line course of alert notifications in the RASFF in time to food from the non-EEA countries and the EEA countries, as well as a very high value of the Pearson's *r* correlation coefficient (0.96) indicated an interdependence of alert notifications from these two groups of countries. Therefore, the goal of the article was to examine the strength of correlation within particular products categories and hazards categories.

Methods: Data for the study came from the RASFF database from the years 1979-2013 covering 8175 alert notifications, including the 2540 notifications to food from the non-EEA countries and 5635 notifications to food from the EEA countries. Within each products category and hazards category examined whether there was a correlation (i.e. the value of calculated statistics *t* exceeded the value of critical statistics $t_{0.05;n-2}$), and then calculated the Pearson's *r* correlation coefficient.

Results: The value of Pearson's correlation coefficient indicated the occurrence of a very high correlation in the products category "Herbs and spices" (0.98), and the high correlation in the following categories: "Bivalve molluscs and products thereof" (0.70), "Dietetic foods, food supplements fortified foods" (0.86), "Fish and fish products" (0.79), "Food contact materials" (0.89), "Fruits and vegetables" (0.88) and "Meat and meat products (other than poultry)" (0.72). However, in the case of hazards categories the very high correlation occurred in the category of "Food additives and flavourings" (0.93) and "Radiation" (0.94) and the high correlation in the case of "Composition" (0.89), "Foreign bodies" (0.88), "Heavy metals" (0.80), "Mycotoxins" (0.81) and "Pathogenic micro-organisms" (0.72).

Conclusions: The results showed the need to pay particular attention by the border control authorities to food which is imported: seafood, herbs and spices, and fruits and presented in this food: heavy metals, pathogenic micro-organisms and mycotoxins. It would also shorten the supply chain and / or limit the import of certain raw materials and products, directing the attention of consumers to food produced first of all in the EEA.

Key words: EEA, RASFF, alert notifications, products categories, hazards categories, correlation analysis.

INTRODUCTION

The RASFF (Rapid Alert System for Food and Feed) is a tool for cross-border exchange of information on the risks to public health in the food chain. This system was developed already in 1979, but his legal status was established in the Regulation No 178/2002 [Bilska and Kowalski 2014, European Commission 2014]. Currently, members of the RASFF are 28 member states of the European Union (EU), the other three countries of the European Economic Area - EEA (Norway, Iceland and Liechtenstein) - total 31 countries, Switzerland, European Commission, European Food Safety Authority and EFTA (European Free Trade Association) Surveillance Authority. Within the RASFF are sent four types of notifications: alert notifications, information, border rejections and news [European Commission 2014].

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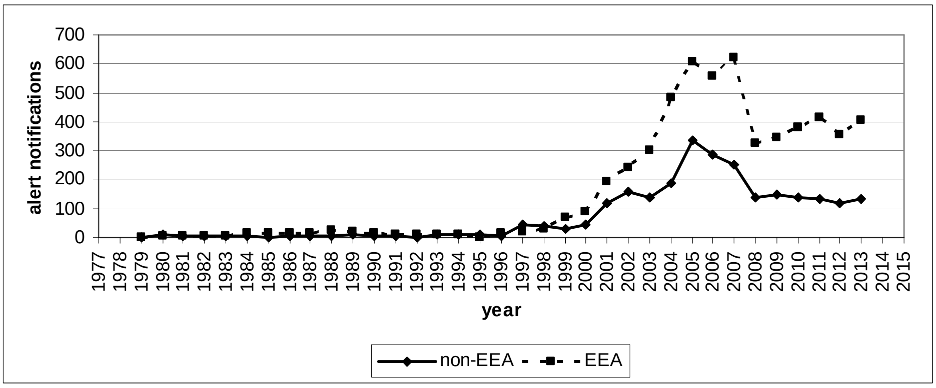
Van de Brug et al. [2014] believes that the RASFF as being based on existing knowledge of known hazards cannot be applied to new or unexpected hazards. It should, however, pay attention to the trends that can be observed thanks to functioning of the RASFF. A similar trend line shape of number of the number of alert notifications to food from non-EEA and EEA countries in the period 1979-2013 (Fig. 1) may indicate a correlation interdependence of these notifications. Dabbene et al. [2014] points out that increases the amount of food withdrawals from the market. He also notes that it may be due to rising imports from countries where food safety requirements are at a lower level.



Source: Own study on the basis [European Commission 2014]

Fig. 1. The alert notifications within the RASFF to food from the non-EEA and the EEA countries in the period 1979-2013

Rys. 1. Powiadomienia alarmowe w systemie RASFF wobec żywności z krajów spoza EOG i z krajów EOG w latach 1979-2013

The value of Pearson's *r* correlation coefficient between the alert notifications of the RASFF to food from the non-EEA and EEA countries amounted 0.96, which indicated very high correlation - see [Crewson 2008] (with value of calculated statistics *t* of 20.51, exceeding the value of the critical statistics $t_{0.05;n-2}$ of 2.03). It can be assumed that EEA countries import raw materials and then use them for the food production or import the final products, which are then repackaged and sold, including also re-export within the EEA.

Therefore, the goal of this article was to examine the strength of correlations within each product category and hazard category, with particular emphasis on those categories, where the correlation was the highest.

MATERIALS AND METHODS

The material for the study came from the RASFF database and covered the years 1979-2013. In this period, there were 8175 alert notifications, including 2540 (31%) to food from the non-EEA countries and 5635 (69%) to food from the EEA countries. In the case, if as the product origin were given several countries, the first mentioned country was adopted as eligible to the group of the non-EEA or EEA countries.

The alert notifications to food from the non-EEA countries (variable *X*) were adopted as values of x_i and alert notifications to food from the EEA countries (variable *Y*) were adopted as values of y_i. The study of the inverse relationship would be unreasonable due to the fact that the RASFF is designed to protect the consumers from the EEA and also because of thesis put in Introduction (relating to the import of raw materials or products into the EEA).

In the analyzed period 1979-2013 the number of observations *n* (number of years) amounted 35. However, within each product category and hazard category, it was limited only to the years (and not in every case occurring one by one), in which there was at least one alert notifications in the RASFF to food from the non-EEA or EEA countries (so, the number of observations *n* was different).

RESULTS AND DISCUSSION

In Table 1 presented the values of critical statistics $t_{0.05;n-2}$, the calculated statistics t and Pearson's r correlation coefficients for the products categories, and in Table 2 for the hazards categories. The value of the critical statistics $t_{0.05;n-2}$, set at a significance level of 0.05, and with the number of degrees of freedom $n-2$.

Taken into account only these categories, where the number of observations n was at least 5 - see [Crewson 2008]. In the case of the products categories, the categories which are already "obsolete" were not included, because it would be unfounded. There was not also examined the correlation in the hazard category "Transmissible spongiform encephalopathies" (TSEs), because within this category the alert notifications to food from non-EEA countries didn't occur. After considering the adopted assumptions, examined 28 out of 35 products categories (within these categories there were 7907 alert notifications, which represented 97% of the population) and 25 out of 26 hazards categories (within these categories there were 8138 alert notifications, which represented 99% of the population).

Table 1. The values of critical statistics $t_{0.05;n-2}$, the calculated statistics t and Pearson's correlation coefficients r for the products categories

Tabela 1. Wartości statystyki krytycznej $t_{0,05;n-2}$, statystyki obliczonej t oraz współczynnika korelacji Pearsona r dla kategorii produktów

Product category	$t_{0.05;n-2}$	$\|t\|$	r
Alcoholic beverages	2.18	|–1.31|=1.31	–
Bivalve molluscs and products thereof	2.36	2.60	0.70
Cephalopods and products thereof	2.57	|–0.70|=0.70	–
Cereals and bakery products	2.08	3.54	0.61
Cocoa and cocoa preparations, coffee and tea	2.07	3.07	0.54
Confectionery	2.12	1.52	–
Crustaceans and products thereof	2.07	3.06	0.55
Dietetic foods, food supplements, fortified foods	2.09	7.20	0.86
Eggs and egg products	2.12	0.54	–
Fats and oils	2.14	0.34	–
Fish and fish products	2.06	6.23	0.79
Food additives and flavourings	2.36	|–0.52|=0.52	–
Food contact materials	2.12	7.95	0.89
Fruits and vegetables	2.04	10.23	0.88
Herbs and spices	2.08	15.34	0.96
Honey and royal jelly	2.23	1.26	–
Ices and desserts	2.14	0.22	–
Meat and meat products (other than poultry)	2.06	5.24	0.72
Milk and milk products	2.06	|–0.37|=0.37	–
Natural mineral water	2.57	1.68	–
Non-alcoholic beverages	2.06	1.39	–
Nuts, nut products and seeds	2.09	3.96	0.67
Other food product / mixed	2.16	|–0.21|=0.21	–
Poultry meat and poultry meat products	2.10	2.05	–
Prepared dishes and snacks	2.14	0.88	–
Soups, broths, sauces and condiments	2.11	2.23	0.48
Water for human consumption (other)	3.18	2.10	–
Wine	2.18	|–1.31|=1.31	–

Source: own study

Table 2. The values of critical statistics $t_{0.05;n-2}$, the calculated statistics t and Pearson's correlation coefficients r for the hazards categories

Tabela 2. Wartości statystyki krytycznej $t_{0,05;n-2}$, statystyki obliczonej t oraz współczynnika korelacji Pearsona r dla kategorii zagrożeń

Hazard category	$t_{0.05;n-2}$	$\lvert t \rvert$	r
Adulteration / fraud	2.13	1.11	–
Allergens	2.14	2.37	0.53
Biocontaminants	2.07	1.98	–
Biotoxins (other)	2.04	|–0.42|=0.42	–
Chemical contamination (other)	2.10	|–0.88|=0.88	–
Composition	2.08	8.73	0.89
Feed additives	2.57	|–1.97|=1.97	–
Food additives and flavourings	2.13	9.76	0.93
Foreign bodies	2.09	8.32	0.88
GMO / novel food	2.31	1.77	–
Heavy metals	2.06	6.52	0.80
Industrial contaminants	2.12	2.53	0.53
Labelling absent/incomplete/incorrect	2.23	|–0.69|=0.69	–
Migration	2.57	2.05	–
Mycotoxins	2.08	6.39	0.81
Non-pathogenic micro-organisms	2.06	1.74	–
Not determined / other	2.11	1.26	–
Organoleptic aspects	2.10	3.01	0.58
Packaging defective / incorrect	2.09	|–1.15|=1.15	–
Parasitic infestation	2.20	|–0.63|=0.63	–
Pathogenic micro-organisms	2.04	5.94	0.72
Pesticide residues	2.07	4.30	0.67
Poor or insufficient controls	2.23	1.17	–
Radiation	2.26	8.05	0.94
Residues of veterinary medicinal products	2.12	2.02	–

Source: own study

The value of calculated statistics $t_{0.05;n-2}$, higher than the value of critical statistics indicated that there was a statistically significant relationship between examined variables X and Y, i.e. alert notifications in the RASFF to food from the non-EEA and EEA countries in 12 (out of 28) products categories and in 11 (out of 25) hazards categories. If the value of calculated statistics t was lower than the value of critical statistics $t_{0.05;n-2}$, a statistically significant relationship between examined variables did not occur (in 16 products categories and 14 hazards categories).

If the relationship occurred, the value of Pearson's r correlation coefficient indicated very high (0.9-1), high (0.7-0.9), moderate (0.5-0.7) and low (0.3-0.5) correlation - see [Crewson 2008].

In the case of products categories the very high correlation occurred in the category "Herbs and spices" (the value of Pearson's correlation coefficient was 0.98) and the high correlation occurred in the following categories: "Bivalve molluscs and products thereof" (0.70), "Dietetic foods, food supplements, fortified foods" (0.86), "Fish and fish products" (0.79), "Food contact materials" (0.89), "Fruits and vegetables" (0.88) and "Meat and meat products (other than poultry)" (0.72). It is worth noting that in the case of product category "Food contact materials" since 2008, when began to notify the border rejection at the EEA border in the RASFF, there has been no further alert notifications in this category, both to food from non-EEA and EEA countries - see [European Commission 2014]. This shows the effectiveness of the actions within this category. The moderate correlation occurred in case of following products categories: "Cereals and bakery products" (0.61), "Cocoa and cocoa preparations, coffee and tea" (0.54), "Crustaceans and products thereof" (0.55), "Nuts, nut products and seeds" (0.67), while the low correlation occurred in the product category "Soups, broths, sauces and condiments" (0.48).

In case of hazards categories the very high correlation occurred in the category "Food additives and flavourings" (0.93) and "Radiation" (0.94). It is worth noting that the hazard category "Food additives and flavourings" also occurs in the products categories where there was no correlation. However, there, the food additives and flavourings should be treated as a raw material for the food production, while here, in hazards categories, as a food contamination (above the acceptable level). The high correlation occurred in case of following hazards categories: "Composition" (0.89), "Foreign bodies" (0.88), "Heavy metals" (0.80), "Mycotoxins" (0.81) and "Pathogenic micro-organisms" (0.72). While the moderate correlation was in following hazards categories: "Allergens" (0.53), "Industrial contaminants" (0.53), "Organoleptic aspects" (0.58) and "Pesticide residues" (0.67).

The subject of alert notifications in the RASFF to certain products categories or hazards categories is raised in the literature on food safety. These are mainly those categories in which notifications are reported most frequently, and in the greatest number.

First of all, it is worth noting that the high or moderate correlation occurred in all products categories that could be classified as seafood, i.e.: "Bivalve molluscs and products thereof", "Crustaceans and products thereof" and "Fish and fish products". Kleter et al. [2009] notes that in the period they studied (2003-2007), notified over 2000 alert and information notifications to seafood in the RASFF. Anacleto et al. [2015] noted also the occurrence of alert notifications in the RASFF to bivalve molluscs and products thereof. Broughton and Walker [2010] pointed out that within the RASFF were transmitted the alert notifications on the occurrence of industrial pollutions in aquaculture products imported from China. Therefore, already in 2004, the European Union and China initiated a project internships and workshops for Chinese inspectors on the RASFF. D'Amico et al. [2014] mentioned, however, that seafood from China has the largest percentage of rejections at the EU border. Jespersen [2014] drew attention to the alert notifications to the shrimp from Bangladesh, but also the pang of Vietnam, contaminated with antibiotics and pesticide residues. On the other hand, as indicated the RASFF notifications in the recent years can be seen a significant reduction of antibiotics residues used in shrimp production in China, Vietnam and Thailand [Rico et al. 2013]. Kleter and Marvin [2009] also pointed to the presence of the chemical hazards in fish. Figueroa [2008] mentioned the alert notifications in the RASFF on cadmium (heavy metal) in fish products. He added that the rejection of such products causes severe losses for exporters from developing countries. They are related not only to the cost of the product itself, but also to the costs of its delivery. While Noël et al. [2011] mentioned the RASFF notifications regarding heavy metals to seafood imported into France and to domestic seafood. Amagliani et al. [2012] pointed out that in the RASFF notifications indicated the presence of Salmonella in fish, cephalopods, bivalves and crustaceans. They indirectly pointed to China, but also Thailand and Vietnam, as countries, which export the largest amount of seafood.

Kleter et al. [2009] drew attention to the presence of a large number of notifications (alerts and information) to spices. Elviss et al. [2009] gave examples of occurrence of Salmonella in herbs imported into the United Kingdom, Denmark and Norway. However, most often the presence of mycotoxins (aflatoxins in particular), for example, in 2012, was notified to fruit and vegetables as well as nuts, nut products and seeds. What is important, however, since 2008 (when border rejections at the EEA border were introduced) to 2012 declined the number of RASFF notifications concerning the presence of aflatoxins. However, in 2012 mycotoxins were the main group of hazards because of which were rejected imported products at the border - see [Marin et al. 2013]. The occurrence of mycotoxins in RASFF notifications also pointed Cheli et al. [2014] (2011) and Kleter et al. [2009] (in 2003-2007 mycotoxins was the second most common hazards category after chemical hazards). García-Cela et al. [2012] pointed out that in 2000-2010 in the RASFF were total over 7000 notifications (alert, information and border rejections) concerning mycotoxins. The largest number of notifications concerned nuts, nut products and seeds, especially pistachios. The authors pointed out the possibility of the appearance of mycotoxins in successive stages from the collection by importing up to provide nuts to the consumer. Van Boxstael et al. [2013] pointed out, in turn, that the European Commission carries out the risk analysis, increasing the number of border controls, depending on the food origin. This includes e.g. Salmonella in basil imported from Thailand or pesticide residues on tomatoes originating in Turkey.

Orford et al. [2014] and Petroczi et al. [2011] mentioned the occurrence of alert notifications in RASFF in the food contact materials. Marvin et al. [2009] drew attention to the RASFF notifications on migration of heavy metals from dishes / utensils to food. This problem also noted Kleter et al. [2009], referring to dishes / utensils from China. He also pointed to the migration of heavy metals from food contact materials to food.

CONCLUSIONS

A correlation relationship of alert notifications in the RASFF to food from the non-EU and the EU countries was found in 12 (out of 28) products categories and in 11 (out of 25) hazards categories. The values of Pearson's *r* correlation coefficient indicated a correlation from very high, through high, moderate to low.

The occurrence of very high correlation was stated in the products category: "Herbs and spices" (0.98), and a high correlation in the following categories: "Bivalve molluscs and products thereof" (0.70), "Dietetic foods, dietary supplements, fortified foods" (0.86), "Fish and fish products" (0.79), "Food contact materials" (0.89), "Fruits and vegetables" (0.88) and "Meat and meat products (other than poultry)" (0.72).Whereas in the case of hazards categories the very high correlation occurred in the categories: "Food additives and flavourings" (0.93) and "Radiation" (0.94) and high correlation in the case of: "Composition" (0.89), "Foreign bodies" (0.88), "Heavy metals" (0.80), "Mycotoxin" (0.81) and "Pathogenic microorganisms" (0.72).

The results show the need to pay by the EEA border control authorities the particular attention to seafood, herbs and spices and fruits which are imported and heavy metals, pathogenic microorganisms and mycotoxins which could be present in them. These products and hazards categories are also most frequently highlighted in the literature. First of all, the scope of border controls should be increased or extended. In addition, measures should be taken in order to shorten the supply chain, both in terms of time and the number of intermediate points. Can also draw the attention of consumers for these products, which are produced mainly in the EEA (not imported). Consumers not only consumed safer food, but also indirectly affected the development of the EU economy.

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ANALIZA KORELACJI POWIADOMIEŃ ALARMOWYCH W SYSTEMIE RASFF WOBEC ŻYWNOŚCI Z KRAJÓW SPOZA EOG I Z KRAJÓW EOG

STRESZCZENIE. Wstęp: System RASFF (Rapid Alert System for Food and Feed), czyli System Wczesnego Ostrzegania o Niebezpiecznej Żywności i Paszach służy do szybkiego wzajemnego informowania się krajów członkowskich Europejskiego Obszaru Gospodarczego (EOG) o zagrożeniach w żywności. Podobny przebieg linii trendu powiadomień alarmowych w systemie RASFF w czasie wobec żywności z krajów spoza EOG i z krajów EOG, a także bardzo wysoka wartość współczynnika korelacji Pearsona r (0,96) wskazały na współzależność powiadomień alarmowych z tych dwóch grup krajów. W związku z tym celem artykułu było zbadanie siły korelacji w ramach poszczególnych kategorii produktów i kategorii zagrożeń.

Metody: Dane do badań pochodziły z bazy danych systemu RASFF z lat 1979-2013, obejmując 8175 powiadomień alarmowych, w tym 2540 powiadomień wobec żywności z krajów spoza EOG i 5635 powiadomień wobec żywności z krajów EOG. W ramach każdej kategorii produktów i kategorii zagrożeń badano, czy istniała korelacja (tzn. wartość statystyki obliczonej t przewyższyła wartość statystyki krytycznej $t_{0,05;n-2}$), a następnie obliczano wartość współczynnika korelacji Pearsona r.

Wyniki: Wartość współczynnika korelacji Pearsona r wskazała na występowanie bardzo wysokiej korelacji w kategorii produktów "Zioła i przyprawy korzenne" (0,98), a wysokiej korelacji w następujących kategoriach: "Małże i produkty pochodne" (0,70), "Żywność dietetyczna, suplementy diety, żywność wzbogacona" (0,86), "Ryby i produkty rybne" (0,79), "Materiały do kontaktu żywnością" (0,89), "Owoce i warzywa" (0,88) oraz "Mięso i produkty mięsne (z wyjątkiem drobiu)" (0,72). Natomiast w przypadku kategorii zagrożeń korelacja bardzo wysoka wystąpiła w kategorii "Dodatki do żywności i środki aromatyzujące" (0,93) oraz "Promieniowanie" (0,94), a korelacja wysoka w przypadku "Składu" (0,89), "Ciał obcych" (0,88), "Metali ciężkich" (0,80), "Mykotoksyn" (0,81) oraz "Mikroorganizmów patogennych" (0,72).

Wnioski: Wyniki badań wskazały na konieczność zwrócenia szczególnej uwagi przez organy kontroli granicznej EOG na m.in. importowaną żywność pochodzenia morskiego, zioła i przyprawy i owoce oraz obecne w nich metale ciężkie, mikroorganizmy patogenne i mykotoksyny. Należałoby także skrócić łańcuch dostaw i/lub ograniczyć import niektórych surowców i produktów, kierując uwagę konsumentów na żywność produkowaną przede wszystkim na terenie EOG.

Słowa kluczowe: EOG, system RASFF, powiadomienia alarmowe, kategorie produktów, kategorie zagrożeń, analiza korelacji

DIE KORRELATIONSANALYSE VON WARNMELDUNGEN IM RASFF-SYSTEM FÜR LEBENSMITTEL AUS DEN EWR- UND NICHT-EWR-LÄNDERN

ZUSAMMENFASSUNG. Einleitung: Das RASFF-System (Schnellwarnsystem für Lebens- und Futtermittel) dient dem Informationsaustausch zwischen den EWR-Mitgliedstaaten über potentielle Gesundheitsrisiken bei Lebens- und Futtermitteln. Ein zeitlich ähnlicher Ablauf von Warnmeldungen im RASFF-System in Bezug auf die Lebensmittel aus den EWR- und Nicht-EWR-Staaten sowie ein sehr hoher Wert des Pearson-Korrelationskoeffizienten r (0,96) deuteten auf eine Korrelation der Warnmeldungen der beiden Staatsgruppen hin. Im Zusammenhang damit war das Ziel des Artikels, die Korrelationsstärke im Rahmen der verschiedenen Produkt- und Risikokategorien zu untersuchen.

Methoden: Die Daten für die Forschungsstudie kamen von der RASFF-Datenbank aus den Jahren 1979-2013, die 8175 Warnmeldungen, einschließlich 2.540 Meldungen für die Lebensmittel aus den Nicht-EWR-Ländern und 5.635 Meldungen für die Lebensmittel aus den EWR-Ländern, umfassten. Innerhalb jeder Produkt- und Risikokategorie wurde untersucht, ob eine Korrelation gegeben ist (d.h. ob der berechnete t-Wert höher als der kritische t0,05;n-2 ist), und danach der Pearson'sche Korrelationskoeffizient r berechnet.

Ergebnisse: Der Wert des Pearson-Korrelationskoeffizienten r deutete auf eine sehr hohe Korrelation in der Produktkategorie "Kräuter und Gewürze" (0,98) und eine hohe Korrelation in folgenden Kategorien: "Zweischalige Weichtiere und daraus entstandene Produkte" (0,70), "Diätetische Lebensmittel, Nahrungsergänzungsmittel und angereicherte Lebensmittel" (0,86), "Fisch und Fischereiprodukte" (0,79), "Gegenstände und Materialien für Lebensmittelkontakt" (0,89), "Obst und Gemüse" (0,88) und "Fleisch und Fleischprodukte (außer Geflügel)" (0,72), hin. In der Risikokategorie hingegen wurde eine sehr hohe Korrelation in der Kategorie "Lebensmittelzusatzstoffe und Aromen" (0,93) und "Strahlung" (0,94) und eine hohe Korrelation im Fall der Kategorien: "Komposition" (0,89), "Fremdkörper" (0,88), "Schwermetalle" (0,80), "Mykotoxine" (0,81) und "Pathogene Mikroorganismen" (0,72) festgestellt.

Fazit: Die Untersuchungsergebnisse zeigten, dass die besondere Aufmerksamkeit der Grenzschutzbehörden u.a. den importierten Meeresfrüchten, Kräutern, Gewürzen und Obst sowie den in diesen Produkten enthaltenen Schwermetallen, pathogenen Mikroorganismen und Mykotoxinen gewidmet werden soll. Es sollte auch die Versorgungskette gekürzt und /oder die Einfuhr bestimmter Rohstoffe und Produkte eingeschränkt sowie die Aufmerksamkeit der Verbraucher auf die vor allen in den EWR-Staaten hergestellten Lebensmittel gerichtet werden.

Codewörter: EWR (Europäischer Wirtschaftsraum), RASFF-System, Warnmeldungen, Produktkategorien, Risikokategorien, Korrelationsanalyse

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INTERMODAL SERVICE - SYSTEM APPROACH

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ABSTRACT. **Introduction:** Transportation services may be described in systemic categories. Intermodal freight transport is a practical expression of the system approach to transport. Development of the intermodal transport system has brought about the need for the comprehensive grasp of transportation processes. Intermodal transport operators manage the whole transportation service organization process. Hence, a question arises whether the service offered by an intermodal transport operator may be interpreted as a complex system service. Systemness of contemporary products and services consists in that their value for clients is predefined by their place in the whole system of products and/or services as well as by the network of their users. The network language, occurring in this paper, is connected with the development of the notion of network, one of the inspiring ideas in organization and management science of the recent years.

Methods: Literature on the intermodal freight transport issue has been analysed by the present author for the purposes of this paper, with a view to the developing idea of marketing of system products. Within the adopted interpretative paradigm, qualitative / quantitative research was used. Case study is used, among others, to interpret a particular situation, in a way that the subsequent description appears as the research result and may be recognized as valuable contribution to the existent knowledge. The aim of the paper is to highlight, following the research results, the necessity to treat the service offered by intermodal transport operators in system categories. Such systemic interpretation points both to the multitude of components of the service and to the arising opportunity for comprehensive solution of the clients' needs and expectations.

Results: The outcomes reveal that the service offered by an intermodal transport operator may be recognized as the complex systemic intermodal service. They contribute to the knowledge of intermodal transport and serve as the stepping point for the development of the concept of systemic marketing in logistic services.

Conclusions: Proper determination of the systemic essence of the intermodal service constitutes the starting point for the identification of the client's problems as well as for the choice of offered solutions, both in the context of essential and additional values. Due to this reason, the management of an intermodal service creation and delivery has the nature of network management, and the values offered by an intermodal service are conditioned by material elements, without which the provision of the service in accordance with the client's expectations cannot be realized.

Key words: Intermodal freight transport, Intermodal service, Transport system, Network.

INTRODUCTION

It is a feature of the contemporary economy that system products and system services gain more and more share. Openness of economies as well as modern communication and transport techniques eliminate space barriers and enable enterprises to competitively cooperate [Witek, Hajduk 2013]. Both the network and inter-business management theories have been developed in the organization and management science [Kozminski, Latusek 2014]. Network is a unique form of connections among businesses, based on interdependence, cooperation and trust. The ever increasing role of system products in the network economy determines the development of a new sub-discipline in the science of marketing, namely, system products/services marketing. In

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Żabiński's [2009] view, a particular task appears for the researchers of system services of professional nature. The so called intermodal service, created by the intermodal freight transport is understood as a professional service. In the case of services of professional character, they cannot be provided unless there is well-developed material infrastructure available (e.g. railways, roads, terminals, means of transport, IT).

The aim of the paper is to present, on the basis of literature analysis, practical observations, as well as preliminary research of qualitative-quantitative character, the thesis that the service offered by intermodal transport operators has features of a system service which is composed of numerous elements and extensively satisfies clients' expectations.

The aim of the paper is to highlight, following the research results, the necessity to treat the service offered by intermodal transport operators in system categories. Such systemic interpretation points both to the multitude of components of the service and to the arising opportunity for comprehensive solution of the clients' needs and expectations.

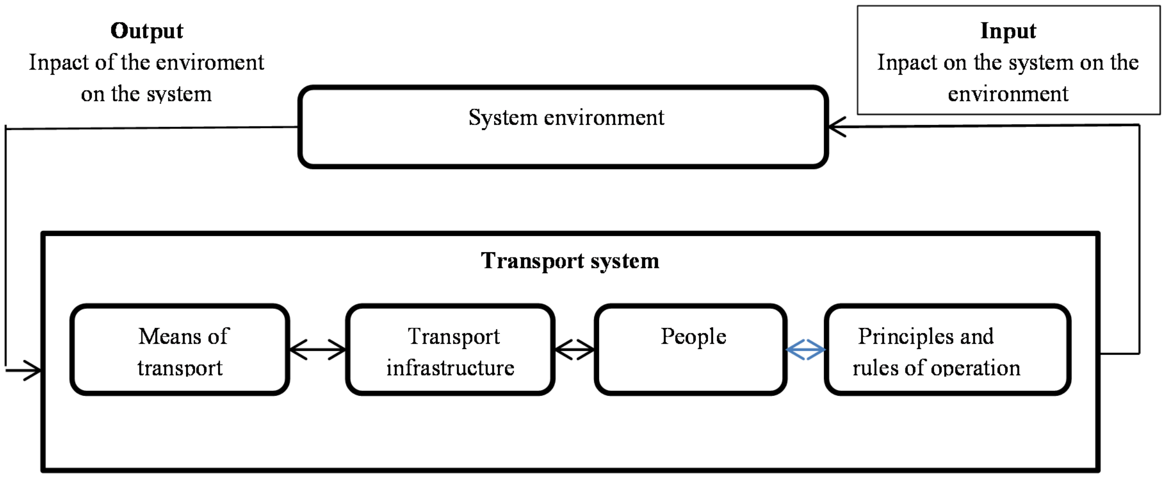
THE ESSENCE OF THE INTERMODAL SERVICE SYSTEMNESS

Transportation services are defined in a variety of ways in specialist literature [Rosa 2013, Rucińska 2012]. Transport is a service-providing business activity which consists in the transfer of goods, people and information. The process of a transport service creation is multiphase and multifunctional. The transportation process essential activities are as follows: haulage, performance and organizing-administrative activities. These operations are integrated under the notion of the transport system. The theory of systems serves as the basis within which a system may be perceived as a set of components, interconnected by relations and chains both within the system and with its environment [Piekarczyk, Zimniewicz, 2010]. In the context of transport such system model is presented in Fig 1. Transport system may be defined as coordinated, from the technical, technological, organizational and trade perspective, rational succession of activities involving haulage, reloading, storage and administration, which all aim at the transfer of freight in time and space, with particular consideration of a variety of load unit. In terms of logistics, a system may be understood as a chain of deliveries [Armenau, 2006] which comprises the haulage - storage system and, then, constitutes the technological link of storage and reloading spots via transportation routes as well as organizational and financial coordination of ordering processes, customer service, administration processes and all other links contained in the system. In the same logistics terms, a system may also be understood as intentionally organized and combined, within a particular economy, physical flow of goods, accompanied by the flow of finances and information [Jacyna, 2013]. A system is looked at as a whole, according to the principle of holism, with the assumption that its proper functioning is maintained if there is compatibility of aims and motives of all its participants.

Intermodal transportation is the practical side of the system approach to transport. System view of the intermodal transport is presented in fig. 2. Development of intermodal system has led to the necessity for different branches of transport to get closer, for the standardization of load units, infrastructure [Liedke, Murillo, 2012] and the need for comprehensive treatment of transport processes. Systemness has led to internal integration of transport processes which take place at least on three planes [Stokłosa 2011]:

- Technical - technological plane, with the adjustment of line infrastructure and spot infrastructure to ensure the service of standardized intermodal units; and IT infrastructure to monitor and facilitate communication and management processes;
- Organizational plane, with independent intermodal transport operators who offer extensive haulage services with their diverse means of transport as well as a variety of logistic services, e.g., reloading, storage, monitoring, etc. They are intermodal transport integrators (logistic operators) in specific transportation chains;
- Managerial plane, where specialized intermodal operators are hired to do

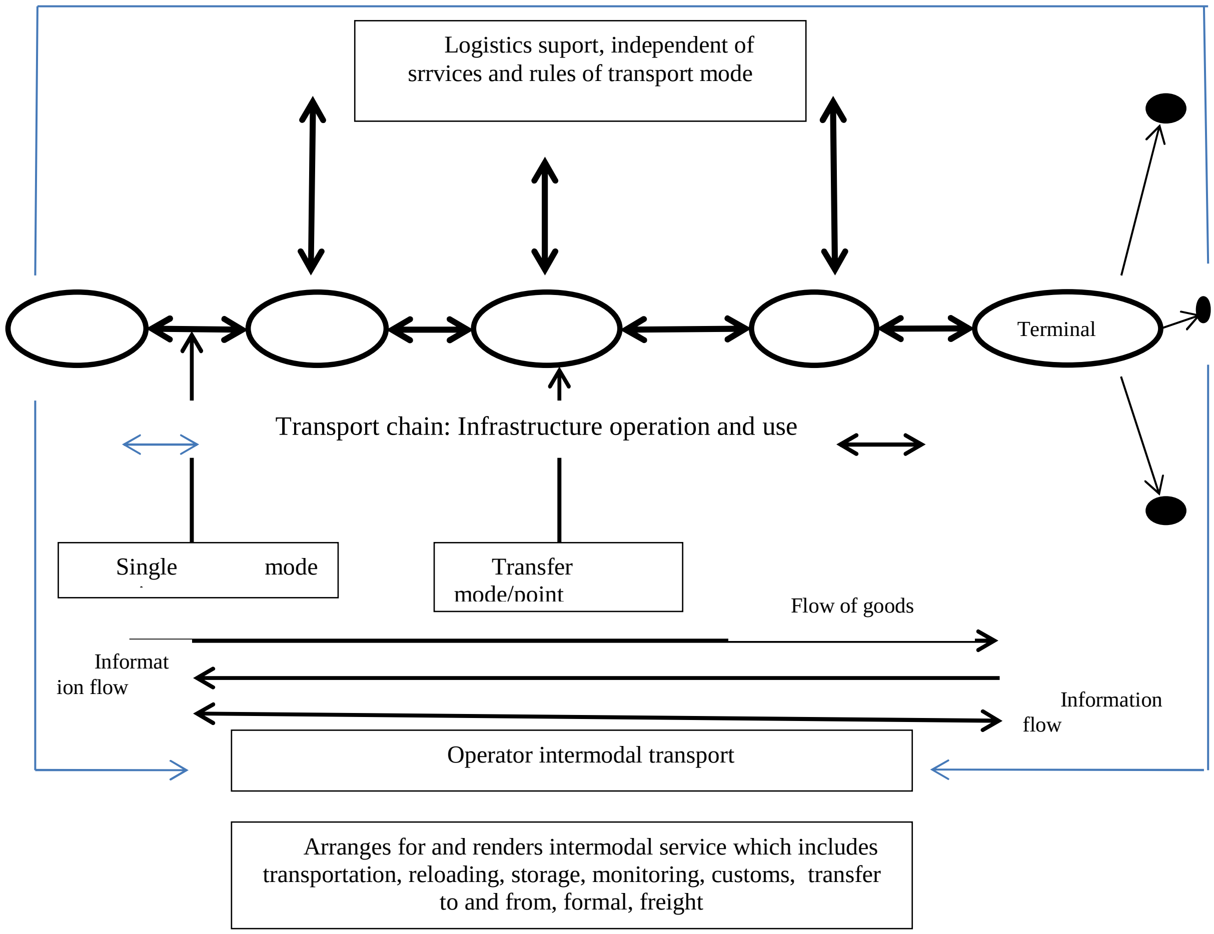
business within new organization frames that now offer packets of services to resolve a client's problems from the moment of registering freight for transportation to the receipt of the delivery. They may offer, among others, a single price for the whole haulage route, or they offer a single shipping document, or arrangement of the whole process in the home-home relation, legal counselling, etc.



Source: Mindur, Hajdul, 2011

Fig. 1. Transport system and its environment
Rys. 1. System transportowy i otoczenie

Intermodal transport operators, while rendering an intermodal service, they manage the whole process and particular activities connected with the transfer of freight and shipment of parcels and they integrate different kinds of services provided by different entities [Jarzemskiene, 2007]. So, can a service offered by an intermodal transport operator be treated as a complex system service? Systemness of contemporary services consists in that the perception of their value for client is determined by the fact that they function in a defined and extended system of services and the network of users. A characteristic feature of a system service is its attribute of networking. This means that the components of the final service are delivered to the final service provider by their producers in the course of the service provision. This refers to the suppliers of services which can be realized independently of the system and, at the same time, can be ordered inclusive of other independent services in a packet which is custom-designed by the final service provider. Then comes the time when the system needs the decision as regards the choice of the management model, e.g. operator, integrator, or conductor model and, cooperation and partnership of all entities engaged in the provision of the service, irrespective of their number. Intermodal transport operator can act in the capacity of the network chief or the system service promotor [Żabiński, 2009]. When one considers Mazurek's [2012] idea of networking triad, then the intermodal transport networking should be referred to the organizational-managerial plane and the way the entities arrange their cooperation. Such interpretation of network engages a lot of businesses driven by either individual or group aims. All members of the network contribute their individual potential to create value [Czakon 2012]. Network management, coordination and integration of exchange are facilitated by both formal and informal tools as well as communication systems. Complexity and networking appear in the intermodal transport. They come as the result of a variety of links that play roles in the technologically combined transport chain. The links are bound by long-term relations that, in the course of the activity, add value to the created service while playing roles both of the supplier and the client for one another [Downar, 2010]. The nature of contemporary competition does not allow businesses to specialize in all planes of their operations. This lies at the root of the particular type of service, the so called logistic service, which is the outcome of the fast-spreading phenomenon of partner outsourcing [Vitasek, 2011]. Logistic service, in academic terms, means that a contractor arranges for transportation and storage of goods, together with its full formal and legal support and realizes this transportation in the logistic system to meet the requirements and expectations of the client. [Coyle, Bardi, Langley, 2002].



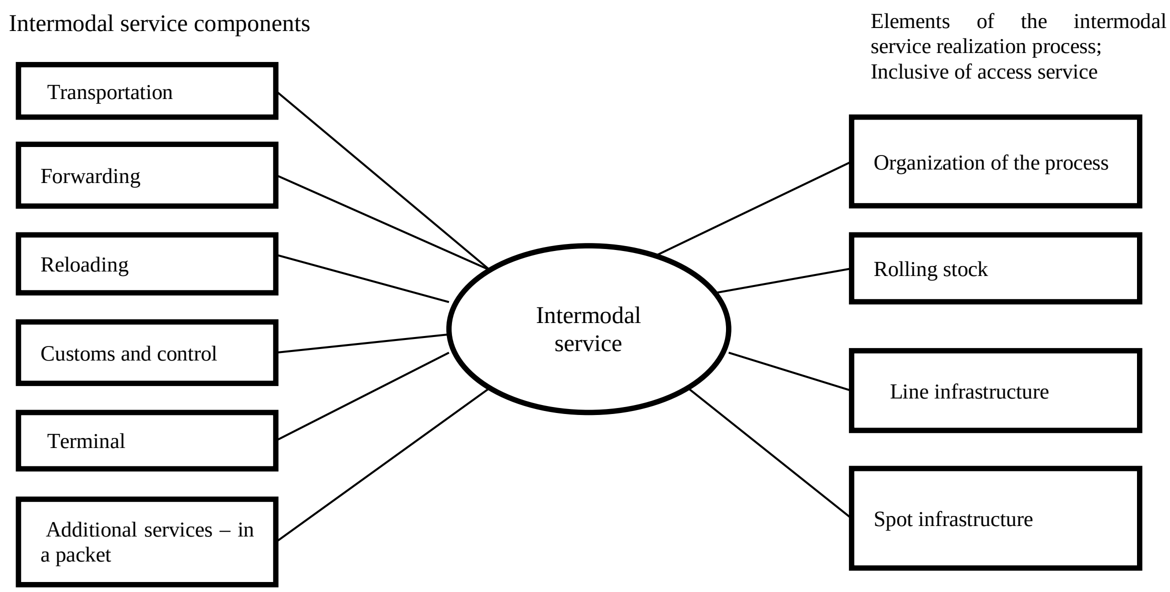
Source: Author's own. Based on Profir, 2012 and Ovidiu 2012

Fig. 2. System approach to intermodal transport
Rys. 2. Podejście systemowe do transport intermodalnego

The essence of the logistic service lies in the moulding of it, in the cooperation with the client, shaping it into the required final form and quality as regards goods and services [Gołembska 2009]. Ciesielski [2005] argues that logistic services comprise earnings-oriented forwarding, transportation and storage services, but also, other supplementary services which facilitate the flow of goods within and among the links of the logistic system. According to Rydzkowski [2004], a logistic service, in wider perspective, comprises transport and forwarding activities and services (e.g. making arrangements), organizing, documenting, customs and inspection activities and services (e.g. phytosanitary, veterinary), terminal services, storage services (refining included). Additionally, extra support may be added, such as financial, insurance or information services. In Dyczkowska's [2014] model of logistic services provision, transportation businesses offer the core and real haulage to their clients while forwarders offer extended haulage services and logistic operators try to present a comprehensive offer of services with the use of the potential product. When Kotler's [2005] idea of the system product is considered as the starting point, it can be assumed that the system service is a set of different but related services whose functions complement one another; the sine qua non condition for a system service to arise does not need to be the compression of component services in one service but their compatibility. It must be also noted that in services the phenomenon of encapsulation occurs. This means that certain services get coated with other service processes [Rudawska 2009] so that the services get integrated in the delivery chain and satisfy the clients by offering them the realization of their tasks with the help of the system service. Intermodal transport connected ideas occur both in theory and in practice where it is defined as the transportation of freight in one and the same load unit or a vehicle through the consecutive modes of transport, exclusive of reloading of the cargo itself in the changing modes of transport [Wronka 2008, Mindur 2014]. The essence of the phenomenon is accurately expressed by the statement that intermodal transport means transportation of goods in load units with the use of means coming from at least two modes of transport, following standardized terms arising from the contract for the intermodal transportation, concluded between a client and the intermodal transport operator [Neider 2012]. Intermodal service, due to its complexity, engages an array of entities whose performance determines the success as well as competitiveness of the intermodal service. From this perspective, intermodal freight transport may be defined as a group of formally independent businesses and hubs [Ishfag, Sox, 2010] which cooperate in the network system based on business and partnership relations. Additionally, realization of an intermodal service is also affected by the whole process organization, the rolling stock and technical condition and parameters of the spot and line infrastructure [Matczak, 2013]. The essential components of the intermodal service are presented in fig. 3.

INTERMODAL SERVICE IN RESEARCH

For the verification purposes of the adopted assumption, and following Żabiński [2007], research-interpretative paradigm, based on grounded theory [Konecki 2000] was used. It refers to the interpretation of phenomena occurring in the process of creation and provision of an intermodal freight service.

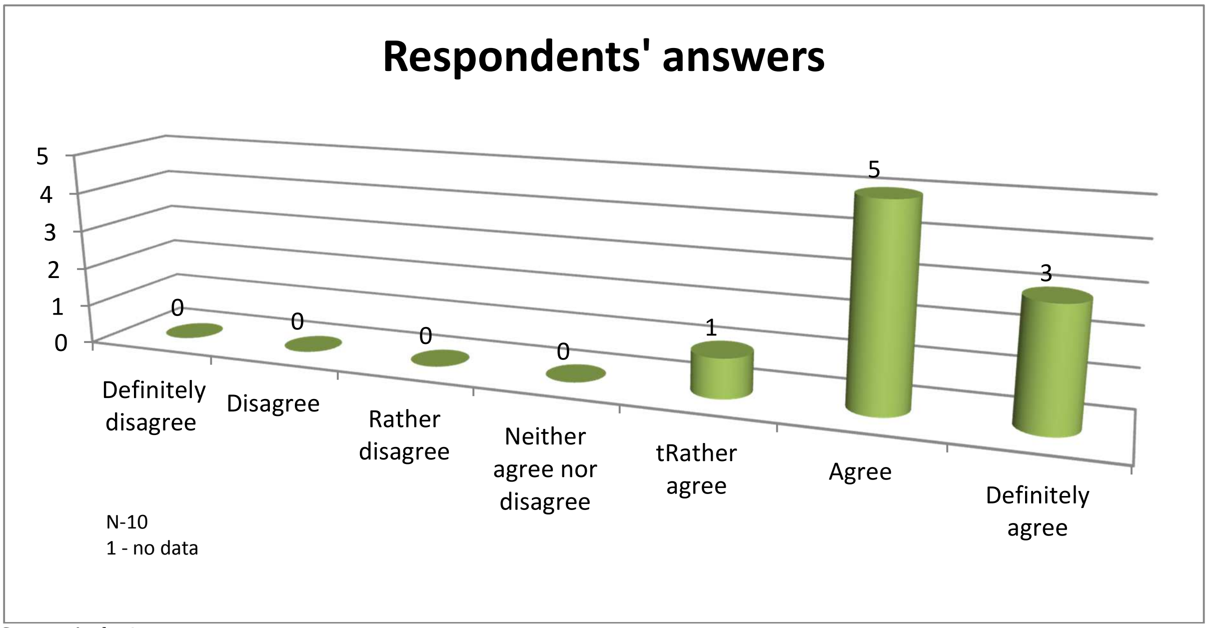


Source: Author's own, following literature study and analysis, with the use of M. Matczak 2013

Fig. 3. Essential components of an intermodal service
Rys. 3. Podstawowe elementy składowe i realizacyjne usługi intermodalnej

The aim of the study was to describe and interpret the operations of entities participating in the creation and provision of the intermodal service. Within the proposed interpretative paradigm, the study was conducted with the use of qualitative methods [Latusek 2011]. The adopted study method was case study research [Strumińska-Kutra, Koładkiewicz, 2012]. This method is applied in research study of marketing management [Żabiński 2007]. Interpretative paradigm assumes that the studied market reality does not objectively exist. Descriptions of phenomena and processes may be the results of such research. Case study is used, among others, to describe the studied situation in the way that the description that arises is treated as the study result and may serve as valuable contribution to the existent knowledge. Basically, case studies proceed in three steps, i.e., exploratory - searching surveys, proper case studies, theory testing with the use of verifying surveys. Following the literature analysis, practical observations and the author's own experience, preliminary theoretical assumptions were made, namely that the intermodal service, offered by the intermodal freight transport operators, may have the features of the system service which is composed of many elements and comprehensively satisfies clients' expectations. Respectively, extensive exploratory surveys were conducted which aimed at the verification of the preliminary theoretical assumptions. The conducted surveys concerned the cases of high importance for the grasping of the subject matter from the point of view of the role and significance on the intermodal services market [Hajdul 2014]; they included both the subjects, so called intermodal transport operators, typical transportation entities, agents who provide services which are the components of the intermodal service, finally, representatives of the links who participate in the chain of intermodal service, e.g., ports or the subjects who promote the idea of their development. 10 extensive exploratory surveys were conducted. In most cases the businesses surveyed operated on the global market and acted as operators, forwarders or terminal owners. Most of them played many roles (carriers, operator) and together with other related businesses organized and provided intermodal services. Small, medium and large businesses were studied. For conclusions, quantitative study, recommended for this stage, was used, i.e. Likert scale with seven response levels [Żabiński 2007]. Following the rules, the surveys contained questions about interpretation, understanding and explanation of the studied problem of the intermodal service. They regarded 5 major areas, i.e., understanding of the contemporary intermodal transport, innovativeness of the intermodal service, understanding and creation of value by the intermodal service, finally, description of the management system of the intermodal service offered by the intermodal freight transport operators. In the first stage, the respondents characterized the issue of the intermodal service. The respondents recognized that the intermodal service has features which qualify it as a complex system service. In common view of the respondents, the system intermodal service is created in the course of transportation services, forwarding, freight, insurance, reloading, terminals, administration, control (e.g. phytosanitary), customs, repairs (e.g. containers), storage and warehousing, security assurance, monitoring and information, .e.g. tracking. Chart 1 presents the spread of responses to the summing-up structured question. In the respondents' opinion, intermodal service resolves up to a dozen or so problems, depending on the service order, e.g. packaging, delivery time optimization, extra services arrangement, such as customs, forwarding, storage, inspection, etc. It was often emphasized that this problem solving deals with coordination, organizing, management of the whole intermodal transport system.

Clients should have their freight transportation problems resolved as provided in the contract. Chart 2 presents the results following the study of this issue.



Source: Author's own

Chart. 1. Respondents' answers, in the seven-level Likert scale, to the contextualized question: Is the service offered by the intermodal transport the complex system intermodal service?
Wykres. 1. Rozkład odpowiedzi według 7 stopniowej skali Likerta podsumowujący w kontekście pytania, Czy usługa oferowana przez transport intermodalny jest złożoną intermodalną usługą systemową?

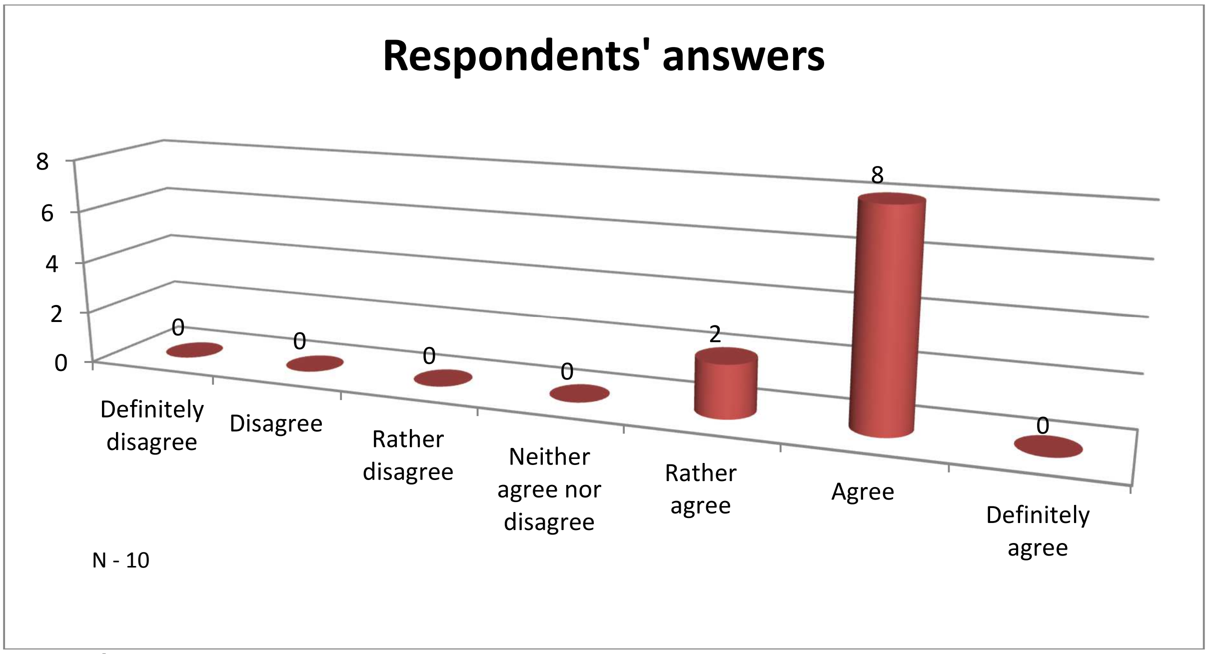


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Chart. 2. Respondents' answers, in the seven-level Likert scale, summing up the issue of comprehensive resolution of the client's problems by the intermodal service.
Wykres. 2. Rozkład odpowiedzi według 7 stopniowej skali Likerta podsumowujący problematykę rozwiązywania przez usługę intermodalną kompleksowo problemów klienta.

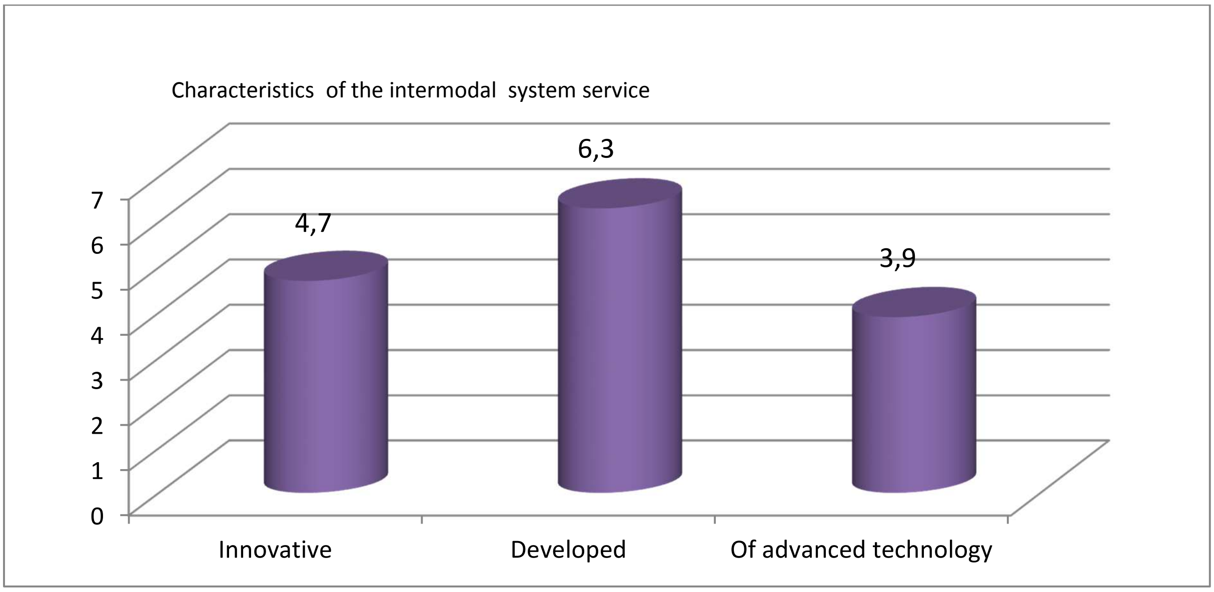

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Chart. 3. Average responses, in the seven-level Likert scale, in the context of view on innovativeness, technology and service improvement.
Wykres. 3. Średnie z pytań z 7 stopniowej skali Likerta w kontekście poglądu na zagadnienia innowacyjności, technologii i doskonalenia usługi.

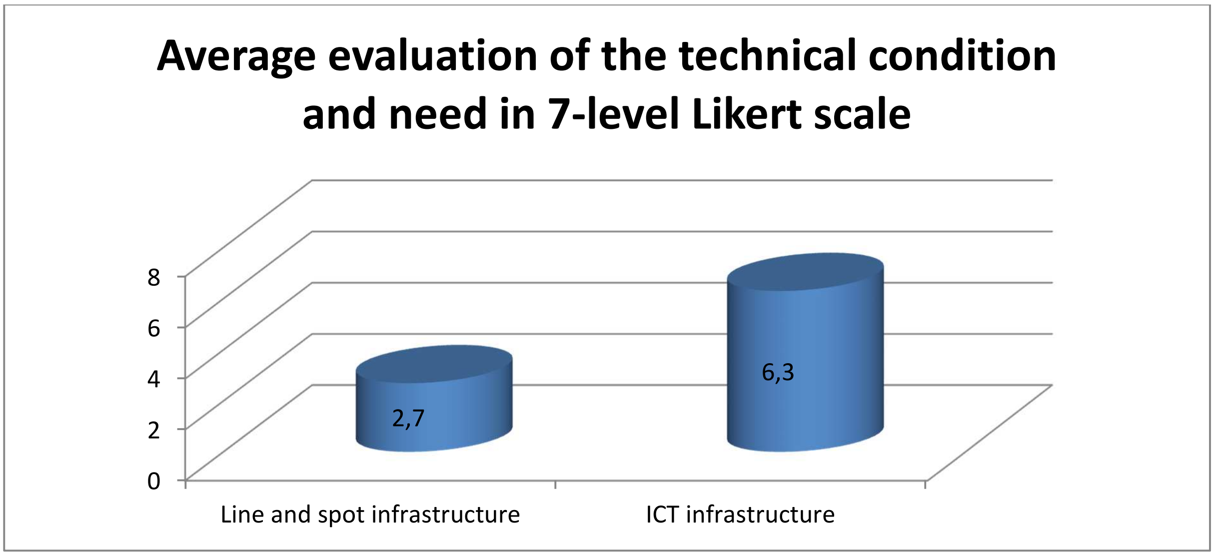

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Chart. 4. Evaluation of the line and spot infrastructure and the role of ICT infrastructure.
Wykres. 4. Ocena stanu infrastruktury liniowej i punktowej oraz roli infrastruktury teleinformatycznej.

The third area, which is vital to understand system services, namely the area of technological advancement, innovativeness and services improvement, respondents intuitively demonstrated concordance with theoretical assumptions adopted in the literature [Żabiński 2012] that "complex system services, and, particularly their component elements do not have to be of advanced technology". Intermodal service must be developed and perfected. Chart 3 presents the perception of the issues of innovativeness, improvement and technology.

The set of issues concerning the value for client caused exceptional amount of controversy. In general, respondents saw the value for client as the client's expectations towards the intermodal transport operator's offer and took it in terms of low price or, sometimes, reliability or comprehensiveness of the service. The value for client was also understood as an offer equipped with technical attributes recognized by the client. Respondents divided the value into essential and additional values. Essential values for clients were associated with regularity, stability, being ecological and comfort. Additional values are those which are individually agreed with the client or they have social or environmental dimension. Most often the respondents expressed their belief that the value for client is created by all departments of a business as well as by all businesses engaged in the creation and delivery of the intermodal service. It was also highlighted that the value is worked out in the course of mutual effort and that it arises on the grounds of cooperation and the maintenance of long-lasting positive relations. The opinion arising from the study in the fifth area - related to the view of the management system, its key components, business model and the market operation strategy - shows the picture of client-oriented business and the values for clients. The management of creation and provision of an intermodal service may be interpreted as the management of the network because the intermodal operator must engage a number of subcontractors, each of whom has their own strategy and business model of operations. The operator must establish such network of connections that its management model is coherent with the whole network. The study shows that intermodal transport operators' strategies are multilevel, modifiable and adjustable to the fluctuating market situation. Taken the dynamics of the market changes and the client's expectations, all the system components must operate in tune and undergo continual improvements so that the client obtains the best possible service. Businesses, in their strategies tend to become leaders, they tend to develop their network of contacts and to raise the standard of the offered services. System service development is subject to material components. Infrastructure poses a serious problem because it does not facilitate the development and competitiveness of the intermodal transport. The respondents negatively evaluated the condition of the line and spot infrastructure and they decisively confirmed the role communication infrastructure. See chart 4.

CONCLUSIONS

Research confirms that intermodal service in perceived in system categories and that the management of the service creation and delivery process is of network management nature. Values offered to clients are subject to material components without which the service for client may not be provided as expected. Research also shows that intermodal services in Poland must be further improved. Success is subject to the assumption that all the elements of the system must, irrespective of their technological advancement, operate in tune and cooperate. Discussions to date and the results of preliminary studies allow to define intermodal service of system character. Intermodal service is a logistically complex system service which, in a comprehensive way, handles tasks posed by its clients and meets their expectations connected with the realization of their enterprise; the service uses standardized packaging in the course of rendering the service through at least two modes of transport, uniformed shipping list throughout the transportation route and is carried out by one service provider who is in charge of the whole organizing process and who accounts to the client irrespective of the number and type of services and businesses engaged in the realization process.

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USŁUGA INTERMODALNA W UJĘCIU SYSTEMOWYM

STRESZCZENIE. **Wstęp:** Usługi transportowe możemy opisać w kategoriach systemowych. Praktycznym wyrazem systemowego podejścia do transportu są przewozy intermodalne. Powstanie systemu transportu intermodalnego spowodowało potrzebę kompleksowego traktowania procesów transportowych. Operatorzy transportu intermodalnego zarządzają całym procesem organizacji świadczenia usługi. Pojawia się zatem pytanie, czy usługę oferowaną przez operatora transportu intermodalnego można traktować jako złożoną usługę systemową. Systemowość współczesnych produktów i usług polega na tym, że o ich wartości postrzeganej dla klientów decyduje fakt, iż funkcjonują one w określonym, rozszerzonym systemie produktów i/lub usług oraz sieci ich użytkowników. Prezentowany język sieci związany jest z rozwojem w naukach organizacji i zarządzania koncepcją sieci, która staje się inspirującą ideą ostatnich lat.

Metody: Dla wyjaśnienia problematyki zastosowano analizę literaturową zagadnienia transportu intermodalnego w ujęciu rozwijającej się koncepcji marketingu produktów systemowych. W ramach przyjętego paradygmatu interpretatywnego wykorzystano badania jakościowo / ilościowe. Studium przypadku jest używane np. do opisu badanej sytuacji w ten sposób, że sam powstały opis jest rezultatem badań i może być uznany za wartościowy wkład do istniejącej wiedzy. Celem artykułu jest zwrócenie uwagi na podstawie wyników badań na konieczność traktowania usługi oferowanej przez operatorów transportu intermodalnego w kategoriach systemowych. Ujęcie systemowe wskazuje na wielość elementów tworzących usługę i wynikające stąd możliwości kompleksowego rozwiązywania potrzeb i oczekiwań klientów.

Wyniki: Uzyskane wyniki wskazują, iż usługę oferowaną przez operatora transportu intermodalnego można uznać za złożoną systemową usługę intermodalną. Poszerzają one wiedzę o transporcie intermodalnym stanowiąc tym samym przyczynek dla rozwoju koncepcji marketingu systemowego w usługach logistycznych.

Wnioski: Właściwa identyfikacja istoty systemowej usługi intermodalnej stanowi podstawę dla rozpoznania problemów klienta oraz proponowanych mu rozwiązań w kontekście wartości podstawowych i dodatkowych. Z tego powodu zarządzanie tworzeniem i świadczeniem usługi intermodalnej ma charakter zarządzania siecią, a wartości oferowane przez usługę intermodalną są warunkowanie elementami materialnymi bez których usługa dla klienta zgodnie z jego oczekiwaniami może zostać niewykonana.

Słowa kluczowe: transport intermodalny, usługa intermodalna, system transportowy, sieć

INTERMODALE TRANSPORTDIENSTLEISTUNGEN IM SYSTEMHAFTEN HERANGEHEN AN DAS PROBLEM

ZUSAMMENFASSUNG. Einleitung: Transportdienstleistungen können in systemhaften Kategorien beschrieben werden. Eine praktische Ausführung des systemhaften Herangehens an den Transport sind intermodale Frachten. Die Entstehung des intermodalen Transportsystems hatte die Notwendigkeit einer komplexen Behandlung von Transportprozessen zur Folge. Intermodale Frachtführer verwalten den ganzen Organisationsproze? bei der Ausführung einer Transport-Diensleistung. Daher kommt die Frage auf, ob die vom intermodalen Frachtführer angebotene Dienstleistung als gebundene System-Dienstleistung aufgefa?t werden kann. Die Systemhaftigkeit gegenwärtiger Produkte und Dienstleistungen beruht auf der Tatsache, dass über deren Wert für die Kunden der Sachverhalt mit entscheidet, dass sie in einem bestimmten, verbreiteten System von Produkten und/oder Dienstleistungen und Netzwerken deren Anwender in Funktion treten. Die dargestellte Sprache des Netzwerkes ist verbunden mit der Entwicklung des Know-hows und des Managements von Netzwerk-Konzepten, die in den letzten Jahren zur inspirativen Management-Idee geworden sind.

Methoden: Zur Erläuterung der Problematik wurde eine Analyse der Gegenstandsliteratur zum intermodalen Transport im Kontext der sich entwickelnden Marketing-Konzeptes für Systemprodukte in Anspruch genommen. Im Rahmen des angenommenen interpretativen Paradigmas nutzte man qualitative/quantitative Untersuchungen aus. Eine Fallstudie kommt z.B. für die Beschreibung eines zu erforschenden Sachverhaltes auf die Art und Weise zur Anwendung, dass der zustande gekommene Beschreibung selbst als ein Forschungsergebnis gilt und als ein wertvoller Beitrag zum bestehenden Wissen auf diesem Gebiet angesehen werden kann. Das Ziel der Abhandlung ist es, angesichts der Forschungsergebnisse auf die Notwendigkeit der Behandlung der durch die Frachtführer angebotenen Dienstleistung für intermodale Transporte als solche in System-Kategorien hinzuweisen. Das systemhafte Herangehen an die Fragestellungen zeigt eine Vielfalt von den eine Dienstleistung schaffenden Elementen und die daraus resultierenden Möglichkeiten für komplexe Lösungen von Kundenbedürfnissen und -erwartungen auf.

Ergebnisse: Die gewonnenen Resultate weisen darauf hin, dass man die vom intermodalen Frachtführer angebotene Dienstleistung als komplexe, intermodale und systemhafte Transport-Dienstleistung ansehen kann. Sie ergänzen das Wissen über den intermodalen Transport und leisten hiermit einen Beitrag zur Entwicklung des Konzeptes eines System-Marketings innerhalb von Logistik-Dienstleistungen.

Fazit: Eine richtige Ermittlung des Wesens einer intermodalen System-Dienstleistung bildet eine Grundlage für die Erfassung von Kundenproblemen und für die Empfehlung von entsprechenden Lösungen im Kontext der grundlegenden und zusätzlichen Werte. Aus diesem Grund weist das Management bei Erstellung und Leistung von intermodalen Dienstleistungen den Chrakter eines Netzwerk-Managements auf, und die aus einer intermodalen Transport-Dienstleistung resultierenden Werte sind durch materielle Elemente bedingt, ohne die eine dem Kunden gerechte Dienstleistung nicht zustande kommen kann.

Codewörter: intermodaler Transport, intermodale Dienstleistung, Transportsystem, Netzwerk

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AN INVENTORY MODEL FOR GENERALIZED WEIBULL DETERIORATING ITEMS WITH PRICE DEPENDENT DEMAND AND PERMISSIBLE DELAY IN PAYMENTS UNDER INFLATION

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ABSTRACT. This paper derives an inventory model is developed for items that deteriorates at a generalized Weibull distributed rate when demand for the items is dependent on the selling price. Shortages are not allowed and price inflation is taken into consideration over finite planning horizon. A brief analysis of the cost involved is carried out by theoretical analysis.

Key words: inventory, inflation, Weibull distribution, selling price dependent demand, delay in payment.

INTRODUCTION

Harris-Wilson's [1915] classical inventory model assumes that the depletion of inventory is due to a constant demand rate. However in real-life situations, there is inventory loss by deterioration. Certain products like food items, drugs, pharmaceuticals, radioactive substances deteriorate during their normal storage period and therefore how to control and maintain inventories of deteriorating items becomes an important problem for decision makers. In this connection, studies of many researchers like Ghare and Schrader [1963], Covert and Philip [1973], Shah and Jaiswal [1977], Cohen [Cohen 1973], Giri and Goyal [1985] are very important.

In the traditional inventory EOQ model, the purchaser must pay for the items as soon as the items are received. However in practice, the supplier may provide a permissible delay to their customers. Thus the delay payment to the supplier is a kind of price discount. Since paying later indirectly reduces the purchase cost, it can motivate customers to increase their order quantity. Goyal [1985] derived an EOQ model under the condition of permissible delay in payments. Aggrawal and Jaggi [1995] extended Goyal's model to allow for deteriorating items. In this connection several papers such as Davis and Gaither [1985], Liao et al. [2006], Teng [2002] are very important. These models were developed with the assumption that the inflation does not have significant role to play on the inventory model. However an inventory represents a capital investment and must complete with other assets for a firm's limited capital funds. Thus, it is important to consider the effects of inflation on inventory system. Buzacott [1975] has considered the effects of inflation on the inventory system by assuming a constant inflation rate. Mishra [1979] derived an inflation model for the EOQ in which the time value of money and different inflation rates were considered. In this connection the studies

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of many researchers like Brahmbhatt [1982], Chandra and Bahner [1985], Uthayakumar and Geetha [2009], Kyo-Lung Hou [2006] are very important. We have also studied the researchers like Mishra [2012], Prandhan [2012], Panda [2013] to develop this paper.

In the present paper, we drive an EOQ model for inventory of items that deteriorate at a generalized Weibull distributed rate with price dependent demand and permissible delay in payments under inflation.

NOTATIONS OF INVENTORY MODEL

The fundamental notations used in this paper are given as follows:

(a) L_H = Length of finite planning horizon.

(b) D[p(t)] : selling price dependent demand per unit time

$$=\lambda - \mu\, p(t)$$

Where λ is fixed demand, λ > 0, μ > 0 and λ >> μ.

(c) p (t)=pe^{rt} : selling price per unit at time

(d) c (t) = ce^{rt} : unit purchase cost at time t, where p is unit selling price at t = 0

(e) A(t) = Ae^{rt} : ordering cost per order at time t, where A is ordering cost at t=0,

(f) The deterioration rate function follows a two parameter generalized Weibull distribution given as

$$\theta(t) = \lambda\beta t^{\beta-1} e^{-\lambda t^{\beta}},\ t > 0$$

(g) h = Inventory holding cost per unit per year excluding interest charges.

(h) r : Constant rate of inflation per unit time.

(i) Q : Optimum order quantity.

(j) T : Optimum cycle time.

(k) IC : Interest charged per annum by the supplier

(l) IE : Interest earned per annum by the retailer (IC > IE)

(m) M_{DP} : Permissible delay period for setting accounts.

(n) I(t) : Instantaneous level of inventory

(o) TRC (p, T) : Total relevant cost over [0, L_H]

(p) NRP (p, T) : Total relevant profit over finite planning horizon

The components of total relevant cost (TRC) consists of

(i) Cost of placing order (CPO)

(ii) Cost of deterioration (COD)

(iii) Cost of carrying inventory excluding interest charges (CCI)

(iv) Cost of Interest charged (IC) for unsold items at the initial time or after permissible delay period M_{DP}

(v) Interest earned (IE) from sales revenue during the permissible delay period [0, M]

Hence,

TRC = CPO + COD + CCI + IC – IE

The net profit is the difference of Gross revenue and total relevant cost, where, Gross Revenue

$$(GR) = (pe^{rT} - ce^{rT}).D[p(t)]$$
$$= (pe^{rT} - ce^{rT}).\lambda\text{-}\mu pe^{rT}$$

ASSUMPTIONS OF INVENTORY MODEL

The fundamental assumptions used in this paper are given as follows:

a. Shortages are not allowed,
b. The Lead time is zero,
c. Inflation rate is constant,
d. The account is not settled during the permissible delay period,
e. During the permissible delay period the generated sales revenue is deposited in an interest bearing account,
f. At the end of credit period, the customer pay off all the unit ordered and starts paying for the interest charged on the items in stock,
g. There is no repair or replacement of the deteriorated units during the given cycle,
h. Deterioration rate follows Weibull distributed with two parameter α and β.

MATHEMATICAL FORMULATION

Let the length of planning horizon is divided into n parts, where n is the number of replenishments occur during the period L_H i.e. L_H = nT.

Due to reasons of market demand and deterioration of the items, the inventory level gradually diminishes during the period [0, T].

The differential equation that governs the variation of inventory with respect to time is

$$\frac{dI(t)}{dt} + \theta(t)\, I(t) = \mu p e^{rt} - \lambda \qquad ; 0 \le t \le T \tag{1}$$

with boundary conditions

I (0) = Q and I (T) = 0

The solution under boundary condition is given by

$$I(t) = \frac{\lambda}{\beta+1}\left(\frac{T^{\beta+1}}{t^{\beta}} - t\right) - \mu p \sum_{k=0}^{\infty} \frac{r^k}{k!\,(\beta+k+1)}\left(\frac{T^{k+\beta+1}}{t^{\beta}} - t^{k+1}\right) \tag{2}$$

Since the lengths of time intervals are all the same, we have

$I(jT+t) = I(t)\ ; 0 \le j \le n-1,\ 0 \le t \le T$

$$\therefore I(jT+t) = \frac{\lambda}{\beta+1}\left(\frac{T^{\beta+1}}{t^{\beta}} - t\right) - \mu p \sum_{k=0}^{\infty} \frac{r^k}{k!\,(\beta+k+1)}\left(\frac{T^{k+\beta+1}}{t^{\beta}} - t^{k+1}\right) \tag{3}$$

The total relevant costs in [0, L_H] consists of the following elements

1. COST OF PLACING ORDERS (CPO)

CPO = A (0) + A (T) + A (2T) + …….. A{(n-1)T}

$$= A\left(\frac{e^{rL_H}-1}{e^{rT}-1}\right) \quad \text{where } L_H = nT \tag{4}$$

2. COST OF DETERIORATED UNITS (COD)

$$\text{COD} = \{C(0) + C(T) + C(2T) + \ldots\ldots\ldots\ldots + C[(n-1)T]\}.I(jT+t)$$

$$= C\left\{\frac{\lambda}{\beta+1}\left(\frac{T^{\beta+1}}{t^{\beta}} - t\right) - \mu p \sum_{k=0}^{\infty} \frac{r^k}{k!\,(\beta+k+1)}\left(\frac{T^{k+\beta+1}}{t^{\beta}} - t^{k+1}\right)\right\}\left(\frac{e^{rL_H}-1}{e^{rT}-1}\right) \tag{5}$$

3. COST OF CARRYING INVENTORY (CCI)

$$\text{CCI} = h\sum_{j=0}^{n-1} C(jT)\int_0^T I(jT+t)\,dt$$

$$= hC\left\{\frac{\lambda}{2(1-\beta)}T^2 - \mu p \sum_{k=0}^{\infty} \frac{r^k}{(1-\beta)(k+2)\,k!}T^{k+2}\right\}\left(\frac{e^{rL_H}-1}{e^{rT}-1}\right) \tag{6}$$

There are two possibilities based on the customer's two choices.

Case I : $T \geq M_{DP}$

Since, optimal cycle length T is greater than the permissible delay time M_{DP}, the interest charged during the period $[M_{DP}, T]$ is given by

$$IC_1 = I_C \sum_{j=0}^{n-1} C(jT) \int_{M_{DP}}^{T} I(jT+t)\,dt$$

$$IC_1 = I_C C \left[\begin{array}{l} \dfrac{\lambda}{2(1-\beta)} T^2 + \dfrac{\lambda}{2(\beta+1)} M_{DP}^2 - \dfrac{\lambda}{(1-\beta^2)} T^{\beta+1} M_{DP}^{1-\beta} \\ -\mu p \displaystyle\sum_{k=0}^{\infty} \left\{ \dfrac{r^k}{(k+2)(1-\beta)\,k!} T^{k+2} + \dfrac{r^k}{(k+\beta+1)\,k!} \left(\dfrac{M_{DP}{}^{k+2}}{k+2} - \dfrac{T^{k+\beta+1} M_{DP}{}^{1-\beta}}{1-\beta} \right) \right\} \end{array} \right] \left(\dfrac{e^{rL_H}-1}{e^{rT}-1} \right) \tag{7}$$

Now Interest earned in $[0,L_H]$ is

$$IE_1 = I_e \sum_{j=0}^{n-1} p(jT) \int_0^{M_{DP}} \left(\lambda - \mu p e^{rt} \right) t\,dt$$

$$= I_e\, p \left[\lambda \frac{M_{DP}{}^2}{2} - \frac{\mu p}{r^2} \left\{ (rM_{DP}-1) e^{rM_{DP}} + 1 \right\} \right] \left(\frac{e^{rL_H}-1}{e^{rT}-1} \right) \tag{8}$$

Now, the total average cost per unit over $[0,L_H]$ is given by

$$TRC_1(p,T) = \frac{1}{T} \left(CPO + COD + CCI + IC_1 - IE_1 \right)$$

So using the equations (4), (5), (6), (7) and (8) in above equation, we have

$$TRC_1(p,T) = \frac{1}{T} \left[\begin{array}{l} A + C \left\{ \mu p \displaystyle\sum_{k=0}^{\infty} \dfrac{r^k}{(\beta+k+1)\,k!} \left(t^{k+1} - \dfrac{T^{k+\beta+1}}{t^{\beta}} \right) + \dfrac{\lambda}{\beta+1} \left(\dfrac{T^{\beta+1}}{t^{\beta}} - t \right) \right\} \\ + hC \left\{ \dfrac{\lambda}{2(1-\beta)} T^2 - \mu p \displaystyle\sum_{k=0}^{\infty} \dfrac{r^k}{(1-\beta)(k+2)\,k!} T^{k+2} \right\} \\ + I_C C \left[\begin{array}{l} \dfrac{\lambda}{2(1-\beta)} T^2 + \dfrac{\lambda}{2(\beta+1)} M_{DP}^2 - \dfrac{\lambda}{(1-\beta^2)} T^{\beta+1} M_{DP}^{1-\beta} \\ -\mu p \displaystyle\sum_{k=0}^{\infty} \left\{ \dfrac{r^k}{(k+2)(1-\beta)\,k!} T^{k+2} + \dfrac{r^k}{(k+\beta+1)\,k!} \left(\dfrac{M_{DP}{}^{k+2}}{k+2} - \dfrac{T^{k+\beta+1} M_{DP}{}^{1-\beta}}{1-\beta} \right) \right\} \end{array} \right] \\ - pI_e \left[\lambda \dfrac{M_{DP}{}^2}{2} - \dfrac{\mu p}{r^2} \left\{ (rM_{DP}-1) e^{rM_{DP}} + 1 \right\} \right] \end{array} \right] \left(\frac{e^{rL_H}-1}{e^{rT}-1} \right) \tag{9}$$

and net profit is given

$$NRP_1(p,T) = GR - TRC_1(p,T) = (pe^{rT} - Ce^{rT})(\lambda - \mu p e^{rT}) - TRC_1(p,T) \tag{10}$$

<u>Case II</u> : $T < M_{DP}$

In this case there is no interest charged.

The interest earned is

$$IE_2 = D[p(t)]I_e \sum_{k=0}^{n-1} p(jT)\left[\int_0^T t\,dt + T(M_{DP} - T)\right]$$
$$= pI_e\left[\left(\lambda - \mu p e^{rt}\right)\left(T\,M_{DP} - \frac{T^2}{2}\right)\right]\frac{(e^{rL_H} - 1)}{(e^{rT} - 1)}$$

Thus the total Relevant cost TRC_2 (p, T) per unit time is

$$TRC_2(p,t) = \frac{1}{T}\left(CPO + COD + CCI - IE_2\right)$$

$$= \frac{1}{T}\left[\begin{array}{l} A + C\left\{\mu p \sum_{k=0}^{\infty} \frac{r^k}{(\beta+k+1)k!}\left(t^{k+1} - \frac{T^{k+\beta+1}}{t^{\beta}}\right) + \frac{\lambda}{\beta+1}\left(\frac{T^{\beta+1}}{t^{\beta}} - t\right)\right\} \\ + hC\left\{\frac{\lambda}{2(1-\beta)}T^2 - \mu p \sum_{k=0}^{\infty} \frac{r^k}{(1-\beta)(k+2)k!}T^{k+2}\right\} \\ - pI_e\left\{\left(\lambda - \mu p e^{rt}\right)\left(T\,M_{DP} - \frac{T^2}{2}\right)\right\} \end{array}\right]\left(\frac{e^{rL_H} - 1}{e^{rT} - 1}\right) \qquad (11)$$

and the net profit is given by

$$NRP_2(p, T) = (pe^{rT} - ce^{rT})(\lambda - \mu p e^{rT}) - TRC_2(p,T) \qquad (12)$$

THEORETICAL RESULT OF THE MODEL

To obtain the optimum values the first order condition for NRP_1 (p,T) to be maximum is given by

$$\frac{\partial\, NRP_1(p,T)}{\partial p} = 0 \quad \text{and} \quad \frac{\partial\, NRP_1(p,T)}{\partial T} = 0$$

Now

$$\frac{\partial\, NRP_1(p_, T)}{\partial T} = 0 \text{ gives}$$

$$\frac{\partial TRC_1}{\partial T} = \lambda rp\,e^{rT} - \lambda Cre^{rT} - 2r\mu p^2 e^{2rT} + 2r\mu\, pCe^{2rT}$$

$$\frac{\partial\, NRC_1(p_1 T)}{\partial p} = 0 \text{ gives}$$

$$\frac{\partial\, TRC_1}{\partial p} = \lambda e^{rT} - 2\mu\, p\, e^{2rT} + \mu C e^{2rT}$$

Which on solving gives the solution say T_1.

It maximizes the net profit because $\frac{\partial^2 NRP_1(p_, T)}{\partial T^2} < 0$, Similarly

$\frac{\partial NRP_2(p,T)}{\partial p} = 0$ can be solved for T say this solution to be T_2

The cycle time $T = T_2$ obtained by solving equation NRP_2 (p,T)

Also it maximizes the net profit because

$$\frac{\partial^2 NRp_2(p,T)}{\partial T^2} < 0$$

Hence,

The Optimum Cycle time

$$T = \begin{cases} T_1 & \text{if } M_{DP} \le T \\ T_2 & \text{if } M_{DP} > T \end{cases}$$

So,

$$Q = \begin{cases} Q(T_1) & \text{if } M_{DP} \le T \\ Q(T_2) & \text{if } M_{DP} > T \end{cases}$$

And the net profit of the inventory system is given by

$$NRP = \begin{cases} NRp_1 & \text{if } M_{DP} \le T \\ NRp_2 & \text{if } M_{DP} > T \end{cases}$$

CONCLUSIONS

The paper studies an inventory model for deteriorating items. The demand for the item is dependent on the selling price. The replenishment source allows the inventory manager a certain fixed period of time to settle his accounts. No interest is charged during this period, but beyond it the manager has to pay an interest. The effect of inflation on various costs is also taken into consideration. The optimum ordering policy is determined by maximizing the profit over the planning horizon.

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MODEL ZARZĄDZANIA ZAPASEM WEIBULLA DLA POPYTU ZALEŻNEGO OD CEN ORAZ OPÓŹNIEŃ W PŁATNOŚCI W WARUNKACH INFLACJI

STRESZCZENIE. Praca przedstawia opracowanie modelu zarządzania zapasem dla towarów, które ulegają zużyciu zgodnie z modelem Weibulla, i których popyt zależny jest od ceny sprzedaży. Braki nie są dozwolone. Czynnik inflacji został uwzględniony dla określonego horyzontu czasowego. Została przeprowadzona krótka teoretyczna analiza kosztów.

Słowa kluczowe: zapasy, inflacja, dystrybucja Weibulla, popyt zależny od ceny zbytu, opóźnienie w płatności

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MODELL DES MANAGEMENTS FÜR DIE WEIBULL-VORRATSHALTUNG FÜR DIE DURCH PREISE BEDINGTE NACHFRAGE UND ZAHLUNGSVERZÖGERUNG BEI INFLATION

ZUSAMMENFASSUNG. Die Arbeit projiziert die Erstellung eines Modells für das Management von Vorräten an den Waren, die gemäß dem Weibull-Modell verbraucht werden und deren Nachfrage durch ihren Preis bedingt ist. Fehlmengen sind nicht zulässig. Der Inflations-Faktor wurde für einen bestimmten Zeithorizont berücksichtigt. Es wurde auch eine kurze theoretische Kostenanalyse durchgeführt.

Codewörter: Vorräte, Inflation, Weibull-Distribution, die durch den Verkaufspreis bedingte Nachfrage, Zahlungsverzug

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TRANSPORTATION PROBLEM BY MONALISHA'S APPROXIMATION METHOD FOR OPTIMAL SOLUTION (MAMOS)

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ABSTRACT. **Background:** This paper finds initial basic feasible solution and optimal solution to the transportation problem by using MAM's (Monalisha's Approximation Method).
Methods: Using the concept of comparison of the transportation problem by other methods of solution, the paper introduces a very effective method in terms of cost and time for solving these problems. This paper extends transportation problem by using different method of obtaining both initial basic feasible solution and optimal solution simultaneously other than existing methods.
Results and conclusions: It is presented a cost saving and less time consuming and accurate method for obtaining the best optimal solution of the transportation problem. With the problem assumptions, the optimal solution can still be theoretically solved using the existing methods. Finally, numerical examples and sensitivity analysis are presented to illustrate the effectiveness of the theoretical results, and to gain additional managerial insights.

Key words: Transportation Problem, Monalisha's Approximation Method for Optimal Solution (MAMOS), Comparative Analysis, Sensitive Analysis

INTRODUCTION

Over the last few years, more and more manufacturers had applied the optimization technique most frequently in linear programming to solve real-world problems and there it is important to introduce new tools in the approach that allow the model to fit into the real world as much as possible. Any linear programming model and transportation model representing real-world situations involves a lot of parameters whose values are assigned by experts' opinion, and in the conventional approach, they are required to fix an exact value to the aforementioned parameters. However, both experts and the decision maker frequently do not precisely know the value of those parameters. If exact values are suggested these are only statistical inference from past data and their stability is doubtful, so the parameters of the problem are usually defined by the decision maker in a certain space. In the mean time typical method helps for obtaining the optimal solution of the transportation model then the post optimal solution gives the managerial implications for the given problem.

Two significant questions may be found in these kinds of problems: how to handle the relationship between the parameters, and how to find the optimal values for the objective function. The answer is related to the problem of numbers.

Lai and Hwang [1992] considered the situations where all parameters are in fuzzy number. (Lai and Huang, 1992) assume that the parameters have a triangular possibility distribution. Bazaraa, Jarvis and Sherali [1990] define linear programming problems with fuzzy numbers and simplex method is used for

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finding the optimal solution of the fuzzy problem. Pattnaik [2012] presented several linear and nonlinear inventory models. Swarup, Gupta and Mohan [2006] explain the method to obtain sensitivity analysis or post optimality analysis of the different parameters in the linear programming problems.

In fact, in order to make transportation problem and linear programming more effective, the certainties that happen in the real world cannot be neglected. Those certainties are usually associated with per unit cost of the product, product supply, customer demand and so on.

The remainder of this paper is organized as follows. In Section 2, it is introduced transportation model. In Section 3, Monalisha's Approximation Method (MAM'S) Model is introduced and the steps are explained. In Section 4, applications are presented to illustrate the development of the model. Comparative analysis is developed in Section 5. The sensitivity analysis is carried out in Section 6 to observe the changes in the optimal solution. Finally Section 7 deals with the summary and the concluding remarks.

TRANSPORTATION MODEL

Minimize $z = \sum_{i=1}^{m}\sum_{j=1}^{n} x_{ij}c_{ij}$ subject to constraints:

$\sum_{j=1}^{n} x_{ij} = a_i, i = 1,2, \dots m$ (supply constraint)
$\sum_{i=1}^{m} x_{ij} = b_j, j = 1,2, \dots n$ (demand constraint)
and $\forall x_{ij} \geq 0$

MONALISHA'S APPROXIMATION METHOD (MAM'S) MODEL

STEPS

Step 1. Determine the cost table from the given problem.

(i) Examine whether total demand equals total demand. If yes, go to step 2.

(ii) If not , introduce a dummy row/column having all its cost elements as zero and supply/ demand as the (+ve) difference of supply and demand.

Step 2. Locate the smallest element in each row of the given cost matrix and then subtract the same from each element of that row.

Step 3. In the reduced matrix obtained in step 2, locate the smallest element of each column and then subtract the same from each element of that column.

Step 4. For each row of the transportation table identify the smallest and the next - to - smallest costs. Determine the difference between them for each row. Display them alongside the transportation table by enclosing them in parenthesis against the respective rows. Similarly compute the differences for each column.

Step 5. Identify the row or column with the largest difference among all the rows and columns. If a tie occurs, use any arbitrary tie-breaking choice. Let the greatest difference correspond to ith row and let 0 be in the ith row. Allocate the maximum feasible amount $x_{ij}=\min(a_i,b_j)$ in the (i, j)th cell and cross off either the ith row or the jth column in the usual manner.

Step 6. Recompute the column and row differences for the reduced transportation table and go to step 5. Repeat the procedure until all the rim requirements (the various origin capacities and destination requirements are listed in the right most outer column and the bottom outer row respectively) are satisfied.

Short Steps of MAM's Method to obtain IBFS and OS of Transportation Problem

- Row minimization/ row reduced matrix
- Column reduced matrix
- Evaluate penalty
- Highest penalty
- At zero do the allocation (corresponding)
- Draw the straight line
- Again draw the new table
- Continue the step from 1
- Until all are not adjusted
- Cost effective and consuming less time than VAM and other methods

NUMERICAL EXAMPLES

Example 1

	D1	D2	D3	D4	Supply (S)
O1	2	3	11	7	6
O2	1	0	6	1	1
O3	5	8	15	9	10
Demand (d)	7	5	3	2	17

Solve the transportation problem of the given data.

Solution

Using MAM'S Method this problem is solved.

Step 1. Determine the cost table from the given problem.

(i) Here total demand equals total demand, go to step 2.

	D1	D2	D3	D4	Supply
O1	2	3	11	7	6
O2	1	0	6	1	1
O3	5	8	15	9	10
Demand	7	5	3	2	17

Step 2. Locating the smallest element in each row of the given cost matrix and then subtracting the same from each element of that row.

	D1	D2	D3	D4	Supply
O1	0	1	9	5	6
O2	1	0	6	1	1
O3	0	3	10	4	10
Demand	7	5	3	2	17

Step 3. In the reduced matrix obtained in step 2, locating the smallest element of each column and then subtracting the same from each element of that column.

	D1	D2	D3	D4	Supply
O1	0	1	3	4	6
O2	1	0	0	0	1
O3	0	3	4	3	10
Demand	7	5	3	2	17

Step 4. For each row of the transportation table identifying the smallest and the next - to - smallest costs. Determining the difference between them for each row in the transportation table. Displaying them alongside the transportation table by enclosing them in parenthesis against the respective rows of the transportation table. Similarly computing the differences for each column of the transportation table.

	D1	D2	D3	D4	Supply	Penalty
O1	0	1	3	4	6	(1)
O2	1	0	0 $\boxed{1}$	0	1	(0)
O3	0	3	4	3	10	(3)
Demand	7	5	3	2		
Penalty	(0)	(1)	(3)	(3)		

Step 5. Identifying the row or column with the largest difference among all the rows and columns. If a tie occurs, use any arbitrary tie-breaking choice. Let the greatest difference correspond to ith row and let 0 be in the ith row. Allocating the maximum feasible amount $x_{ij}=\min(a_i,b_j)$ in the (i, j)th cell and cross off either the ith row or the jth column in the usual manner.

	D1	D2	D3	D4	Supply	Penalty
O1	0	0 $\boxed{5}$	0	1	6	(0)
O3	0	2	1	0	10	(0)
Demand	7	5	2	2		
Penalty	(0)	(2)	(1)	(1)		

Step 6. Recomputing the column and row differences for the reduced transportation table and go to step 5. Repeating the procedure until all the rim requirements (the various origin capacities and destination requirements are listed in the right most outer column and the bottom outer row respectively) are satisfied.

	D1	D3	D4	Supply	Penalty
O1	0	0 $\boxed{1}$	1	1	(0)
O3	0	1	0	10	(0)
Demand	7	2	2		
Penalty	(0)	(1)	(1)		

	D1	D3	D4	Supply	Penalty
O3	0 $\boxed{7}$	1 $\boxed{1}$	0 $\boxed{2}$	10	(1)
	7	1	2		

Optimal Solution

	D1	D2	D3	D4	Supply
O1	2	3 $\boxed{5}$	11 $\boxed{1}$	7 $\boxed{5}$	6
O2	1	0	6 $\boxed{1}$	1	1
O3	5	8	15 $\boxed{1}$	9 $\boxed{2}$	10
Demand	7	5	3	2	17

Thus the optimal allocation is:
$x_{12} = 5, x_{13} = 1, x_{14} = 5, x_{23} = 1, x_{33} = 1 \; and \; x_{34} = 2$.

The transportation cost according to the MAM's method is:

$$Total\ cost = TC = (3 \times 5) + (11 \times 1) + (7 \times 5) + (6 \times 1) + (15 \times 1) + (9 \times 2) = 100$$

Total minimum cost will be Rs. 100.

Example 2

	D1	D2	D3	D4	Supply (S)
O1	19	30	50	10	7
O2	70	30	40	60	9
O3	40	8	70	20	18
Demand (d)	5	8	7	14	34

Solve the transportation problem of the given data.

Solution
Using MAM's method the optimal solution is obtained.

Step 1. Determine the cost table from the given problem.
(i) Here total demand equals total demand, go to step 2.

	D1	D2	D3	D4	Supply
O1	19	30	50	10	7
O2	70	30	40	60	9
O3	40	8	70	20	18
Demand	5	8	7	14	34

Step 2. Locating the smallest element in each row of the given cost matrix and then subtracting the same from each element of that row.

	D1	D2	D3	D4	Supply
O1	9	20	40	0	7
O2	40	0	10	30	9
O3	32	0	62	12	18
Demand	5	8	7	14	

Step 3. In the reduced matrix obtained in step 2, locating the smallest element of each column and then subtracting the same from each element of that column.

	D1	D2	D3	D4	Supply
O1	0	20	30	0	7
O2	31	0	0	30	9
O3	23	0	52	12	18
Demand	5	8	7	14	

Step 4. For each row of the transportation table identifying the smallest and the next - to - smallest costs. Determining the difference between them for each row. Displaying them alongside the transportation table by enclosing them in parenthesis against the respective rows. Similarly computing the differences for each column.

	D1	D2	D3	D4	Supply	Penalty
O1	0	20	30	0	7	(0)
O2	31	0	0 $\boxed{7}$	30	9	(0)
O3	23	0	52	12	18	(12)
Demand	5	8	7	14		
Penalty	(23)	(0)	(30)	(12)		

Step 5. Identifying the row or column with the largest difference among all the rows and columns. If a tie occurs, use any arbitrary tie-breaking choice. Let the greatest difference correspond to ith row and let 0 be in the ith row. Allocating the maximum feasible amount x_{ij}=min(a_i,b_j) in the (i, j)th cell and cross off either the ith row or the jth column in the usual manner.

	D1	D2	D4	Supply	Penalty
O1	0	20	0	7	(0)
O2	31	0 $\boxed{2}$	30	2	(30)
O3	23	0	12	18	(12)
Demand	5	8	14		
Penalty	(23)	(0)	(12)		

Step 6. Recomputing the column and row differences for the reduced transportation table and go to step 5. Repeating the procedure until all the rim requirements (the various origin capacities and destination requirements are listed in the right most outer column and the bottom outer row respectively) are satisfied.

	D1	D2	D4	Supply	Penalty
O1	0 $\boxed{5}$	20	0	7	(0)
O3	23	0	12	18	(12)
Demand	5	6	14		
Penalty	(23)	(20)	(12)		

	D2	D4	Supply	Penalty
O1	20	0 $\boxed{2}$	2	(20)
O3	0 $\boxed{6}$	12 $\boxed{12}$	18	(12)
Demand	6	14		
Penalty	(20)	(12)		

Optimal Solution

	D1	D2	D3	D4	Supply
O1	19 $\boxed{5}$	30	50	10 $\boxed{2}$	7
O2	70	30 $\boxed{2}$	40 $\boxed{7}$	60	9
O3	40	8 $\boxed{6}$	70	20 $\boxed{12}$	18
Demand	5	8	7	14	34

Thus the optimal allocation is:
$x_{11} = 5, x_{14} = 2, x_{22} = 2, x_{23} = 7, x_{32} = 6, x_{34} = 12$.

The transportation cost according to the MAM's method is:

Total cost

TC=(19×5)+(10×2)+(30×2)+(40×7)+(8×6)+(20×12)=743

Total minimum cost will be Rs. 743.

COMPARATIVE ANALYSIS

Table 1 explains the comparative analysis of the minimum total transportation cost of MAMOS with VAM and MODI methods. MAMOS method of obtaining the minimum total transportation cost is the best method in comparison to the other methods as the total cost is optimum with exercising less steps.

Table 1. Comparative Analysis of MAMOS with VAM and MODI
Tabela 1. Analiza porównawcza MAMOS z VAM i MODI

Examples	Minimum	Method							% change of VAM and MAM	% Change of MODI and MAM
		Row minima	Column minima	Matrix minima	North West Corner Rule (NWCR)	Vogel's Approximation	MODI	Monalisha's Approximation method (MAM) for IBFS and OS		
1	Total Cost (Rs.)	112	116	112	116	102	100	100	2	0
2	Total Cost (Rs.)	1110	779	814	1015	779	743	743	36	0

Table 2. Sensitivity Analysis of Optimal Total Transportation Cost with respect to the Parameters such as Supply and Demand (Example 1)
Tabela 2. Analiza wrażliwości optymalnego kosztu transportu z uwzględnieniem paramaterów dostaw i popytu (Przykład 1)

Variable	Value	Iteration	x_{11}	x_{12}	x_{13}	x_{14}	x_{21}	x_{22}	x_{23}	x_{24}	x_{31}	x_{32}	x_{33}	x_{34}	TC	% Change in TC
S_1	5	6	0	5	0	0	0	0	1	0	6	0	2	2	99	1
d_1	6															
S_1	4	6	0	4	0	0	0	0	1	0	5	1	2	2	99	1
d_1	5															
S_1	3	6	0	3	0	0	0	0	1	0	4	2	2	2	99	1
d_1	4															
S_1	8	6	0	5	3	0	0	0	0	1	9	0	0	1	103	3
d_1	9															
S_2	2	6	0	6	0	0	0	0	2	0	7	0	1	2	98	2
d_2	6															
S_2	2	7	0	5	1	0	0	0	2	0	7	0	1	2	106	6
d_3	4															
S_3	9	7	0	5	1	0	0	0	1	0	6	0	1	2	95	5
d_1	6															
S_3	8	6	0	3	3	0	0	0	0	1	7	0	0	1	87	13
d_2	3															
S_3	8	6	0	5	1	0	0	0	0	1	7	0	0	1	71	29
d_3	1															
S_3	9	7	0	5	1	0	0	0	1	0	7	0	1	1	91	9
d_4	1															

SENSITIVITY ANALYSIS

Table 2 represents the sensitivity analysis of the optimum total transportation cost with respect to the parameters such as demand and supply of Example 1.TC is less sensitive to the parameters (S_1,d_1) and (S_2,d_2). TC is moderately sensitive to the parameters (S_2,d_3) and (S_3,d_1) and TC is more sensitive to the parameters (S_3,d_2), (S_3,d_1) and (S_3,d_4).

CONCLUSIONS

The main contribution of this paper is to deriving the optimal transportation cost by using Monalisha's Approximation Method with less steps in comparison to the VAM and MODI methods. Based on the optimal solution it allows taking a decision interactively with the decision maker in decision space. The decision maker also has additional information about the availability of the violation of requirement factor and availability factor in the constraints, and about the compatibility of the cost of the solution with his wishes for the values of the objective function which extend the classical transportation models with no sensitivity analysis in the past. By using LINGO 13.0 version software sensitivity analysis is evaluated for obtaining the managerial implications in decision space. These analysis of the results are established which present a number of insights into the economic behavior of the firms, and can serve as the basis for empirical study in the future. Thus, there are possible extensions to improve our model. The decision maker can intervene in all the steps of the decision process which makes our approach very useful to be applied in a lot of real-world problems where the information is uncertain with nonrandom, like environmental management, marketing, production area.

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METODA MONALISHY OPTYMALIZACJI PROBLEMU TRANSPORTOWEGO (MAMOS)

STRESZCZENIE. **Wstęp:** W pracy zostało przedstawione rozwiązanie problemu transportowego przy zastosowaniu MAM (metody przybliżeń Monalishy).
Metody: Poprzez porównanie rozwiązania problemu transportowego z innymi możliwymi rozwiązaniami, została zaprezentowana metoda efektywnie uwzględniająca takie czynniki jak koszt i czas. Metoda ta rozwiązywania problemu transportowego stosuje inne podejście dla uzyskania rozwiązania bazowego, jaki i optymalnego w porównaniu do innych istniejących metod.
Wyniki i wnioski: Metoda ta minimalizuje koszty i czas realizacji dla uzyskaniu optymalnego rozwiązania problemu transportowego. Rozwiązanie te może być teoretycznie osiągnięte przy zastosowaniu innych metod pod warunkiem pewnych założeń. Zaprezentowane przykłady liczbowe oraz analiza wrażliwości przybliża efektywność teoretycznych rezultatów i możliwość praktycznego ich zastosowania.

Słowa kluczowe: problem transportowy, optymalizacyjna metoda przybliżeń Monalishy, analiza porównawcza, analiza wrażliwości

DIE MONALISHA-METHODE FÜR DIE OPTIMIERUNG DES TRANSPORTPROBLEMS (MAMOS)

ZUSAMMENFASSUNG. Einleitung: In der vorliegenden Arbeit wurde eine Lösung des Transportproblems unter Anwendung der MAM (der Monalisha-Approximationsmethode) dargestellt.
Methoden: Mithilfe des Vergleiches einer Lösung des bestehenden Transportproblems mit anderen möglichen Problemlösungen wurde eine Methode, die die Faktoren Kosten und Zeit effektiv berücksichtigt, projiziert. Die betreffende Methode für die Lösung von Transportproblemen nimmt eine andere Vorgehensweise für die Erzielung sowohl einer grundlegenden, als auch einer optimalen Lösung im Vergleich mit anderen bestehenden Methoden, in Anspruch.
Ergebnisse und Fazit: Die betreffende Methode reduziert weitgehend die Kosten und Ausführungszeit zwecks der Erzielung einer optimalen Lösung des gegebenen Transportproblems. Die Lösung kann theoretisch erzielt werden bei Anwendung von anderen Methoden und bestimmten Annahmen. Die dargestellten Zahlenbeispielen und die Empfindlichkeitsanalyse projizieren die Effizienz der theoretischen Resultate und die Möglichkeit deren praktischer Anwendung.

Codewörter: Transportproblem, Monalisha-Approximationsmethode, Vergleichsanalyse, Empfindlichkeitsanalyse.

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THE DESIGN OF THE PUBLIC TRANSPORT LINES WITH THE USE OF THE FAST GENETIC ALGORITHM

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ABSTRACT. **Background:** The growing role of public transport and the pressure of economic criteria requires the new optimization tools for process of public transport planning. These problems are computationally very complex, thus it is preferable to use various approximate methods, leading to a good solution within an acceptable time.
Methods: One of such method is the genetic algorithm mimicking the processes of evolution and natural selection in the nature. In this paper, the different variants of the public transport lines layout are subjected to the artificial selection. The essence of the proposed approach is a simplified method of calculating the value of the fit function for a single individual, which brings relatively short computation time even for large jobs.
Results: It was shown that despite the introduced simplifications the quality of the results is not worsened. Using the data obtained from KZK GOP (Communications Municipal Association of Upper Silesian Industrial Region) the described algorithm was used to optimize the layout of the network of bus lines located within the borders of Katowice.
Conclusion: The proposed algorithm was applied to a real, very complex network of public transportation and a possibility of a significant improvement of its efficiency was indicated. The obtained results give hope that the presented model, after some improvements can be the basis of the scientific method, and in a consequence of a further development to find practical application.

Key words: genetic algorithm, public transport, optimization, bus lines.

INTRODUCTION

Due to constantly increasing number of cars the congestion of city centers increases, resulting in worse conditions of life and work in these areas. In many affluent countries that have experienced this problem much earlier these disadvantages were significantly reduced with an emphasis on the development of the public transport. At the same time the central control in the public transport sector is often abandoned: local authorities and local governments grant the necessary authority to commercial organizations. As a result the economic aspects take on a very great importance in the management of the public transport [Zhao 2006].

STATE OF RESEARCH

So, having regard to the limited number of means of transport and staff the most important issues are: optimal routes planning, determine the frequency of courses and the allocation of the transport means [Ceder and Wilson 1986]. In fact, each of these issues is a complex optimization problem, but generally some routines without mathematical reasoning are often used to solve them [Quak 2003]. The first attempts of strict approach to these issues date from the first half of the twentieth century [Patz 1925], more advanced works were created in the 80s, which is related to a significant increase in performance and

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availability of computers [Magnanti, Wong 1984].

Formally, the problem of designing of routes and timetables is NP - hard, so the use of the strict algorithms for such tasks is virtually impossible, due to the extremely long computation time. It is therefore necessary the use of approximate methods, which do not guarantee obtaining the optimal solution, but lead to good solutions within an acceptable time [Bielli, Caramia, Carotenuto 2002]. Especially readily used here are the artificial intelligence methods inspired by the collective behavior of living organisms [Yu, Yang, Cheng, Liu 2005] or based on evolutionary concepts [Ngamchai, Lovell 2003]. Most authors boil down the optimization problem to simple choice of a subset from a predetermined set of established communication lines [Chakroborty, Dwivedi 2002].

In the present work the development of the artificial intelligence methods [Król 2012, 2013] used to solve the problem of routes designing, determine the demand for transport means and determine the frequency of courses is continued. In contrast to the above-mentioned approaches here the full flexibility in shaping the routes is allowed during optimization.

PUBLIC TRANSPORTATION NETWORK MODEL

The main element of the public transportation network model is a weighted directed graph, whose vertices correspond to the bus-stops and the edges correspond to the possibilities of direct transit between stops.

The next important element of the model is the transportation demands. They can be established in a static or dynamic mode. In the first case the transportation needs are described by the origin - source matrix. The elements of the matrix just specify the total number of passengers who want to move between pairs of stops. In the second case there is a sequence of records, which specify the groups of passengers appearing at subsequent times at various stops with the intention of traveling to the relevant target stops.

A single communication line is a series of stops forming a closed loop - ending at the initial stop. There are no restrictions on the course of the line: it can be either circular route, as well as the typical route "back and forth". The total number of available means of transport (buses) and their capacity is determined in advance. Also the initial number of the communication lines is given.

In the process of optimizing the number of the communication lines, their shapes, the buses allocated to them and the waiting times between consecutive courses are adjusted.

GENETIC ALGORITHM AS AN OPTIMIZATION METHOD

Optimization methods using genetic algorithms mimic the process of evolution in the living nature [Arabas 2004]. Different versions of the solutions (individuals who are members of the solution population) compete for the transition to the next generation. These solutions are subject to the random changes (mutations) and randomly exchange some parts of the structure (crossover). The combination of these random operations with the targeted, but also random selection pressure leads towards the optimal solution.

Each individual in the population exposed to the selection corresponds to one of the possible variants of the communication lines layout.

A mutation is random, usually a small change in the structure of solution. The probability that an individual will be subject to mutation is a parameter of the algorithm. Several types of mutations were assumed:

- change in the allocation of buses between the lines,
- change of the waiting time between courses on a randomly selected line,
- change of the number of the lines,
- change of the direction on a randomly selected line,
- realignment of the randomly selected line.

Crossover is the exchange of parts of the structure within randomly selected pair of individuals - randomly selected subsets of the lines are transferred.

If a mutation or crossover leads to the formation of an incorrect individual, the operation is cancelled.

As an unambiguous measure of the quality of a solution the total duration of the transport operation was established - the objective function is the time elapsed from the start of the first course till the delivery of the last passenger to his destination stop. During the optimization this time is minimized. Because the fit function must be an increasing function of the quality of an individual the inverse of the objective function is here used.

In previous works the procedure calculating this time has imitated the real behavior of the passengers [Król 2012, 2013]. Each evaluated individual in the populations, which is a variant of the solution determines the shape of the line and the waiting time between courses - it allows for the determination of the time of the events in the system: bus departures from the subsequent stops. These events are key moments during the simulation. In these moments, the passengers make decisions concerning the route choice and possible transfer stops. Their full knowledge of the schedule was here assumed, which allows them to plan a trip in order to reach the destination as soon as possible. For each just occurred event, for each destination (for passengers at the bus stop and in the bus) all future events of their interest (target and interchange) were calculated.

Such procedure, although well reflecting the reality was very time-consuming and the its application to the real communication networks containing hundreds of stops led to calculations requiring several weeks of CPU time. To make matters worse, the time needed grew very rapidly with the size of the task.

The present paper proposes a substantial simplification, which allows for significant acceleration of the calculations without any loss of quality. The essence of the new approach is the observation that in a real urban environment, with a high frequency of courses and crowded streets precise determination of the time of departure from any bus stop is generally impossible. There is much more important for passengers to be sure that the time interval between two successive departures of buses on the same line with the same stop is more or less constant. Thus, the bus line can be seen as a delineated in the communication network "channel" of a certain capacity and specific times of driving to the next stop (transfer or destination). In this case, for each event, it is a need to select only the most promising at the moment, "channel" (using Dijkstra's algorithm). If the transfer is required (this is a different line than the current one, for which the event occurred), the average waiting time equal to half the time between successive departures is added. Since the analysis of the situation for the event does not require the prediction of all future events, the number of travel options is very limited (each variant is uniquely determined by the current stop, the target stop and the chosen line). In this situation, further improvement was introduced: the best travel options are stored and where the repetition of the event occurs it is not necessary to re of the very time consuming analysis.

When creating the next generation the roulette wheel method is used: the probability of transition to the next generation of an individual is proportional to the value of fit function.

The initial population consists of the identical individuals, for which the shapes of the lines are determined by the popular heuristic procedure [Baaj, Mahmassani 1995, Fusco, Gori, Petrelli 2002]. Its principle is to search the two stops with the greatest transportation needs and the demarcation of the fastest route between them. Successive, due to transportation needs stops either already belong to the route, or are attached to it now. Buses are assigned to the lines evenly with the available pool. Optimization begins therefore from a relatively good solution.

RESULTS

At the first stage the fast new version of the algorithm with the existing one was compared. The subject of the tests was a simple model of the public transportation network consisting of 20 stops [Król 2013]. To meet the transportation needs the 20 buses of a capacity of 60 passengers each were allocated, initially distributed between 4 lines. The transportation needs were established in a static mode, the total number of passengers was 2595. Figure 1 shows the graph of the network with the transportation needs for individual stops (the radius of the circle is proportional to the number of passengers for which the stop is an initial or a destination stop).

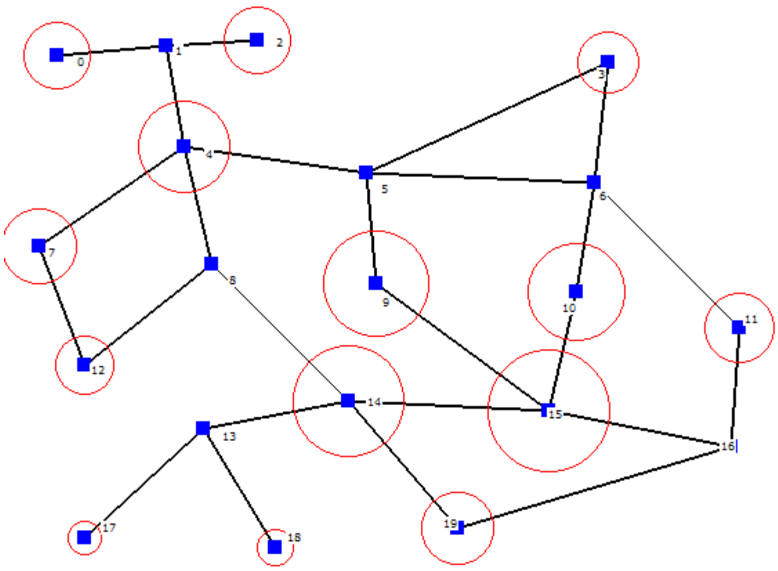

Fig. 1. Graph of the tested public transportation network and the transportation needs
Rys. 1. Graf testowej sieci komunikacji publicznej i potrzeby transportowe

For a fair comparison of the both algorithms, each of them was running several times (genetic algorithm is non-deterministic procedure). The obtained results are gathered in Table 1. As an output of the algorithm the total time of realization of the transportation needs (in minutes) was selected.

Table 1. Comparison of the results obtained using both algorithms
Tabela 1. Porównanie wyników otrzymanych przez zastosowanie obu algorytmów

Criterion	Algorithm	
	Full	Fast
Computation time	9’20”	1’04”
The best result	137’	140’
Average result	150’	148’
Standard deviation	6.7’	7.0’

While analyzing the optimization process it also can be seen that a fast algorithm reaches the final solution much sooner - since about 30 generations the solution has not been practically improved. Meanwhile, the solution of the full algorithm became stable only at about 70 generation. Figure 2 shows the comparison of the average values of the fit function during the optimization for the both algorithms. Thus, the advantage in speed of the fast algorithm is even greater. In addition, the time consumed by the fast algorithm increases with the square of the number of stops, in the case of the full algorithm, this increase is much steeper.

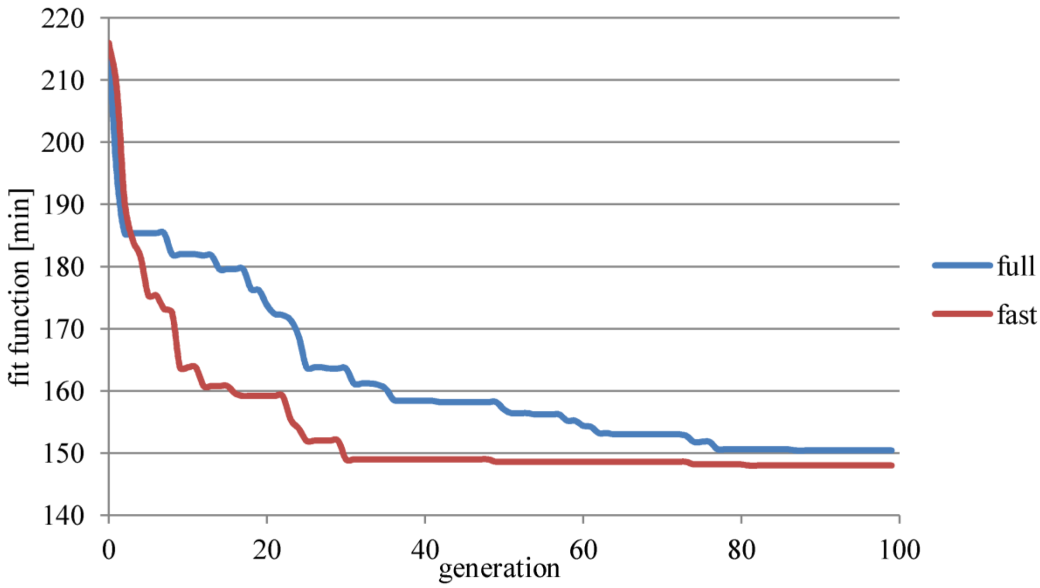

Fig. 2. Comparison of the optimization progress for the both algorithms
Rys. 2. Porównanie przebiegu optymalizacji dla obu algorytmów

After comparing the both algorithms the fundamental research phase was implemented: the fast algorithm was applied to a real, very complex network of public transportation. As the subject of the study a part of the bus lines network of Communications Municipal Association of Upper Silesian Industrial Region (KZK GOP) located inside the city of Katowice was selected. The data acquired from KZK GOP under the work of Giejsztor [2014] was here used. Figure 3 shows a simplified graph of the public transportation network within the Katowice. Transportation needs have been introduced in a static mode, in the form of a source - destination matrix, and values of the elements of this matrix are based on the actual measurements of fillings in buses in March 2011. These values were adjusted using a simulated annealing algorithm so as to get the best accordance with actual fillings. The obtained values describe the average numbers of passengers who want to start their trip in one hour of morning rush time. Since the routes of many lines cross the borders of Katowice and lead to other cities in the region, the summed external transportation needs were assigned to the border stops. As can be seen most passenger intends to travel to and from the city center, lots of traffic is also associated with several stops located on large housing estates on the outskirts of the city. The participation of the trips crossing the borders of the city is much smaller. The details describing the model are summarized in Table 2.

Table 2. The data describing the communication network model of Katowice
Tabela 2. Dane opisujące sieć komunikacyjną w Katowicach

Parameter	Value
Number of stops	281
Initial number of lines	80
Number of buses	350
Capacity of a bus	120
Total number of passengers	24839
Initial time of realization of the transportation needs	225’

The values in Table 2 correspond to KZK GOP resources involved in the operation of bus lines in the area of Katowice. The initial layout of communication lines has been generated by the heuristic procedure mentioned above.

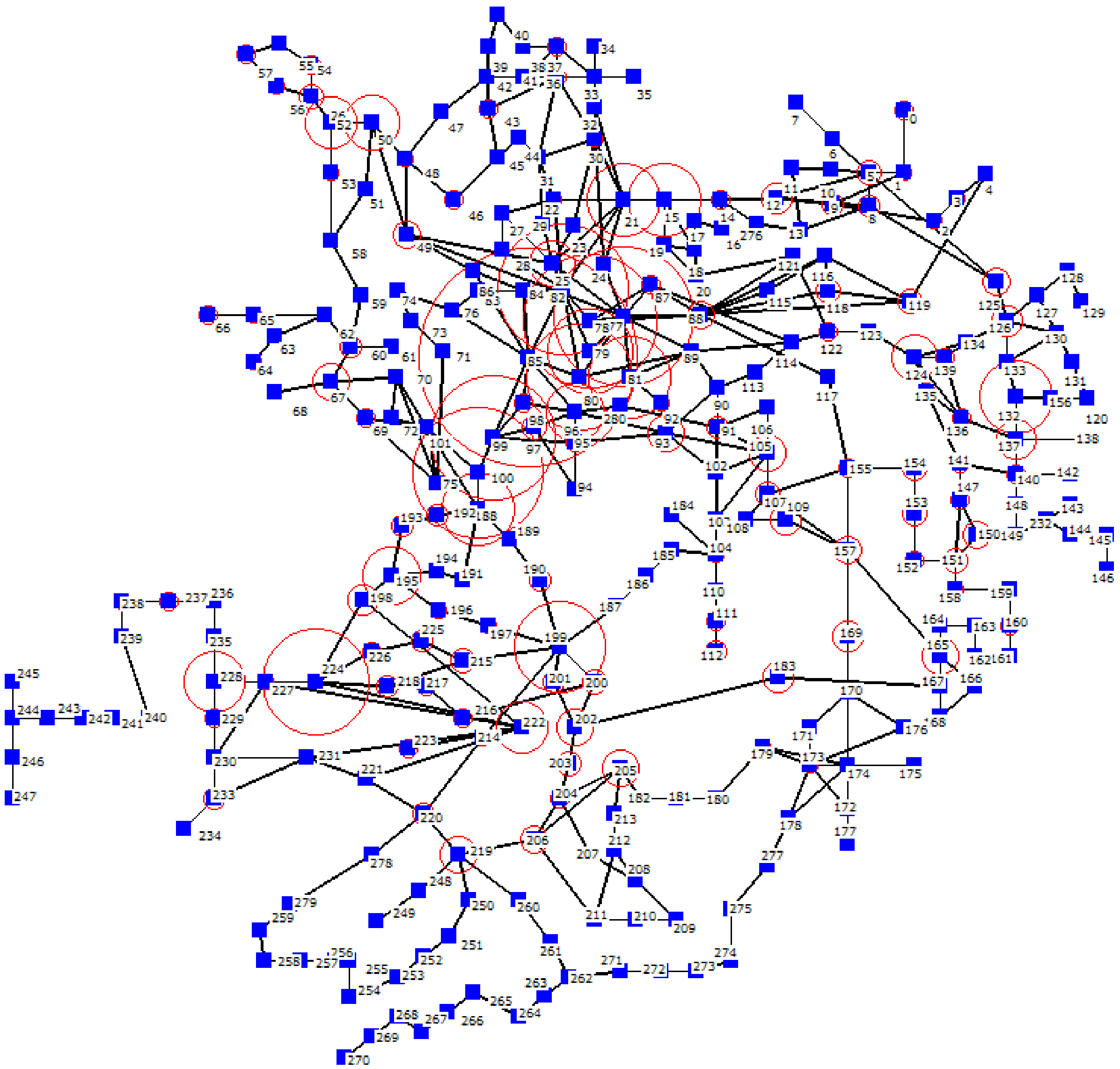

Fig. 3. Graph of the public transportation network and the transportation needs of Katowice
Rys. 3. Graf sieci komunikacji publicznej Katowic i potrzeby transportowe

As a result of the optimization of the communication lines layout the reduction of the time of realization of the transportation needs to 152 minutes was achieved (an improvement of 33%). CPU time required to obtain such result was on the order of a few hours.

In a further series of tests the actual layout of bus lines was optimized. Already preliminary comparison suggests that it is far from optimal. The initial time of realization of the same transportation needs in this case was about 320 minutes. After optimization, the result obtained was similar to the previous (an improvement of more than 50%).

CONCLUSIONS

The paper presents the application of the modified genetic algorithm for the design of the communication lines and the timetable. The proposed algorithm is based on the earlier works, and the essence of the introduced changes is the "macroscopic" look at a public communication line - as a channel of a certain capacity instead of the considerations of movement of the individual vehicles. Tests have shown that both approaches yield identical results, and the new algorithm is many times faster.

The proposed algorithm was applied to a real, very complex network of public transportation and a possibility of a significant improvement of its efficiency was indicated.

The obtained results give hope that the presented model, after some improvements can be the basis of the scientific method, and in a consequence of a further development to find practical application.

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PROJEKTOWANIE PRZEBIEGU LINII KOMUNIKACJI PUBLICZNEJ ZA POMOCĄ SZYBKIEGO ALGORYTMU GENETYCZNEGO

STRESZCZENIE. **Wstęp:** Rosnąca rola komunikacji publicznej przy jednoczesnym nacisku kryteriów ekonomicznych wymaga zastosowania nowych narzędzi optymalizacyjnych do procesu planowania transportu publicznego. Problemy te są bardzo złożone obliczeniowo, więc korzystne jest zastosowanie różnych metod przybliżonych, prowadzących do uzyskania dobrych rozwiązań w akceptowalnym czasie.

Metody: Jedną z takich metod jest algorytm genetyczny, naśladujący procesy ewolucji i doboru naturalnego w przyrodzie. W prezentowanej pracy sztucznemu doborowi podlegają różne warianty układu linii komunikacji publicznej. Istotą proponowanego podejścia jest uproszczony sposób obliczania wartości funkcji dostosowania pojedynczego osobnika, co przynosi stosunkowo krótki czas obliczeń nawet dla dużych zadań.

Wyniki: Pokazano, że mimo wprowadzonych uproszczeń, jakość uzyskanych rezultatów nie ulega pogorszeniu. Korzystając z danych uzyskanych od KZK GOP (Komunikacyjny Związek Komunalny Górnośląskiego Okręgu Przemysłowego) zastosowano opisywany algorytm do optymalizacji układu części sieci linii autobusowych znajdujących się w obrębie miasta Katowice.

Wnioski: Zaproponowany algorytm zastosowano do rzeczywistej, bardzo złożonej sieci komunikacji publicznej uzyskując znaczącą poprawę jej efektywności. Otrzymane rezultaty dają nadzieję, że prezentowany model po udoskonaleniu i może być podstawą naukowej metody, a w konsekwencji dalszego rozwoju znaleźć praktyczne zastosowanie.

Słowa kluczowe: algorytm genetyczny, transport publiczny, optymalizacja, linie autobusowe.

PROJEKTIERUNG VON FAHRSTRECKEN IM ÖFFENTLICHEN VERKEHR ANHAND EINES SCHNELLEN GENETISCHEN ALGORITHMUS

ZUSAMMENFASSUNG. Einleitung: Die wachsende Rolle des öffentlichen Verkehrs bei gleichzeitiger Beeinflussung von wirtschaftlichen Kriterien bedarf für die Planung des öffentlichen Transports der Anwendung von neuen Optimierungswerkzeugen. Die Problemstellungen sind hinsichtlich der Berechnungen sehr kompliziert, daher ist die Anwendung von unterschiedlichen Approximationsmethoden, die zur Erzielung von guten Lösungen in einem akzeptablen Zeitraum führen, sehr brauchbar.

Methoden: Eine solche Methode stellt der genetische Algorithmus, der die in der Natur auftretenden Evolutionsprozesse und die natürliche Selektion nachzuahmen vermag, dar. Verschiedene Varianten von Fahrstrecken-Verläufen im öffentlichen Verkehr unterliegen in der vorliegenden Arbeit einer künstlichen Selektion. Der Swchwerpunkt der vorgeschlagenen Vorgehensweise beruht auf einer vereinfachten Berechnungsmethode des Funktionswertes der Anpassung eines Einzelwesens an einen gewissen Sachverhalt, was eine relative kurze Berechnungszeit, auch im Falle von größeren Berechnungsaufgaben, gewährleistet.

Ergebnisse: Es konnte projiziert werden, dass trotz der eingeführten Vereinfachungen die Qualität der gewonnenen Berechnungsresultate aufrechterhalten blieb. Aufgrund der Daten, die vom Kommunalen Verkehrsverband des Oberschlesischen Wirtschaftskreises gewonnen wurden, hat man den ausgearbeiteten Algorithmus für die Optimierung eines Teiles von Buslinien innerhalb des Verkehrssystems der Stadt Katowice in Anspruch genommen.

Fazit: Der vorgeschlagene Algorithmus wurde innerhalb eines wirklichen, sehr komplizierten, öffentlichen Verkehrsnetzes eingesetzt, wobei man eine bedeutende Verbesserung dessen Effektivität erzielte. Die dabei gewonnenen Resultate lassen die Hoffnung entstehen, dass das projizierte Modell nach weiterer Vervollkommnung zu einer wissenschaftlichen Methode werden und in Folge einer weiteren Entwicklung eine praktische Anwendung finden kann.

Codewörter: geneticher Algorithmus, öffentlicher Verkehr, Optimierung, Buslinien

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MODEL OF THE IMPACT OF PARAMETERS CONTROLLING REPLENISHMENT IN THE BS (MIN-MAX) CONTINUOUS REVIEW SYSTEM ON THE ACTUAL INVENTORY AVAILIBILITY

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ABSTRACT. **Background:** Due to random changes in demand, inventory management is still - despite the development of alternative goods flow management concepts - an important issue both in terms of costs of maintenance and replenishment as well as the level of service measured by inventory availability levels. There are a number of replenishment systems to be used in such conditions, but they are most often formed on the basis of two basic ones: a system based on the reorder point and based on periodic inspection. This paper refers to the former system, the BS system (min-max), in which an order is placed after reaching inventory level B (information level, reorder point) for a quantity allowing to reach level S. This system is very often used in business practice. Observations conducted under realistic conditions indicate the need to improve the classical models describing the system. This results, among other things, from the fact that the actual level of available inventory at the start of the replenishment cycle may be significantly lower than level B, resulting in lower than expected levels of customer service. Taking account of this phenomenon through model determination of the cumulative distribution function for the observed difference makes it possible to select the correct parameters to control the replenishment system in question and - therefore - to achieve the expected economic effects.

Methods: The object of the study is to create a mathematical model allowing the determination of the required inventory level B taking into account the difference Δ between this level and the actual level of inventory at the start of the replenishment cycle. To determine the effect of various factors such as demand distribution parameters in the adopted unit of time and the difference between level S (max) and B (min), a dedicated tool (simulator in EXCEL spreadsheet) for determining the distribution of frequency of value Δ has been developed. Then a mathematical model allowing the determination of the distribution and its parameters as a function of the difference r = S-B for virtually any distribution of demand has been developed and implemented in a separate EXCEL spreadsheet.

Results: It was found that there is the need to take into account the distribution of the difference between the information level B (the reaching or exceeding of which is a signal to place an order) and the actual level of inventory at the start of the replenishment cycle when determining the inventory replenishment control parameters in the BS system. A mathematical model allowing to determine the incidence and distribution of function of value depending on the demand distribution parameters and difference r between the S level (max) and B level (min) has been developed and used for calculations. High compatibility of results obtained from model calculations with the results obtained through simulation imitating real events has been shown.

Conclusions: The model described in this paper will allow a more accurate determination of parameters that control the BS system to safeguard the required level of service and conditions relating to the volume of deliveries. Further work is required to develop an effective model solution for a general formula presented in this paper used to calculate the B parameter as a function of the required service level and the S parameter depending on the designated (e.g. economic) average delivery.

Key words: inventory management, restocking in the BS system (min-max, up-to-level review continuous review replenishment model), level of service, modelling, simulation.

INTRODUCTION

The discussed BS inventory replenishment system [ELA, 1994] consists in that an order may be placed at any moment when available inventory achieves or drops below B-level, while order quantity is calculated as a difference between determined maximum level (S) and available inventory [ELA, 1994].

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The BS system is widely used in practice, particularly in the case of a limited number of relatively big releases.

In literature, the system is often referred to as up-to-level continuous review (in opposition to fixed order continuous review, BQ-level according to ELA terminology). It should be noted that in numerous publications, the term "up-to-level" also refers to a periodical review, in the classical ST variant, and Ss. The subject of papers based on the discussed system (BS in continuous review) is different aspects of inventory replenishment. They include such elements as determining a system's optimum parametres considering cost-related criteria (e.g. [Babai., Jemai, Dallery, 2011], where demand distribution compatible with Poisson's distribution, characterising slowly-rotating entries, was adopted). Other papers present the effectiveness of various forecasting methods in implementing the BS-system (e.g. [Teunter, Sani, Li, Disney, Gaalman, 2014]. In most cases, the research is based on an assumption on the stochastic nature of changes to quantities influencing the execution of a system, quantities of deficiencies and scale of the so-called pent-up demand (e.g. [Taleizadeh, Taghi, Niaki, Meibodi, 2013]. In most papers, developed algorithms are used to simulate studied processes.

The works analysed usually assume that inventory replenishment commences upon the achievement of reorder point B. Practice and initial simulation tests carried out by the author of this paper show that in many cases it happens with a level of inventory much lower than the set B-level. Thus, the purpose of the paper is to determine the impact of different factors (particularly the distribution of frequency in which non-zero demand quantities and values of parametres B and S occur), and the impact of this phenomenon on inventory replenishment, particularly in relation to service level.

CHARACTERISTICS OF THE BS SYSTEM

General rules governing the execution of the BS system include:

1) Determining the controlling parametres:
   - setting the required service level (method of factor definition and factor value),
   - calculating parametres of demand distribution in an adopted time unit (random changes exclusively),
   - determining LT - replenishment lead time
2) Specifying informational level (reorder point) B. In a classic approach, informational level B is specified on the basis of dependence

$$B = D \cdot LT + SS \qquad (1)$$

where:
D – mean demand in an adopted time unit (e.g. mean daily/weekly demand)
LT - replenishment lead time between review and receipt of delivery.
SS - safety stock expressed in the following way:

$$SS = \omega \cdot \sigma_{DLT} \qquad (2)$$

where:
ω – safety coefficient, dependent on adopted service level and type of distribution of demand occurrence frequency,
σ_{DLT} - standard deviation of demand in replenishment cycle time

In general cases (random variability of demand and replenishment cycle time), the following formula applies:

$$\sigma_{DLT} = \sqrt{\sigma_D^2 \cdot LT + \sigma_{LT}^2 \cdot D^2} \qquad (3)$$

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

3) Determining level S, to which inventory will be replenished upon ordering. It should be borne in mind that difference between levels S and B will determine mean order quantity. In a simplified approach, S =

B+Q, where Q may be, for instance, economic order quantity (Q = EOQ).

4) An inventory replenishment procedure compatible with set parametres, which consists in that in a specific moment, resulting from an adopted review cycle,
   - current status of economic stock (available, disposed stock) S_e is determined

$$S_e = S_W + S_o + S_{er} - S_b \qquad (4)$$

where:

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

   - and an order in the following quantity is made:

$$q = S - S_e \qquad (5)$$

Figure 1 illustrates rules governing the implementation of the BS system.

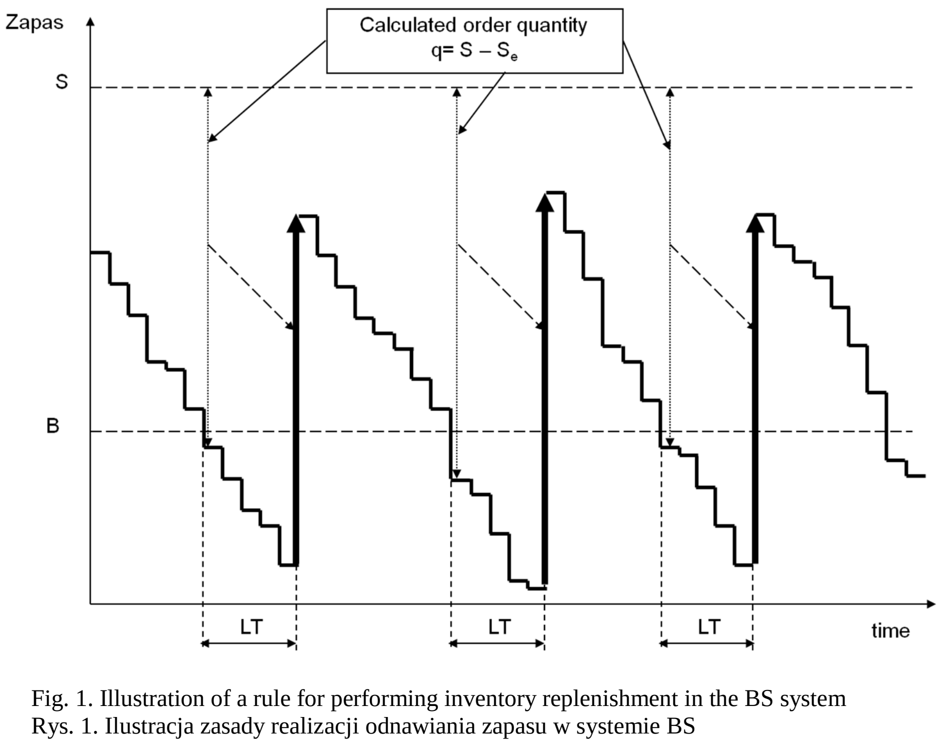


Fig. 1. Illustration of a rule for performing inventory replenishment in the BS system
Rys. 1. Ilustracja zasady realizacji odnawiania zapasu w systemie BS

Considerations presented in the paper assume invariability of replenishment cycle time T ($\sigma_T \approx 0$). In such a case, dependence (1) will assume the following form:

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

An additional assumption concerns a type of distribution of demand D. Normal distribution has been assumed as a characteristic one for fast-moving goods.

A premise underlying the considerations presented in the article was the fact that, according to the assumption, upon making an order (more generally, upon commencing a replenishment cycle), available inventory is usually lower than B-level. Difference between B and actual level of economic stock S_e on commencing the cycle has been here defined as Δ:

$$\Delta = B - S_e \qquad (7)$$

For further considerations, the following abbreviations have been adopted:

- **D** – arithmetic mean from all demand quantities
- σ_D - standard deviation from all demand quantities
- **D*** - average (arithmetic mean) from non-zero demand quantities
- σ_{D*} - standard deviation calculated from non-zero demand quantities

Simulation tests of the BS inventory system carried out by the author have shown dependence between service level calculated as probability of servicing demand in a replenishment cycle (α Service Level) and a difference between levels B and S (**r**=S-B). An example of this dependence has been shown in Figure 2a. A simulation experiment described below was carried out to confirm these observations.

The tests were performed with the use of an authorship application made in an Excel spreadsheet.

To explain the phenomenon observed during the simulation, illustrated in Figure 2, distribution of frequency of quantity **Δ** in function r was tested in detail. To this end, a tool (simulator) was configured in a way to additionally allow the measurement of actual inventory level on launching a replenishment cycle, thus upon the meeting of condition $S_e \leq B$). The registration allowed determining the distribution of variable **Δ** (**Δ** = B – S_e) and calculating its parametres.

Both in the simulation experiment and in further model calculations, a classic probabilistic definition defining service level as probability of non-occurrence of inventory shortage in a period covering replenishment cycle LT has been adopted as a definition of service level influencing practical use of dependence (3). It is defined as probability of servicing demand α Service Level [Tempelmeier H., 2000].

SCOPE OF SIMULATION TESTS SERVING THE CONSTRUCTION AND VERIFICATION OF THE MODEL

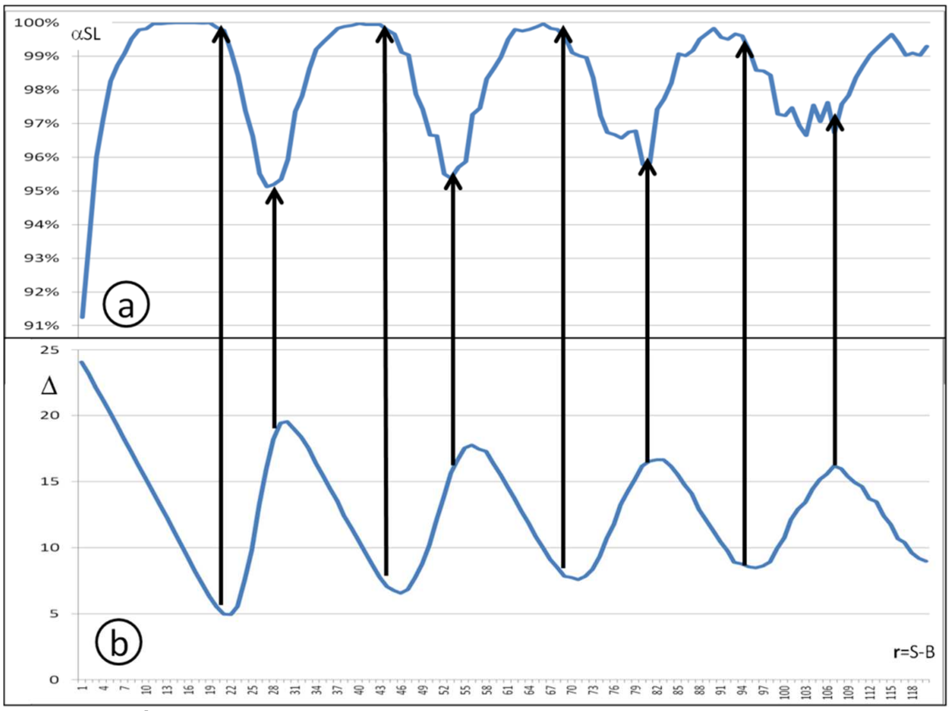
The main source of data for simulating inventory replenishment are randomly generated time series of demand for an adopted time unit (1 day was adopted). Mean parameters of generated distributions were: mean **D** = 25.06, standard deviation σ_D=2.50. The nature of changes in demand allows assuming that zero values do not occur in a time series of demand, thus: **D***=**D**=25.06 and σ_{D*}=σ_D=2.50. Generated distributions were compatible with a normal distribution, which was verified with the Kolmogorov–Smirnov test.

Simulation tests performed made it possible to specify (for an adopted demand distribution) dependence between quantities Δ and **r**. It has been shown in Figure 2b.

The first step towards developing a mathematical model of the observed phenomenon was the definition of model dependence of the value of expected difference Δ on difference **r**: E(Δ)=f(**r**).

The model's character is discreet. Studied values of difference r correspond to successive natural figures. It will correspond to the majority of actual cases which deal with a defined individual quantity of releases. Thus, for any value of index j: $r_j = S_j - B$. It was also assumed that $r_1 = 1$ and $r_{j+1} = r_j + 1$.

Calculation of expected value E(Δ)=f($\mathbf{r}_j$) is of recursive nature. While in the case when $D_i^* \geq r_j$, there is $\Delta_{i,j} = D_i^* - r_j$,
for $D_i^* < r_j$ there is $\Delta_{i,j} = E(\Delta_{r_j - D_i^*})$.



Source: own study

Fig. 2. The courses of dependence of an adopted αSL - 2a service level indicator and difference Δ ($\Delta = B - S_e$) – 2b, on the difference of levels **r**=S – B

Rys. 2. Otrzymane drogą symulacji przebiegi zależności przyjętego wskaźnika poziomu obsługi POP - 2a, oraz różnicy Δ ($\Delta = B - Z_w$) – 2b, od różnicy poziomów **r**=S-B.

Table 1. Rules of calculation of expected value E(Δ)=f($\mathbf{r}_j$)

Tabela 1. Zasady obliczania oczekiwanej wartości E(Δ)=f($\mathbf{r}_j$)

	D^*_i	$D^*_1=1$	$D^*_2=2$	$D^*_3=3$	$D^*_4=4$		D^*_{max-1}	D^*_{max}
r	$\Sigma f(D^*_i)=1$	$f(D^*_1)$	$f(D^*_2)$	$f(D^*_3)$	$f(D^*_4)$	.	$f(D^*_{max-1})$	$f(D^*_{max})$
$r_1=1$	**Δ(r₁)**	**0**	**1**	**2**	**3**	.	$\mathbf{D^*_{max-2}}$	$\mathbf{D^*_{max-1}}$
$r_2=2$	**Δ(r₂)**	Δ(r₁)	**0**	**1**	**2**	.	$\mathbf{D^*_{max-3}}$	$\mathbf{D^*_{max-2}}$
$r_3=3$	**Δ(r₃)**	Δ(r₂)	Δ(r₁)	**0**	**1**	.	$\mathbf{D^*_{max-4}}$	$\mathbf{D^*_{max-3}}$
$r_4=4$	**Δ(r₄)**	Δ(r₃)	Δ(r₂)	Δ(r₁)	**0**	.	$\mathbf{D^*_{max-5}}$	$\mathbf{D^*_{max-4}}$
....								
r_{max-1}	$\mathbf{\Delta(r_{max-1})}$	$\Delta(r_{max-2})$	$\Delta(r_{max-3})$	$\Delta(r_{max-4})$	$\Delta(r_{max-5})$	.		
r_{max}	$\mathbf{\Delta(r_{max})}$	$\Delta(r_{max-1})$	$\Delta(r_{max-2})$	$\Delta(r_{max-3})$	$\Delta(r_{max-4})$	.		

$G[D^*_i;r_j] = 0$	$G[D^*_i;r_j] = 1$

Source: own study

The above rules have been presented in Table 1. For $D^*=4$ and **r**=3, for instance, the difference is: Δ = 4 – 3 =1, and this quantity (occurring with a probability equal to $f(D^*=4)$ is included in the calculation of expected value E(Δ) = Δ(**r**=3).

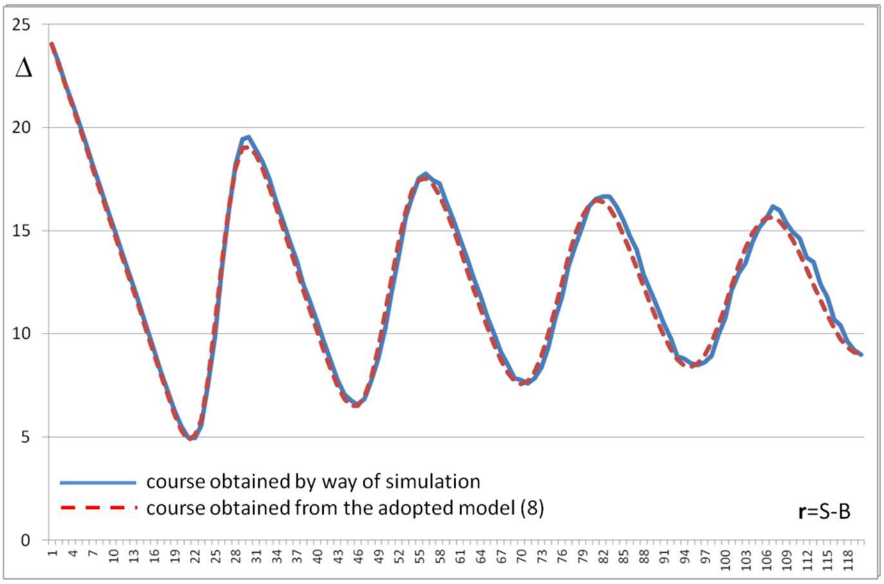
For $D^*=3$ and r=4, on the other hand, the difference is: Δ = 3 – 4 = –1. For calculating expected value E(Δ) = Δ(r=4), in this case, value E(Δ) = Δ(r=1) will be calculated "earlier".

The above elements allow presenting the rule for calculating expected value E(Δj) in the following manner:

$$E(\Delta_j) = \Delta(r_j) = \sum_{i=1}^{i_{max}} G[D_i^*; r_j] \cdot (D_i^* - r_j) \cdot f(D_i^*) + \sum_{i=1}^{i_{max}} \{1 - G[D_i^*; r_j]\} \cdot \Delta(r_j - D_i^*) \cdot f(D_i^*) \qquad (8)$$

where: $G[D_i^*; r_j] = \begin{cases} D_i^* \geq r_j \rightarrow G[D_i^*; r_j] = 1 \\ D_i^* < r_j \rightarrow G[D_i^*; r_j] = 0 \end{cases}$

Figure 3 illustrates compatibility of courses of dependence Δ = f(**r**) obtained by way of simulation and with the use of the presented model (formula 8).



Source: own study

Fig. 3. Comparison of courses Δ=f(**r**) for results obtained by way of simulation and with the use of the mode (formula 8)
Rys. 3. Porównanie przebiegów Δ=f(**r**) dla wyników otrzymanych drogą symulacji i przy zastosowaniu modelu (formuła 8)

Using the model to determine the quantity of parametres B and S, which control the functioning of the system and guarantee maintaining required service level, and observing restrictions or requirements related to the volume of sales, requires modifying the classic formula to enable it to calculate reorder level B (formula 6).

In the first approximation, expected quantity E(Δ) was added to the formula.

$$B = D \cdot LT + E(\Delta) + \omega \cdot \sigma_D \sqrt{LT} \qquad (9)$$

As it was done previously, variation of replenishment cycle time was neglected.

Thus, for the adopted reorder level B, expected service level may be determined on the basis of dependence:

$$POP = \Phi[\omega] = \Phi\left[\frac{B - D \cdot LT - E(\Delta)}{\sigma_D \cdot \sqrt{LT}}\right] \qquad (10)$$

On the basis of courses presented in Figure 4a, it may be concluded that using the formula (9) would provide understated levels of reorder point B for specific values of difference **r**, which in practice would mean lower service levels than expected.

To improve compatibility of both courses, standard deviation of difference Δ (σ_Δ) was additionally introduced to calculations of safety stock. In calculations, a commonly-known dependence on the calculation of a random variable $Var(X) = E(X^2) - [E(X)]^2$ was adopted.

Previously specified quantity E(Δ) was used, and expected value E(Δ²) was calculated in the same way at it has been presented above.

$$E(\Delta_j^2) = \sum_{i=1}^{i_{max}} G[D_i^*; r_j] \cdot (D_i^* - r_j)^2 \cdot f(D_i^*) + \sum_{i=1}^{i_{max}} \{1 - G[D_i^*; r_j]\} \cdot [\Delta(r_j - D_i^*)]^2 \cdot f(D_i^*) \qquad (11)$$

Thus, with the use of results obtained from formulas (8) and (11), standard deviation of Δ (σ_Δ):was calculated:

$$\sigma_{\Delta_j} = \sqrt{E(\Delta_j^2) - [E(\Delta_j)]^2} \qquad (12)$$

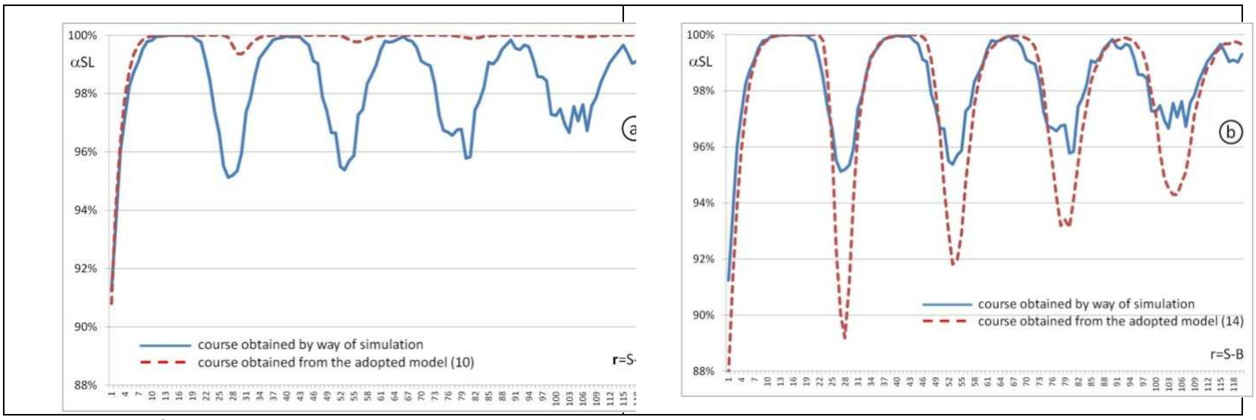
On the basis of these calculations, formula (12) was broadened to the following form:

$$B = D \cdot LT + E(\Delta) + \omega \cdot \sqrt{\sigma_D^2 \cdot LT + \sigma_\Delta^2} \qquad (13)$$

As it can be seen, it was assumed here that distributions of both variables (D_T=D·LT and Δ) are compatible with a regular distribution, which would allow using a common safety coefficient and simple determination of expected service level.

$$POP = \Phi[\omega] = \Phi\left[\frac{B - D \cdot LT - E(\Delta)}{\sqrt{\sigma_D^2 \cdot LT + \sigma_\Delta^2}}\right] \qquad (14)$$

Comparison of results of simulation tests and quantities obtained from the model once again pointed at a significant discrepancy (Fig. 4b), however of a different nature than in the case of formula (10) (Figure 4a).



Source: own study

Fig. 4. Comparison of courses αSL=f(r) for results obtained by way of simulation and with the use of models described by formulas 10 (Fig. 4a) and 14 (Fig. 4b).
Rys. 4. Porównanie przebiegów POP=f(r) dla wyników otrzymanych drogą symulacji i przy zastosowaniu modeli opisanych formułami 10 (rys. 4a) oraz 14 (rys. 4b).

On the basis of courses presented in Figure 4, it may be concluded that using formula (9) would this time provide overstated levels of reorder B for specific values of difference **r**, which in practice would mean unnecessarily higher service levels than expected.

The above would mean that most probably, at least for certain scopes of difference **r**, the assumption regarding the compatibility of distribution of quantity Δ with regular distribution is incorrect. To this purpose, detailed simulation tests were carried out in order to determine the character of distribution, occurrence frequency and a course of distribution function of difference Δ, for various levels of variable **r**.

It was stated that for **r** values with greatest deviations between simulation results and the model, distribution f(Δ) is of complex nature and is indeed a mixture of two distributions resulting from distribution f(D*). It has been illustrated in Figure 5.

Thus, an attempt at developing a model of distribution f(Δ) for different levels of difference **r** was taken. As in the case of a model for an expected value and standard deviation Δ, it is a complex recursive model possible to be implemented in a spreadsheet.

As it was in the case of determining E(Δ) and σ_Δ, the model was verified by creating a table (i_{max}=50) x (j_{max}=500).

$$f(\Delta_{i,j}) = G[i;j;i_{max}] \cdot f(D^*_{i+j}) + \sum_{k=0}^{i_{max}} H[D^*_{i+k};r_{j-1-k}] \cdot f(\Delta_{i+k,j-1-k}) \cdot f(D^*_{i+k}) \qquad (15)$$

where: $G[i;j;i_{max}] = \begin{cases} i-j \le i_{max} \rightarrow G[i;j;i_{max}] = 1 \\ i-j > i_{max} \rightarrow G[i;j;i_{max}] = 0 \end{cases}$

and $H[D^*_{i+k};r_{j-1-k}] = \begin{cases} D^*_{i+k} \le r_{j-1-k} \rightarrow H[D^*_{i+k};r_{j-1-k}] = 1 \\ D^*_{i+k} > r_{j-1-k} \rightarrow H[D^*_{i+k};r_{j-1-k}] = 0 \end{cases}$

Figure 15 shows high compatibility of the model distribution with distribution obtained by way of simulation.

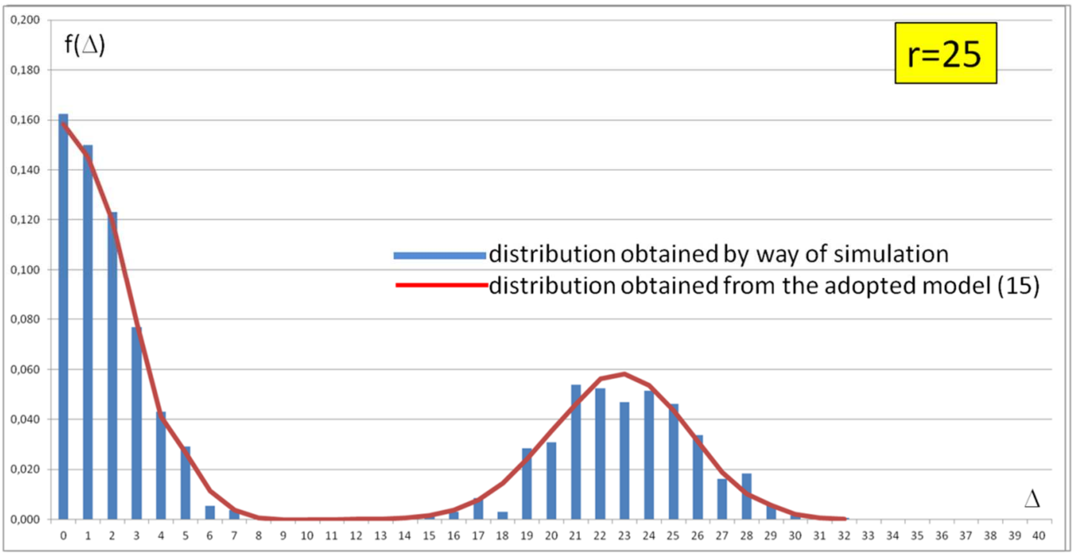


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Fig. 5. An experimental (simulation result) and model distribution of frequency with which a quantity of difference Δ - f(Δ)) occurs, for a case in which significant deviation of service level obtained during simulation from a quantity calculated with the use of formulas (10) and (14) was observed (see Fig. 4).

Rys. 5. Doświadczalny (jako wynik symulacji) i modelowy rozkład częstości występowania wielkości różnicy Δ - f(Δ)), dla przypadku, w którym obserwowano znaczące odchylenie poziomu obsługi otrzymanego w trakcie symulacji, od wielkości obliczonej przy wykorzystaniu formuł (10) i (14) (patrz rys. 4)

It allowed testing distribution for different r-values. Examples of calculation results have been shown in figures presented in Table 2: The consequence of diversified courses of density function f(Δ) is the diversification of the course of distribution function F(Δ), also shown there.

On the basis of observations described above, another modification of formula was suggested in terms of calculating reorder level B by extending formula (12) to the following form:

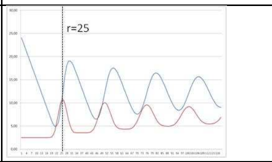
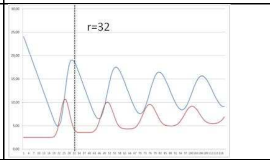
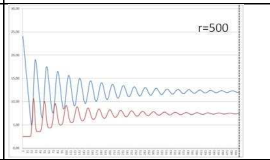
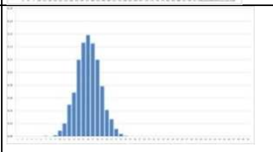
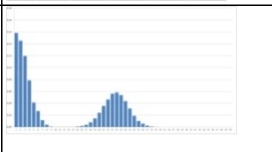
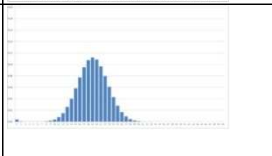
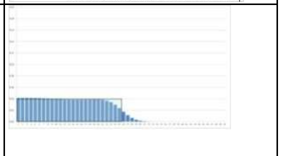
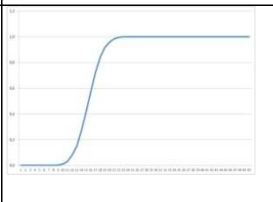
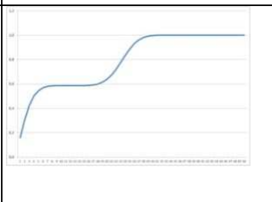
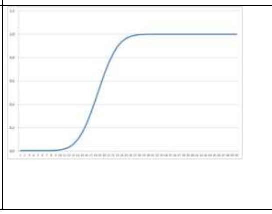
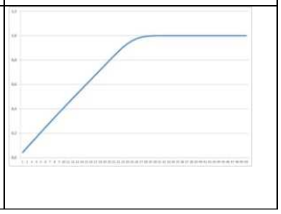
$$B = D \cdot LT + E(\Delta) + \sqrt{\omega^2_{\alpha SL} \cdot \sigma^2_D \cdot LT + \left[\Delta_{F(\Delta)=\alpha SL} - E(\Delta)\right]^2} \qquad (16)$$

where:

$\omega_{\alpha SL}$ – safety coefficient in terms of variability of demand corresponding to an adopted service level αSL, according to the type of demand distribution,

$\Delta_{F(\Delta)=\alpha SL}$ – value of Δ, for which distribution function $F(\Delta)$ equals the assumed service level αSL.

Table 2. Selected distributions of occurrence frequency and distribution function Δ for various levels of difference **r** (**r**=S-B)
Tabela 2. Wybrane rozkłady częstości występowania oraz dystrybuanty różnicy Δ, dla różnych poziomów różnicy **r** (**r**=S-B)

	r = S – B = 10	r = S – B = 25	r = S – B = 32	r = S – B = 500
E(Δ)=f(**r**) σ_Δ=f(r)				
Distribu-tion f(Δ)				
Distribution function F(Δ)				

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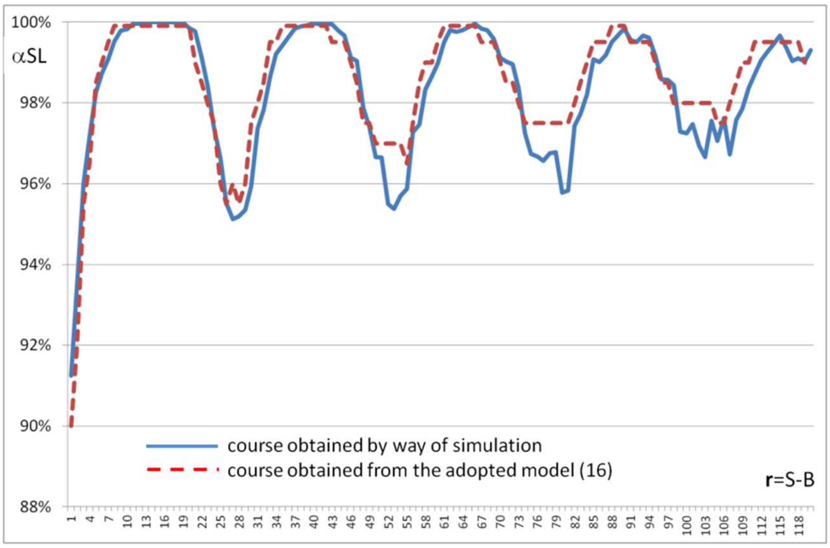

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Fig. 6. Comparison of courses αSL=f(**r**) for results obtained by way of simulation and with the use of the model (on the basis of formula 16)
Rys. 6. Porównanie przebiegów POP=f(**r**) dla wyników otrzymanych drogą symulacji i przy zastosowaniu modelu (na podstawie formuły 16)

As it can be seen, it was assumed that both variables (D_{LT} and Δ) are treated independently and may be subject to various distributions. Formula (16) does not allow simple determination of dependences regarding an expected service level, nevertheless, however, with assumed level of reorder B, it is possible to approximately set service level αSL which complies with dependence (16). Achieved results compared with courses obtained by way of simulation have been shown in Figure 6.

CONCLUSIONS

A model (or rather three models with different degrees of complexity) of the impact of parameters controlling replenishment in the BS (MIN-MAX) continuous review model on the actual inventory availability has been presented. It was possible by determining mathematical models of dependences that allow setting expected value, standard deviation and distribution density of difference Δ between specified level of reorder B and actual level of economic stock S_e upon commencing an inventory replenishment cycle.

Implementing these models in an Excel spreadsheet allowed specifying model dependences Δ, σ_Δ and f(Δ) as a function of variable **r** (difference between levels S and B) for any non-zero distributions of the value of demand D^*. Obtained results showed high compatibility with results of simulation tests, both for dependence Δ=f(**r**), and σ_Δ=f(**r**).

The condition for achieving a model's compatibility with simulation results with reference to a service level αSL indicator (probability of servicing demand in an inventory replenishment cycle) was the inclusion of distribution F (Δ) and a fact that it generally differs from a distribution function regarding the distribution of non-zero values of demand F(D^*) in the model.

The presented model may support the selection of parametres B and S of the discussed inventory replenishment system from the perspective of both expected service level and cost efficiency.

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MODEL WPŁYWU PARAMETRÓW STERUJĄCYCH ODNAWIANIEM ZAPASÓW W PRZEGLĄDZIE CIĄGŁYM TYPU MIN-MAX (BS) NA RZECZYWISTY POZIOM ICH DOSTĘPNOŚCI

STRESZCZENIE. **Wstep:** Zarządzanie zapasami w warunkach losowych zmian popytu jest wciąż - mimo rozwoju alternatywnych koncepcji zarządzania przepływem dóbr - ważnym zagadnieniem zarówno z punktu widzenia kosztów utrzymania i uzupełniania zapasów, jak i poziomu obsługi mierzonego poziomem dostępności zapasu. Istnieje szereg systemów uzupełniania zapasu w takich warunkach, przy czym stanowią one najczęściej rozwinięcie dwóch podstawowych: systemu opartego na punkcie ponownego zamówienia oraz opartego na przeglądzie okresowym. Artykuł odnosi się do pierwszego z nich, systemu BS (min-max), w którym zamówienie składane jest po osiągnięciu przez dostępny zapas poziomu B (poziomu informacyjnego, punktu ponownego zamówienia), w wielkości stanowiącej uzupełnienie do poziomu S. System ten jest bardzo często stosowany w praktyce gospodarczej. Obserwacje prowadzone w rzeczywistych warunkach wskazują konieczność udoskonalania klasycznych modeli opisujących ten system. Wynika to m. in. z tego, że rzeczywisty poziom dostępnego zapasu w chwili rozpoczęcia cyklu uzupełnienia może być znacząco niższy od poziomu B, co skutkuje niższymi od oczekiwanych poziomami obsługi klienta. Uwzględnienie tego zjawiska poprzez modelowe wyznaczanie dystrybuanty obserwowanej różnicy pozwala na poprawny dobór parametrów sterujących omawianym systemem odnawiania zapasu i - tym samym - osiągnięcie oczekiwanych efektów ekonomicznych.

Metody: Przedmiotem prezentowanych badań było stworzenie modelu matematycznego pozwalającego na wyznaczanie poziomu informacyjnego w tzw. systemie BS (inaczej min-max) odnawiania zapasu uwzględniającego różnicę pomiędzy wyznaczonym poziomem B, a rzeczywistym poziomem zapasu w chwili rozpoczęcia cyklu uzupełnienia. Dla wyznaczenia wpływu różnych czynników, m. in. parametrów rozkładu popytu w przyjętej jednostce czasu oraz różnicy pomiędzy poziomami S (max) oraz B (min), opracowano dedykowane narzędzie (symulator w arkuszu kalkulacyjnym EXCEL) pozwalające na określenie rozkładu częstości występowania wartości. Następnie opracowano i zaimplementowano w odrębnym arkuszu EXCEL model matematyczny pozwalający na wyznaczanie tego rozkładu i jego parametrów, jako funkcji różnicy r=S-B dla praktycznie dowolnego rozkładu popytu.

Wyniki: Wykazano konieczność uwzględnienia przy wyznaczaniu parametrów sterujących odnawianiem zapasu w systemie BS rozkładu różnicy pomiędzy poziomem informacyjnym B (którego osiągnięcie lub zejście poniżej niego stanowi sygnał do złożenia zamówienia), a rzeczywistym poziomem zapasu w chwili rozpoczęcia cyklu uzupełnienia. Opracowano i wykorzystano do obliczeń model matematyczny pozwalający na wyznaczenie rozkładu częstości występowania i dystrybuanty wielkości w zależności od parametrów rozkładu popytu oraz różnicy r pomiędzy poziomami S (max) oraz B(min). Stwierdzono wysoką zgodność wyników otrzymanych z obliczeń modelowych z wynikami otrzymanymi w drodze symulacji, imitującej rzeczywiste zdarzenia.

Wnioski: Przedstawiony w artykule model pozwoli na bardziej precyzyjne wyznaczanie parametrów sterujących systemem BS, gwarantujących zachowanie wymaganego poziomu obsługi oraz uwarunkowań dotyczących wielkości dostaw. Dalszych prac wymaga opracowanie efektywnego modelowego rozwiązania przedstawionej w artykule ogólnej postaci formuły na obliczenie parametru B w funkcji wymaganego poziomu obsługi) oraz parametru S w zależności od wyznaczonej (np. ekonomicznej) średniej wielkości dostawy.

Słowa kluczowe: zarządzanie zapasami, odnawianie zapasu w systemie BS (min-max, up-to-level continous review replenishment model), poziom obsługi, modelowanie, symulacja.

MODELL DER EINWIRKUNG DER PARAMETER ZUR STEUERUNG DER BESTANDSERNEUERUNG IM SYSTEM DER DAUERÜBERWACHUNG VOM TYP MIN-MAX (BS) AUF DIE TATSÄCHLICHE LIEFERBARKEIT DER BESTÄNDE

ZUSAMMENFASSUNG. Einleitung: Trotz der Entwicklung von alternativen Konzepten zur Materialfluss-Steuerung bleibt das Bestandsmanagement unter zufälligen Nachfrageveränderungen ein wichtiges Anliegen, sowohl in Hinsicht auf die Kosten der Unterhaltung und Ergänzung von Beständen, als auch in Hinsicht auf die Servicequalität, gemessen an der Lieferbarkeit der Bestände. Es gibt eine Reihe von Systemen zur Bestandsergänzung unter den o. g. Umständen, wobei es sich meistens um die Entwicklung von zwei grundlegenden Systemen handelt: gestützt auf den Punkt der Neubestellung und auf die periodischen Übersichten. Der Artikel bezieht sich auf das erste der beiden, auf das BS-System (Min.-Max.), bei dem die Bestellung erfolgt, nachdem der lieferbare Bestand das Niveau B erreicht hat (Informationsniveau, Punkt der Neubestellung), und zwar in einer Menge, die eine Ergänzung bis auf das Niveau S ermöglicht. Dieses System wird in der praktischen Wirtschaft sehr häufig angewendet. Beobachtungen in realistischen Zuständen weisen auf die

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Notwendigkeit hin, die klassischen Modelle zur Beschreibung dieses Systems zu verbessern. Dies ergibt sich u. a. daraus, dass der tatsächlich lieferbare Bestand zum Zeitpunkt der Einleitung des Ergänzungsverfahrens wesentlich niedriger sein kann, als das B-Niveau, was zu einer Verschlechterung der Kundenbetreuung führt. Durch eine Berücksichtigung dieses Phänomens durch die modellhafte Festlegung der Verteilungsfunktion im Rahmen der beobachteten Diskrepanz können eine richtige Einstellung der Parameter zur Steuerung des erwähnten Systems der Bestandserneuerung und damit auch die Erreichung der erwünschten wirtschaftlichen Ziele erreicht werden.

Methoden: Gegenstand der dargestellten Untersuchungen war die Erstellung eines mathematischen Modells, mit dem das Informationsniveau für die Bestandserneuerung in dem sog. BS-System (anders "min-max" genannt) als der Unterschied zwischen dem festgelegten B-Niveau und dem tatsächlichen Bestand zum Zeitpunkt der Einleitung des Ergänzungsverfahrens festgelegt werden kann. Um den Einfluss unterschiedlicher Faktoren, etwa der Parameter der Nachfrageverteilung innerhalb des angenommenen Zeitraums, und der Unterschiede zwischen dem Bestand S (max) und B (min) zu berücksichtigen, wurde ein zielgerechtes Tool (ein Simulator im EXCEL-Kalkulationsbogen) entwickelt, mit dem die Verteilung der Auftrittshäufigkeit von Werten festgestellt werden kann. Anschließend wurde in einem gesonderten EXCEL-Bogen ein mathematisches Modell entwickelt und umgesetzt, mit dem diese Verteilung und deren Parameter als eine Funktion der Differenz r=S-B für praktisch jede Nachfrageverteilung festgelegt werden kann.

Ergebnisse: Es wurde aufgezeigt, dass bei der Festlegung der Parameter zur Steuerung der Bestandserneuerung im BS-System die Differenz zwischen dem Informationsniveau B, (dessen Erreichung oder Unterschreitung das Bestellungssignal darstellt) und dem tatsächlichen Bestand zum Zeitpunkt der Einleitung des Ergänzungsverfahrens berücksichtigt werden soll. Es wurde ein mathematisches Modell erstellt und bei Berechnungen eingesetzt, anhand dessen die Verteilung der Häufigkeit und die kumulative Verteilung der Größe festgelegt werden können, und zwar je nach Verteilungsparametern und der Differenz r zwischen den Bestandsniveaus S (max) und B (min). Es wurde eine hohe Vereinbarkeit zwischen den Ergebnissen der Modellberechnungen und den Ergebnissen einer Simulation festgelegt, die die tatsächlichen Vorgänge imitieren sollte.

Fazit: Mit dem im vorliegenden Beitrag dargestellten Modell können die Parameter zur Steuerung des BS-Systems detaillierter festgelegt werden, sodass die Einhaltung der erwünschten Qualität der Kundenbetreuung und der Liefermengen sichergestellt werden kann. Weiterer Arbeiten bedarf dennoch die Entwicklung einer effektiven, modellhaften Lösung der im Beitrag allgemein dargestellten Formel für die Berechnung des Parameters B in der Funktion des erforderlichen Niveaus der Kundenbetreuung und des Parameters S, je nach der festgelegten (z. B. wirtschaftlichen) mittleren Liefergröße.

Codewörter: Bestandsmanagement, Bestandserneuerung im BS-System (min-max, up-to-level continous review replenishment model), Kundenbetreuung, Modellierung, Simulation

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ESTIMATING ORDER-PICKING TIMES FOR RETURN HEURISTIC - EQUATIONS AND SIMULATIONS

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ABSTRACT. **Background:** A key element of the evaluation of warehouse operation is the average order-picking time. In warehouses where the order-picking process is carried out according to the "picker-to-part" rule the order-picking time is usually proportional to the distance covered by the picker while picking items. This distance can by estimated by simulations or using mathematical equations. In the paper only the best described in the literature one-block rectangular warehouses are considered.

Material and methods: For the one-block rectangular warehouses there are well known five routing heuristics. In the paper the author considers the return heuristic in two variants. The paper presents well known Hall's and De Koster's equations for the average distance traveled by the picker while completing items from one pick list. The author presents own proposals for calculating the expected distance.

Results: the results calculated by the use of mathematical equations (the formulas of Hall, De Koster and own propositions) were compared with the average values obtained using computer simulations. For the most cases the average error does not exceed 1% (except for Hall's equations). To carry out simulation the computer software Warehouse Real-Time Simulator was used.

Conclusions: the order-picking time is a function of many variables and its optimization is not easy. It can be done in two stages: firstly using mathematical equations the set of the potentially best variants is established, next the results are verified using simulations. The results calculated by the use of equations are not precise, but possible to achieve immediately. The simulations are more time-consuming, but allow to analyze the order-picking process more accurately.

Key words: order-picking, warehousing, heuristics, simulations.

INTRODUCTION

Despite the growing automation, there are still very common warehouses in which the order-picking process takes place in accordance with the "picker-to-part" rule. In those warehouses the order-picking time is affected mainly by such activities as: picker's movement, searching and extracting items and additional operations (scanning, banding, paperwork, etc.). The main task to be performed to optimize the average order-picking time is better determination of the picker's route. This can be done in a few ways, e.g. through: proper location of the pick-up / drop-off point (PD), choosing the right order-picking heuristic and (at the warehouse design stage) determining the appropriate number and length of aisles in which the items will be stored. For the most studied in the literature one-block rectangular warehouses (with two main aisles) there are well known 5 heuristics for determining the picker's route and even the very fast algorithm for optimal route.

At the design stage of storage area when the needed number of slots is established, the goal is to optimize the number and the length of picking aisles and the localization of the PD point. This task can be solved by means of time-consuming simulations or using mathematical equations. In this paper the equations for the average distance traveled by the picker while picking the items from one pick list and moving according to the return

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heuristic will be presented. The equations discovered by the author and the equations known from literature will be compared with the results obtained by the use of the simulation.

ORDER-PICKING

The most laborious and time-consuming warehouse process is order-picking (it generates approximately 55% of warehouse operating costs), which includes retrieving items from storage locations in response to a specific customer request [De Koster, Le-Duc and Roodbergen, 2007]. In more detail about the functions of order-picking and about the possibilities of optimization of this process in polish literature treat Krawczyk and Jakubiak [2011], Kłodawski and Jacyna [2011], Kłodawski [2012] oraz Kłodawski and Żak [2013].

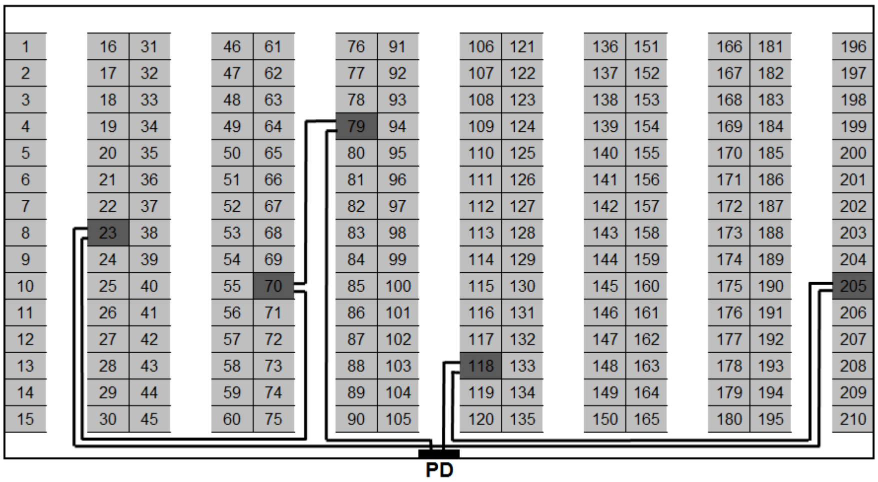
The problem of optimization the average (expected) order-picking time for the specific warehouse parameters, the size of pick lists and routing heuristic is very important at the design stage of warehouses. The task is achieved usually by the use of time-consuming simulations. The scientists often assume that the picker's travel time is an increasing function of travel distance [De Koster, Le-Duc and Roodbergen, 2007]. Then the issue of minimizing the order-picking time can be solved by the search of the shortest route. The expected distance traveled by the picker can be determined in two ways: by the use of simulations or mathematical equations. For the first time as the statistical problem this task was treated by Kunder and Gudehus [1975]. Although written in German, the paper is very often cited to this day. The issue was further developed, among others, by Hall [1993] and De Koster and Van Der Poort [1998]. A more advanced analysis, taking into account the ABC classification based on items turnover was carried out by Jarvis and McDowell [1991] and Le-Duc and De Koster [2005].

The route covered by the picker can be determined by one of the following heuristics: s-shape, midpoint, return, largest gap and combined (the Polish translations of the heuristics names can be found in the paper of Jacyna and Kłodawski [2012]). There is also a very fast Ratliff and Rosenthal algorithm for determining the optimal route, although for different reasons, it is not used in practice [De Koster, Le-Duc and Roodbergen, 2007].

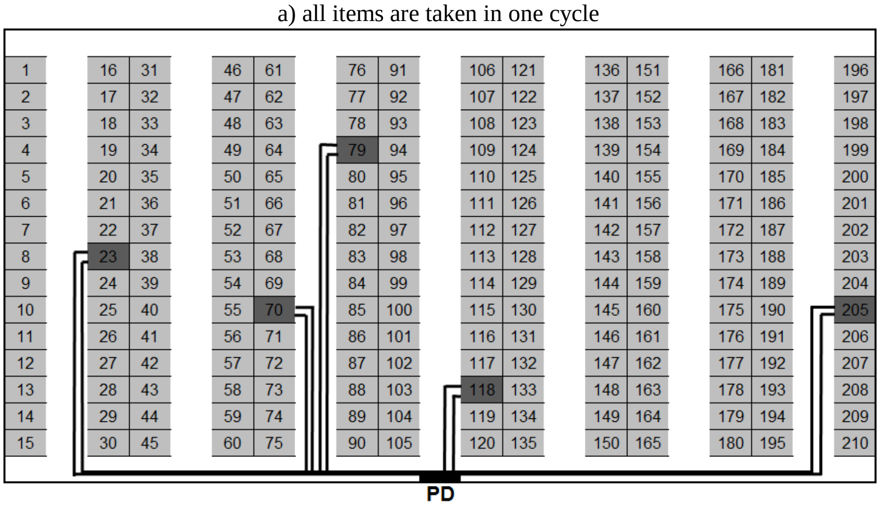
The efficiency of the order-picking process is directly affected by the appropriate storage location assignment. Jakubiak [2013] showed that much more important than the method of determining the picker's route, is to optimize the assignment of items to slots. The problem of dynamic allocation of items in the warehouse was defined by Lewczuk [2012]. These issues, although very important, will not be the subject to further analysis in this paper. The research will be limited to the return heuristic and the attempt to the quick order-picking time estimation (through the distance) using mathematical equations. In the paper two ways of order-picking using return heuristics will be considered: the first one where all items are picked in one cycle and the second one where each item (different index) is collected in a separate cycle (figure 1). The study will take into account two possible locations for the Pick-up / Drop-off Point. The equations for the order-picking time taking into account the technical characteristics of devices that support this process (forklift trucks) can be found in the paper of Fijałkowski [2003].

In the next two chapters the equations for the average order-picking time are presented: the Hall's and De Koster's conceptions and the proposal of the author. The following notation was adopted:

- d_h - average distance traveled by the picker in the main aisle,
- d_v - average distance traveled by the picker in the picking aisles,
- D - average total distance traveled by the picker while completing one pick list: $D=d_h+d_v$,
- d_1 - distance between the entrances to the two adjacent picking aisles (figure 2),
- d_2 - length of the picking aisle (figure 2),
- n - number of different items (indexes) on the pick list,
- N - total number of picking aisles,
- j - number of picking aisle,
- m - number of slots in one side of the picking aisle.



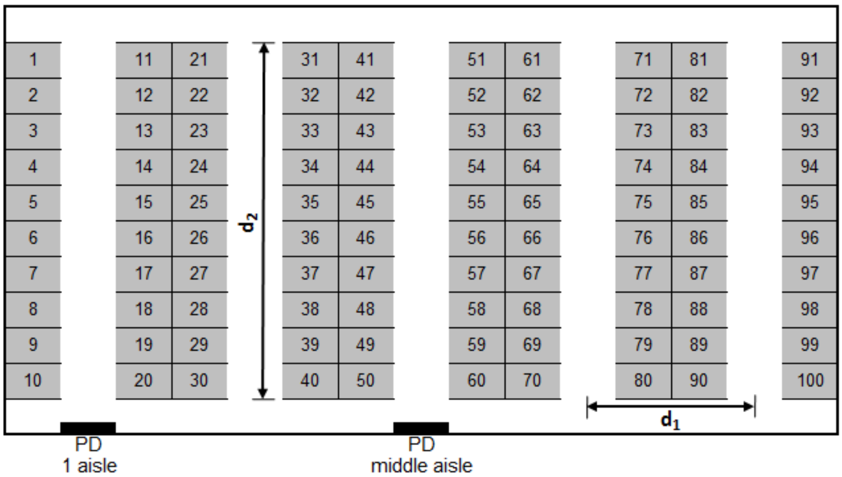
a) all items are taken in one cycle



b) each item is taken in a separate cycle

Source: own elaboration.

Fig. 1. Two versions of the picker's routing for the return heuristic
Rys. 1. Dwie wersje heurystyki return (wszystkie towary pobierane są w jednym cyklu / każdy wyrób pobierany jest w osobnym cyklu)



Source: own elaboration.

Fig. 2. The possible locations of the Pick-up / Drop-off points and the basic distances in the warehouse
Rys. 2. Możliwe lokalizacje punktu przyjęcia i wydania towarów oraz podstawowe odległości w magazynie

ESTIMATION OF THE AVERAGE DISTANCE TRAVELED BY THE PICKER IN THE MAIN AISLE

The determination of the average distance traveled by the picker in the main aisle while each item is taken in a separate cycle is relatively simple. The picker after taking each item returns to the Pick-up / Drop-off point. For each item the distance in the main aisle is traveled twice: from the PD point to the appropriate slot and with the item: from the slot to the PD. For the case in which the Pick-up / Drop-off point is located in front of the first picking aisle the average distance can be calculated using equation:

$$d_h = n \cdot (N-1) \cdot d_1 \qquad (1)$$

If the PD point if located in front of the middle aisle (when the number of picking aisles is odd) or in front of one of the two middle aisles (when the number of picking aisles is even), the average distance traveled by the picker in the main aisle can be calculated as follows:

$$d_h = \begin{cases} n \cdot \dfrac{N}{2} \cdot d_1 & \text{when } N \text{ is even,} \\ n \cdot \left(\dfrac{N-1}{2} + \dfrac{N-1}{2N} \right) \cdot d_1 & \text{when } N \text{ is odd.} \end{cases} \qquad (2)$$

It is somewhat more complicated to calculate the average distance traveled by the picker in the case where in one cycle more than one different items (indexes) are completed. Hall [1993] noticed that one can use the uniform distribution to estimate this value. If we assume that the length of the main aisle is equal 1, the items from pick list can be treated in some approximation as a realization of a random variable with uniform distribution on the interval <0,1>. Such assumptions are acceptable in the case where the demand for each stored item is the same (more precisely: all items occur on pick lists with the same frequency). Then apply the well known equations for the expected value of the minimum and maximum of n numbers randomly generated from the uniform distribution:

$$E(\min\{x_1, x_2, ..., x_n\}) = \frac{1}{n+1},$$

$$E(\max\{x_1, x_2, ..., x_n\}) = \frac{n}{n+1}.$$

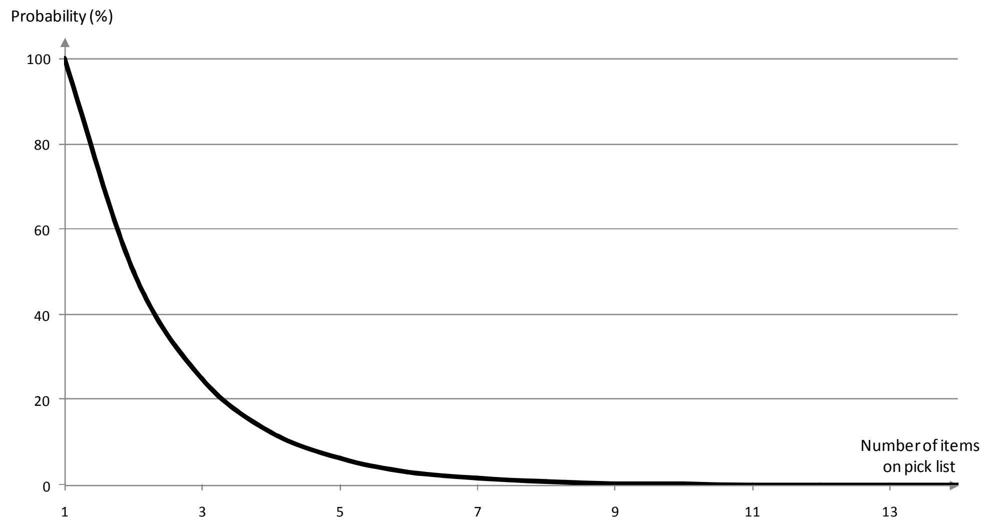
In the case where the Pick-up / Drop-off point is located in front of the middle picking aisle, the average distance traveled by the picker can be calculated by subtracting the expected location of the item from pick list which is the nearest to the left wall from the expected location of the needed item farthest from the left wall in the warehouse:

$$\begin{aligned} d_h &= 2 \cdot (N-1) \cdot d_1 \\ &\cdot \left(E(\max\{x_1, x_2, ..., x_n\}) - E(\min\{x_1, x_2, ..., x_n\}) \right) \\ &= 2 \cdot (N-1) \cdot d_1 \cdot \left(\frac{n-1}{n+1} \right) \end{aligned} \qquad (3)$$

This equation will give correct results only when the items from each pick list will be placed on both sides of the PD point. Hall claims that it applies only when the number of items n on pick lists is big enough (more than 5) - figure 3 shows that it should be even up to twice greater. Otherwise, Hall shows how to modify the formula.

If the Pick-up / Drop-off point is located in the front of first picking aisle, then $E(\min\{x_1,x_2,\ldots,x_n\})=0$, and the modified Hall's equation will take the form:

$$d_h = 2 \cdot (N-1) \cdot d_1 \cdot \left(\frac{n}{n+1} \right). \qquad (4)$$



Source: own elaboration.

Fig. 3. The probability of finding all the items from pick list on the one side of Pick-up / Drop-off point (the original Hall's equation gives poor results)
Rys. 3. Prawdopodobieństwo znalezienia się wszystkich towarów z listy kompletacyjnej po jednej stronie punktu przyjęcia i wydania towarów (oryginalny wzór Halla daje błędny wynik)

The task of determining the distance traveled by the picker in the main aisle can be solved in another way: by designating the probabilities of passing by the picker next to the entrances to the following picking aisles (it is not important whether the picker enters the picking aisle or not):

$$P_j = \begin{cases} 1-\left(\dfrac{N-j}{N}\right)^n & for\ \ j<a, \\ 1 & for\ \ j=a, \\ 1-\left(\dfrac{j-1}{N}\right)^n & for\ \ j>a, \end{cases}$$

where:
P_j - probability that the picker will pass next to the entrance of j picking aisle,
a - number of picking aisle with the PD point.

The average distance traveled by the picker in the main aisle can than by calculated using the equation:

$$d_h = 2\cdot\left(\sum_{j=1}^{N} P_j - 1\right)\cdot \qquad (5)$$

When the PD point is located in front of the first picking aisle: a=1. Then the equation (5) can be reduced to form:

$$d_h = 2\cdot\left(\sum_{j=1}^{N}\left(1-\left(\frac{j-1}{N}\right)^n\right)-1\right)\cdot \qquad (6)$$

When the PD point is located in front of the middle picking aisle:

$$a = \begin{cases} \dfrac{N}{2} & when\ N\ is\ even, \\ \dfrac{N+1}{2} & when\ N\ is\ odd. \end{cases}$$

ESTIMATION OF THE AVERAGE DISTANCE TRAVELED BY THE PICKER IN THE PICKING AISLES

The distance traveled by the picker in the picking aisles is - in contrast to the distance crossed in the main aisle - independent from the location of the Pick-up / Drop-off point. For the case in which in one cycle the picker picks only one item (one index), the average position of the needed item in the picking aisle is equal to half the length of the aisle. After picking an item the picker has to return to the PD point, so the average total distance is equal (twice a half) the length of the picking aisle:

$$d_v = n\cdot(m+1)\cdot\frac{d_2}{m}\cdot \qquad (7)$$

The picker has to enter the picking aisle, so a small value has to be added to the distance (in the equation (7) in the expression in the brackets it was assumed that the distance from main aisle to the first slot in the picking aisle is equal to the width of a slot, that is why the number of slots was increased by 1). The equation (7) measures the average distance traveled by the picker in the picking aisles while completing one pick list, so the result has to be multiplied by the number of picked items n.

For the case in which in one cycle more different items are collected, the problem is no longer so simple. According to the conception of Kunder and Gudehus [1975] expanded later by Hall [1993] as well as Le-Duc and De Koster [2005] the expected value of the distance traveled by the picker in the picking aisles is equal to the sum of the products of expected distance crossed in each picking aisle and the corresponding probabilities. For the return heuristic the distance traveled by the picker in one picking aisle depends on the number of items to be picked in this aisle and the length of the aisle. If the probabilities of occurrence on pick lists for all items are the same, then for calculating the expected distance in the picking aisles - like in the case of estimation the distance crossed in the main aisle - one can use the uniform distribution. In each picking aisle the picker has to cover the distance to the farthest slot with needed item and then return to the main aisle. That is why the expected value of the maximum of n numbers generated from uniform distribution has to be multiplied by 2 (and of course by the length of the aisle). A little more laborious could be the calculation of the probability distribution P(x) of the number of items from one pick list to be picked in one picking aisle. As it is assumed that the number of slots in each aisle is the same and the picking probabilities for all items are equal, so the P(x) distributions for every picking aisle are identical, too. Then average distance covered by the picker in the picking aisles can be calculated as follows:

$$d_v = 2 \cdot N \cdot d_2 \cdot \sum_{i=1}^{n} \left(\frac{i}{i+1} \cdot P(x=i) \right). \qquad (8)$$

As the calculation of the probability distribution P(x) may cause some computational problems, the equation (8) can be simplified. The expected value of the number of picking aisles visited by the picker is equal to:

$$E(N_v) = N \cdot P(x>0) = N \cdot \left(1 - \left(\frac{N-1}{N} \right)^n \right) .$$

The average number of items picked from different slots if one picking aisle is equal to $\frac{n}{E(N_v)}$. By making simple substitutions, the average distance traveled by the picker in picking aisles during completing one pick list can be calculated as follows:

$$d_v = 2 \cdot \frac{\frac{n}{E(N_v)}}{\frac{n}{E(N_v)}+1} \cdot d_2 \cdot E(N_v) = 2 \cdot \frac{n \cdot d_2}{\frac{n}{N \cdot \left(1-\left(\frac{N-1}{N}\right)^n\right)}+1} . \qquad (9)$$

COMPARING EQUATIONS WITH SIMULATIONS

To check the effectiveness of the equations presented in previous chapters, a lot of experiments was performed. Using formulas the average distance traveled by the picker in the main aisle and in the picking aisles was calculated for different: number of picking aisles, number of slots in one picking aisle and the size of pick list. The results were compared with average values obtained by the use of simulation tool Warehouse Real-Time Simulator [Tarczyński, 2013]. The accuracy of equations was measured using error function:

$$E = \left| \frac{d - d^{sym}}{d^{sym}} \right| \cdot 100\% ,$$

where:
d - value calculated by the use of appropriate equation ($d=d_h \vee d=d_v$),
d^{sym} - average value obtained by simulations.

Table 1. Error function values for the distance traveled in the main aisle
Tabela 1. Błąd oszacowania odległości pokonanej przez magazyniera w głównym korytarzu

Error	Each item picked in a separate cycle PD by the first aisle	Each item picked in a separate cycle PD by the middle aisle	Whole pick list completed in one cycle PD by the first aisle
Average	0,82%	0,37%	0,17%
Minimum	0,73%	0,01%	0,02%
Maximum	0,95%	0,94%	0,77%
Error	Whole pick list completed in one cycle (Hall) PD by the first aisle	Whole pick list completed in one cycle PD by the middle aisle	Whole pick list completed in one cycle (Hall) PD by the middle aisle
Average	3,61%	0,21%	8,22%
Minimum	2,18%	0,01%	4,94%
Maximum	5,86%	0,82%	15,27%

Source: own elaboration.

Table 2. Error function values for the distance traveled in the picking aisles
Tabela 2. Błąd oszacowania odległości pokonanej przez magazyniera w bocznych alejkach

Error	Each item picked in a separate cycle	Whole pick list completed in one cycle (De Koster)	Whole pick list completed in one cycle
Average	0,90%	0,33%	1,56%
Minimum	0,14%	0,02%	0,01%
Maximum	2,07%	1,02%	3,31%

Source: own elaboration.

Tables 1 and 2 show obtained values of error function. The average error for all equations was smaller than 10%. The relatively worst results were obtained for Hall's conception - especially the original formula (3) gave the average value of the error function equal to 8,22%, and the maximum 15,27%. The value of the error function decreases with increasing: the number of picking aisles in the warehouse and the number of different items of pick lists. For the other analyzed methods of estimating the average distance traveled in the main aisle the error value is smaller than 1% (usually strongly). For the distance covered by the picker in the picking aisles best results were obtained by the use of De Koster's formula (8). For the equation (9), which is easier to practical implementation the average error is a little bigger, but still acceptable (smaller than 2%).

CONCLUSIONS

The order-picking time is usually proportional to the distance traveled by the picker - then in order to compare different variants of warehouse functioning and work organization one can calculate instead of the order-picking time - the average distance covered while completing one pick list. The mean values of the distance for different warehouse parameters and the size of pick lists can be designated be the use of simulation tools or mathematical equations. Simulations give the accurate results and allow to analyze the order-picking process in a more complete way (among others instead of average values one gets a full probability distributions), but simulations are usually quite time-consuming. The results obtained by the use of mathematical equations are not as accurate, however, they are possible to achieve immediately.

The average distance traveled by the picker while completing one pick-list is a function of routing heuristic, the size of pick list and warehouse parameters (the number and length of picking aisles, the number of slots in each picking aisle, the location of Pick-up / Drop-off point). The problem of designating the optimal values of the number and length of picking aisles, when only the number of slots in the warehouse is constant can be solved in two stages. Firstly, using mathematical equations the acceptable configurations are determined. Afterwards, by means of more time-consuming simulations the results are verified, the more precise outcomes are calculated and the best variant is chosen. The performed experiments show that it suffices to consider in the second stage only variants not worse than the best one (after the first stage) by more than 10%.

In the paper only one routing heuristic was analyzed and it was assumed that the demand for all stored items is the same. The problem will significantly complicate when the research will cover more heuristics, and the items will be divided according to ABC classification on groups with different rotation ratio. Then the proposed two-stage approach will be probably the only possible way to optimize the order-picking time.

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SZACOWANIE CZASÓW KOMPLETACJI ZAMÓWIEŃ DLA HEURYSTYKI RETURN - WZORY I SYMULACJE

STRESZCZENIE. **Wstęp**: Kluczowym elementem oceny funkcjonowania magazynu jest średni czas kompletacji zamówień. W magazynach, w których kompletacja odbywa się wg zasady "człowiek do towaru" czas kompletacji zazwyczaj jest proporcjonalny do dystansu pokonanego przez magazyniera, który może być oszacowany za pomocą symulacji lub z wykorzystaniem wzorów matematycznych. W artykule rozpatrywane są najlepiej opisane w literaturze magazyny prostokątne jednoblokowe.

Metody: Dla magazynów prostokątnych jednoblokowych znanych jest 5 heurystyk wyznaczania trasy magazyniera. W artykule autor rozpatruje jedną z nich: metodę return (w dwóch wersjach). Przedstawione są wzory na średnie dystanse pokonywane przez magazyniera podczas procesu kompletacji zamówień znane z prac Halla i De Kostera. Autor przedstawia też własne propozycje.

Rezultaty: Wyniki uzyskane w wyniku zastosowania wzorów matematycznych (wzory Halla, De Kostera i autora artykułu) porównano z rezultatami symulacji komputerowych. Dla większości wzorów średni błąd szacunku nie przekracza 1% (wyjątkiem są wzory Halla). Do przeprowadzenia symulacji wykorzystano program Warehouse Real-Time Simulator.

Wnioski: Czas kompletacji zamówień jest funkcją wielu zmiennych i jego optymalizacja nie jest zadaniem łatwym. Może być jednak przeprowadzana dwuetapowo: najpierw korzystając ze wzorów matematycznych wybiera się zbiór wariantów potencjalnie najlepszych, następnie wyniki weryfikuje się za pomocą symulacji. Wyniki uzyskane za pomocą wzorów nie są dokładne, ale możliwe do uzyskania natychmiast. Symulacje są bardziej czasochłonne, ale umożliwiają pełniejszą analizę czasu kompletacji zamówień.

Słowa kluczowe: kompletacja zamówień, magazynowanie, heurystyki, symulacje.

DIE BEWERTUNG VON KOMMISSIONIERUNGZEITEN FÜR DIE RETURN-HEURISTIK - FORMELN UND SIMULATIONEN

ZUSAMMENFASSUNG. Einleitung: Ein wichtiges Element bei der Beurteilung des Lagerbetriebs ist die durchschnittliche Zeit der Kommissionierung. Wenn die Kommissionierung nach dem "Mann-zur-Ware"- Prinzip stattfindet, dann ist die Zeit üblich proportional zu der Distanz, die der Kommissionierer laufen muss. Die Strecke kann mit mathematischen Formeln oder anhand einer Simulation festgelegt werden. Dieser Artikel projiziert rechteckige Ein-Block-Läger, die in der Fachliteratur am besten abgehandelt sind.

Methoden: Für die rechteckigen Ein-Block-Läger sind fünf Routing-Heuristiken bekannt. In dem Artikel wurden zwei Versionen der Return- Heuristik untersucht. Die Formeln für die Ermittlung mittlerer Distanzen der Kommissionierung von Hall und De Koster wurden mit dem Vorschlag des Autors verglichen.

Ergebnisse: Die durch Anwendung der Formeln gewonnenen Ergebnisse wurden mit Hilfe von Simulationen verifiziert. Für die meisten analysierten Versuche betragen die durchschnittlichen Schätzfehler weniger als 1% (nur die Formeln von Hall sind die Ausnahme). Die Simulationen wurden im Warehouse Real-Time Simulator durchgeführt.

Fazit: Die Zeit der Kommissionierung ist die Funktion vieler Variablen und die Optimierung ist nicht einfach. Die Minimierung der Distanz und der Zeit der Kommissionierung kann in zwei Stufen durchgeführt werden. In der ersten Stufe werden unter Anwendung der Formeln die besten Varianten ausgewählt. In der zweiten Stufe werden die Ergebnisse mit Hilfe von Simulationen verifiziert. Die durch die Anwendung der Formeln gewonnenen Ergebnisse sind ungenau, aber per sofort erreichbar. Die Simulationen sind zeitaufwendig, doch die Analyse ist vollständig.

Codewörter: Kommissionierung, Lagerung, Heuristiken, Simulationen

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RENEWED MER MODEL OF INTEGRAL MANAGEMENT

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ABSTRACT. **Background:** The research work on entrepreneurship, enterprise's policy and management, which started in 1992, successfully continued in the following years. Between 1992 and 2011, more than 400 academics and other researchers have participated in research work (MER research program) whose main orientation has been the creation of their own model of integral management.
Results: In past years, academics (researchers and authors of published papers) from Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Byelorussia, Canada, the Czech Republic, Croatia, Estonia, France, Germany, Hungary, Italy, Poland, Romania, Russia, the Slovak Republic, Slovenia, Switzerland, Ukraine, and the US have cooperated in MER programs, coming from more than fifty institutions. Thus, scientific doctrines of different universities influenced the development of the MER model which is based on both horizontal and vertical integration of the enterprises' governance and management processes, instruments and institutions into a consistently operating unit.
Conclusions: The presented MER model is based on the multi-layer integration of governance and management with an enterprise and its environment, considering the fundamental desires for the enterprises' existence and, thus, their quantitative as well as qualitative changes. The process, instrumental, and institutional integrity of the governance and management is also the initial condition for the implementation of all other integration factors.

Key words: MER model, holistic approach to governance and management, integration, integral management.

PURPOSE OF THE CONTRIBUTION

The beginnings of the creation of the MER Model of Integral Management (further in the text: the MER Model) date back to the year 1992 and 1993 [Belak 1993, Belak, Kajzer 1994, Belak, Mugler 1994]. In the last twenty years all activities within the frame of the MER program (research and with the research connected symposiums and publications) have been directed towards enterprises and similar institutions in different environments as well as in diverse life, developmental and business situations. A great part of these activities have been dealing with small and medium-sized enterprises, last years also with family enterprises. Scientists (researchers as well authors of published papers) from more than fifty (mainly university) institutions have been co-operating in the MER program all these years. Especially intensive work on the MER Model was going on during the transition period before the entry of Slovenia and other post socialist countries in the European Union. The MER Model has been published several times with special focus on the particularities of the transition period [Belak et al. 1997, Belak 2003, Kajzer, Duh, Belak 2008]; it was also represented at various conferences [Belak, Kajzer 1998, Belak, Duh 2004, Belak, Kajzer 2003, Belak, Kajzer 2004, Knez-Riedl 2004, Duh 2004, Belak 2004, Belak, et al. 2005, Belak, Duh, Belak 2006, Belak, Duh, Belak 2008].

A year ago the decision was made to start thoroughly renewing the MER Model since

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many changes of conditions in the economic and other social environment in Slovenia and in many other posts socialist countries have been taking place. The renewed MER Model was published at the end of the year 2010 in the book entitled "Integral Management - MER Model" [Belak 2010] and in proceedings of the MEB 2011 conference [Belak, Duh 2011, Belak, Milfelner 2011]. In this "new" model many changes were introduced, especially some new success factors were added. During the last years of comprehensive presentation of the MER Model several researches were carried out in Slovenian enterprises about enterprises meeting the governance and management principals as thought by MER model of integral management. Out of these researches we present the insights on enterprise culture.

BASIC FEATURES OF THE RENEWED MER MODEL OF INTEGRAL MANAGEMENT

The MER model is based on the multi-dimensional integration of management with the enterprise and its environment while taking into consideration the enterprise's basic purposes of surviving and developing. Basic features of the MER model are presented in Figure 1 and discussed in the continuation of the paper.

The MER model is based on rich scientific foundation and research cognitions on governance and management of which are of special and crucial importance as follows:

- cognitions on the differentiation between an enterprise and management as an object and as a subject of the managerial activity as well as co-dependencies between management and an enterprise;
- understanding the characteristics of the enterprise's environments (conditions and changes of conditions, needs, and expectations), their influences on an enterprise as well as the management of an enterprise;
- understanding the requisite compatibility of opportunities identified in the environment with the existent and potential capabilities of an enterprise;
- process comprehension of an enterprise, understanding the diversity of enterprises and their influences on the necessary adjustments of management;
- understanding the enterprise's life cycle and developmental cycle, special situations and goals of enterprises, and their influences on particularities of management; and
- cognitions on entrepreneurial, efficient (in profit-oriented enterprises, also profitable), and ethical as well as credible creation of positive synergy effects for increasing competitiveness, effectiveness, and value of an enterprise.

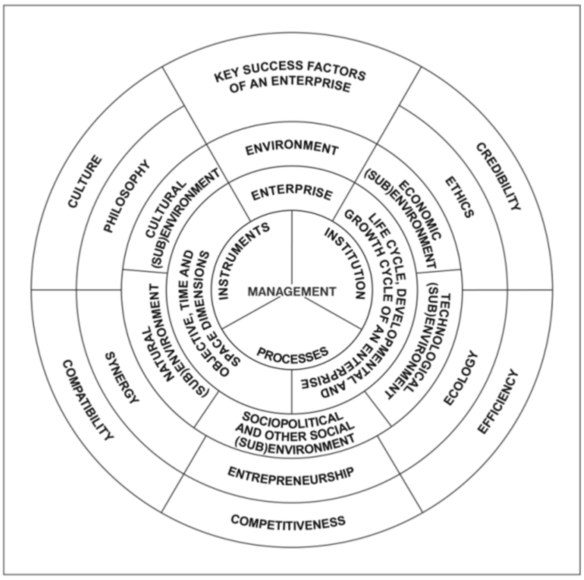

Fig. 1. The MER Model of Integral Management
Rys. 1. Model MER zintegrowanego zarządzania

The description of the MER model can be summarized in the following three major fields:

1) Integral management: its dimensions and special managements, which are presented in the first circle in Figure 1.
2) An enterprise and its environment, which are presented in the second and the third circles in Figure 1.
3) Success factors of an enterprise, which are presented in the fourth and the fifth circles in Figure 1.

MANAGEMENT

Three dimensions of management are incorporated into the MER Model and that are: management as a process, management as an institution and management as the system of instruments. Additionally the presented MER Model deals with management from specific aspects and dimensions. From the system point of view the management is understood in these three dimensions as a partial system and not as a subsystem of an enterprise in which it exists. Management processes, instruments and institutions are horizontal and vertical integrated in consistent functioning wholeness. Process, instrumental and institutional integration of management is at the same time the fundamental condition for bringing into force all other integration factors.

Process Dimension

The process dimension of the MER Model is based on the integration of:

- hierarchical levels of the management process (political level, strategic management level and tactical-operational management level),
- basic functions of the management process (planning, organizing, directing, control) and
- process functions (preparation of information, decision making, undertaking measures).

Hierarchical levels of the management process. The process dimension of the MER Model is based on understanding the hierarchy of the management process. What is typical of management activities is that the global and developmental definitions of an enterprise are followed by the more detailed, operational definitions. There is hierarchical order in:

- defining a vision and a policy of an enterprise at the highest, political level; the enterprise's policy consists of a mission, purposes and basic goals;
- identifying strategic opportunities and developing strategies for implementing the policy at the middle, strategic level;
- planning and allocating resources and tactical-operational tasks at the lowest, tactical and operational levels.

Processes at different hierarchical levels, described above, need to be integrated into one holistic and complex process. Therefore, in the MER Model no special attention is given to distinguishing between governance and management processes because of the need for linking and interweaving processes at all hierarchical levels. The need for integration of governance and management processes into one complex and holistic process is stressed also in other models of integral management.

Basic functions: planning, organizing, directing and control. The management process in the MER Model begins with planning which is followed by organizing and directing of implementation. Control is not the last step in this sequence. It is needed many times in between and together with planning, organizing, directing of implementation and implementation itself. Planning, organizing, directing and control are present at all hierarchical levels of the management process.

Process functions: preparatory information activities, decision making and measures undertaking. The essence of management processes represent decision making and measures undertaking processes. Both, decision making and measures undertaking processes are needed in all stages and at all levels of the management process. Decisions are based on information. The preparation of the needed data and information is based on collecting, processing, storing and communicating data and information. Information processes, like decision making processes, are presented in all basic functions and at all levels of the management process. The purpose of the management processes is achieved by the process of undertaking measures. The realization of measures is always done at the level which is hierarchical lower from the level at which the decision was made. Political decisions are realized by strategies, strategic decisions by structuring of resources, decisions on structuring of resources by making decisions on the tactical-operational level and by the realization in the basic processes of an enterprise.

Instrumental Dimension

Management as an instrumental system consists of values, business and management guiding principles, styles, techniques and management methods. Values as well as business and management guiding principles globally define relationships between an enterprise, its environment and its employees. The chosen management styles and techniques are based on them. Among different management styles two extremes can be distinguished, that are authoritarian and participative management style, and their combinations. Among different management techniques we distinguish the following ones: management by objectives, management by exception, management by delegation and management by system. Regarding the management methods, during the process of developing the MER Model the priority has been given to the business planning methods, especially the methods of enterprise's start-up and developmental planning.

Institutional Dimension

The institutional dimension of the MER Model represents those people who are involved in the governance and management of an enterprise (i.e. governance and management structures). Boundaries between the governance and management structure have been disappearing more and more by the development of the integral management models. Research shows the growing need for integration of both structures. Among those involved in the governance and management processes hierarchically can be distinguished between: owners making decisions on the policy of an enterprise, top management making decisions on strategies, middle management making decisions on the optimal allocation of resources (tactics) and first line management making decisions on the distribution of tactical-operational tasks.

Definition of the involved people carrying out the management functions (i.e. institutional dimension) is done regarding their responsibilities in decision making processes. Management processes consist besides of decision making also of planning, organizing, directing and control activities. People involved in these activities are experts within the enterprise, very often also managers or even those from governance structure, if they possess the needed expert knowledge.

In the MER Model special attention is given to managers' personal characteristics, competencies, authority and motivation as well as to organizational models of management.

Specific Viewpoints and Dimensions

Enterprises often find themselves in the particular circumstances. Very often these circumstances are associated with crisis, or liquidation of a company, with start-up of an enterprise or acquisition of the existing one or with the type of an enterprise (e.g., small or large enterprise, a family enterprise, commercial one, etc.), as well as with the specific objectives of the company (e.g., to achieve higher quality or to become more innovative, etc.). In such cases, management should deal with these special and particular circumstances of an enterprise, its particular features and/or direct it activities toward achieving enterprise's primary (fundamental) goals. These lead to special managements such as crisis management, change management, total quality management, innovation management, ecologic management, lean management and others. Such special managements are not isolated parts, but partial systems of integral management in all its dimensions; such partial system of management is different every time.

MER model of integral management is designed to provide process, instrumental and institutional integrity of management from all specific viewpoints. It enables the optimal use of resources while meeting specific requirements of enterprises (either because of specific conditions, circumstances or goals) and flexible setting of the enterprises' priorities considering the requirements of specific management. It is designed to fulfill all these requirements of an enterprise taking into the consideration its management processes, instruments and institution. Governance and management of an enterprise should not be partial regardless of the situation and conditions in which an enterprise finds itself, and regardless of the enterprise's goals. An enterprise should not tackle only one specific crisis and forget others managerial issues and because of this finds itself in another crisis.. Or do everything to achieve certain goal (e.g., to increase sale in specific market and forgets other markets or to solve only long-term strategic tasks and problems and forgets short-term, tactical-operative tasks). We are convinced that the integral management (i.e., the MER model of integral management) should encompass all special viewpoints which are needed to achieve sustainability and success.

ENTERPRISE AND ENVIRONMENT

An enterprises, understood as the narrow environment in which (and for which) the management is active, integrates "its own" management with the characteristics of its own reality (activity, processes, resources, organization and structures) in certain place at certain time. This integration takes place in an enterprise which is in one of different phases of life, growth and developmental cycle; in the majority of cases an enterprise is at the same time in more than one phase of the mentioned cycles. From the dynamic point of view an enterprise is constantly changing and therefore moving from one phase to another. Also in this case the MER Model provides the necessary integration of management with the enterprise and its environment.

Integration of management with philosophy, culture and ethics as well as with entrepreneurship and ecology could not be isolated only to certain part of an enterprise and/or its environment. This integration of an enterprise with its broader environment (economic, cultural, natural, technological and sociopolitical sub-environments), which is implemented in operational, market and cognitive spheres of the enterprise's functioning, is manifested as the enterprise's external competence to align the enterprise's potential outputs (i.e. services, products) with the needs and expectations of the environment; this alignments should be done from the objective, time and space point of view. The integration of enterprise's internal factors (material as well non-material) is manifested as internal competence, also the capability of an enterprise, for efficient functioning and achieving synergy in all areas and by these satisfying needs and expectations of environment better than competitors.

The objective dimension of the MER model is expressed by its applicability for all types of enterprises (in the broader sense of the term) regardless their activity, size, legal form, etc. The MER model is designed for enterprises in different life cycle phases, developmental and growth stages, of course with certain modifications. These lead to special managements (e.g.: start-up management, developmental management, management of an enterprise in bankruptcy, etc.). The MER Model is designed also for enterprises which find themselves in special situations or follow different sets of goals.

From the time perspective, the MER Model is designed to be used in all time dimensions (for longer as well as shorter time periods); with planning for the future and with control and intervention measures for the present time (in all cases taking into consideration the cognitions from the past).

Regarding the space dimension the MER Model enables functioning of management in all three places (market, operational and cognitive) of an enterprise - that means in all dimension of enterprise's environment. In MER solutions special attention is devoted to small and medium-sized enterprises (also family ones), enterprises in crisis and management particularities of such enterprises.

KEY SUCCESS FACTORS OF AN ENTERPRISE

Key success factors (as well as success itself) are of crucial, strategic importance for all enterprises. Therefore, enterprises should devote a great deal of their attention to these factors. They should identify them and permanently trying to improve them. Based on the present scientific cognitions and knowledge the following success factors were incorporated into the MER Model: internal and external compatibility of an enterprise, credibility, efficiency, competitiveness, entrepreneurship, synergy, culture, philosophy, ethics and ecology.

Culture, Philosophy, Ethics and Credibility

Enterprise's culture has been defined as encompassing values, rules, beliefs and assumptions that are shared by organizational members and used in handling and behaviour of especially internal enterprise's stakeholders. Developmental improvement of an enterprise is not possible without the simultaneous change of its culture; the changing of culture (in the head of enterprise's stakeholders!) is usually very demanding and long-lasting process. The culture of the broader society as well as the culture of an enterprise is very complex. The circle of enterprise's culture on the level of science, religion, philosophy, art and technique is considered within the MER Model; this circle starts and ends in the environment. The culture based on the contemporary scientific findings, the universal credible (and also responsible) philosophy, the comprehensive artistic way of expression, the friendly techniques of the enterprise's functioning and the enterprise's credible handling of all stakeholders as well as credible behaviour of each stakeholder (in the name and for account of the enterprise) to other stakeholders are incorporated into the MER Model. We are striving for such an ethics which results in the holistic credibility of an enterprise. An enterprise which is not credible cannot become (and stay) continuously successful. The realization of the enterprise's credibility is therefore not possible without ethical behaviour of all its stakeholders. There exist mutually relationship in implementation of ethics and credibility. The demand for credible behaviour of all enterprise's stakeholders (owners, managers and others) in all circumstances is also incorporated into the MER Model. The credibility has to be established and implemented mutually: from the side of an enterprise as an institution to every enterprise's stakeholder and from each stakeholder (in the name and for the account of the enterprise!) to all other stakeholders.

Entrepreneurship, Synergy and Ecology

Enterprises cannot be successful in long term without the people who possess the characteristics of entrepreneurs; also enterprises cannot be successful if individuals are entrepreneurial but the conditions in enterprises are not established to promote entrepreneurship or even hinder the entrepreneurial actions of employees. Creativity, intuition, imagination, visionariness, carefulness, courage, honesty, patience, diligence, personal motivation and preparedness to work, persistence, dynamics, initiative, risk-propensity and sense for change, judgmental competences, firmness, decision-making abilities and preparedness for pioneer work are the essence of entrepreneurship. Within the MER Model we argue that entrepreneurship in an enterprise is needed and is crucial for enterprise's success; therefore, the conditions have to be established in order to encourage entrepreneurial activities among enterprise's stakeholders, especially among enterprise's internal stakeholders.

Synergy and the creation of positive synergy effects are considered within the MER Model as the key success factors of every enterprise. The care for the creation of positive synergy effects is permanently present in all dimensions of the MER Model. We believe that an enterprise which achieves negative synergy effects cannot be successful; usually such enterprises decline and die very soon. If an enterprise consciously makes the decision which leads to zero or even negative synergy effects, such a decision must be based on well grounded reasons as well as the enterprise must know how long such situation will last and when the negative or zero effects will be replaced with the positive ones.

Regarding the ecology as one of the success factors within the MER Model we place in the center the enterprise's handling with the environment. In the MER Model we especially point out the requisite holistic ecological functioning and behavior of an enterprise. We argue that the environmental friendly (ecological) philosophy and enterprise's policy, strategies and tactical-operative functioning are needed. An enterprise should not consider its ecological efforts as a burden; it should see these efforts as an attempt to improve its competitive position and by this also its performance. An enterprise should strive to raise ecological awareness by its all stakeholders, also external ones. We encourage with the MER Model the credible, ecological directed behavior of enterprises all the time and everywhere.

Internal and External Compatibility of an Enterprise

The holistic compatibility of an enterprise with its environment is needed in order to be successful. We believe that internal and external compatibility of an enterprise in its vision and policy, in strategies and processes as well as in enterprise's structure is needed. It is necessary to achieve the alignment of previous mentioned with the identified expectations and needs of the environment as well as mutually within the enterprise itself, within the specific time, place, quantity and quality. An enterprise should achieve the compatibility of the environment (i.e. its expectations and needs) with all enterprise's processes, components and structures. The alignment is always the process of changing (either of an enterprise or the environment). The faster the enterprises are changing the more successful they become. With the MER Model we are bringing into force the active attitude of an enterprise toward changes and also call attention to the requisite dealing with changes as business opportunities for the enterprise; in this way we argue the need for introducing two special dimension of integral management, that are the proactive management of opportunities and change.

Efficiency and Competitiveness

Efficiency of an enterprise is an important success factor. Regarding the efficiency the demands for rationality, speed and cost optimization of realization of activities and processes are in the center of our attention. The main question here is how to work and how to conduct activities as well as the entire technical, technological and working processes. Efficiency of an enterprise is expressed by the way of carrying out all processes; that means not only by carrying out the basic processes but also the governance and management processes as well as the information processes. An enterprise should (besides constantly taking care of efficiency) also constantly checking whether or not its products (or services) still satisfy the needs of the buyers. This means that an enterprise should make the right things (products or services) in the right way. Efficiency in "doing the right things" is useful and necessary; in doing "the wrong things" the efficiency can even be harmful. However, if an enterprise does the right things less efficient than other enterprises, it will very soon remain without the buyers. In such a case an enterprise will no longer be able to exist. In order to become more competitive an enterprise must recognize (and know) which characteristics of its offer are for the environment (i.e. buyers) of importance (and are also priority) and how to improve them in comparison to competitors, or how to develop new characteristics of its products and services; that means to develop such characteristics that competitors' products or service have not possessed yet. Many approaches of studying the ways of improving competitiveness have been established. Let us remind you on the MER's efforts of brining into force the requisite holistic of process approach. The idea for establishing an enterprise should not be grounded on its outputs (i.e. enterprise's offer); an enterprise should be established based on the identification of the needs and expectation of the buyers, then by making the decision on the purposes, goals, business process and structure of such an enterprise that will be able to provide competitive products (or services) to the market. With the MER Model we are promoting the holistic credible behavior in the processes of improving the competitiveness of enterprises.

THE INSIGHTS OF SELECTED RESEARCHES

During the last years after the comprehensive presentation of the MER Model several researches were carried out in Slovenian enterprises in order to find out more about current state of enterprises' governance and management and presence of integral management concepts in Slovenian enterprises. The comprehensive research has not been carried out yet, however, in this contribution we present the findings of selected partial researches on the differences in enterprises' culture (i.e., core values and ethical climate) as constitutive elements of ethical behaviour of family and non-family enterprises, the type of culture and particularities of ethical climate in relation to the enterprise's life cycle, the impact of the enterprise's culture to the enterprise's success, and the particularities of business ethics implementation at different stages of enterprise's life cycle.

In their research [Belak et al. 2010] argued that in order to achieve the optimal effectiveness level of business by ethical behaviour, the initiated measures of business ethics should never be implemented as isolated tools, but only in the frame of a full and complete ethics program. The initiated business ethics measures have to be correctly adjusted and coordinated, as well as integrated, in a common business ethics concept, program or plan. An enterprise's top management can be considered as the "agent" responsible for harmonization of stakeholders' interests as well as different cultures; therefore we argue that formulation and implementation of an ethics program strongly depend on top management. In our opinion, the top management can also be considered as the executor of the enterprise's culture (values and norms initiated by the enterprise owners), which represents one of the most important elements in the context of an enterprise's ethical behaviour. The research has shown that credibility and ethical behaviour of an enterprise can be achieved only through holistic enterprise planning [Belak et al. 2010]. It should be implemented from top to bottom, starting with the enterprise owners' values that influence enterprise's vision and enterprise's policy [21Thommen 2003] and to the fundamental (basic) - realization process and in all of its own pore incorporated also in enterprise environment. One of the important authors' [Belak et al. 2010] argumentation is also that the proposed concept of the holistic planning of constitutional elements and implementation measures of enterprise ethics has a major impact to the environment of an enterprise functioning and vice versa.

Following the above described theoretical background [Duh, Belak, Milfelner 2010] carried out research, which examined the association between the degree of family involvement in an enterprise and its influence on the enterprise's core values, culture and ethical climate as the constitutional elements of enterprise ethical behaviour. In regard to the type of enterprise culture, the research results demonstrated a stronger presence of clan culture characteristics in family than in nonfamily enterprises. In other words, family enterprises are more personal, in which employees act and feel like part of the family; leadership is considered to be mentoring. The management in the enterprises observed was characterized by teamwork and participation; employees showed a high level of mutual trust and commitment to their enterprises. The studied family enterprises emphasized human development, trust and openness. Since the research results show a stronger presence of hierarchical and market culture characteristics in non-family enterprises (albeit not at statistically significant levels in the case of hierarchical culture), non-family enterprises appeared to be more dynamic in the entrepreneurial sense: People are willing to take higher risks, are more competitive, and are achievement oriented. Although a high degree of 'care for people' is present in non-family enterprises, these enterprises showed a strong tendency for innovation and risk taking, market aggression and orientation towards results. The management in these enterprises expressed high demands and achievements. The research findings indicate that people in these enterprises trusted one another, but based on their significant commitment to innovation and goal accomplishment. Therefore, new challenges and prospects for new opportunities in these enterprises are very important. According to their desire for success, their primary goal is the domination at the marketplace. The results also point to a stronger culture in family businesses than in non-family ones. Although the difference is not statistically significant, the results are very similar to those of Vallejo [Vallejo 2008], demonstrating that in family businesses the level of Core Values, Culture and Ethical Climate adoption and acceptation of the values and norms is higher. Furthermore, the level of compatibility of values and norms within the examined enterprises (e.g. between various departments) as well as the level of compatibility of values and norms between enterprises and the environment of their functioning is higher in family businesses than in non-family ones.

The research cognitions [Duh, Belak, Milfelner 2010] also showed that the functioning of non-family enterprises indicates a lower level of connection among co-workers, top management, and employees as well as less loyalty, anchoring of enterprise values and norms, and capacity for innovative behaviour, which can be considered one of the key success factors in business. Our research raises important issues regarding nonfamily enterprises' high level of hierarchical culture. Such enterprises are neither able to tolerate differences among employees or stakeholders nor are prepared to stimulate or use individuals' talents in accordance with the enterprises' visions, missions and policies. The alienation between top management and employees can have an important further implication, such as alienation between the enterprise and its environment, which can make the enterprise incapable of efficiency and effectiveness. Thus, these enterprises should implement all measures - informal as well as formal - of business ethics to foster, support, and transform the ethical core values in the higher presence of the clan culture and caring climate characteristics and achieve consistency among mission, vision, enterprise values and culture, which is of essential meaning for enterprise's long run success.

In their research [Belak, Mulej 2009] revealed some differences in enterprise ethical climate per enterprise life cycle stages. The research indicated movement towards a more and more bureaucratic method of enterprise functioning, as an enterprise moves from the pioneer stage towards the stage of turn-over. This pattern of functioning can also indicate a lower level of connection between co-workers, top-management and employees, as well as less loyalty, anchoring of enterprise values and norms, and capacity for innovative behaviour, which can be considered as one of the key success factors in business. Our research raises important issues regarding the enterprises in mature stage or turn-over stage, which are neither able to tolerate differences among employees as well as between all stakeholders nor prepared to stimulate or use the individuals' talents in accordance with the enterprises' visions, missions and policies. The alienation between top management and employees can have an important further implication such as alienation between the enterprise and its environment, which can make enterprise incapable of efficiency and effectiveness.

The research cognitions about the enterprise climate type can be supported also by the research cognitions about the enterprise culture type [Belak 2009]. Those research findings show that, through the life cycle stages, enterprises make a transition from a "clan" culture, where a very personal and familiar way of functioning can be observed, towards a "hierarchy" culture, where formal structures and procedures are in focus. Besides, the dependency of an enterprise's culture type on its life cycle stage, the research indicated that the culture strength depends on the life cycle stage, as well. In the enterprise life cycle transition (from pioneer enterprise towards the enterprise in turn-over), the culture strength changes from strong towards weak, as well. The research results showed that pioneer and growing enterprises are therefore more successful in implementing the enterprise's norms, values, vision, mission and strategic goals through the entire management and governance process (from the owners through the top and middle management to the operational level of the enterprise) than are mature enterprises and enterprises in turn-over. These results also reveal that the pioneer and growth enterprise culture is more compatible with the culture of the environment where they function than the culture in mature enterprises and enterprises in turn-over.

In a frame of business culture [Belak, Milfelner 2011] carried out the research on Culture as Enterprise's Key Success Factor, which showed that enterprises, which are more customer (externally) oriented, show better market performance as well as better financial performance. The cognitions also show that more employee (internally) oriented enterprises, show positive impact to their market as well as to their financial performance. These cognitions also partly confirm the theoretical argument that enterprise long term success can be ensured only by practicing the external (effectiveness) as well as internal (efficiency) orientation of enterprise, both together.

CONCLUSIONS

For the conclusion we would like to write a few words on the implementation of the MER Model in the economic and other social environment!

The MER Model has been verified several times during the process of its creation. Very often verifications of different parts of the MER Model were done in the praxis of participating enterprises or by presenting the MER Model at different scientific symposiums and conferences, at faculties and other schools by giving lectures. The MER Model (or its parts) has been introduced in many books and reviewed journals; the most comprehensive presentation of the MER Model is done in the two already cited books [Belak 2003, Belak 2010]. The written contributions on the MER Model are open to the academic and professional discussion and judgment. The opinions, remarks and other responses received have been contributing significantly to improving the quality of the MER Model. Certain dimensions of the MER Model have already been implemented in some Slovenian companies. Numerous participants of trainings and other educational events have been using the acquired knowledge on the MER Model in solving business and management problems, which can be supported also by the insights of the carried out researches.

The knowledge on the MER Model of integral management is built in the study programs, especially in those at the Faculty of Economics and Business at the University of Maribor. The cognitions about the systematical incorporation of the MER Model in the study programs were presented at the 6th International Conference on Management, enterprise and benchmarking in Budapest in 2008 [Belak, Duh, Belak 2008]. Three years later we are even more convinced that the use of the MER Model in the students' study work is important and bring satisfying result; the acquired experiences indicate that the presence of the MER Model in the study programs and the incorporation of the MER Model into the pedagogical process have been successful. In December 2014 LAP Lambert Academic Publishing has published a monograph "Integral Management and Governance: Basic Features of MER Model" [Belak, Belak Duh]. In January 2015 Mojca Duh and Jernej Belak as editors of "Integral Management and Governance: Empirical Findings of the Selected Fields of the MER model" invited everybody to explore the cognitions of the researchers - co-creators of the MER model - from various countries, including Argentina, Austria, Croatia, Germany, Poland, Switzerland, and Slovenia.

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MODEL MER ZITEGROWANEGO ZARZĄDZANIA

STRESZCZENIE. **Wstęp:** Prace badawcze nad przedsiębiorczością, polityką przedsiębiorstw oraz zarządzania, rozpoczęte w 1992, były z sukcesem kontynuowane w kolejnych latach. W okresie od 1992 do 2011, ponad 400 pracowników naukowych brało udział w projekcie badawczym (program badawczy MER), którego głównym celem było stworzenie własnego modelu zarządzania zintegrowanego.

Wyniki: W ostatnich latach, w programach MER brali udział pracownicy naukowi (biorący udział w badaniach oraz autorzy publikowanych prac), którzy pochodzi z ponad 50 instytucji z Austrii, Belgii, Bośni i Hercegowiny, Bułgarii, Białorusi, Kanady, Czech, Chorwacji, Estonii, Francji, Niemiec, Węgier, Włoch, Polski, Rumunii, Rosji, Słowacji, Słowenii, Szwajcarii, Ukrainy i Stanów Zjednoczonych. W wyniku tego, doktryny naukowe różnych uniwersytetów miały wpływ na rozwój modelu MER, który to opiera się zarówno na horyzontalnej jak i wertykalnej integracji zarządzania przedsiębiorstwem, procesów zarządzania, instrumentów oraz instytucji w jeden spójny operacyjny organizm.

Wnioski: Prezentowany model MER jest oparty na wielopoziomowej integracji zarządzania i kierowania przedsiębiorstwem oraz jego otoczeniem, uwzględniając podstawowe dążenia przedsiębiorstwa do jego istnienia, jak również jego ilościowych i jakościowych zmian. Proces instrumentalnego oraz instytucjonalnego zintegrowania zarządzania przedsiębiorstwem jest także wstępnym warunkiem wdrożenia innych czynników integracji.

Słowa kluczowe: model MER, podejście holistyczne do zarządzania i kierowania, integracja, zintegrowane zarządzanie

DAS ERNEUERTE MER-MODELL FÜR EIN INTEGRIERTES MANAGEMENT

ZUSAMMENFASSUNG. Einleitung: Die im Jahre 1992 begonnenen Forschungsarbeiten zur Unternehmenslust und -politik und zum integrierten Management wurden in den nachfolgenden Jahren mit Erfolg fortgestetzt. Im Zeitraum von 1992 bis 2011 haben über 400 wissenschaftliche Mitarbeiter am Forschungsprojekt (im Forschungsprogramm MER), das auf die Ausarbeitung eines eigenen Modells für das integrierte Management hinzielte, teilgenommen.

Ergebnisse: In den letzten Jahren nahmen im Rahmen der MER-Programme wissenschaftliche Mitarbeiter (die sich an den Forschungsarbeiten beteiligten und ihre Forschungsergebnisse veröffentlichten) von über 50 Forschungseinrichtungen aus Österreich, Belgien, Bosnien und Herzegovina, Bulgarien, Wei?russland, Kanada, aus der Tschechei, Kroatien, Estland, Frankreich, Deutschland, Ungarn, Italien, Polen, Rumänien, Russland, aus der Slovakei, Slowenien, aus der Schweiz, aus der Ukraine und den Vereinigten Staaten teil. In Anbetracht dessen haben die Forschungsdoktrinen von unterschiedlichen Universitäten einen Einfluss auf die Entwicklung des MER-Modells, das sich sowohl auf die horizontale, als auch vertikale Integration von Managementmodellen im Unternehmen, von Managementprozessen, angewendeten Tools und Einrichtungen in ein einheitliches Operationskörper stützt, ausgeübt.

Fazit: Das projizierte MER-Modell ist auf das Mehrebenen-Integrationssystem für Management und Leitung des Unternehmens und seiner Umgebung gestützt, wobei die grundlegenden Geschäftsziele seiner Existenz, sowie dessen quantitative und qualitative Veränderungen berücksichtigt werden. Der Prozess der instrumentalen und institutionellen Integration des Unternehmensmanagements ist somit auch die einleitende Voraussetzung für die Einfürung von anderen Integrationsfaktoren.

Codewörter: MER-Modell, holistisches Herangehen an Management und Leitung, Integration, integriertes Management

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THE DETERMINANTS OF LOGISTICS COOPERATION IN THE SUPPLY CHAIN - SELECTED RESULTS OF THE OPINION POLL WITHIN LOGISTICS SERVICE PROVIDERS AND THEIR CUSTOMERS

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ABSTRACT. **Introduction**: The paper is focused on some selected aspects of the cooperation between logistics service providers and their customers and considers the results of comparative analysis of importance assessment of the variables determining: the scope and nature of that cooperation, quality of providers' sales offer as well as changes in their customer service policy.

Methods: To analyze the underlying problem direct research was conducted, i.e. a survey based on a questionnaire among 50 logistics service providers and 50 shippers. The sample was determined on special purpose. In the statistical analysis chi-square independence test, U Mann-Whitney's test as well as Cramer's V and Spearman's rho correlation ratios were used.

Results: There were observed significant statistical differences between analyzed groups in the way the cooperation is perceived. The most vital discrepancies are related to customers' satisfaction degree and the assessment of the influence the providers' prices and competencies have on the cooperation. For the customers, declaring higher degree of the satisfaction from the cooperation, service quality was the most important factor. However, for the service providers, price factor was the most important one. Moreover, some differences in the answers related to changes in the service were observed, mainly with reference to: logistics capacity, out-of-loss shipments and communication.

Conclusions: The group of customers revealed to be little demanding about logistics service. They tended to order mainly routine services, not demanding special skills from the service providers. This is the most probable reason why customers/providers preferred cooperation with greater number of entities. The customers, unlike service providers, also didn't have the need to develop more advanced forms of cooperation. Moreover, the observed differences related to the importance hierarchy of the cooperation determinants as well as service standards, should be considered by the logistics service providers when continuing their cooperation with customers.

Key words: logistics service providers, customers, cooperation, logistics service, satisfaction.

INTRODUCTION

This paper presents the results of research on selected aspects of a cooperation between the logistics service providers and entities ordering logistics services. According to the authors, publications on this issue in Poland are few and far between. However, this issue seems to be important for at least two reasons. Firstly, in the world literature an increased interest in logistics outsourcing has been underlined for many years [Rollins et al. 2011, Mangan, et al. 2008, Lai 2004]. Secondly, the research results show that a cooperation with the service provider based on partnership relations has a positive impact on the business activities conducted in the supply chain [Jayaram et al. 2010]. For example, according to Thakkar et al. [2005], this cooperation,

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despite being more complex, contributes to an increased flexibility of the supply chain.

LOGISTICS COOPERATION IN THE SUPPLY CHAIN - THEORETICAL APPROACH

The term "cooperation" is generally understood as a particular type of activity that businesses decide to pursue together in a particular place and time. It is emphasized that the essence of cooperation lays in the achievement of a common goal or in the provision of mutual support to one another, if the goals are not interrelated [Smith 2012]. A similar importance of this concept is presented by Ciesielski and Długosz [2010], who define cooperation as a "combination of mutual benefits achieved by a joint effort." The research shows that businesses decide to cooperate to strengthen their competitive position or to continue their development [Nowicka 2011]. In addition, willingness on part of the businesses to share resources is considered to be a particularly important aspect of cooperation [Krzyżanowska 2013].

In terms of a cooperation in the area of logistics, the activities undertaken in this respect are of paramount importance in the supply chain management. Richey et al. [2012] are of the opinion that it is difficult to effectively manage the supply chain without an effective cooperation. In this case, an efficient meeting of the demand of the final purchaser becomes the priority. However Harrison and van Hoek [2010] note that the majority of entities are unable to fulfill this task without the assistance of other businesses, which in practice results in an increased, interest in logistics services. In other words, physical flows in the supply chain become more frequently the domain of specialized businesses, known as logistics service providers or "third participants". Such an understanding of cooperation means an activity undertaken on different levels of the supply chain, starting from the supply source and ending on the shop shelf. It should also be noted that the logistics service provider does not enter into relationships with the main participants in the supply chain only, but also develops relationships with SME businesses. The research conducted by Zowada [2015] suggests that one should appreciate the logistics cooperation with customers of this sector because it constitutes an important source of revenue for the logistics sector.

The service providers offer their customers a wide range of cooperation forms. The service can be carried out both on the basis of a contract governing the obligations of both parties, or be of a more casual nature. In the first case, one talks about contract logistics, which is considered to be the most profitable form of cooperation. In practice, this type of service is provided by 3PL, which offer a wide range of tailored solutions. Under the contract logistics, one can provide services in the field of transport, forwarding and storage, which are the foundation of any logistics offer [Świtała 2013], as well as such value-added services as: co-packing, co-manufacturing and processing of returns, which are examples of "made to measure" services [Hanus, Kempny et al. 2010]. Apart from the reductions of costs, the basic benefits of 3PL services include streamlining of the operations, achieved to a great extent by reducing the stock levels in the customer's warehouses and by shortening the delivery cycle [Rajesh et al. 2011].

The literature provides with many examples of the key role of service providers in the supply chain [Fabb-Costes et al. 2008, Fulconis et al. 2006]. There can be also noticed a trend towards a further intensification of their activities, and notes that this group is increasingly more responsible for the integration of the supply chain [Jayaram, Tan 2010]. In this regard, a special role is attributed to the 4PL, which are described as the supply chain coordinators [Selviaridis et al. 2007] or integrators [Hanus 2012]. The research indicates that 4PL have the most extensive scope of services covering the entire supply chain. In addition, these service providers have the strongest position in the logistics market [Świtała 2013].

Taking into account the above-mentioned tendency of the customers to purchase logistics services, attention should be also pay to the various forms of logistics cooperation. In this regard, one finds of interest the typology presented by Hsiao et al. [2010] which distinguishes 4 levels of logistics cooperation (the first two levels concerning the operational activity, and the remaining two ones - strategic management). In the opinion of the authors, the relationships between the service provider and the customer are generally unstable on the first level. This is the least binding form of cooperation in which one provides standard services, usually relating to the carriage and storage of cargo. In the second case, the cooperation is based on a short-term contract and covers a wider range of services. Apart from the basic services, one also offers services tailored to the needs of customers, including value-added ones. The next level of cooperation exists in the case of services tailored closely to the needs of the customer (i.e. service customization) and means a further strengthening of the ties existing between the parties to the relationship. According to the authors in this form of co-operation the service provider, apart from offering physical activity-based services, also performs managerial functions associated with logistics planning and controlling. According to the authors, full outsourcing is the highest, 4th level of cooperation. In this type of relationship, the service provider is distinguished by capacities and competences in the field of supply chain management. Among other competences, it integrates 3PL logistics services and determines the location of new nodes in the network. The authors' research also suggests that this form of cooperation is the most beneficial to the customers.

RESEARCH MATERIAL AND METHODS

The research was conducted in the Silesian voivodeship at the turn of 2013 and 2014 on a sample of 100 entities representing two communities, i.e. logistics service providers and their customers. The sample was chosen deliberately. In both cases, a decision was made to have the same number of respondents and to eliminate representatives of micro-enterprises from the measurement. The respondents were directly interviewed by pollsters of Research and Knowledge Transfer Centre UE in Katowice. The research questionnaire consisted mainly of scaled closed questions (ordinal and nominal scales). The responses of the managers covered the last two years of logistics cooperation.

The IBM SPSS software version 20.1 was used to prepare the results. In the statistical description the chi-square independence test, the Mann-Whitney U test, as well as the Cramer V and Spearman's rho correlation coefficients were used. It was assumed that the result was statistically significant for $p < 0.05$.

Half of the customers group (I) consisted of manufacturing enterprises and half of trading enterprises. The sample was dominated by companies with foreign capital. The national origin of the capital was declared by 34% of the respondents. Almost 90% of the respondents were employed in the SME sector. The interviews were mostly conducted with middle and senior managers, usually with company owners and directors as well as with workers employed as heads of production, logistics and sales departments. In terms of the geographic scope, companies operating on the national or regional market constituted the largest subgroup. Over 30% of the respondents indicated that they conducted international activity. The FMCG (sale of food, clothing, household chemicals, etc.) was the main area of activity of the trading companies, whereas the manufacturing companies mentioned construction, food production, machinery and equipment manufacturing as well as furniture production, as their core business.

The group of service providers (II) was mostly made up of small and medium-sized enterprises. Large entities were represented by 12 representatives of the logistics sector (24%). Companies participating in the survey were mainly represented by middle and senior managers responsible for logistics and sales service. The operational staff accounted for 10% of the studied sample. The studied population was dominated by companies pursuing their business activity on the international level (58%). 20% of the respondents were entities operating on the all-Polish market. Every tenth company turned out to be a global logistics service provider.

Companies with Polish capital were the most numerous group of respondents (64%), 14 participants declared to be founded on foreign capital and 4 respondents - mixed one.

In the studied period representatives of the logistics sector offered their customers a complex and diverse range of services. The respondents had at average more than 6 products in their offer ($\bar{x}$=6.50, σ = 3.37). Most businesses offered 8 services (D = 8) and every fifth company had more than 10 products in their offer. The portfolio of the service providers was dominated by transport (86%), shipping (60%) and storage (56%) services. Customer service based on contract logistics (3PL) was declared by 28% of the respondents, while provision of contract logistics and supply chain management services (4PL) was declared by 42% of the respondents. In the remaining cases, the logistics service related on the provision of simple services without a permanent contract (2PL).

ANALYSIS AND DISCUSSION OF THE RESEARCH RESULTS

The nature and extent of cooperation between the research participants

Under the cooperation the customers were ordering on the most frequent basis national transport services (70% of the respondents). Answers provided by the respondents also showed a wide use of shipping services (56%) and services relying on the carriage of cargo within the international traffic (46%). A relatively large percentage of companies also ordered postal and courier services (40%). Less interest was observed in storage services (24%), reverse logistics (20%) and customs services (18%). Even fewer customers used logistics consultancy services (12%) or outsourced delivery service based on the cross-docking (12%) or JiT (10%) system. Value-added services such as in-house (6%), co-manufacturing (4%), and co-packing (2%) turned out to be the least popular.

The conducted research showed that the average number of purchased services amounted to 3.64, with the dominant equaling to 3. The high standard deviation (σ = 2.50) indicates significant discrepancies in the declarations made by the respondents. And so: 38% of the respondents outsourced 1-2 services, 10% - 4 services, and 28% - at least 5 services. In 4 cases, the number of purchased services amounted to 8, and in 1 - 13. For obvious reasons, the number of ordered services was positively correlated with the amount of monthly expenses. Generally speaking, the wider range of services was outsourced, the higher level of expenditure was declared by the customers (Spearman rho coefficient = 0.531, p <0.01). In most cases the monthly expenses for logistics services amounted up to PLN 10 thousand. (38%). 12% of the respondents declared to be spending up to PLN 20 thousand. The same number indicated an amount of up to PLN 30 thousand. A higher budget for logistics services was recorded by 18% of the surveyed companies, out of which 6% declared expenses for external services in the amount of PLN 50 thousand and in 12% - up to PLN 200 thousand. It should also be noted that every fifth examined company failed to provide their answer.

Respondents from the group (I) were also asked to specify the number of service providers whom they ordered logistics services. Most respondents cooperated with at least 6 service providers (50%). 12% of the entities maintained contacts with only one service provider. More than a quarter of the respondents maintained relationships with 2-3 service providers, while 16% of the respondents cooperated with 4-5 service providers. The research indicates a long period of cooperation, usually lasting a few years. Over 60% of the respondents indicated that the cooperation period was 4 years and longer, 8% said that the cooperation had been lasting for three years, and 14% marked the two-year period.

The statistical analysis revealed the existence of a strong positive correlation between the number of service providers and the amount of the monthly budget of the customers for logistics services. The research results show that with an increased number of maintained relationships, the expenditure on logistics services grew, too (Spearman rho coefficient = 0.355, $p < 0.05$). An even stronger dependence was observed in the case of the length of the cooperation. The longer the period of cooperation declared by the customers, the more service suppliers the customers were bound with (Spearman rho coefficient = 0.386, $p < 0.01$). However, no relationship between the number of service providers and the quantity of the ordered / requested services could be found.

Responses of the customers indicate the existence of various forms of cooperation in the field of logistics. The most common form was cooperation without a permanent contract. This was the choice of 68% of the surveyed companies, although it should be emphasized that in the analyzed period, the majority of the surveyed companies had a reliable service provider whom they entrusted their cargo. The remaining companies, in each case prior to the order, evaluated the offers available in the market and on this basis decided on the selection of the service provider. 30% of the entities ordered services on the basis of an agreement. The cooperation on the basis of a contract logistics was pursued with division into full or partial outsourcing (20% and 10% respectively). According to sole answer, it was the contractor (cargo supplier/recipient) who selected the service provider responsible for logistics services.

Figure 1 shows an overall level of satisfaction with the course of the existing cooperation in both groups. In group (I), the average score on a 5-grade scale was 4.38, and in group (II) - 3.94. Although in both cases the level of satisfaction remained at a relatively high level, the purchasers of services were more satisfied with the cooperation. 90% of the customers positively assessed their relationships with the service providers, out of which 50% assessed it very positively. For comparison, a positive opinion on the cooperation with the customers was expressed by 74% of the service providers, out of which only 22% assessed it in very positive terms. Interestingly, one in four service providers gave a neutral answer ("neither satisfied nor dissatisfied"). This means that a large part of the representatives of the group (II) were not able to clearly assess their relationships with their customers. Results of the Mann-Whitney U test show that a difference in the assessment between these two groups is highly statistically significant ($U = 839.00$, $p = 0.002$ **).

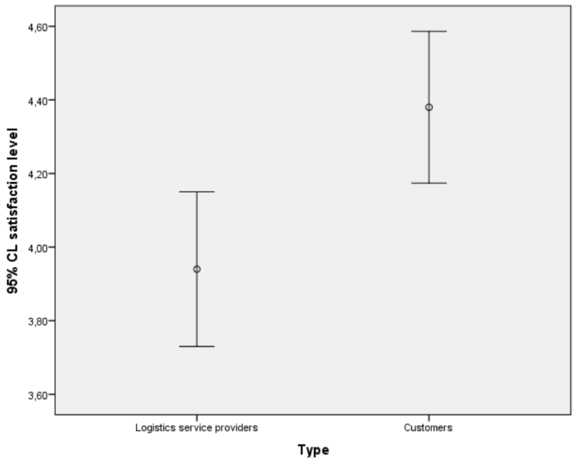

Fig. 1. The level of satisfaction with the course of the existing cooperation in both groups
Rys. 1. Ogólny poziom zadowolenia z przebiegu dotychczasowej współpracy - rozkład ocen usługodawców i klientów

Customers participating in the research were also asked to determine whether the above declared way of cooperation was appropriate for them. The research showed that the respondents preferred positive answers: "rather yes" (30%) and "definitely yes" (40%). A declared form of cooperation did not significantly affect the opinion of the respondents. Moreover, 90% of the surveyed companies confirmed their willingness to continue the above cooperation as well as the fact that the company responsible for handling their cargo met their individual logistics needs. Most likely, just for this reason, in group (I) one recorded higher levels of satisfaction, compared to group (II). What's more, the customers were willing to get involved in a long-term cooperation with service providers, but often only in the casual form - without a clear willingness to strengthen the ties in the near future.

Assessment of the significance of determinants affecting the logistics cooperation

The research shows that a decision to undertake logistics cooperation is determined by a set of different factors. The results presented in Table 1 also indicate the existence of several discrepancies in the assessment of the importance of these factors from the perspective of both groups. In both cases, the average scores on a 5-grade scale frequently oscillated between the values of 4 and 5, which mean that when assessing the importance of individual determinants, the surveyed entities usually attributed to them a significant part in their decision to order the services of a company specializing in this field. According to the customers, the quality of the provided services is a determinant which has the greatest impact on the decision to start cooperation with a logistics service provider and on the course of this cooperation (4.82). It should be noted that in this case, the most opinions focused on the highest score (5). The results also show the best coherence, as evidenced by the smallest standard deviation ($\sigma = 0.44$). One should also emphasize the importance of the human factor. According to the customers, competences of the employees of the service provider are the second most important criterion for logistics cooperation (4.54). Also in this case, the answers given by the respondents are characterized by a greater coherence than in other matters. The most surprising opinion was recorded with respect to the price of the service, the importance of which, taking into account the average score, is at the same level as the reputation of the service provider (4.44) and only slightly higher than the company's experience in the provision of logistics services (4.40).

Table 1. Comparative analysis of the assessment of the significance of selected determinants affecting the logistics cooperation
Tabela 1. Analiza porównawcza oceny znaczenia wybranych determinant kształtujących współpracę logistyczną

No	Description	Customers (I)		Service providers (II)		Statistical description	
		$\bar{x}$	σ	$\bar{x}$	σ	U	P
1.	Service quality	4,82	0,44	4,56	0,76	1075,00	0,095
2.	Service price	4,44	0,78	4,84	0,42	910,00	0,003**
3.	Competences of the employees	4,54	0,54	4,10	0,86	907,50	0,010*
4.	Experience	4,40	0,78	4,50	0,76	1134,50	0,365
5.	Reputation	4,44	0,81	4,50	0,76	1184,00	0,600
6.	Comprehensiveness of the provided services	4,26	0,77	4,36	0,83	1139,50	0,404
7.	Market coverage	4,16	0,88	4,18	1,19	1129,50	0,368
8.	Service individualization	4,00	1,03	4,12	0,87	1202,00	0,726
9.	Intralogistics solutions, including IT and automated product identification	3,52	1,01	3,38	1,12	1166,00	0,546

According to the service providers, the service price had the greatest impact on the customers' decision to start / continue cooperation (4.84). The respondents were in this case the most unanimous in their assessments ($\sigma = 0.42$). The service quality ranked second (4.56), followed ex aequo by the company's experience (4.50) and reputation in the market (4.50). Respondents in both groups agreed that from among the factors taken into account, the intralogistics solutions had the least impact on the cooperation. Most respondents were convinced of the average importance of this factor (in both groups the dominant was 3).

When analyzing the data in Table 1, the greatest differences in responses between group (I) and (II) were observed in the case of two criteria, i.e. the price (0.40) and the competence of employees (0.44). The customers within the sample attributed more importance to the professional competences, and less importance to the price, compared to the service providers. Analysis of the Mann-Whitney U test showed that in the first case the difference between group (I) and (II) had been statistically significant ($p < 0.05$), and in the second case - highly statistically significant ($p < 0.01$). A noticeable difference was also observed in the case of the quality of the provided services (0.26). It is clear that the customers assess it better than the service providers, although the differences in the declarations are not statistically significant ($p = 0.095$). On the other hand, the greatest unanimity of the responses was recorded as regards the importance of the coverage (0.02) and the reputation of the service provider (0.06).

Changes in logistics services in the opinion of the surveyed entities

Declarations of the logistics sector show that in the past two years there have been changes beneficial to the customers on the domestic market. One has seen an improvement both in the quality of the logistics aspects and in the interpersonal service. It is worth noting that a large number of the service providers declared to implement changes in the area of modern technologies. The research shows that in the last two years the surveyed companies have been investing on the most frequent basis in new forms of communication with customers, mainly in the development of e-services and mobile services. 36% of the respondents declared to provide their customers with new Internet applications, and 23% - with mobile ones. At the same time, 37% of the respondents confirmed that they had adjusted their customers' websites and e-tools for the mobile devices.

When it comes to the customers, the participants were asked to indicate how in their opinion the logistics services had changed over the last two years. From among all entities the average score on a 5-grade scale was 3.60 - which is well above the average. The dominant amounted to 4, which means that the tested sample was dominated by a positive assessment ("the service has improved"). The customers indicated the changes in the service providers' activities, which had contributed most to the improvement of the logistics cooperation. In the surveyed group, the emergence of new services and changes in the manner of their provision was indicated most frequently.

Further answers of the respondents correlate with the above assessment. Both the customers and the service providers declared that in the past two years the quality of the provided services had improved (Table 2). In group (II), to the improvement of the logistics potential (94%), meaning the ability to handle more orders, and to the timely delivery (92%) were indicated most frequently. According to the service providers, their efficiency in providing their customers with information about the handled load had increased too (88%). On the other hand, the customers most often perceived improvement in quality with regard to the typical operational aspects, namely: delivery timeliness (76%), speed (74%) and flexibility (70%). In both groups, improvement in the quality of the after-sales service was the least popular answer.

The research results presented in Table 2 show that representatives of group (I) declared more rarely positive changes in the service, compared to representatives of group (II). This is especially visible with regard to the damage-free deliveries and capacity. In both analyzed cases, the difference in the responses exceeds 30%. A highly significant correlation ($p < 0.01$) was also recorded in the case of the information flow. Improvement in the information flow was confirmed by nearly 90% of the service providers, but only 66% of the customers. A statistically significant relationship ($p < 0.05$) also occurs in the case of the timeliness and completeness of the deliveries (in the group of service providers, the response rate was respectively 92% and 76%, and in the group of the customers - 76% and 54% respectively) and error-free documentation (positive changes were confirmed by 86% of the service providers and 60% of the customers). A relationship close to a statistical significance was observed in the case of personal service. Information on this subject indicate that the logistics service providers preferred more often positive answers, compared to the customers.

Table 2. Changes in the provision of logistics services - comparative analysis
Tabela 2. Zmiany w świadczeniu usług logistycznych - analiza porównawcza

No	Improvement in the quality of the logistics services within the scope of:		Service providers (II)	Customers (I)	Statistical description		
					Chi-2	P	V Cramer
1.	Timeliness of deliveries	N	46	38	4,76	4,76	0,027*
		%	92,0	76,0			
2.	Speed of deliveries	N	42	37	1,50	1,50	0,163
		%	84,0	74,0			
3.	Completeness of deliveries	N	38	27	5,32	5,32	0,018*
		%	76,0	54,0			
4.	Damage-free deliveries	N	43	26	13,51	13,51	0,000**
		%	86,0	52,0			
5.	Error-free documentation	N	43,0	30,0	8,85	8,85	0,012*
		%	86,0	60,0			
6.	Information flow	N	44	33	6,83	6,83	0,008**
		%	88,0	66,0			
7.	Logistics potential (service capacity)	N	47	30	16,32	16,32	0,000**
		%	94,0	60,0			
8.	Flexibility of deliveries	N	40	35	1,33	1,33	0,178
		%	80,0	70,0			
9.	Post-sale services/complaints	N	30	27		0,37	0,343
		%	60,0	54,0			
10.	Personal service	N	41	33		3,33	0,055~
		%	82,0	66,0			

CONCLUSIONS

The obtained research results do not allow to draw explicate conclusions. On the one hand, in general, it can be concluded that the competences achieved by the service providers make them an attractive partner in the logistics cooperation. This conclusion is confirmed by the results of studies which indicate a high level of satisfaction with the existing cooperation and an improved quality of the provided services declared by both groups. On the other hand, customers participating in the research proved to be little demanding in terms of the logistics services. In the analyzed period they ordered in most cases routine services, the provision of which does not require special skills from the service providers. Most likely, for this very reason this group maintained relationships with more entities. Also the customers did not feel the need to develop more advanced levels of cooperation, which was important for the representatives of the other group. It is worth noting that a similar conclusion was drawn from studies carried out in 2011. The research shows that only 10% of the logistics market customers declared they had signed a contract for logistics services [Świtała 2011]. The reluctance on part of the customers to establish a long-lasting cooperation with the service providers was also confirmed by study conducted by Niestrój [2014], which showed that only 37% of the respondents, mainly representatives of large logistics service providers, had 10 or more contract customers, the other major groups focused on 3-5 entities (24%) or did not perform any contract-based services at all (23%).

The main aim of the research was to assess the importance of selected determinants affecting the course of logistics cooperation. The research shows that a decision to start / continue cooperation is influenced by many quantitative and qualitative factors. In both cases, respondents most frequently attributed to them a significant influence on decisions regarding cooperation. Additional analysis revealed the existence of clear differences between the surveyed groups in the positioning of selected service factors in the order of importance. This applies in particular to the service price and the competences of the personnel. In this case, the importance of the human factor in the group of customers should be noticed. It can be assumed that underestimation of the human factor by the service providers can constitute an obstacle in the transition to higher levels of logistics cooperation. There were also observed differences in the responses relating to changes in the service, especially in relation to the service capacity, damage-free deliveries and exchange of information. The research shows that despite declaring their satisfaction with the current service, not all customers felt that the changes implemented by the service providers had resulted in the improvement of the service. Thus, it can be tentatively concluded that innovations introduced by the service providers have not always been aimed at standardizing the offer and serving the mass customer.

Limitations and directions for future research

The presented research results are not free from limitations and do not exhaust the undertaken subject. It is worth noting that the tests were carried out on relatively small group of companies and therefore the results should be cautiously interpreted. The customer group was represented only selected economic activities and sectors. First, the customer group did not include representatives of service companies who due to the specific nature of their activity, could provide some interesting conclusions about the nature and scope of logistics cooperation with the service providers. The research did not include representatives of sectors important to the logistics service providers, i.e. automotive and pharmaceutical sectors, either. Particularly, it would be advisable to expand the research by the opinions of representatives of the automotive sector, because they are customers who generate a significant demand for logistics services. It is also worth noting that both samples were dominated by the SME businesses. For this reason, it would also be advisable to increase the share of large enterprises in the following studies.

The conducted research may serve as a source of guidance for managers from the logistics sector as regards the provision of personalized logistics services to their customers in the near future. Having the research results in mind, the service providers should plan innovations in their offers more carefully, preceding them with a thorough study of the expectations of their customers. Research results indicating the possibility of further improvement in the customer service process should be considered important to the development of the logistics cooperation. In this respect, one should take steps to improve the quality of the after-sales service, which has not received much attention in the recent years.

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DETERMINANTY WSPÓŁPRACY LOGISTYCZNEJ W ŁAŃCUCHU DOSTAW - WYBRANE WYNIKI BADANIA OPINII USŁUGODAWCÓW LOGISTYCZNYCH I ICH KLIENTÓW

STRESZCZENIE. **Wstęp:** Artykuł koncentruje się na wybranych aspektach współpracy usługodawców logistycznych z klientami, ze szczególnym uwzględnieniem wyników analizy porównawczej oceny znaczenia determinant odpowiedzialnych za jej zakres i charakter, a także jakości świadczonych usług oraz zmian w polityce obsługi klienta.
Metody: Podjęty problem badawczy zrealizowano na podstawie badań bezpośrednich, które przeprowadzono z zastosowaniem metody wywiadu kwestionariuszowego wśród 50 usługodawców logistycznych oraz 50 przedsiębiorstw zlecających obsługę logistyczną. Próbę badawczą dobrano w sposób celowy. W analizie statystycznej wykorzystano test niezależności chi-kwadrat, test U Manna-Whitneya oraz współczynniki korelacji V Cramera i rho-Spearmana.
Wyniki: Odnotowano istotne statystycznie różnice w sposobie postrzegania współpracy pomiędzy badanymi grupami. Główne rozbieżności dotyczyły poziomu zadowolenia klientów oraz oceny wpływu cen świadczonych im usług i kompetencji obsługujących ich pracowników na przebieg współpracy. Dla klientów, deklarujących większą satysfakcję z tytułu współpracy z usługodawcami, najważniejsza była jakość usług. Z kolei usługodawcy największą wagę przypisywali głównie cenie. Odnotowano także różnice w odpowiedziach dotyczących zmian w obsłudze, zwłaszcza w odniesieniu do: potencjału logistycznego, bezszkodowości dostaw oraz wymiany informacji.
Wnioski: Grupa usługobiorców okazała się mało wymagająca pod względem obsługi logistycznej. Klienci zlecali głównie usługi rutynowe, których świadczenie nie wymagało od usługodawców szczególnych umiejętności. Najprawdopodobniej właśnie dlatego, dostawcy/odbiorcy ładunków utrzymywali relacje z większą liczbą podmiotów. Nie odczuwali oni także potrzeby budowania bardziej zaawansowanych poziomów współpracy, na czym zależało przedstawicielom drugiej grupy. Odnotowane w badaniu różnice, zarówno te dotyczące hierarchii ważności poszczególnych determinant, jak i te odnoszące się do standardów obsługi, powinny zostać uwzględnione przez usługodawców podczas ich dalszej współpracy z klientami.

Słowa kluczowe: usługodawcy logistyczni, klienci, współpraca, obsługa logistyczna, satysfakcja

DETERMINANTEN DER LOGISTISCHEN ZUSAMMENARBEIT IN DER LIEFERKETTE - AUSGEWÄHLTE UNTERSUCHUNGS-ERGEBNISSE DER BEFRAGUNG VON LOGISTISCHEN DIENSTLEISTUNGSANBIETERN UND IHREN KUNDEN

ZUSAMMENFASSUNG. Einführung: Der Artikel konzentriert sich auf die ausgewählten Aspekte der Zusammenarbeit der logistischen Dienstleistungsanbietern mit ihren Kunden, mit besonderer Rücksicht auf die Ergebnisse der Vergleichsanalyse von Bedeutungsbewertung der Determinanten, die sowohl für ihren Umfang und Charakter als auch für die Dienstleistungsqualität und Veränderungen in der Kundendienstpolitik verantwortlich sind.
Methoden: Das besprochene Forschungsproblem wurde anhand der direkten Untersuchungen durchgeführt, die mit der Anwendung der Fragebogenmethode unter 50 logistischen Dienstleistungsanbietern und 50 Unternehmen erstellt wurden. Die Untersuchungsprobe wurde zielgerecht angepasst. In der statistischen Auswertung wurden unterschiedliche Verfahren wie: der Chi-Quadrat-Unabhängigkeitstest und der U Mann-Whitney-Test, sowie die V-Cramer und die Rho-Spearman Korrelation angewendet.
Ergebnisse: Es wurden relevante statistische Unterschiede in der Beurteilung der Zusammenarbeit zwischen den untersuchten Gruppen festgestellt. Die Hauptabweichungen betrafen das Niveau der Zufriedenheit der Kunden sowie die Bewertung des Einflusses der Preise von geleisteten Dienstleistungen und die Kompetenz der sie bedienenden Mitarbeiter auf den Verlauf der Zusammenarbeit. Für die Kunden, die größere Zufriedenheit wegen der Zusammenarbeit mit den Dienstleistungsanbietern aufweisen, war die Qualität der Dienstleistungen von Bedeutung. Hingegen haben die Dienstleistungsanbieter den größten Wert auf den Preis gelegt. Es wurden auch die Unterschiede in den Antworten, die die Veränderung der Dienstleistung betreffen, festgestellt, vor allem in Bezug auf logistisches Potenzial, schadenfreie Lieferungen und Informationsaustausch.

Fazit: Die Gruppe der Dienstleistungsempfänger erwies sich als wenig anspruchsvoll hinsichtlich der logistischen Kundenbedienung. Die Kunden beauftragten vor allem routinemäßige Leistungen, deren Ausführung keine Sonderkenntnisse von Dienstleistungsanbietern erfordert haben. Höchstwahrscheinlich gerade deswegen hielten die Anbieter/Empfänger der Ladungen Beziehungen zu der größten Zahl der Subjekte. Sie haben auch keine Notwendigkeit empfunden, neue fortgeschrittene Stufen der Zusammenarbeit aufzubauen, worauf die Vertreter der zweiten Gruppe großen Wert gelegt haben. Die in der Untersuchung gezeigten Unterschiede, sowohl diese, die die Wichtigkeit der Hierarchie von einzelnen Determinanten betreffen, als auch diese, die den Servicestandard betreffen, sollen daher von den Dienstleistungsanbietern während der weiteren Zusammenarbeit mit Kunden berücksichtigt werden.

Codewörter: logistische Dienstleistungsanbieter, Kunden, Zusammenarbeit, logistische Kundenbedienung, Zufriedenheit.

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CYCLIC DELIVERY-SCHEDULING PROBLEM WITH SYNCHRONIZATION OF VEHICLES' ARRIVALS AT LOGISTIC CENTERS

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ABSTRACT. **Background:** In this paper a cyclic delivery-scheduling problem with vehicles serving fixed routes is presented. Each vehicle is assigned to one route to which some manufacturers' warehouses and logistics centers belong. A vehicle is to be loaded at a manufacturer's warehouse, then to deliver goods to a logistics center and may be also loaded there with other goods and to transport them to the next node along the route. One logistic center belongs to several routes, so the goods delivered by one vehicle may continue their journey by another truck. For every route the frequency of the vehicle is fixed and known. The objective here is to obtain such synchronization of vehicles arrivals in logistics centers, so that it is possible to organize their arrivals in repeatable blocks.

Methods: In the paper the cyclic delivery-scheduling problem with vehicles serving fixed routes is formulated as a MIP model. Due to the fixed routes and desirable synchronization of vehicles arrivals in shared points this problem seems to be similar to the public transit network timetabling problem. Because of that the model presented here was based on a model dedicated to the public transit network timetabling problem, where optimization criterion was to maximize synchronization of vehicles' arrivals at the shared nodes.

Results: Mixed integer programming model was employed for solving several cases of cyclic delivery-scheduling problem with vehicles serving fixed routes. Computational experiments are reported and obtained results are presented.

Conclusions: The mixed integer programming model for the cyclic delivery-scheduling problem with synchronization of vehicles arrivals at logistic centers presented in this paper can be utilized for generating schedules for a group of vehicles serving fixed long routes. It may result in reducing total operational cost related to this group of vehicles as well as in reducing the goods travel time from the place of origin to their destination.

Key words: cyclic delivery scheduling problem, mixed-integer programming, optimization, synchronization, logistics.

INTRODUCTION

This paper is devoted to the possible utilization of a MIP model for the cyclic delivery-scheduling problem for a network of manufacturers' plants and logistics centers where vehicles' serve fixed routes. The objective of this formulation of cyclic delivery-scheduling problem is to obtain such synchronization of vehicles arrivals in logistics centers and load time, so that it is possible to organize their arrivals in repeatable modules.

In a logistics center all the processes of handling, loading and discharging goods as well as document circulation processes are controlled with an internal logistics management system. Efficiency of this system results in efficiency of the entire logistics center, therefore both separate modules as well as the complex system are designed and implemented with the aim to increase efficiency of warehousing and inventory management. These goals are obtained through shortening time of receipting and dispatching operations, speeding-up handling operations,

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eliminating or reducing bottlenecks in handling and warehousing processes. In result the utilization rate of storage areas is supposed to increase, inventory costs are supposed to decrease, and level of customer service quality should raise [Chudzik 2006, Sitko and Gajdzik 2013].

In research on optimization of internal logistics management systems mathematical and IT tools are utilized. With these tools researchers are able to precisely identify warehousing and logistical capabilities of an enterprise, to monitor an individual consignment, to analyze size and due-dates of deliveries as well as to plan and schedule deliveries [Krystek 2011].

In modern approach to logistics systems loading, handling, dispatching, warehousing and inventory management processes are organized according to the 4R model: a consignment should be delivered in required quantity to right place in right time and all the deliveries should be served in right order [Gudehus and Kotzab 2009]. Right order and right time are crucial for scheduling routes for deliveries that need to be trans-shipped or handled in logistics centers or container terminals. In a system of cyclic-deliveries this problem is getting even more meaningful, since all the deliveries within the fixed network are being repeated with fixed frequencies. Therefore, when some consignments are to be handled between vehicles serving different fixed routes, then arrivals of these vehicles should be synchronized, so that the handling operations can be carried on quickly and goods can be temporarily stored in the storing area next to the loading ramp. Both the logistic center and a final customer benefit from such approach to cyclic-deliveries scheduling. First of all, the travel time of the consignment reduces, so the customers receive their delivery earlier. Secondly, the loading ramp devices are calibrated once and they can be utilized both for unloading one vehicle and reloading another, so the efficiency of the given loading ramp increases. Certainly, the above mentioned approach to the cyclic-deliveries scheduling process can be adopted when we can control vehicles' departure times from the first point along their route. What is more the schedule has to include due-date and delivery orders as well as resources and specific character of a given logistics center [Ambroziak, Lewczuk 2008].

In general cyclic delivery-scheduling problem addresses numerous issues. Different mathematical models were developed for this problem, because different set of aspects were taken into account in each of them [Groenevelt et al.1992, Raa and Dullaert 2007]. Cyclic delivery-scheduling is important in food industry due to the problem of how to organize properly lots of perishable goods to be delivered [Akkerman et al. 2010, Chudzik 2006]. This problem is also vital in municipal services management [Kazan et al. 2012]. Synchronization of cyclic deliveries is crucial for supply chain management in a system with one producer and many customers, especially when demand changes on the seasonal basis [Chang and Chou 2012, Ekici et al. 2014]. The cyclic delivery-scheduling is getting more complicated when time windows for arrivals have to be taken into consideration [Ambroziak and Jachimowski 2011, Ulrich 2013] as well as when the objective is to minimize the number of vehicles serving the system [Campbell and Hardin 2005] or when for some deliveries departure or arrival times are established in advance and cannot be changed [Leunga, Chen 2013].

The objective of research to which this paper is devoted was to synchronize arrival times at logistics centers, so that vehicles serving different routes can be organized in repeatable groups. Synchronization is understood here as a situation when time between arrivals of two vehicles of different routes at a logistics center does not exceed certain value. In this paper the cyclic delivery-scheduling problem with synchronization of vehicles arrivals at logistic centers was presented as a theoretical problem for which MIP model was developed. The model was employed for solving a set of exemplary situations - computational experiments are presented and a selection of obtained results is reported.

CYCLIC DELIVERY-SCHEDULING PROBLEM WITH SYNCHRONIZATION OF VEHICLES' ARRIVALS AT LOGISTIC CENTERS

In the paper a cyclic delivery-scheduling problem with vehicles serving fixed routes is presented. Each vehicle is assigned to one route to which some manufacturers' warehouses and logistics centers belong. A vehicle is to be loaded at a manufacturer's warehouse, then to deliver goods to a logistics center and there may be loaded with other goods and transport them to the next node along the route. One logistic center belongs to several routes, so the goods delivered by one vehicle may continue their journey with another truck. In this problem routes are fixed and known in advance as well as delivery size. For every route the frequency of vehicles is fixed and known. The objective of this formulation of cyclic delivery-scheduling problem is to obtain such synchronization of vehicles arrivals in logistics centers and load time, so that it is possible to organize their arrivals in repeatable blocks. If vehicles, between which goods are handled, arrive in a logistics center simultaneously or one right after another, then goods-to-be-handled can be temporarily stored in the storing area next to the loading ramp. For every logistic center we can determine how long goods can be stored in the storing area next to the loading ramp, so we can compute a time window for two subsequent vehicles' arrivals to be considered as a synchronized pair. For cyclic deliveries the frequency of delivery of each route is also known, therefore we can try to establish departure times of every vehicle, so the total number of synchronizations in the entire network is maximal.

Every change of limits of a node's time window influences significantly on the total number of synchronizations. Obviously, when a time window for a single logistic center gets changed (either widened or narrowed) it may result in changing schedules of other routes as well as it may influence operational costs of the logistic center itself. Therefore, analysis of obtained solutions (delivery schedule for each route and number of synchronizations) may provide the management of a logistics center with information useful for both planning functioning of the center and planning departure times of the cyclic-delivery-vehicles from the first nodes of their routes, so that efficiency of the entire system may increase.

Due to the fixed routes and desirable synchronization of arrivals at nodes shared by different routes this approach to the cyclic delivery scheduling problem seems to be similar to city transit network timetabling problem [Ibarra-Rojas and Rios-Solis 2012, Ceder et al. 2001, Eranki 2004]. Therefore the model developed for the cyclic delivery scheduling problem was inspired by the model that was originally developed for bus synchronization timetabling problem. In both models the objective is to maximize number of synchronization of arrivals in shared nodes.

MIXED INTEGER PROGRAMMING MODEL FOR THE CYCLIC DELIVERY SCHEDULING PROBLEM WITH SYNCHRONIZATION OF VEHICLES' ARRIVALS AT LOGISTIC CENTERS

For the cyclic delivery scheduling problem with synchronization of vehicles' arrivals at logistic centers a MIP model based on the BTP model [Ibarra-Rojas i Rios-Solis 2012] was developed. In the model following sets, variables and parameters were utilized: I – set of routes, B – set of nodes (logistic centers), J^{ij} – set of pairs $<i, j>$, where i-th and j-th routes share a node, S^{ijb} – set of triples $<i, j, b>$ where i-th and j-th routes share b-th node, T – parameter, planning horizon, that is the period during which all the deliveries must departure from the first nodes of their routes, fr_i – parameter, number of the deliveries to be scheduled for the i-th route, H_i – parameter, fixed headway of the i-th route, t_{ib} – parameter, travel time between the first node of the i-th route and the b-th node, w_b – parameter, minimal interval between arrivals of consecutive deliveries in the b-th node, W_b – parameter, maximal interval between arrivals of consecutive deliveries in the b-th node, M – big number.

In this model two types of variables were utilized: X_{ip} – departure time of the p-th delivery of the *i*-th route, Y_{ijbpq} – presence or absence of synchronization between every pair of deliveries that arrive in the *b*-th node.

As it was already mentioned, the objective is to maximize the number of synchronizations of the entire system. Synchronization is understood as simultaneous of consecutive arrivals of vehicles serving different routes in the shared node. Interval between these two arrivals should not exceed the range (w_b; W_b).

Table 1. Mixed integer programming model for the cyclic-delivery scheduling problem with time windows
Tabela 1. Model programowania całkowitoliczbowego mieszanego dla problemu harmonogramowania cyklicznych dostaw z oknami czasowymi

Objective function:		
$\max \rightarrow \sum_{i\in I}\sum_{j\in I}\sum_{b\in B}\sum_{p\in F_i}\sum_{q\in F_j} Y_{ijbpq}$	$i, j\in I; b\in B; 1\le p\le fr_i; 1\le q\le fr_j$	(1)
Subject to:		
$X_{i,1}\le H_i$	$i\in I$	(2)
$X_{i,fr_i}\le T$	$i\in I$	(3)
$T-H_i\le X_{i,fr_i}$	$i\in I$	(4)
$X_{i,p+1}-X_{ip}=H_i$	$i\in I, 1\le p\le fr_i-1$	(5)
$(X_{jq}+t_{jbq})-(X_{ip}+t_{ibp})\le W_b+M*(1-Y_{jibqp})$	$i, j\in I; b\in B; 1\le p\le fr_i; 1\le q\le fr_j$	(6)
$(X_{jq}+t_{jbq})-(X_{ip}+t_{ibp})\ge w_b-M*(1-Y_{jibqp})$	$i, j\in I; b\in B; 1\le p\le fr_i; 1\le q\le fr_j$	(7)
$Y_{ijbpq}\le 1-Y_{jibqp}$	$i, j\in I; b\in B; 1\le p\le fr_i; 1\le q\le fr_j, <i,j,b>\in S^{ijb}$	(8)
$Y_{ijbpq}=0$	$i, j\in I; b\in B; 1\le p\le fr_i; 1\le q\le fr_j, <i,j,b>\notin S^{ijb}$	(9)
$X_{ip}+t_{ibp}=Z_{ibp}$	$i, j\in I; b\in B; 1\le p\le fr_i; 1\le q\le fr_j, <i,b>\in J^{ib}$	(10)
$X_{ip}\in\{0,1,...T\}$	$i\in I, p\le fr_i$	(11)
$Y_{ijbpq}\in\{0,1\}$	$i, j\in I; b\in B; 1\le p\le fr_i; 1\le q\le fr_j$	(12)
$Z_{ibp}\in\{0,1,2,...\}$	$i\in I; b\in B; 1\le p\le fr_i;$	(13)

Source: own work based on the BTP model [Ibarra-Rojas and Rios-Solis 2012]

COMPUTATIONAL EXPERIMENTS - UTILISATION OF A MIP MODEL FOR THE CYCLIC DELIVERY SCHEDULING PROBLEM WITH SYNCHRONIZATION OF VEHICLES' ARRIVALS AT LOGISTIC CENTERS

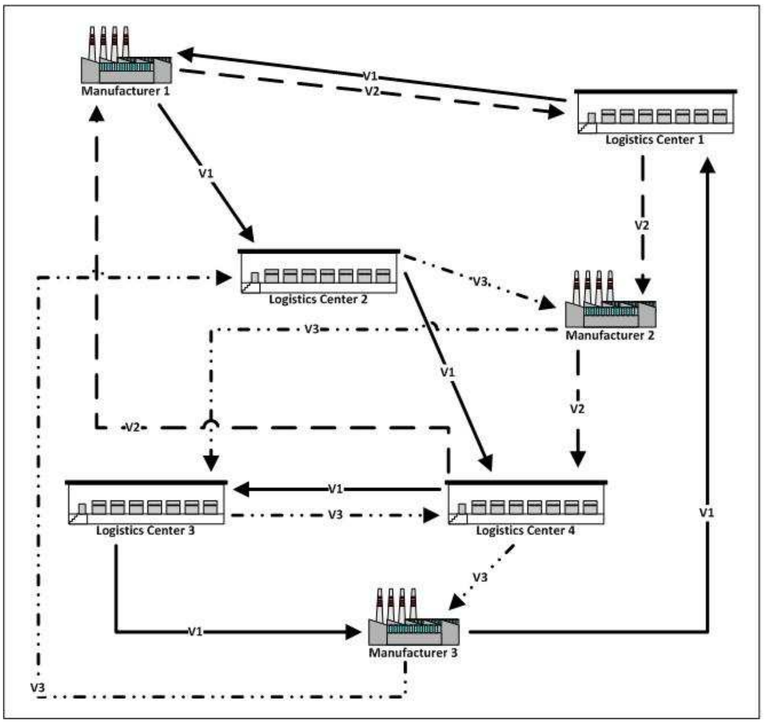
Cyclic deliveries are performed along three fixed routes. For each route a separate group of vehicle is assigned to serve deliveries along this route. Vehicles of a given group (V_k) transport goods between three producers (M_i) and four logistics centers (LC_j). The order of service (route) was defined for every group of vehicle and it cannot be changed. We assume that every group of vehicle is big enough, so for every delivery scheduled to any possible time there is a vehicle available to serve it.

Vehicles serve following routes:
Route V1: M1 – LC2 – LC4 – M3 – LC1 – M1
Route V2: M1 – LC1 – M2 – LC4 – M1
Route V3: M2 – LC3 – LC4 – M3 – LC2 – M2.

During the planning horizon from the first node of the *i*-th route exactly fr_i deliveries must departure. For every route (i) their headways (H_i) – that is intervals between departures of consecutive deliveries from the first node – are known and they are fixed during the entire planning horizon.

As it was already mentioned, synchronization Y_{ijbpq} is understood as arrivals of the *p*-th delivery along the *i*-th route and the *q*-th delivery along the *j*-th route in the *b*-th node simultaneously of consecutively, if the interval between these two arrivals should not exceed the range (w_b; W_b). For this problem a 60-hour planning horizon *T* will be utilized in computations. What is more, it was assumed that time of delivery receiving and reloading may be neglected.

For solving the problem the MIP model presented in the previous chapter was utilized. After solving a problem we obtain departure time of each delivery from the first node of its route. On that basis we can compute the arrival time of each delivery at every node along its route. To simplify the problem we assumed that the travel time between each pair of subsequent nodes equals 1 hour. The scheme of this problem is presented in the Fig. 1.



Source: own elaboration

Fig. 1. Scheme of a network for which cyclic delivery scheduling problem with synchronization of vehicles' arrivals at logistic centers is to be formulated
Rys. 1. Schemat przykładowej sieci, dla której zostanie sformułowane zadanie harmonogramowania dostaw cyklicznych z warunkiem synchronizacji przyjazdów do centrów przeładunkowych

In Table 2 and Table 3 data utilized in computational experiments are presented. In Table 3 number of deliveries to be scheduled for every route and headways adopted for each route are presented. In Table 3 information of upper (W_b) and lower (w_b) limits of time windows are provided. Upper limits of time windows may yield different values.

Table 2. Data utilized in computational experiments
Tabela2. Dane do eksperymentów obliczeniowych

	Headway H_i [h]	**Number of deliveries**
Route *V*1	7	4
Route *V*2	7	4
Route *V*3	3	10

Source: own elaboration

Computations were conducted with a computer equipped with a processor Intel® Core™i3 2.20 GHz and 4 GB RAM. Searching for a solution was limited in advance by time limit that was equal 1000 seconds. This amount of time was enough to obtain optimal solution for every case. For this problem 144 cases was solved – 144 is the total number of combinations of time windows' limits, w_b and W_b (see Table 3).

Selected results are to be found in the Table 5. Results obrained for these selected cases show relations between the width of time windows and the number of synchronizations obtained for the entire network and for individual nodes. This information is important for managing the whole network. In Table 4 we present the solution of the case where maximal number of synchronizations was obtained (the highest result amongst 144 cases) and solutions of cases where maximal number of synchronizations was obtained for individual nodes.

Table 3. Data utilized in computational experiments
Tabela 3. Dane do eksperymentów obliczeniowych

Warehouse	M1	M2	M3	LC1	LC2	LC3	LC4
Node in the model	1	4	7	2	3	6	5
Lower limit of time window (w_b)	0	0	0	0	0	0	0
Upper limit of time window (W_b)	1, 2, 3	1, 2	1, 2	1, 2, 3	1, 2	1, 2	1

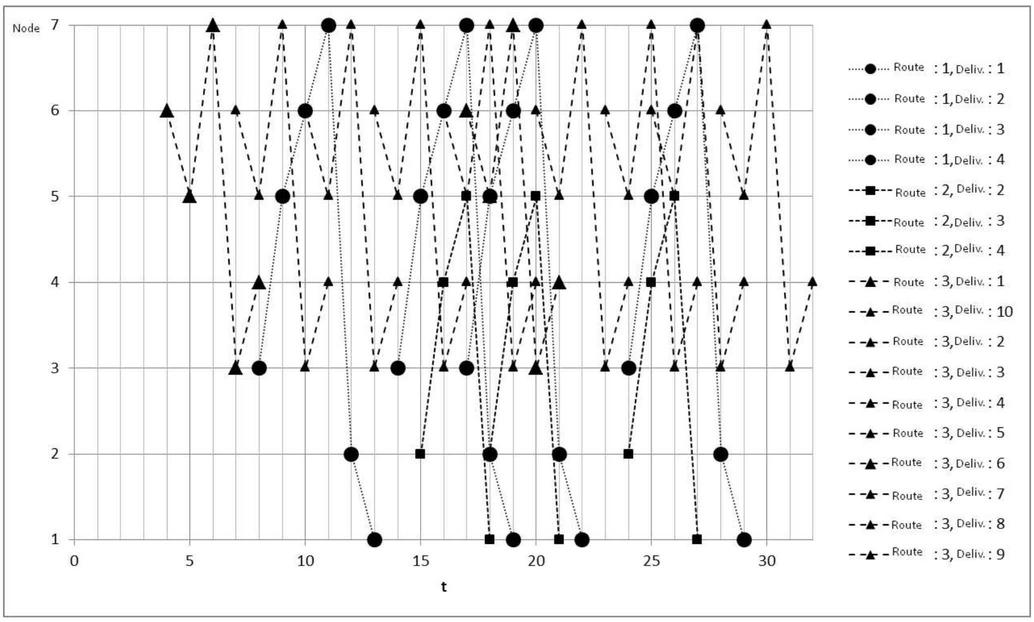
Source: own elaboration

Table 4. Selected results of computational experiments
Tabela 4. Wyniki rozwiązania eksperymentu obliczeniowego

Case	Upper limit of time window (W_b) in the *b*-th node (lower limit: $w_b = 0$)							Number of synchronizations in the *b*-th node							Total numer of synchronizations
	M1	LC1	LC2	M2	LC4	LC3	M3	M1	LC1	LC2	M2	LC4	LC3	M3	
	1	2	3	4	5	6	7	FC_1	FC_2	FC_3	FC_4	FC_5	FC_6	FC_7	FC
1	*3*	*3*	*2*	*2*	*1*	*2*	*2*	5	5	8	9	14	7	10	58
2	*3*	*1*	*2*	*2*	*1*	*2*	*2*	7	3	8	7	16	8	8	57
3	*1*	*3*	*1*	*2*	*1*	*1*	*1*	4	6	7	8	10	6	4	45
4	*2*	*3*	*2*	*1*	*1*	*2*	*2*	5	4	9	5	15	7	8	53
5	*1*	*3*	*1*	*2*	*1*	*2*	*2*	4	5	5	10	11	9	8	52
6	*2*	*1*	*2*	*1*	*1*	*2*	*2*	4	2	8	4	17	8	8	51
7	*1*	*1*	*1*	*1*	*1*	*2*	*2*	3	3	4	5	14	10	8	47
8	*2*	*3*	*2*	*2*	*1*	*2*	*2*	5	5	8	9	14	7	10	58

Source: own elaboration

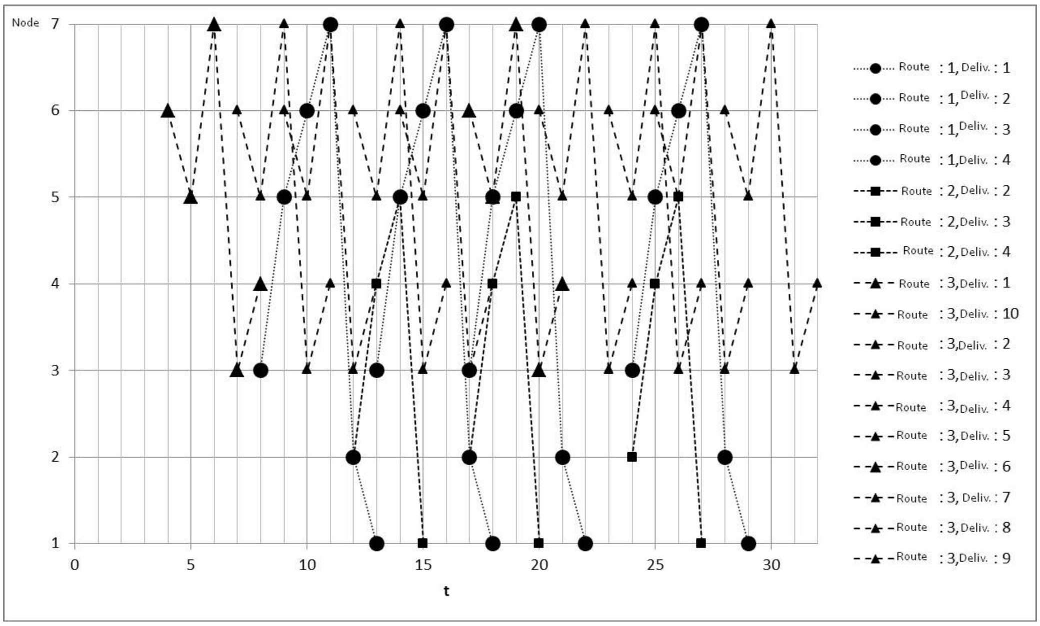
As it was to be expected the solution with the highest value of the objective function (58 synchronizations) was obtained for the case with the widest time windows. In Table 4 this case is presented as a Case 1, and it is illustrated with Figure 2.



Source: own elaboration

Fig. 2. Illustration to results obtained for Case 1 from Table 5 (the case with the maximal number of synchronizations in the LC4 node)
Rys. 2. Graficzne przedstawienie wyników dla zadania nr 1 z Tabeli 5 (przypadek z największą liczbą synchronizacji w sieci)

In Figure 2 moments of arrivals of every vehicle to every node belonging to its route are presented. Cyclic repetition of deliveries is to be observed for each route. This solution can be compared with the one obtained for Case 5 - the highest number of synchronizations in logistic center no. 4 (node no. 5) amongst all the 144 solved cases. LC4 is shared by all the three routes, so synchronization in this node can be crucial for the system. In Case 6 the number of synchronizations obtained in LC4 equaled 17 and the total number of synchronizations was 51, while in the Case 1 they were, respective, 14 and 54. What is to be emphasized is the fact that the maximal number of synchronizations in LC4 was achieved when some upper limits of time windows did not have their maximal width; in Case 6 upper limits of time windows in nodes M1 and LC1 were lower than in Case 1.



Source: own elaboration

Fig. 3. Illustration to results obtained for Case 6 from Table 5 (the case with the maximal number of synchronizations in the LC4 node)
Rys. 3. Graficzne przedstawienie wyników dla zadania nr 6 z Tabeli 5 (przypadek z największą liczbą synchronizacji w węźle LC4)

CONCLUSIVE REMARKS

In this paper results obtained for a small network were presented. Continuation of research in this field is recommended, since there are many other aspects of cyclic deliveries that were not taken into consideration here. Amongst them are to be listed: deliveries to warehouses or logistics centers where many deliveries can be received in the same time, costs of travel and waiting time or vehicle assignment problem.

The approach to the cyclic delivery scheduling problem with synchronization of vehicles' arrivals at logistic centers together with the MIP model may be utilized as a supportive tool for decision-making problems in delivery planning. With the model presented in this paper we can obtain solution in reasonable time, however, assumptions adopted here simplify scheduling in a logistic center, since we focus on a specific kind of deliveries. Therefore the research in this area should be continued and the model should be developed by adding further aspects of the problem.

ACKNOWLEDGEMENTS

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PROBLEM HARMONOGRAMOWANIA DOSTAW CYKLICZNYCH Z WARUNKIEM SYNCHRONIZACJI PRZYJAZDÓW DO CENTRÓW PRZEŁADUNKOWYCH

STRESZCZENIE. **Wstęp**: W pracy przedstawiono problem harmonogramowania dostaw cyklicznych wykonywanych przez pojazdy obsługujące ustalone i niezmienne trasy. Każdy pojazd obsługuje inną trasę, gdzie ma za zadanie dostarczyć towar do centrum logistycznego, a także załadować tam inny towar i przewieźć go do kolejnego punktu trasy lub wykonać pusty przejazd do kolejnego punktu załadunku. Wspólnymi punktami tras pojazdów są centra logistyczne, w których niejednokrotnie towar przywieziony przez jeden pojazd, wyrusza w dalszą drogę następnym pojazdem z rozpatrywanej grupy. Przejazdy po każdej trasie realizowane są ze stałą częstotliwością. Celem dla wspomnianego problemu harmonogramowania dostaw cyklicznych jest uzyskanie synchronizacji przyjazdów i pobytu pojazdów w centrach logistycznych tak, aby możliwe było grupowanie ich obsługi w bloki.
Metody: Ze względu na sztywno wyznaczone trasy oraz pożądaną synchronizację przyjazdów do punktów wspólnych tras problem ten wykazuje podobieństwo do problemów układania rozkładów jazdy komunikacji miejskiej. Dlatego przy konstruowaniu modelu matematycznego dla tego problemu wykorzystano model przygotowany pierwotnie dla zadania układania rozkładów jazdy komunikacji miejskiej z kryterium optymalizacji związanym z synchronizacją przyjazdów na przystanki wspólne.
Wyniki: Eksperyment obliczeniowy polegał na rozwiązaniu i porównaniu uzyskanych wyników dla zbioru zadań programowania całkowitoliczbowego mieszanego dla problemu harmonogramowania cyklicznych dostaw z warunkiem synchronizacji przyjazdów do centrów przeładunkowych.
Wnioski: Przedstawiony model MIP dla zadania harmonogramowania cyklicznych dostaw z warunkiem synchronizacji przyjazdów do centrów przeładunkowych może być wykorzystywany do tworzenia harmonogramów do planowania kursów cyklicznych wykonywanych przez grupę pojazdów obsługujących ustalone długie trasy. Pozwoli to na racjonalne planowanie pracy centrum logistycznego i pośrednio wpłynie na obniżenie kosztów, a także skrócenie czasu podróży towaru z punktu wysyłki do odbiorcy.

Słowa kluczowe: harmonogramowanie dostaw cyklicznych, optymalizacja, synchronizacja, programowanie całkowitoliczbowe mieszane

DAS PROBLEM DER TERMINPLANUNG VON ZYKLISCHEN LIEFERUNGEN UNTER DER VOTRAUSSETZUNG DER SYNCHRONISATION VON ANKÜNFTEN IN GÜTERVERKEHRS-ZENTREN

ZUSAMMENFASSUNG. Einleitung: In der Arbeit wurde das Problem der Terminplanung von zyklischen Lieferungen dargestellt, die von Fahrzeugen mit festgelegten und unveränderten Routen bedient werden. Jedes Fahrzeug bedient anderen Weg, wo es die Aufgabe hat, die Ware zum Logistikzentrum zu liefern, dort eventuell andere Ware abzuholen und zum nächsten Punkt auf dem Weg weiter zu transportieren oder auch einen leeren Transport zum nächsten Lieferungspunkt auszuüben. Die gemeinsamen Punkte für diese Fahrzeuge sind Güterverkehrszentren, in denen die von einem Fahrzeug transportierte Ware mehrfach mit einem anderen Fahrzeug aus der berücksichtigten Gruppe weiter befördert wird. Die Fahrten sind auf jeder Strecke mit fester Frequenz realisiert. Das Ziel der genannten Problemstellung ist eine solche Synchronisation von Fahrten und Aufenthalten der Fahrzeugen in Logistikzentren, die ihre gruppenweise Bedienung und Abfertigung ermöglicht.
Methoden: In Anbetracht der fest bestimmten Fahrstrecken und einer erwünschten Synchronisation der Fahrten zu gemeinsamen Punkten zeigt dieses Problem eine Ähnlichkeit zu den Fragestellungen, die bei der Zusammenstellung von städtischen Verkehrsfahrplänen auftauchen. Daher wurde bei der Ausgestaltung eines mathematischen Modells für die Lösung dieses Problems ein Modell verwendet, das ursprünglich für die Aufgabenlösung der Zusammenstellung von Verkehrsfahrplänen mit dem Kriterium der Optimierung für die Synchronisation von verbundenen Ankünften in gemeinsame Haltestellen vorbereitet wurde.
Ergebnisse: Das Berechnungsexperiment verließ sich auf die Lösung und Vergleichung der gewonnenen Ergebnissen für die Aufgabenstellung der ganzzahligen gemischten Optimierung des Problems der Terminplanung von zyklischen Lieferungen mit der Voraussetzung einer optimalen Durchfahrtsynchronisation zu Güterverkehrszentren.

Fazit: Das dargestellte Modell der ganzzahligen Optimierung für die Aufgabe der Terminplanung von zyklischen Lieferungen mit der Voraussetzung der Fahrtsynchronisation zu Güterverkehrszentren kann zum Bilden von Zeitplänen für die Planung von zyklischen Kursen der Fahrzeugengruppen, die feste und lange Fahrstrecken bedienen, verwendet werden. Das erlaubt, die Arbeit des Logistikzentrums rationell zu planen sowie die Kosten und Transportzeiten zwischen Lieferanten und Empfängern zu reduzieren.

Codewörter: Terminplanung von zyklischen Lieferungen, die ganzzahlige Optimierung, Synchronisation.

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INTEGRATION OF PRODUCTION AND SUPPLY IN THE LEAN MANUFACTURING CONDITIONS ACCORDING TO THE LOT FOR LOT METHOD LOGIC - RESULTS OF RESEARCH

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ABSTRACT. **Background:** The review of literature and observations of business practice indicate that integration of production and supply is not a well-developed area of science. The author notes that the publications on the integration most often focus on selected detailed aspects and are rather postulative in character. This is accompanied by absence of specific utilitarian solutions (tools) which could be used in business practice.

Methods: The research was conducted between 2009 and 2010 in a company in Wielkopolska which operates in the machining sector. The solution of the research problem is based on the author's own concept - the integration model. The cost concept of the solution was built and verified (case study) on the basis of conditions of a given enterprise (industrial data).

Results: Partial verifiability of results was proved in the entire set of selected material indexes (although in two cases out of three the costs differences to the disadvantage of the lot-for-lot method were small). In case of structure of studied product range, a significant conformity of results in the order of 67% was achieved for items typically characteristic for the LfL method (group AX).

Conclusions: The formulated research problem and the result of its solution (only 6 material items) demand a lot (orthodoxy) in terms of implementation conditions. The concept of the solution has a narrow field of application in the selected organizational conditions (studied enterprise). It should be verified by independent studies of this kind at other enterprises.

Key words: lot for lot, selection of product range, simulation of inventory costs.

INTRODUCTION

The contemporary world has at its disposal a number of technical and organizational solutions in the area of company and supply chain management. However, the requirements of present times clearly show that all these achievements of the management science and practice are still insufficient. The needs of a contemporary customer confronted with the possibilities of meeting these needs by organizations create a number of problems which stem not only inside the company, but mainly in the general conditions of world economy. Therefore, more and more attention is paid to rational use of resources and adaptive solutions which allow a quicker response to changing market environment. The savings generated by correct use of resources will certainly contribute to the increase of the organization's effectiveness. The ubiquitous reduction of cycles (time parameter) at acceptable cost level remains a valid direction of actions in business practice. From the perspective of market needs, the best method of action is the one which satisfies such need the quickest.

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The remedy to these challenges of our times can be the lean manufacturing concept. It attaches great significance to economical commitment of resources (elimination of waste) in connection with the activities aiming at improvement of the organization (kaizen). Undoubtedly, the positive effects of lean manufacturing can be felt very quickly within a single organization (local optimization). However, it is not before we apply this concept holistically to all links of supply chain that the entire potential can be seen (systemic solutions). This requires though that the solutions are developed and used above the functional and organizational divisions.

ENVIRONMENT AND SCOPE OF APPLICATION OF THE LOT-FOR-LOT METHOD

The integration of production and supply in the lean manufacturing conditions requires that the concept of the solutions conforms to the requirements of lean concept [Fertsch 2010]. Two key criteria should be considered to this end:

- minimizing the products supply cycles,
- elimination of inventories.

In case of classical methods of determining the size of lots in planning of material requirements [Orlicky 1975], each method to a greater or lesser extent can influence the length of supply cycles. But only one solution allows to eliminate the inventory - the lot-for-lot method (LfL).

In the lot-for-lot method, the quantity is exactly equal to the net requirement (no more, no less), hence any inventory is impossible. The ordering/ supply cycle is determined by the moment the demand occurs. An unquestionable advantage of this method is adaptation of supply size to needs in terms of time and quantities. A disadvantage is high transport costs (ordering costs) and high changeover costs (costs of starting the manufacturing). The first problem is solved by negotiating favourable transport rates, the other by reducing the changeover times (SMED method).

The lot-for-lot method is used [Orlicky 1975]:

- in supply: for expensive bought-in items and/or items with highly discontinuous requirement,
- in production: for expensive parts made to order (one-off production) or sporadic starts for low repeatability parts (used to eliminate the dead, non-rotating items).

Hence, according to the ABC classification [Cyplik 2005], which reflects the importance of individual items mostly in terms of value, the lot-for-lot method applies to group A - items with high cost contribution (in case of this criterion the situation is clear).

The value of an item which assigns it to group A can be reached by volume or by price. In addition to the most favourable case - large volume and high price - two more cases are possible [Krzyżaniak 2003]:

- regular requirement/large volume at low price;
- irregular requirement/small volume at high price.

Thus, according to the XYZ classification, which reflects the importance of individual items mostly in terms of amounts (size of e.g. purchase), the items A from the lot-for-lot method can be assigned to group X (large volumes) or to group Z (small volumes).

OVERCOMING THE LIMITATIONS OF THE LOT-FOR-LOT METHOD

The author was interested only in bought-in items purchased from outside suppliers (supply). Taking this into account, in further study the application of the lot-for-lot method was limited to groups AX and AZ. Group AX (large value, large volume) fits perfectly the conditions of lean manufacturing. It can be equated to cyclical manufacturing of product range in lines (replenishment of inventory) to which the product range was allocated according to the characteristics of value streams (product families) [Rother and Shook 1998; Rother and Harris 2001, Harris and Harris and Wilson 2003]. In such case, there will be rather no obstacles to lean manufacturing in the Just-in-Time conventions implemented operationally using the lot-for-lot method due to high volume. The problems appear when the resultant lot size for the lot-for-lot method is unsatisfactory (too small). This situation will certainly take place in case of items from group AZ. It is then necessary to overcome the existing limitations.

The limitations of the lot-for-lot method can be divided into two categories:
- theoretical (conventional) limitations resulting from the logic of the LfL method,
- actual limitations connected with the business reality.

The theoretical limitations include, i.e.:
- absence of safety margin (a physical reserve of material at the manufacturer's),
- absence of quantitative flexibility of supply (lot size = net needs),
- absence of time flexibility of supply (delivery time = occurrence of need).

The actual limitations include, i.e.:
- supplier's production capacity (logistic maximum),
- lower order limit (logistic minimum),
- purchase budget,
- ordering costs (de facto transport costs).

When forming the lot, also in the lot-for-lot method, taken into account are the economic and organizational actors which are related to the conditions of companies and the features of material items. There are three ways to eliminate the aforementioned limitations:
- using a substitute material (with different lot sizing),
- changing the lot size (vertical lot accumulation),
- changing the delivery time (speeding up).

The first solution has only a potential significance, but is given here for completeness of our considerations. The second solution - vertical lot accumulation - is promising and offers a few options. The third solution is inacceptable, it clearly contradicts the assumptions. Bringing the delivery date forward negates the JiT/LfL logic as it destroys the need-supply relationship and results in creation of an inventory.

SELECTION OF PRODUCTS FOR INTEGRATION

The research was conducted in a company in Wielkopolska which operates in the machining sector. The production process involves standard steps for this type of industry: forging/ casting, machining and assembly. The company currently has a wide spectrum of products (diversified range) manufactured in one plant (concentration of production at a single location). The restructuring of the company evolves towards streamlining the organization and implementation of the lean manufacturing approach [Domański and Cyplik and Hadaś and Pruska 2011].

The set of final products of the company was reviewed for the research. 1104 different final products were identified on the basis of production documentation which was made available. Products families were identified on the basis of design and technological similarity, and the families are represented by the most standard product in each group (structure and technology). This selection of product range was described in another publication [Domański and Hadaś 2008]. The selection allowed to narrow down the spectrum of analysis to 17 representative products. With such sample, the research horizon was set to one year broken down to weeks (52 timing units). The stream size in a given week is a sum of all products constituting the stream. In order to reduce the labour intensity, the research was then limited to one quarter of the year. Second quarter was chosen for representativeness of the results (weeks 14 to 26). The next step was disaggregation of needs within product families. The requirements for individual materials were determined for each of 17 streams according to the MRP (material requirements planning) logic by multiplying the production plan for a stream by repeatability of a given material in a representative product. He total of 431 different materials was identified. According to the assumptions, only materials purchased from eternal suppliers were considered. This narrowed down the research to 245 purchase items. The ABC and XYZ classification was made on this sample of 245 items. The value analysis ABC gave 8 material indexes which generate 81% of turnover. The material items from group A constitute 3.3% of all indexes. The quantitative analysis XYZ gave 30 indexes for group X and 171 indexes for group Z, which represent 12.2% and 69.8% of all materials. The quintessence of these analyses was the cross analysis ABC/XYZ. The final selection included 6 material items, 3 from the group AX and 3 from the group AZ.

The summary of the selection stage included a comparison of these 6 material positions with the structures of 17 representative products for material-final product relations. The aim was to test the uniqueness (material is used exclusively for one single product) and the versatility (material is used for more than one product). The result was 100% uniqueness - no shared materials in products (there was always "one material - one product" relationship).

The results obtained using the LfL method according to the zero inventory variant [Głowacka-Fertsch and Fertsch 2004] were compared with the results of another lot sizing method. We arbitrarily chose the FOQ (Fixed order Quantity) method.

Table 1. LfL vs FOQ - comparative analysis, synthesis
Tabela 1. PnP vs SWP - analiza porównawcza, synteza

Material index	Group	LfF Method	FOQ Method
Material 223	AX	better	worse
Material 225	AX	worse	better
Material 75	AX	better	worse
Material 222	AZ	better	worse
Material 77	AZ	worse	better
Material 226	AZ	worse	better

Source: own study

The synthetic research results show a proportional distribution of effectiveness of both methods. Please note domination of the LfL method in the group AX and its incidental nature in the group AZ. It is hard to formulate more general conclusions because of the small sample size (only 6 indexes). However, it can be assumed that the environment for the LfL method is rather large volumes (quantitative). This requires however a deeper research on a different industrial plant.

CONDITIONS OF APPLICATION OF THE LOT-BY-LOT METHOD AS A LEAN INTEGRATION TOOL

As a complement and complement of the research results, the author decided to look for a coefficient and mathematical function which could determine the conditions of using the lot-by-lot method without the need for a scrupulous calculation of the MRP table [Fertsch 2003].

Two categories of inventory management costs were considered [Krzyżaniak 2003]:
- inventory replenishment costs Kg (gathering, renewal),
- inventory keeping costs Ku (storage, warehousing).

Two cases are possible when these categories are compared with each other:
(1) Kg < Ku,
(2) Kg > Ku.

The sought after conditions of application are the case when L < P, that is:

$$Kg < Ku \rightarrow \text{LfL method.}$$

In any different case when L > P:

$$Kg > Ku \rightarrow \text{another lot sizing method.}$$

After mathematical transformations we obtain:

$$Kg < Ku$$
$$(P / WD) \cdot kg < 0,5 \cdot WD \cdot c \cdot u_o \quad / : u_o$$
$$(P \cdot kg) / WD \cdot u_o < 0,5 \cdot WD \cdot c \quad / \cdot WD$$
$$(P \cdot kg) / u_o < 0,5 \cdot WD^2 \cdot c \quad / : P$$
$$kg / u_o < 0,5 \cdot WD^2 \cdot c / P$$

The left size of the inequality can be treated as a certain logistic characteristic of lot sizing method (αME), described by the following relationship:

$$\alpha ME = kg / u_o$$

where:

P - planned demand (purchases) in the considered period,
WD - lot (order) size,
kg - unit gathering costs,
c - purchase cost,
u_o - coefficient of inventory keeping costs.

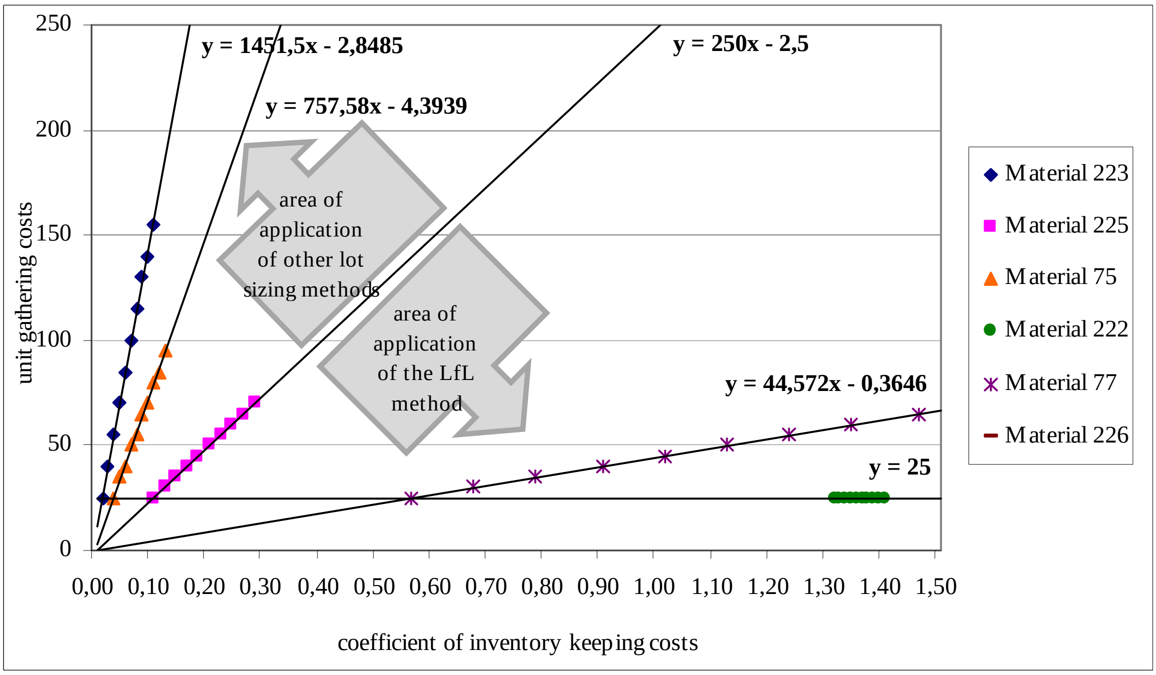
The right side of the inequality represents the characteristics of material index (áMA), described by the following relationship:

$$\alpha MA = 0{,}5 \cdot WD^2 \cdot c / P$$

The conditions of application sought by the author are the case when:

$$\alpha ME < \alpha MA.$$

The inventory replenishment costs were simulated in an Excel spreadsheet. The results were stored in the matrix arrangement: supply size vs unit gathering cost. Inventory keeping costs were simulated in another Excel spreadsheet. The results were also stored in the matrix arrangement: supply size vs coefficient of inventory keeping costs. The final Excel spreadsheet included the simulation of the inventory cost comparison. The results show the area of application of the LfL method and the areas where other (remaining) supply lot methods should be used. Only variable costs were considered. This choice is a result of the fact that the size of simulated supply is related to generation of a certain level of variable costs. Curves were plotted for individual material indexes (first 10 values were used as independent variables). Then, the analytical form of the function was obtained using the trend line (a linear character was assumed) - formulas for individual indexes (Fig. 1).



Source: own study

Fig. 1. Area of application of the lot-for-lot method and the area of application of alternative methods
Rys. 1. Obszar stosowania metody partia na partię oraz obszar zastosowania metod alternatywnych

Each function is a so-called limit curve, with the area of application of the LfL method on one side of the curve and the area of application of other lot sizing methods on the other side. The correctness of equations can be checked by making substitutions in the formulas: when x is a certain inventory keeping cost, we calculate y - unit gathering cost.

CONCLUSIONS

Lean manufacturing as one method of action is by no means a universal recipe. It can be successfully implemented in practice only under specific organizational and production conditions. Certainly, lean manufacturing well fits the reality of contemporary production. Better use of resources and perfection of enterprises by organizational improvement is a cost effective (low-budget) option, though often difficult to carry out and maintain in a longer timeframe.

The solution of the research problem is based on the lot paradigm - a specific stream of goods flowing between the interested spheres: supply - production. The accepted method of solving the problem - lean manufacturing - has imposed the flow synchronization character - the Just in Time model implemented operationally using the lot-for-lot method. The author hopes that this idea and viewpoint will be developed by others into next specific utilitarian solutions (tools and implementations).

The Just in Time practice or the lot-for-lot model are treated as solutions which do not create inventories. This is true and false at the same time. If we assume that the supplied amount is equal to the requirement in a unit of time, then theoretically there is no inventory. The catch is hidden in the determination of length of a period of time (assumed timing unit). In reality, not all pieces will be used in an instant, this will happen gradually as time flows. Hence, in such case we can say that there is a temporary inventory and related inventory keeping cost. The remedy to avoid this paradox is to strive for as short timing units as possible.

The paper also attempts to test the sense of using the lot-for-lot method also from the perspective of taking the inventory keeping cost into consideration. The simulations have shown the frames of application is this concept. Realistically, it must be admitted that this method can be used only for a few initial values of the function because gradually the inventory costs are becoming increasingly important.

The paper tries to fill the existing tool gap. Identification of pro-integration factors within specific configurations, knowing the direction and force of these factors, and establishing the system to measure the integration are among the current problems and phenomena of contemporary business. The paper sketches the road to look for answers in the area of integration for both scholars - theoreticians of management - and practitioners who deal with improving the supply and production processes in the context of operational activities.

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INTEGRACJA PRODUKCJI I ZAOPATRZENIA W WARUNKACH SZCZUPŁEGO WYTWARZANIA WEDŁUG LOGIKI METODY PARTIA NA PARTIĘ - WYNIKI BADAŃ

STRESZCZENIE. **Wstęp**: Przeprowadzone badania literaturowe oraz obserwacje praktyk biznesowych wskazują, iż integracja sfery produkcji ze sferą zaopatrzenia stanowi narzędziowo mało zagospodarowany obszar nauki. Autor zauważa, iż publikacje dotyczące integracji koncentrują się najczęściej na wybranych aspektach szczegółowych i mają raczej charakter postulatywny. Obserwuje się jednocześnie brak propozycji konkretnych rozwiązań utylitarnych (instrumenty) możliwych do biznesowego stosowania.

Metody: Prace badawcze prowadzono na przestrzeni lat 2009-2010 w jednym z wielkopolskich przedsiębiorstw zaliczanych do branży obróbki mechanicznej. Rozwiązanie problemu badawczego nastąpiło w oparciu o autorską koncepcję - model integracji. Opierając się na warunkach wybranego przedsiębiorstwa (dane przemysłowe), dokonano budowy i weryfikacji kosztowej koncepcji rozwiązania (studium przypadku).

Wyniki: W całym zbiorze wyselekcjonowanych indeksów materiałowych wykazano połowiczną sprawdzalność wyników (choć w dwóch z trzech przypadków różnice kosztowe na niekorzyść metody partia na partię były niewielkie). W przypadku struktury rozpatrywanego asortymentu, dla pozycji typowo charakterystycznych dla metody PnP (grupa AX), uzyskano znaczącą zgodność wyników rzędu 67%.

Wnioski: Sformułowany problem badawczy i wynik jego rozwiązania (zaledwie 6 pozycji materiałowych), stawiają duże wymagania (ortodoksyjność) co do warunków wdrożenia. Koncepcja rozwiązania ma w obranych warunkach organizacyjnych (badane przedsiębiorstwo) wąski obszar stosowania. Należałoby to potwierdzić niezależnymi badaniami tego typu w innych przedsiębiorstwach.

Słowa kluczowe: partia na partię, selekcja asortymentu, symulacja kosztów zapasów.

INTEGRATION VON FERTIGUNG UND VERSORGUNG IN DER SCHLANKEN PRODUKTION GEMÄß DER LOGIK NACH DER METHODE LOSGRÖßE AUF LOSGRÖßE - FORSCHUNGSERGEBNISSE

ZUSAMMENFASSUNG. Einleitung: Die durchgeführten Literaturstudien und die Wahrnehmungen von Business-Praktika ergeben, dass die Integration der Fertigung mit der Beschaffung hinsichtlich der eingesetzten Tools einen relativ wenig erforschten Wissenschaftsbereich der Logistik darstellt. Der Autor ist der Ansicht, dass die die Integration anbetreffenden Veröffentlichungen sich meistens auf ausgewählte, detaillierte Aspekte konzentrieren und eher einen postulativen Charakter besitzen. Gleichzeitig beobachtet man einen Mangel von konkreten, einsetz- und brauchbaren Lösungen (Tools) für praktische Anwendung.
Methoden: Die Forschungsarbeiten wurden im Zeitraum 2009-2010 in einem der großpolnischen Unternehmen für mechnische Verarbeitung durchgeführt. Die Lösung des Forschungsproblems erfolgte anhand eines Autorkonzeptes - mithilfe eines Integrationsmodells. In Anlehnung an den Ist-Zustand des ausgewählten Unternehmens (industrielle Echt-Daten) wurde ein Lösungskozept und dessen Kostenanalyse in Form einer Fallstudie erarbeitet.
Ergebnisse: In der ganzen Gruppe der ausgesonderten Material-Indexe zeigte man eine halbwertmäßige Prüfbarkeit der Ergebnisse (obwohl in zwei von drei Fällen die Kostendifferenzen zuungunsten der Methode Losgröße auf Losgröße nicht groß bemessen waren) auf. Angesichts der Struktur des behandelten Sortiments erzielte man fuer die fuer die LaL-Methode (Gruppe AX) charakteristischen Positionen eine weitgehende Übereinstimmung der Ergebnisse in Höhe von 67%.
Fazit: Das formulierte Forschungsproblem und das Ergebnis dessen Lösung (lediglich 6 Materialpositionen) stellen hohe Herausforderungen (Orthodoxie) an die Voraussetzungen der Einführung dar. Das Lösungskonzept findet unter den betreffenden, organisatorischen Bedingungen (das analysierte Unternehmen) ein eher schmales Anwendungsgebiet. Dies sollte mit unabhängigen Forschungen dieser Art in anderen Unternehmen noch bestätigt werden.

Codewörter: Losgröße auf Losgröße (LaL), Aussonderung des Sortiments, Simulation von Vorratskosten

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A SOCIAL NETWORK MODEL OF SUPPLY CHAIN MANAGEMENT IN FORMAL AND INFORMAL INTER-FIRM ENGAGEMENT

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ABSTRACT. **Background:** This research looks into the different effects of firms' network structural positions in an upstream supply network upon the firms' level of relational capital outcomes. Previous research has largely focus on the context of decentralized network structure. However, the supply network is a centralized network because of the existence of the focal firm. The existence of the focal firm may influence the impact of relational capital outcomes.
Methods: The objective of this research is to determine the type of network structural positions required to obtain reasonable relational capital outcome in upstream supply network.
Results and conclusions: This study found that, network structural positions i.e. betweeness centrality contributed to firms' level of relational capital influence. In conclusion, firms, embedded in upstream supply network benefits differently in terms of relational capital through different degree of embeddedness. Firms' resources should be re-aligned to match the benefits with the different network structural positions.

Key words: Supply Chain Management; Network Studies; Inter-Organizational Relations; Social Capital; Supply Chain Complexity.

INTRODUCTION

The last decades have seen an increase in managerial concern regarding the complexity of the supply chain, more specifically the upstream supply network. The upstream supply network refers to the firms that reside in the upstream flow of the supply network. The upstream supply network has become more complex due to the increase interactions and interrelations among the suppliers' firms as well as the number of the firms. These firms which are the suppliers of materials and services to the focal firms are connected or involved with each other directly or indirectly through the supply of materials to the focal firms or manufacturer.

One of the main strategies of managing these inherent complexities that is often adopted by supply chain managers includes reductionist approach. The traditional reductionist arguments state that firms opted for the removal from the complex upstream supply chain of partners who are not meeting the performance requirements of the supply chain in an attempt to manage the complexity arising from extensive inter-firm relationships [Choi, Kim 2008]. These strategies may prove to be effective in the short term, but may negatively impact the focal firms in the long run. These negative effects may emerge as firms' involvement in a network of inter-firm relation, creates an important element of intangible capital, which is the relational social capital. This involvement among the firms in the upstream supply network is essentially the firm embeddedness in the upstream supply

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network structure. However, recent arguments suggest that simply removing these underperforming firms may not be the best way, as firms may remove partners who are resourceful or more influential, but these characteristics are not visible through good accounting measures. In this vein, Cockburn and Henderson [1998] in addition to Putnam [1993; 2000] posited that approaches that value and appreciate these complex inter-firm relations may be better alternatives. This is because, firms have been found to benefit through embeddedness with other firms in a network structure.

Network embeddedness constitutes an important element that Putnam [1992] identifies as being the relational capital [Cousins et al. 2001]. Cousins et al. [2006] stated that relational capital was the configuration of relationships within the network structure, as well as with the broader network structure of the firm. It has been documented that the level of embeddedness increases relational capital from the interactions [Cousins et al. 2006]. More specifically, organizational researchers have confirmed that organizational involvement in a decentralized network structure impacts upon organizational relational capital outcomes such as the level of influence [Gulati, Gargiulo, 1999; Podolny, Page, 1998]. Thus, a firm's embeddedness in the network structure may produce relational capital that may then have the potential to generate other benefits such as reduced costs and greater flexibility [Reagans, Zuckerman, McEvily 2004].

The upstream supply network is essentially a centralized network structure. It is a centralized structure through the existence of the focal firm that monitors and administers transactions in the upstream supply chain for the production of the finished goods and services. This centralized coordination often involves a focal firm or manufacturer, typically operating in the center of the transformation process [Choi, Krause 2006]. Since relational capital outcomes emerge through interactions in a free flow, decentralized, network structure [Gulati, Gargiulo 1999; Podolny, Page 1998], application of the integrated network to the issues of centralized upstream supply network complexity may require deeper understanding of the impact of the centralized network structure. This research raised this concern following the argument of Putnam [1992] which posited that relational capital emerged largely in a decentralized network structure. This is because; a centralized coordination such as the focal firm in the upstream supply network may introduce effects unknown, or remove potential benefits to the firms in the upstream supply network. For example, since the central coordinator (i.e. the focal firm), is often the most powerful firm in the supply base having arms-length control that monitors actions of the network member, it is also a profit-driven entity with the most investment in the supply network. Occasionally albeit unintended, a Machiavellian portrayal may affect the level of relational capital among the firms in the centralized network structure. In addition, the centralized nature of network governance has been found to reduce the horizontal connection which is prominent for the creation of relational capital in a network structure [Poppo, Zenger 2002]. Since these horizontal connections are significant for generating the relational capital posited by Putnam [1992], a key question would be: will firm involvement or embeddedness in the centralized upstream supply network produce the same relational capital outcomes?

LITERATURE REVIEW

Granovetter [1985] advanced the concept of embeddedness as an effort by which to explain economic behavior of an organization. According to Granovetter [1985], embeddedness refers to the level of involvement of a firm in the network of inter-relations. A firm's levels of involvement have an impact upon its actions or behavior in the network. Granovetter [1985] posited that transactions between actors in a network are embedded in a social context economic decisions and outcomes are affected not only by the actor's isolated relations with other individuals or firms in the network but also by the structure of the overall network of relations within which the actor resides. Economic behaviors are embedded in the network of relations that provide the context for economic processes [Granovetter 1985]. As every behavior materializes through some form of outcome, almost all economic processes are presumed to be embedded in the networks of relations. Thus organizational performance is influenced by the pattern of embeddeness of the organization in the network. Since in the upstream supply network, firm embeddedness relate to the degree of the interaction that a firm may has with other firms in the network which are a direct reflection of the firm degree of inter connectivity with others in a network. Hence, one may conclude that organization performance in the supply network may also be influenced by the organization embeddedness pattern such as its centrality and connection [Scott 1998] with other organizations in the supply network [Mueller 2000]. This is because, structurally, supply network is virtually formed by the connectivity or links between firms where the integration progressively forms the ultimate structure, which is the supply network itself. The relationship is also known in the literature as the buyer-supplier relationship [Beamon, 1999]. According to Choi and Kim [2010], a buyer-supplier relationship represents a dyad, or two nodes and one link, in network terms. Each node can be conceptualized as an actor performing activities for generating value Choi [2008]. The firms need resources from its supplier organization, and the supplier needs contracts and payments from the buyer. On top of that the firms also interact with each other to share information regarding market opportunities and new threats [Choi 2008]. As a consequence, these phenomena create a link and form a dyad or a buyer-supplier relationship. Because a firm in the supply network often has links to other firms, the firm is then impliedly linked to the new indirectly connected organizations. Similarly, with the supplier organization, this will also bring to the dyad their links with other organizations either directly or indirectly [Lamming et al., 2000]. Conclusively, a buyer-supplier relationship is not only a dyad. It is also part of a network that has come to bear on individual nodes to the relationship through each other's extended business relationships. This form of inter-firm relations or connectivity created the complexity in the supply network structure.

Despite the increase recognition of the importance and applicability of network embeddedness perspective to buyer-supplier relationships, researchers still address the relational dynamics of buyer-supplier relationships from variety of firm-level analysis, rather than the network perspective [Carter, Ellram, Tate 2007], using various theoretical approaches such as resource-based view of the firm [Cao, Zhang 2011; Holweg, Pil 2008; Ordanini, Rubera 2008; Zsidisin, Ellram, Ogden 2011], transaction cost economics [Cao, Zhang 2011; Cheung, Myers, Mentzer 2010] and relational view of the firm [Sanders, Autry, Gligor 2011]. The level of analysis in much of such existing literature still centres on the isolated dyadic ties between buyer-supplier organizations. However, no firm is an island [Gibbons, Holden, Powell 2009], rather they are embedded in larger network structure of interconnected firms [Choi, Kim 2008]. Furthermore, with the advent of supply network as the prevalent structure of buyer-supplier relationship rather than the chain metaphor [Harland et al. 2001; Lamming et al. 2000], it is imperative in the context of this study to take the perspective of buyer-supplier relationship to the embeddedness context within which the buyer-supplier interaction took place. As many scholars have posited, the actions and performance of an organization can be more explained by examining the relationship in which the organization is embedded in [Ahuja, 2000; Gulati, 1999; Zaheer, Bell 2005]. Thus, this research adopts the perspective of network embeddedness in its effort to deepen the understanding of the impacts of the relational dynamics on the performance of the organizations.

Although there has been increase number of research regarding firms embeddedness in network, however, the literature is silent about the relationship between organizational embeddedness and organizational social capital in a centrally governed supply network that is a network governs by a strong focal organization which enforces and monitors the supply and demand of materials by other sub organizations in the network. Network scholars have found a strong relationship between organizational embeddednes in network structure and organizational social capital in a decentralized network form of organization [Wasserman, Galaskiewicz 1994, Ter Wal, Boschma 2009, Chang 2003a, McEvily, Zaheer 1999, Ahuja 2000, Anderson et al. 1994, Provan et al. 2007, Galaskiewicz, Marsden 1978, Johnson, Mareva 2002, Haibin, 2004, Breschi, Lissoni 2005, Hite et al. 2005].

In this research, although no doubt organizational social capital emerged in network forms of organizations, we argue that the presence of a central actor of or dominant power such as the focal organization in a supply network, may change the pattern of inter connectivity and ties among organizations in the network hence the impact to the organizational social performance. At the minimum, the flow of information may have to go through the central actors before it can be disseminated to other actors in the network. Furthermore, the formal power of the central organization may add new perspectives to the informal, social control mechanism operating in the network.

HYPOTHESIS

In this study, the researcher argues that contract ties, information-sharing ties, referral made ties and referral received ties constitute networks among firms in the centralized upstream supply network structure. The researcher further explains the important characteristics of these and clarifies how and why these ties or inter-firm relations constitute the networks. First, inter-firm relations such as: contract ties, information-sharing ties, referral made ties, and referral received ties are conduits of information [Srividasan 1999]. Ahuja [2000] stated that inter-firm relations could also function as the communication channels between firms and their partners. For instance, it was found by McEvily and Zaheer [1999] that relevant advice obtained by managers from their colleagues in other firms is instrumental in developing the capabilities and innovation of the respective firms. Wasserman and Faust [1994] stated that a network was made up of a finite set of actors and relations. The authors added that the relations between the actors defined the actors of the network. In the following networks, namely: contract tie, information-sharing tie, referral made tie and referral received tie; actors are the firms. Similarly, the relations are, specifically: contract, information-sharing, referral made, and referral received, all of which exist in the upstream supply chain.

In this study, the researcher argues that, among the firms that are embedded in the centralized upstream supply network; some will obtain more relational capital compared to other firms as a result of this embeddedness. Thus, the level of relational capital influence will depend upon the network structural positions of the firms in both formal and informal inter-firm relations. The network structural positions namely: betweeness centrality. In this research, the researcher posited that firm embeddedness based on this network structural position implies a firm level of relational capital outcomes in the upstream supply network structure.

Centrality relates to the coreness of a firm position in a network of inter-firm relationships [Freeman 1979]. By coreness is meant central location of the firms in the network. Network analysts relate centrality with control and power as function of certain relational characteristics [Hanneman, Riddle 2005]. Centrality can be measured as characteristics of the overall network in which it is called centralization. Centrality can also be measured at the actor level property. Centralization index ranges from 0 to 1, provides a measure of variation around a central tendency, similarly to the standard deviation [Knoke, Kuklinski 1982; Knoke, Yang 2008]. The measures of centralization commonly applied in the social network research is the betweeness centrality.

The betweeness centrality concept measures the degree to which a firm in the centralized upstream supply network is located between the path connecting two or more firms [Freeman 1979; Wasserman, Faust 1994; Scott 1998].

Betweeness centrality index refers to the extent to which an actor is located in a bridging position between actors of a network. For example, let us suppose actor B is located in a betweeness centrality position between actor A and C in a triad network [Freeman 1979]. Because of the bridging position of the actor, betweeness centrality is also an indication of an actor's brokerage power in the network. Betweeness centrality index is defined as:

$$\text{Betweeness Centrality} = \frac{\sum_{j>k} gjk(ni)/Gjk}{(g-1)(g-2)/2}$$

Where gjk and gjk(ni) are the minimum ties needed for linking actor, i and actor j in the network of g nodes. Index score of zero shows that an actor is not occupying any bridging position in the network of g actors, while an index score of one indicates that the actor is in a bridging position among all the network actors ([Wasserman, Faust 1994]. Ibarra [1993] stated that, actors that occupy this brokerage position often possessed the advantage as the broker for the flow of information among the network actors. Hence, taking away a node betweeness centrality index may result in the network becoming disconnected through the indirect connections.

Influence is the indirect measure of firm power [Freeman 1979]. For example, Oliver and Montgomery [1996], using data from in person interviews with the directors of 20 organizations in Oregon, found that the organization with the greatest influence within the system is the one that has the best ability to allocate funds.

Power can be derived in an inter-firm relationship from the resources that a firm may hold in its inventory. Resource control can alleviate a firm's influence over others. Emerson [1962] found that a firm may have influence upon other firms when these firms rely upon it for the resources that they need for operations. It follows that the more other firms rely upon one firm for resources, the more powerful or influential the resourceful firm will be perceived in the network [Hager, Galaskiewicz, Larson 2004].

Resource dependency theory argues that firm centrality in inter-firm relationships can be the result of frequency of interactions or exchanges that take place among firms in the network. Furthermore, firm centrality also functions as a gate-keeper of resources which increases the influence of the firm in the network structure.

Aligned with previous works [Farmer, Rodkin 1996; Freeman 1979; Galaskiewicz, Bielefeld, Myron 2006; Ibarra1993; Mehra, Kilduff, Brass 2001; Nahapiet, Ghoshal 1998], the researchers posited that influential or powerful firms tend to be located at the centre of a network. Consequently, the researcher posited that, in the context of the centralized upstream supply network structure:

Hypothesis: Firm's embeddedness following their betweeness centrality position in the centralized upstream supply network through different inter-firm relations impact the level of influence that the firm may acquire from other network members.

METHODOLOGY

Align with the objectives of this study; the design and methodology of are based on the theoretical and analytical framework of the Social Network Analysis (SNA). For this study, an upstream supply network of a small maritime industry seemed to be an ideal setting. A supply network in the maritime industry is a material-intensive enterprise. Much of the activities and activities are highly dynamics and are widely dispersed throughout the network. Materials and information flow are transferred through interactions among different firms. Because firms in supply network operate in an environment of high degree of complexity [Bozarth et al. 2009] and uncertainty [Wilding 1998a], these firms seek an edge through connections or interactions with the members of the network.

The research site of this study is located in the country Malaysia. The researcher profiles different supply networks critically to determine the most suitable network for study. One of the networks, here labelled as APMMHQ-1 supply network, was found to be the appropriate site for this exploration. The top level managements were approached for possible participations in the study. After several communication about the goal of this study and the potentials benefits for the APMMHQ-1 supply network, positive commitments were received from the top managements to participate and granting participations to this study. In network studies, all the actors that are located within the naturally occurring boundaries are included for analysis. Consequently, network studies do not use samples as in the conventional sense, rather, it seek to include all of the actors in some population or populations [Hanneman and Riddle 2005]. Defining and locating the boundaries of a network is utmost important in a network study. To identify and define the target population within the APMMHQ-1 upstream supply network for RHIB, for this study, the author combines the realist and the nominalist approach.

A survey instrument was used to collect majority of the information needed for this study. Surveys and questionnaire are traditional tools to help network researchers to obtain data on inter-organizational relationships (Wasserman and Faust, 1994). Leading network researcher such as Galaskiewicz and Marsden (1978), Knoke and Kuklinski (1982), Burt (2004), and Borgatti and Li (2009a) established the credibility of this technique for the collection of network data on inter-organizational transactions such as information transfer, resource transfer and joint activities. Survey is suitable for this type of study because it allows the researcher to tap into the participants' subjective perceptions of interactions rather than objective measure of interactions, which many situations are hard to get access to for confidentiality reasons (Diani, 2002). The survey instrument used in this study followed standard survey design features such as asking general information questions at the beginning, followed by more specific questions, and lastly the most probing questions at the end. The survey questionnaire consisted of closed ended questions and open ended questions. In general the questionnaire were framed following the standard of Choi and Hong (2002), Provan and Milward (1995), Stone (2001), Corteville and Sun (2009) and Cross and Parker (2004).

For data analysis, the researcher performed exploratory social network analysis (visual analysis) of buyer-supplier organizations network by exploring the network maps and the network structural measures. For this purpose, this research adopted a spring-embedding visualization method in the UCINET program whereby a network layout is computed using force directed algorithm. More specifically, the algorithm place nodes based on node repulsion and equal edge length bias. When so configured, the placement of nodes in the sociogram is based on forcing the nodes apart and tending to select placements that lead to equal edge lengths (i.e., equal length lines between nodes). This particular layout has the advantage of detecting network centrality patterning [Polites,Watson 2008]. For these routines, this research applied the network imaging software within the UCINET [Borgatti et al. 2002] i.e. the NetDraw, which is equipped with sophisticated visualization techniques. Visual representation of supply networks can provide useful direction for researchers, and starting point to developed subsequent quantitative analyses [Choi, Hong 2002b].

FINDINGS AND DISCUSSION

Exploratory Network Analysis: Visual Analysis of Social Network Influence Network Map and Betweeness Centrality. In Figure 1, the researcher found that the influential firms of the network are also the nodes or firms having the highest embeddedness scores and the highest influence scores. For example, APMMHQ-1 is observed to be highly influential with an influence score of 20 and also highly embedded in the contract tie based on betweeness centrality, as indicated by the large node size. In addition to that, the periphery network members are also the less influential among the firms. For example, PMKURAU-9, DMKLIGGI-15, and PMMRSNG-17 are among the less influential firms which also possessed low embeddedness scores based on betweeness centrality in contract tie.

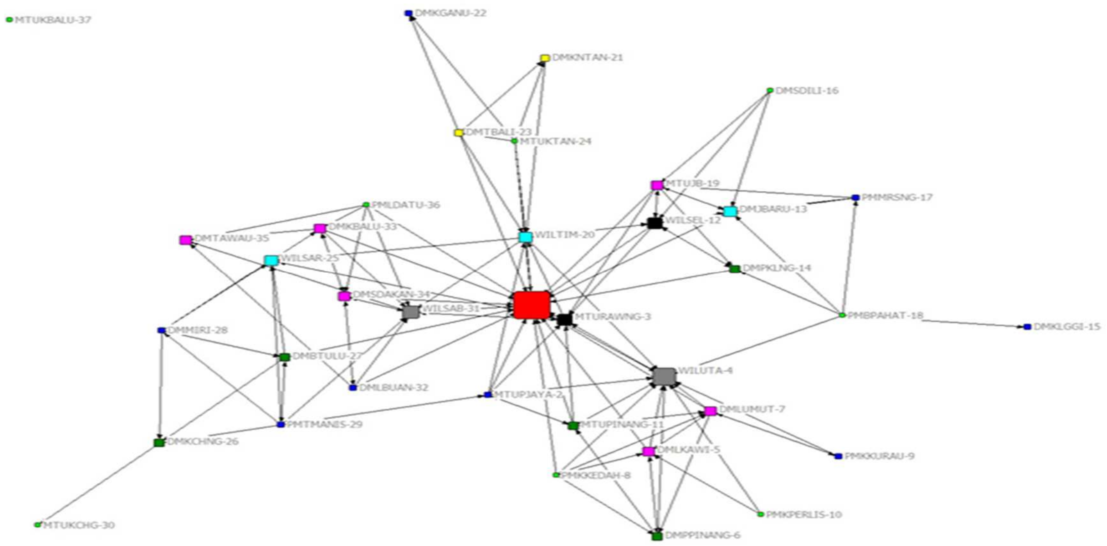

Fig. 1. Influence Network and Firm Embeddedness Based On Betweeness Centrality In Contract Tie
Rys. 1. Sieć wpływów i zależności w oparciu o wskaźnik centralizacji gniazda sieci we współpracy gospodarczej

Figure 2 shows the sociogram of influence network with organizations' embeddedness based on betweeness centrality in information-sharing tie and the respective level of influence of firms. From a visual perspective of the sociograms in Figure 1, it can be seen that the influential firms of the network are also the nodes or firms with the highest embeddedness scores and the highest influence scores. For example, APMMHQ-1 is observed to be highly influential with an influence score of 20 and also highly embedded in the contract tie based on betweeness centrality, as indicated by the large node size. In addition to that, the periphery network members are also less influential in the firms.

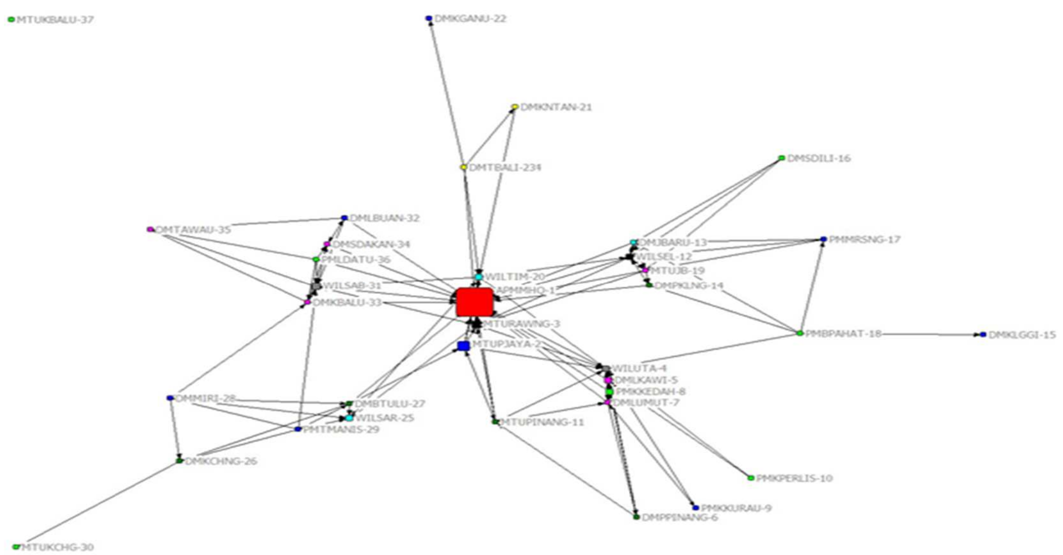

Fig. 2. Influence Network And Firm Embeddedness Based On Betweeness Centrality in Information Sharing Tie
Rys. 2. Sieć wpływów i zależności w oparciu o wskaźnik centralizacji gniazda sieci przy przepływie informacji

Figure 3 shows the sociogram of influence network with organizations' embeddedness based on betweeness centrality in referral made tie and the respective level of influence of firms. Figure 3 shows that firms which are highly embedded based on betweeness centrality in referral made ties are also influential in the network, particularly the respective cluster of clique that the firms belongs to. For example, AMPPHQ-1 is highly embedded in the referral made tie and is also highly influential in the network, particularly in its own cluster, with MTUPJAYA-2, MTURAWNG-3, and WILTIM-20. In addition, WILUTA-4 is highly embedded in the referral made tie and also highly influential in the influence network; more specifically, its cluster of PMKKEDAH-8, DMLKAWI-5 and DMLUMUT-7. Similarly, WILSAB-31 is highly embedded in the referral made tie and is also influential in its cluster with PMLDATU-36, DMSDAKAN-34, DMKABALU-33, and DMLBUAN-32 respectively. Thus, the visual analysis indicates that the level of firms' embeddedness in the network could impact upon the level of reputation that a firm may experience from other network members. Figure 4 shows the network maps of influence network with firm embeddedness attributes based on betweeness centrality in referral received tie. In Figure 4, embeddedness based on betweeness centrality in referral received tie has mixed effects upon firms. In the majority of clusters, it was found that there is one highly embedded firm that is considered influential in the clusters or network or clusters as a whole. Similarly, this study also found that one firm that is less embedded in the referral received tie (based on betweeness centrality index) possessed one of the highest influence ratings in the network, i.e. APMMHQ-1.

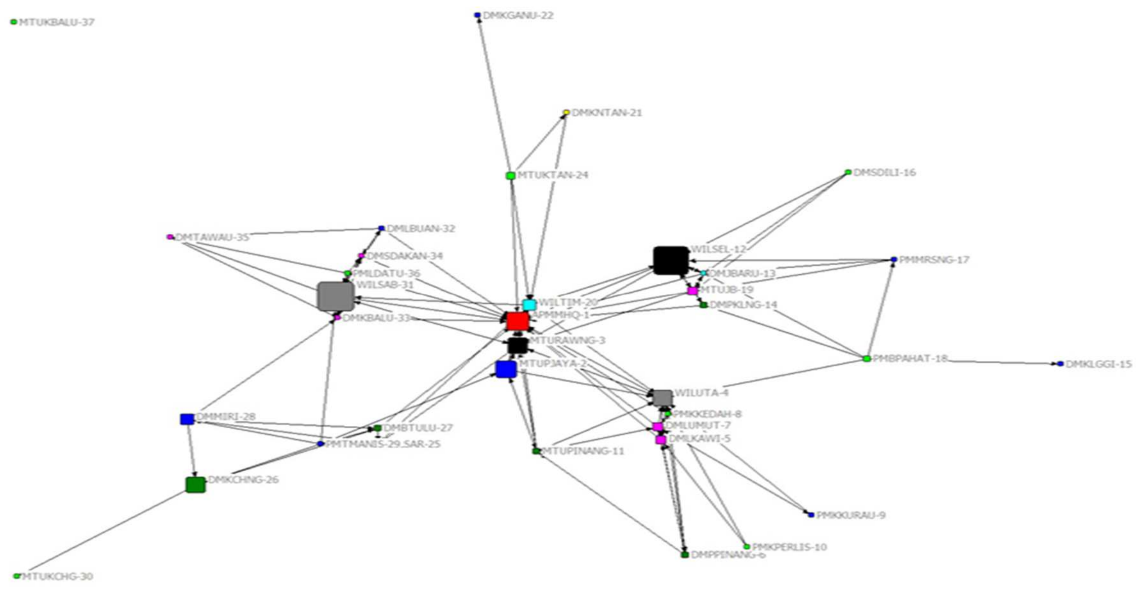

Fig. 3. Influence Network and Firm Embeddedness Based On Betweeness Centrality in Referral Made Tie
Rys. 3. Sieć wpływów i zależności w oparciu o wskaźnik centralizacji gniazda sieci przy w modelu referencyjnym wyjściowym

Figure 4 shows the network maps of influence network with firm embeddedness attributes based on betweeness centrality in referral received tie. In Figure 4, embeddedness based on betweeness centrality in referral received tie has mixed effects upon firms. In the majority of clusters, it was found that there is one highly embedded firm that is considered influential in the clusters or network or clusters as a whole. Similarly, this study also found that one firm that is less embedded in the referral received tie (based on betweeness centrality index) possessed one of the highest influence ratings in the network, i.e. APMMHQ-1.

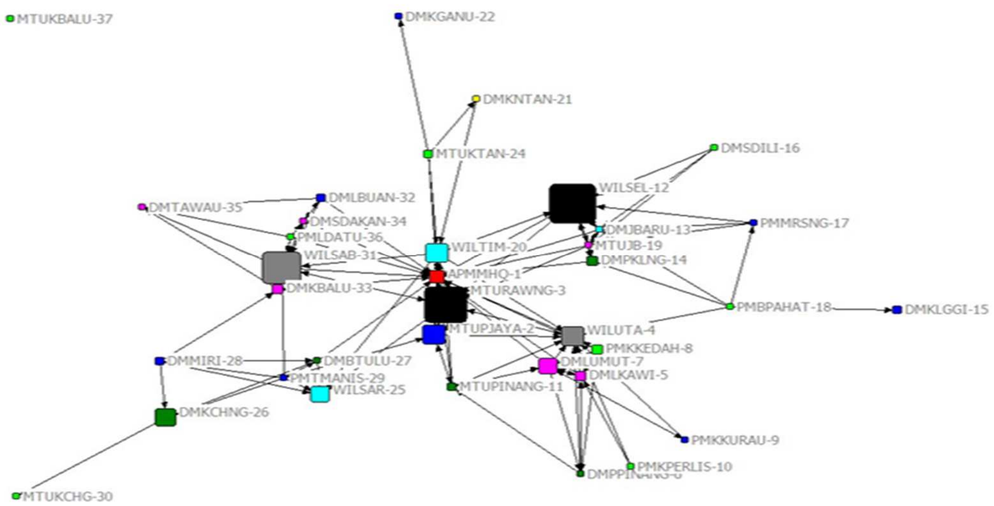

Fig. 4. Influence Network and Firm Embeddedness Based On Betweeness Centrality in Referral Received Tie
Rys. 4. Sieć wpływów i zależności w oparciu o wskaźnik centralizacji gniazda sieci w modelu referencyjnym wejściowym

DISCUSSION

The exploratory gave interesting insight into the implication of firm embeddedness upon its relational capital outcomes in a centralized upstream supply network structure. The objective of this section is to discuss the findings of this study and how it contributes to theory and practice. This study draws attention to firms' embeddedness or involvement in the various types of relationships in a centralized upstream supply network and the underlying impacts of this embeddedness. More specifically, the researcher examined the relationship between a firm's level of embeddedness, based on its network structural positions in the centralized upstream supply network and the relational capital influence.

In the context of a centralized upstream supply network inter-firm relationship, it can be seen that related parties in the network of relationships encounter conflicts through goal incongruence and suspicions of asset abuse. Similarly, where a party considers it has been unfairly treated by another party, there will be a higher chance of a more complex supply network resulting from these inter-firm relationships. Organizational study scholars such as Powell [1996] and Putnam [1998] have proposed the adoption of a network form of organizational governance. They posit that this is an acceptable means to the inter-firm relations complexity as it can create numerous relational capital outcomes, such as influence. Further, it can also contribute to an increase of competitive advantage and economic performance in the context of decentralized network structure to the firms embedded in the network structure.

Consequently, the researcher addressed the issue of inter-firm relationships in the centralized upstream supply network by investigating the pattern of firm embeddedness through its network structural positions in the four types of inter-firm relations. It was evident to the exploratory network analysis of the network maps and network embeddedness measures that firm embeddedness in the centralized upstream supply network was related to the degree of formality of the network tie.

The first argument relates to the pattern of embeddedness of firms based on the types of network relations. In the context of the centralized upstream supply network structure, firms were found to be more embedded or involved in network relations that require fewer formal coordination approaches than in the network relations that were formally managed through terms and regulations. An example of this is the contract tie, as evidenced through the increased level of connectivity among firms shown in Figure 1(contract tie network map), Figure 2 (information-sharing tie network map), Figure 3 (referral made tie network maps) and Figure 4 (referral received tie network map). The results of the exploratory network analysis conformed to similar findings in the literature. For example, Polanyi [1957] posited that the embeddedness of economic actions was supplemented by market approach in the post-industrial societies. In addition, Granovetter [1985] reiterated this position in his study, wherein the author posited that all economic actions were embedded in networks of social relations. Following that, Uzzi [1997] found that in the apparel business, although contracts govern the transactions between firms, the author found that firms rely most upon the web of social exchanges. The finding of the exploratory network analysis adds to the views of Polanyi [1957], Granovetter [1985] and Uzzi [1997]. Similar to these authors, this study found that, at least in the APMMHQ-1 upstream supply network for RHIB; formal coordinative relations (such as the contract tie) only represent a small part of the actual interaction that exists in the upstream supply network structure. It was also determined that the other (or maybe the larger) portion of the network economic action is transmitted through a network of social relations.

The finding also reveals that firm embeddedness in the contract ties, information-sharing and referrals ties respectively have no effect upon the level of reputation. In this case, the findings of Osman [2013] contradict other earlier findings in the literature, such as those by Burt [1995] and Anderson [1999]. Osman [2013] argued that the effect of embeddedness on reputation may be disrupted by the spill-over effects (Anderson 1999] that firms may experience through their connections to firms with bad rapport in the network structure. Although spill-over effects are not tested in this study (potentially for future research), the consequences of how firms with bad history may spill over to other network members to whom they are connected are well-known in the literature. Consequently, caution must be taken when forging new partnerships or collaborations. Histories of performance and actions of the potential partners must be factored in before decisions of collaborations are forged. In addition, the centralized nature of the upstream supply network may alter the effects on relational capital outcomes, as found in the studies of Burt [1995] and Anderson [1999].

CONCLUSION AND RECOMMENDATION

This study contributes to the extant body of relational capital, strategy and network literature. The relationship between inter-firm relations and relational capital has long been studied, but the empirical proof of a relationship in the context of a centralized network of relations was limited [Provan 2004]. With the advancement of globalization, the upstream supply network has become more complex over the years. As the upstream supply network has become more complex, focal firms tend to monitor and administer the transactions and activities in the network, thereby creating a centralized network structure. Although Putnam [1990] argues that relational capital exists in a network structure of relations, the context of this research mainly focuses on the decentralized network structure. Choi [2008] made a number of propositions regarding several benefits that occur when firms are embedded in the centralized upstream supply network structure. This includes understanding which firms can be influential and relied upon for resources. They warn the readers against dismissing partners in the centralized upstream supply network structure, based on accounting measures, when these firms are actually more influential and reliable with regard to their resources and connections.

Relational capital exists in networks of inter-firm relations, such as in the centralized upstream supply network structure [Putnam 1999]. Being related to other firms in the upstream supply network is beneficial to firms subject to their holistic understanding of their embeddedness in the network structure. The inter-firm relations in the upstream supply network structure not only emerged from the formal administrative, but were also initiated through other webs of social exchanges. Among the firms that are embedded in the centralized upstream supply chain, some will gain more benefits compared to others as a result of firm embeddedness or involvement based on the respective network structural positions.

In addition, this research has tested and confirmed the presence of relational capital outcomes in the context of a centralized network structure. This refers, at least, to the relational capital influence in the context of a centralized upstream supply network structure. Organizational network researchers such as Putnam [1993] and Uzzi [1997] have examined cooperation in naturally-occurring horizontal network or decentralized network structures. Supply network, in its original form, is related to a managed organization network or centralized network, as initial formations are motivated by the needs of the focal firm to manage and administer the transactions of materials based on certain agreements. The difference between the naturally-occurring decentralized network structure and centralized network can be described as the bottom-up and top-down approach of cooperation. The top-down approach is facilitated by formal criteria. As this study's analysis indicates, cooperation is not totally antagonistic towards formal control. For instance, a high density index of the network structure of the informal information-sharing ties compared to the formal contract network indicates the high connectivity of firms in the information-sharing network rather than the contract network. The intensity of ties may represent the adaptability of cooperation in the centralized upstream supply network. These findings reaffirm the contention that even the formal, hierarchical institutions do not impede cooperation activities between the firms in the network and consequently, the creation of relational capital [Ostrom, Walker 2000]. In other words, this study's finding suggests that stocks of relational capital do exist in the context of a centralized network structure, even though the hierarchical network has been considered as an impediment to growth.

In conclusion, by considering the overall implications of our study, we may conclude that complexity is not all bad. Managers need to consider their firm's existing embeddedness in order to exploit the competitive advantage of supply network inter-organizational relationships. Firms that fail to understand the underpinnings of these relationships stand to face more difficulties within the network itself. For this reason managers that intend to obtain competitive advantage from the network must engage with other partners more effectively. No doubt, some firms are at an adequate standing, while others are struggling in some areas. The framework of this study can be applied by managers who are committed in engaging other network members.

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MODEL POWIĄZAŃ SOCJALNYCH W OBRĘBIE ŁAŃCUCHA DOSTAW W PRZYPADKU FORMALNEJ I NIEFORMALNEJ WSPÓŁPRACY BIZNESOWEJ

STRESZCZENIE. **Wstęp:** Różne efekty wpływu pozycji firm w strukturze powiązań łańcucha dostaw typu upstream na poziom oferowanych przez te firmy jakości obsługi był przedmiotem przeprowadzonych badań. Wcześniejsze badania koncentrowały się głównie na zawartości zdecentralizowanej struktury sieciowej. Jednak łańcuch dostaw jest siecią scentralizowaną z powodu istnienia firmy o największym znaczeniu w obrębie tego łańcucha. Istnienie takiej firmy wpływa na relacje i sposób działania pozostałych firm w łańcuchu.
Metody: Celem pracy było określenie typu pozycji w strukturze sieciowej wymaganej w celu uzyskania zadowalających relacji w obrębie łańcucha dostaw typu upstream.
Wyniki i wnioski: Pozycja w strukturze sieciowej, tj. wartość wskaźnika centralizacji gniazda sieci (betweeness centrality) wpływa na poziom oddziaływania na innych, możliwy do realizacji przez daną firmę. Firmy znajdujące się w strukturze łańcucha dostaw w różny sposób korzystają z możliwości oddziaływań na innych w zależności od ich pozycji w tym łańcuchu. Zasoby firmy powinny być tak dobrane, aby mogła ona czerpać korzyści, znajdując się w różnych pozycjach w obrębie danej struktury sieciowej.

Słowa kluczowe: zarządzanie łańcuchem dostaw, prace nad siecią, stosunki międzyorganizacyjne, kapitał socjalny, kompleksowość łańcucha dostaw.

EIN MODELL FÜR SOZIALE VERBINDUNGEN INNERHALB DER LIEFERKETTE IM FALLE EINER FORMELLEN UND INFORMELLEN BUSINESS-KOOPERATION

ZUSAMMENFASSUNG. Einleitung: Gegenstand der durchgeführten Erforschung war es, unterschiedliche Effekte des Einflusses der Position von Firmen in der Struktur der Verbindungen innerhalb der Lieferkette vom Type upstream auf das Niveau der durch diese Firmen angebotenen Service-Qualität zu ermitteln. Frühere Forschungen konzentrierten sich hauptsächlich auf den Inhalt dezentralisierter Netzwerk-Strukturen. Die Lieferkette stellt jedoch ein zentralisiertes Netzwerk wegen Bestehen einer meist einflussreichen Firma innerhalb der betreffenden Lieferkette dar. Das Vorhandensein einer solchen Firma beeinflusst also interne Verhältnisse und Wirkungsmodelle der anderen, an der Lieferkette beteiligten Firmen.
Methoden: Das Ziel der Arbeit war es, die Art der Position in der Netzwerk-Struktur , die für die Erzielung von zufriedenstellenden Realationen innerhalb der Lieferkette vom Type upstream erforderlich ist, zu bestimmen.

Ergebnisse und Fazit: Die Position in der Netzwerk-Struktur, d.h. der Wert der Zentralisation-Kennziffer des Netzwerk-Nestes (betweeness centrality) beeinflusst das Niveau der möglichen Einwirkung einer Firma auf die anderen Beteiligten. Die in der Netzwerk-Lieferketten befindlichen Firmen nehmen die Möglichkeit der Beeinflussung von anderen, und zwar in Abhängigkeit von ihrem Range in der betreffenden Lieferkette, in Anspruch. Die Ressourcen einer Firma sollten daher so gestaltet sein, dass sie Nutzen schöpfen kann, unabhängig von deren momentan unterschiedlichen Position innerhalb der gegebenen Netzwerk-Struktur.

Codewörter: Management der Lieferkette, Arbeiten am Netzwerk, zwischenorganisationelle Verhältnisse, soziales Kapital, Komplexität der Lieferkette.

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THE IMPACT OF LEAN MANAGEMENT IMPLEMENTATION ON ORGANIZATIONAL OPERATIONAL PERFORMANCE

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ABSTRACT. **Background:** The research aims to develop the consensus between different operational improvement strategies, to address the relationship between the operational characteristics (lean) and operational performance of the organization.

Methods: Variables from which the extraction of the outcomes has been established include operational performance, daily schedule adherence, repeat production and flow oriented layout. The technique of data analysis is selected to be Correlation and multiple regressions. The aim for performing these tests is to highlight association of lean strategy with the operational performance.

Results and conclusions: The positive association is being established amongst the operational performance and the daily schedule adherence, flow oriented layout and the repeat production. It is suggested to the supply chain management that they must entail their production team for having repetition in their work and become efficient in their production. They must be reached to their optimization level, where they have to extract less waste and have high level of the production.

Key words: Operational performance, daily schedule adherence, repeat production, flow oriented layout.

INTRODUCTION

Implementation of the lean strategy has indicated many difficulties in the improvement of the productivity. Lean strategy believes in eliminating all the aspects that are not used to add value in the production system, for the attainment of excellent product and service. Many of the companies put their focus on developing the lean strategy at their floor levels and try to avail competitive advantage on at that level. This has not yet resulted in relying over the integrative approach [Dávid, Krisztina 2013]. Lean revolution has been seen in the foreign companies and the concept of lean production is very new to the companies of Pakistan.

It has been reported by the researchers that lean strategy has resulted in the reduction of human efforts up to 50%. It has also tended to reduce the efforts involved in the tool investment, manufacturing space and the product development. Due to the efforts of the lean strategy, the quality has been improved by 200 to 500% [Azharul, Kazi 2013].

Lean production is the multi-dimensional approach that includes the variety of management practices that has focus on the supplier management, quality and the reducing waste. Such mechanism is known as just in time inventory management. JIT term is originated from the concept of buying without holding the parts and components to be delivered at the time of the production. The key element of the development for the lean

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production with JIT has been seen in many companies. The concept has been started becoming broadened with the postponement of the unnecessary buying of the resources, until they require. The lean production must require the rapid flow of the goods and information along with the value chain [Peter et al. 2012].

The flow management is deemed to get focus over the reduction of the coordination and the management cost. For instance, this includes the using of the small lots, small production runs and reducing the coordination efforts by started dealing with the less numbers of suppliers [Sanjay 2011].

For coping up with the increasing competitiveness in the industry, manufacturing companies are attempting for the improvement of their operations, by addressing the specific needs of the business. There are numerous path of operational improvement and depending upon the individual need of the business, company applies their strategy. The lean, just in time and the agile are the most common operational improvement in today's time. Managers of the companies have found these strategies as the specific solution to the problem, rather than just a step in improving the manufacturing [Peter et al. 2012].

According to the Sanjay [2011] a company must be able to apply these strategies for the improvement of the programs and fulfillment of the gaps between the market needs and the manufacturing capabilities of the business. They must be cosine and clear in what they are intended to attain with the improvement in the operational strategy. Managers must also be familiar with the steps taken for the improvement of the operations so that they can realize that what is required to be applied and what outcome is required to be attained with the applied improvement. Howsoever, it is still gauged that the present literature is unclear about different operational improvement strategies and their particular differences (Mattias, Jan 2009]. So in this current research project, the researcher has established an aim to develop the relationship between different operational characteristics strategies and the operational performance.

Implementation of the lean strategy has indicated many difficulties in the improvement of the productivity. Lean strategy believes in eliminating all the aspects that are not used to add value in the production system, for the attainment of excellent product and service. Many of the companies put their focus on developing the lean strategy at their floor levels and try to avail competitive advantage on at that level. This has not yet resulted in relying over the integrative approach [Dávid, Krisztina 2013]. Lean revolution has been seen in the foreign companies and the concept of lean production is very new to the companies of Pakistan.

Hence the aim is to analyze that how companies of Pakistan have adopted the concept of the lean production and how they have managed to improve their production, by implementing the lean production in their companies.

LITERATURE REVIEW

Daily schedule adhere and operational performance

Parana and Sekar [2013] have worked on six sigma and explored the outcome studding over the literature review. The topic has been studied with the purpose of investigating over the issues which improve the implementation of lean system in an organization. The factors that are added for the inclusion of the assessment are lean production, small and medium enterprises, daily adhere, operational performance and lean manufacturing For the studied topic, the methodological approach is adopted by the researcher is quantitative in nature they make the modal which concluded their result. Results indicated to derive the outcomes as the lean anchorage in the LSS process consider as the weak but there is significant relationship between them.

Jamshed [2003] have worked over the topic of total management of quality over the production level or productivity. The topic has been studied with the purpose of investigating over the factors or determinants of quality management which increase the productivity.

The factors that are added for the inclusion of the assessment are productivity, returns, factor of quality management, daily adherence, and operational performance. For the studied topic, the methodological approach is adopted by the researcher is the case study which highlights the application of quality management over the production level. Results indicated to derive the outcomes as the effective utilization of resources in production need the proper quality management.

Lokman and Lanita [2014] have worked over the topic of role of performance and the manufacturing strategy. The topic has been studied with the purpose of investigating over the competition in market concerning with the mass information technology. The factors that are added for the inclusion of the assessment are growth, competition, daily adhere, operational performance and manufacturing strategy For the studied topic, the methodological approach is adopted by researcher is conducting interviews of 92 general manager of reputed organization of Australia and apply the test to reach over the results. Results indicated to derive the outcomes as the JIT practice in market competition have significant relationship over the financial performance of company moreover the managers use information system which increases the growth of organizations.

Mattias and Jan [2009] have worked over the topic of the lean and the agile manufacturing: external and the internal drivers and the performance outcomes. The topic has been studied with the purpose of investigating external and the internal factors. The factors that are added for the inclusion of the assessment are lean production, flexibility, cost, quality, agile production, lean management, daily schedule adherence and the operations of the management. For the studied topic, the methodological approach is adopted as structural equation modeling. The model is developed for the assessment of the performance in the seven countries. Results indicated to derive the outcomes as the agile and the lean manufacturing is different in terms of the outcomes and the drivers. Competitive intensity of the industry has been decreased due to the internal and the external drivers in the agile manufacturing. The indication given by the researchers is to add more numbers of industries and the countries for the assessment of the topic.

Dávid and Krisztina [2013] have worked over the topic of the lean production and the business performance by international empirical results. The topic has been studied with the purpose of investigating financial performance, daily adhere, operational performance lean production, business performance, and lean strategy. The factors that are added for the inclusion of the assessment are business performance and lean production and for that concern the approach used by the researcher is quantitative. The researcher took the data of 23 countries for the time period of 2005 to 2006. Moreover the applied statistical techniques for concluding the results are regression analysis, ANOVA and cluster. Results indicated to derive the outcomes as the business performance is highly influenced by the lean production and operational activity.

Flow oriented layout and operational performance

Jan and Per [2013] have worked over the topic of the measuring the evidence for the lean by reviewing of the international peer reviewed by journal articles. The topic has been studied with the purpose of investigating the lean through reviewing the researches. The factors that are added for the inclusion of the assessment are lean production, lean levels, research work, flow orientation, operational performance and tool box lean. For the studied topic, the methodological approach is adopted as regression analysis. Results indicated to derive the outcomes as the clear definition of the lean has been explained in supply chain, yet more definitions are required. The indication given by the researchers is to add other aspects as well.

Todd and et al. [2011] have worked over the topic of the measuring the learning to become lean. The topic has been studied with the purpose of investigating influence of the external information sources in the lean improvements. The factors that are added for the inclusion of the assessment are lean production, flow orientation, operational performance, manufacturing industries, and management information. For the studied topic, the methodological approach is adopted by surveys and the partial square method. Results indicated to derive the outcomes as the commitment and the lean sources have relationship information sources. The indication given by the researchers is to add values in the research for future.

Dharmasri and Vathsala [2012] have worked over the topic of perception related to right decision making with the support of organization. The topic has been studied with the purpose of investigating the job satisfaction and lean production in Srilanka. The factors that are added for the inclusion of the assessment are employee behavior, flow orientation, operational performance, job satisfaction, lean production and decision making. For the studied topic, the methodological approach is adopted by researcher is quantitative in nature in which they collected the data of 616 employees of different organizations and for concluding the result they applied regression analysis. Results indicated to derive the outcomes as the three is the significant impact over the decision making of employees and organizational support. Moreover the relationship between lean production and job satisfaction is significant.

Mohamad and et al. [2013] have worked over the topic of developing lean readiness in the manufacturing industry of Kuwait. The topic has been studied with the purpose of investigating the working of lean system and small medium enterprises that how they work together. The factors that are added for the inclusion of the assessment are lean readiness level, critical success factor, small medium enterprises, flow orientation, operational performance and the determinants of growth. For the studied topic, the methodological approach is adopted by the researcher is mixed approach first they conducted the interviews for data collection then they apply the reliability test and t test on SPSS software. Results indicated to derive the outcomes as the current polices have significant impact over the lean system but now doubt some other barrier will affect the system of lean.

Repetitive production and operational performance

Peter et al. [2012] have worked over the topic of the lean and working environment by reviewing literature. The topic has been studied with the purpose of investigating the newly introduced concept for the wellbeing of the environment. The factors that are added for the inclusion of the assessment are lean production, employee's involvement, research work, lean production, repeat production, operational performance, health, manual workers and implementation. For the studied topic, the methodological approach is adopted as regression analysis, by conducting 11 different studies. Results indicated to derive the outcomes as the negative association is sustained among the employee's health and employee's performance from the lean production. The indication given by the researchers is to add other than the manufacturing industry.

Sanjay [2011] have worked over the topic of the measuring the Leanness of the organization. The topic has been studied with the purpose of investigating the lean and its success due to effective value chain and accounting. The factors that are added for the inclusion of the assessment are manufacturing system, culture, lean strategy, repeat production, operational performance, and auditing. For the studied topic, the methodological approach is adopted as regression analysis. For the studied topic, the methodological approach is adopted as audit is required for the lean vision. The indication given by the researchers is to add other than manufacturing industry.

Jagdeep and Harwinder [2012] have worked over the topic of continuous improvement in the production lean. The topic has been studied with the purpose of investigating the review of future implementation. The factors that are added for the inclusion of the assessment are manufacturing process, repeat production, operational performance, production management, management techniques and continuous improvement. For the studied topic, the methodological approach is adopted by the researcher is analyzing over the previous literature papers. Results indicated to derive the outcomes as the continuous improvement program is very beneficial for the growth of manufacturing process.

Ki-Hoon and In [2011] have worked over the topic of environmental practice and carbon footprint. The topic has been studied with the purpose of investigating the environmental practice in the company Hyundai motors co. The factors that are added for the inclusion of the assessment are employee performance, repeat production, operational performance, strategies and policies. For the studied topic, the methodological approach is adopted by the researcher is the case study analysis moreover the qualitative approach has been used to conduct the interviews of employee of Korean based company. Results indicated to derive the outcomes as the carbon management have significant impact over the management of supply chain.

Veera and et al. [2011] have worked over the topic of performance management in the area of supply chain management. The topic has been studied with the purpose of investigating the performance of supply chain in the electronic industry of Malaysia. The factors that are added for the inclusion of the assessment are supply chain management, performance management, repeat production, operational performance, and growth of the organization. For the studied topic, the methodological approach is adopted by the researchers is quantitative in nature for getting the results the researcher gathered the data of 125 electronic companies and applied the structure modal equation to conclude the findings. Results indicated to derive the outcomes as the supply chain management have significant impact over the profitability of firms.

Conceptual framework

Under the branch of the supply chain, the concept of lean and the just in time production has been prevailing. The latest development and the theoretical settings suggested by [Peter, et al. 2012] have enabled the companies to apply and implicate the new concept and thereby enable to get in to the win-win situation. The theory suggested by [Sanjay 2011] is based over optimization and efficient production. The key element of the development for the lean production with JIT has been seen in many companies. The concept has been started becoming broadened with the postponement of the unnecessary buying of the resources, until they require. The flow management is deemed to get focus over the reduction of the coordination and the management cost, [Dávid, Krisztina 2013]. Lean revolution has been seen in the foreign companies and the concept of lean production is very new to the Pakistani companies. Therefore, considering the available literature, a conceptual framework is made which will be followed in this study. It is shown in Figure 1.

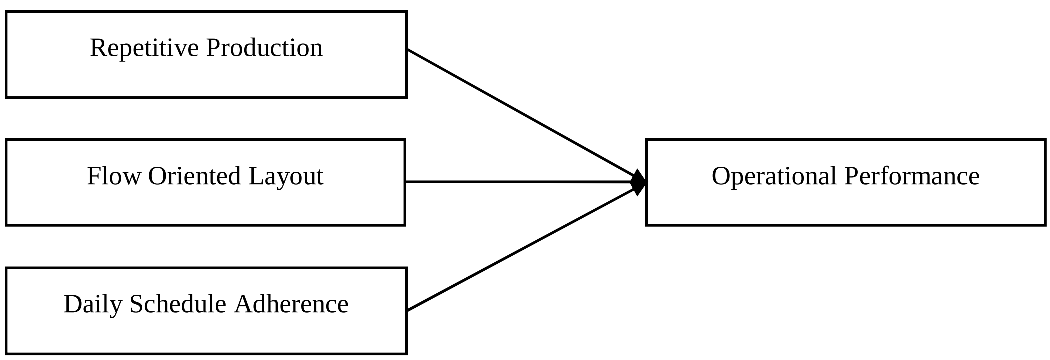

Fig. 1. Conceptual Framework
Rys. 1. Koncepcja pracy

Hence based on the literature and proposed conceptual framework, four hypotheses were developed given as follows:

H_{a1}: Daily schedule adherence has a positive relationship with operation performance
H_{a2}: Flow oriented layout has a positive relationship with operational performance
H_{a3}: Repetitive Production has a positive relationship with operational performance
H_{a4}: There is a significant impact of daily schedule adherence, flow oriented layout and repetitive production on operational performance.

METHOD

Design of the research is correlational, and is quantitative in nature since quantitative approach is good in the case to attain the objectivity in the result and to remain save from the incorporation of biased attitude, for the gauging of the outcome. Manufacturing sector of Pakistan was targeted for research since this sector justified the conceptual linkage from the theory. Total 300 respondents were participated in this research. Convenient sampling was used to select the organizations. Supply chain managers of the manufacturing firms are the respondents.

A structured survey questionnaire was used for data collection. All items are on a five point Likert Scale ranging from 1 "Strongly Disagree" to 5 "Strongly Agree". This questionnaire was developed by adapting scales and dimensions for the dependent and independent variables.

Based upon the research model presented in figure 1 following econometric equation was developed and examine through multiple regressions analysis.

$$OP = \alpha + \beta_1\, DSA + \beta_2\, RP + \beta_3\, FOL + e$$

Here OP represent operational performance, DSA represent the daily schedule adherence, RP is the repeat production, FOL is the flow oriented layout and e is representing the error term. The model was evaluated to measure the relationship and association among the lean strategy and the operational performance.

FINDINGS AND DISCUSSION

This section explains the relevancy of the outcomes with the designed objectives of the research. The assessment of the data is being done through factor analysis, Pearson's correlation matrix and multiple regression analysis. The data for this research has been collected through self-administered survey. To measure the reliability of the adopted questionnaire Cronbach's Alpha test was used to ensure that the values are greater than 0.6 [Sekaran 2005]. Cronbach's Alpha test confirmed that all variables are well above the standard level (see table 1).

Table 1a. KMO and Bartlett's Test
Tabela 1a. KMO i test Bartletta

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.881
Bartlett's Test of Sphericity	Approx. Chi-Square	1438.777
	Df	153
	Sig.	.000

All three variables were examined and presented separately for validity test along with operational performance. The Kaiser-Meyor-Olkon (KMO) and Bartlett's test of sphericity was used to examine the validity of the questionnaire in pilot testing. The results of each variable are presented in table 1a.

The KMO test and Bartlett's test of sphericity explained the appropriate results for further data analysis as KMO test has the higher value than .5 and Bartlett's test of sphericity has the significance value of < .05. Hence, in light of the results presented in table 1a, of each variable, prove valid and thus found appropriate for the research.

The analysis of Factor classified in four groups and these factors explained 68.254% out of total variation. Table 1b shows the item number which were loaded in the four respective factors.

Table 1b. Rotated Component Matrix Summary
Tabela 1b. Wyniki macierzy składników

	Component			
	DSA	**FOL**	**RP**	**OP**
DSA1	.774			
DSA2	.549			
DSA3	.739			
DSA4	.551			
DSA5	.520			
FOL1		.507		
FOL2		.701		
FOL3		.697		
FOL4		.406		
RP1			.650	
RP2			.747	
RP3			.617	
RP4			.412	
OP1	.			679
OP2				.632
OP3				.604
OP4				.652
OP5				.674
Cronbach's alpha score	.740	.761	.740	.764

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 5 iterations.

Association of daily schedule adherence, flow oriented layout, repetitive production with operational performance

To test H_{a1} - H_{a3} we employed Pearson's correlation test. The correlation metric is presented in table 2.

As presented in the table the relationship of daily schedule adherence and flow oriented layout with operational performance is reported at moderate level (r=.542; .535 respectively), moreover the sig value (0.000) is less than 0.05 which means that the relationship is highly significant.

Table 2. Pearson's Correlation Summary
Tabela 2. Wyniki korelacji Pearsona

		DSA	FOL	RPS	OP
Daily Schedule Adherence	Pearson Correlation	1			
	Sig. (2-tailed)				
Flow Oriented Layout	Pearson Correlation	.572**	1		
	Sig. (2-tailed)	.000			
Repetitive Production	Pearson Correlation	.247**	.398**	1	
	Sig. (2-tailed)	.000	.000		
Operational Performance	Pearson Correlation	.542**	.535**	.398**	1
	Sig. (2-tailed)	.000	.000	.000	

However, the relationship of repetitive production with operational performance is reported at low level (r= 0.398) moreover, the relationship is also highly significant. Hence, on the bases of results H_{a1} - H_{a3} are accepted.

Impact of daily schedule adherence, flow oriented layout, repetitive production with operational performance

To test H_{a4} we employed multiple regression test. The MLR results are presented in table 3 and 4.

The un-standardized regression coefficient for predicting operational performance from daily schedule adherence, flow oriented layout, repetitive production are .364, .199, and .251 respectively; the standardized coefficient are .345, .253, and .212; the significance level (sig.) or p of all predictors are reported as significant since all values are less than .05 and the degree of freedom for the F test are 3 for the regression and 297 for the residual. Hence it may be reported as B= (.345+.253+.212), F (3, 297) = 68.013, p < .000; r = .638. The summary of the results are presented in table 3 and 4.

Table 3. Multiple Linear Regression Summary
Tabela 3. Wyniki liniowej regresji wielokrotnej

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Df	F	Sig.
1	.638[a]	.407	.401	.7125117	3 297	68.013	.000[b]

a. Predictors: (Constant), RPS, DSA, FOL
b. Dependent Variable: OP

Table 4. Coefficients[a] Summary
Tabela 4. Wskaźniki[a]

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
	(Constant)	.562	.162		3.471	.001		
	DSA	.364	.057	.345	6.340	.000	.672	1.488
	FOL	.199	.045	.253	4.390	.000	.602	1.661
	RPS	.251	.058	.212	4.360	.000	.841	1.189

a. Dependent Variable: OP

The multiple regression predicting operational performance from the reported variables is statistically significant because the 'Sig.' is less than .05. Thus, we accept the hypothesis of association and state that operational performance is statistically significant predictor of reported variables. Using the R2 from the model summary table 3, we can say that r2 = .407, indicating that 40.7% of the variance in operational performance is predicted by daily schedule adherence, flow oriented layout and repetitive production. Hence it may be inferred that organizations following the above practices generally have higher operational performance in organization.

In the research, analysis is done on different operational strategies to check whether results of operational performance are aligned with the existent literature. The daily schedule adherence is having positive link with the operational performance hence inferred that increase in daily schedule adherence is going to increase the operational performance. Based on the above findings from the analysis, the hypothesis of daily schedule adherence has a positive relationship with operation performance and supports the findings of Carmen et al. (2007).

Moreover, the findings depicted that flow oriented layout has also a positive link with the operational performance and inferred that increase in flow oriented layout increases the operational performance. Our study results supported the previous findings of Richard [2002] as reported earlier. Lastly, the positive linkage of repeat production with operational performance supports the research findings of Peter et al. [2012].

CONCLUSIONS

The conclusion is based over the assessment of operational performance over the daily schedule adherence, flow oriented layout and the repeat production. The positive association is being found amongst the studied variables. The operations of the company are positively linked with the daily schedule adherence. This is quite valid for this study as well, as the companies have to follow their daily schedule and they have to adhere to the schedules developed by their production managers [Sanjay 2013]. The same procedure has to be repeated for all the operational and production days, to have efficient and effective production. Task repetition will automatically enhance the credibility and efficacy of the work. Similar findings have been extracted by making review done in the section of literature review and is explored that daily schedule adherence tend to increase the operational performance. Based over the extracted result, it is suggested to the supply chain management that they must have written and implemented plan for their labor and other personnel. All of the personnel and labor must know their daily tasks and must adhere to this schedule for the efficient production.

Flow oriented layout has positive association with the operational performance. Since the companies has to follow a synergy of the work. They have to follow the orientation of the layout and work in accordance with that layout. The activities that are required to be done in the first stance must be done in the first stance, or else it will destroy the other work as well. Hence, it is the duty of the labor to follow their flow orientated layouts and work as they supposed to work for the efficient production and enhancing their operational performance. Hence it is suggested to the supply chain management that they must have proper training and guidance to the labor and the production team about the flow oriented layouts, to enable them in knowing that which format they are required to followed for the attainment of the efficient production.

The operations of the company are positively linked with the flow oriented layout. Since organizations have to repeat their production to make sure that their customers will be facilitated with same quality products, with every production. However they have to decrease the production time and lead time, without compromising over the quality and this can be done by repeating the production process again and again and becoming efficient. Hence it is suggested to the supply chain management that they must entail their production team for having repetition in their work and become efficient in their production. They must be reached to their optimization level, where they have to extract less waste and have high level of the production.

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WPŁYW WDROŻENIA ZARZĄDZANIA TYPU LEAN NA DZIAŁANIA OPERACYJNO-ORGANIZACYJNE

STRESZCZENIE. **Wstęp:** Celem pracy jest opracowanie konsensusu pomiędzy różnymi operacyjnymi strategiami usprawniającymi w celu znalezienia zależności pomiędzy operacyjnymi cechami organizacji a jej postępowaniem operacyjnym.
Metody: Zmienne niezależne, które zostały użytego dla uzyskania zmiennej zależnej to działalność operacyjna, przestrzeganie dziennego harmonogramu, powtarzalność produkcji oraz schemat przepływu. Dane zostały poddane analizie korelacji i regresji wielokrotnej. Celem tych analiz był zbadanie zależności pomiędzy strategią Lean a działalnością operacyjną.
Wyniki wnioski: Stwierdzono pozytywną zależność pomiędzy działalnością operacyjną a przestrzeganiem dziennego harmonogramu, powtarzalnością produkcji oraz schematem przepływu. Powinno to służyć jako wskazówka dla zarządzających łańcuchem dostaw aby dążyli do powtarzalności w swojej pracy, co pozwoli na osiągnięcie efektywności produkcji. Należy osiągnąć optymalny poziom, przy którym poziom strat będzie najniższy a poziom produkcji najwyższy.

Słowa kluczowe: działalność operacyjna, przestrzegania dziennego harmonogramu, powtarzalność produkcji, schemat przepływu

EINFLUSS DER EINFÜHRUNG VON LEAN-MANAGEMENT AUF OPERATIV-ORGANISATORISCHES HANDELN

ZUSAMMENFASSUNG. Einleitung: Das Ziel der Arbeit ist es, einen Konsens zwischen unterschiedlichen, operativen Verbesserungsstrategien auszuarbeiten zwecks der Ermittlung von Abhängigkeiten zwischen den operativen Merkmalen einer Organisation und deren operativem Handeln.
Methoden: Die unabhängigen Variablen, die für die Gewinnung der abhängigen Variable angewendet wurden, manifestieren sich in operativer Tätigkeit, in der Beachtung des Tageszeitplanes, in der Wiederholbarkeit der Fertigung und im Ablaufschema. Die Daten wurden hinsichtlich der Korrelation und der mehrmaligen Regression analysiert. Das Ziel dieser Analysen war es, die Abhängigkeiten zwischen der Lean-Strategie und dem operativen Handeln zu erfassen.

Ergebnisse und Fazit: Es wurde eine positive Abhängigkeit zwischen dem operativen Handeln und der Beachtung des Tageszeitplanes, ferner der Wiederholbarkeit der Fertigung und dem Ablaufschema festgelegt. Dies sollte als Empfehlung für die Manager der Lieferkette dienen, die eine Wiederholbarkeit ihrer Arbeit anstreben sollten, um eine Produktionseffizienz erzielen zu können. Man sollte also ein optimales Niveau anstreben, bei dem das Ausmaß von Verlusten am niedrigsten und das Produktionsniveau am höchsten bemessen sein werden.

Codewörter: operatives Handeln, Beachtung des Tageszeitplanes, Wiederholbarkeit der Fertigung, Ablaufschema

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ROLE OF PARKING IN THE HOTEL SUPPLY CHAIN MANAGEMENT

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ABSTRACT. **Background**: Supply chain management in tourism has only recently become the topic of the scientific research. The hotel product as a tourist product presents a specific mix of services and products The focus of this study has been placed on the hotel company, that, in order to create such a product, builds its own network of partners (companies, co-workers), to bring together and coordinate activities intended to result in the desired features of the hotel product.

This study was evaluated as a scientifically relevant because until now the position of parking services in the hotel product has not been analyzed from the perspective of the hotel efforts and abilities to provide parking places for their guests by analyzing to which extent a good and available parking space really affects the quality of the hotel product.

The aim of the study was to define the framework in which the supply chain management acts with reference to the parking service and stakeholders in the network.

Methods: The method of interviewing hotel managers was used to obtain necessary data. Through the simple numerical calculations including the number of parking spaces and the capacity of the hotel accommodation we tried to identify the interrelationship, i.e. the degree of alignment of the respective sizes.

Results: It turned out that towns of Rijeka and Opatija are faced with a shortage of parking spaces, especially during the tourist season. The trend of providing parking services for guests in hotel-owned garages or car parks is typical for the everyday hotel operation and the shortage of such an option, is resolved through the lease of a certain number of parking spaces in public garages and car parks. These parking spaces are away from the hotel, the guests' dissatisfaction is a normal consequence of such a decision and it is mitigated through the commercial measures. Hotel management considers a provided parking space an important element of the hotel product quality, although they mostly do not have concrete proposals to provide a sufficient number of parking spaces for hotel guests.

Conclusion: The research confirmed the set hypothesis about the importance of parking in the quality of the hotel product. Hotels should persist on providing a sufficient number of parking spaces for their guests. In situations when there is no an available parking space they should opt for the construction of the underground garages, which are expensive solutions, but the investment can pay off through the increased occupancy of hotel capacities and a higher price for the better quality of product. The cooperation with local authorities is of great importance.

Solutions with remote private car parks or public car parks regularly cause guests' dissatisfaction, however its real nature and its consequences could not be shown in this research. Another problem has been pointed out in the study - coach parking, which also deserves the interest of a scientific research.

Key words: supply chain, hotel, parking.

INTRODUCTION

Road transport plays a major role in tourist travel. By the means of the road transport a complete journey can be made or they can be used in the initial-final part of the journey to bridge the part of the journey that cannot be made by the means of some other type of transport. The share of the road transport in the world tourist flows amounted to 40% in 2013 [www.unwto-tourism-highlight] in the Republic of Croatia in 2014 it amounted to 88% [Čorak et al. 2015], for Europe

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a relatively high proportion of land transport in amount of 54% in 2010 is mentioned due to the developed infrastructure [www.UNWTO_TT2030_EU28% 20 (1).pdf]. This data classifies the Republic of Croatia in the "road" tourist destinations, and makes it different than other Mediterranean countries. The European practice shows that Europeans visiting the tourist destinations in the Mediterranean travel in 48% of cases by plane, 32% use a personal car, while 10% of them travel by coach to their holiday destination [Mrnjavac et al. 2008].

The use of motor vehicles is characterized by a continuous exchange of movement and stationary state. A lot of attention is paid on the one hand to the movement of road vehicles through intensive building of the infrastructure that meets the highest standards of comfort and safety, the application of information and communication systems in the management of the urban traffic and the like; but on the other hand non stationary state of road vehicles is rarely perceived as a problem. In spite of the fact that road vehicles do not move for a number of reasons, only parking is analyzed in this study, i.e. intended stationary state aimed at using some other tourist services during the journey. In the focus of the scientific interest is the city, settlement respectively, which besides satisfying the needs of the local population and economic activities, acts as a destination on the tourist market.

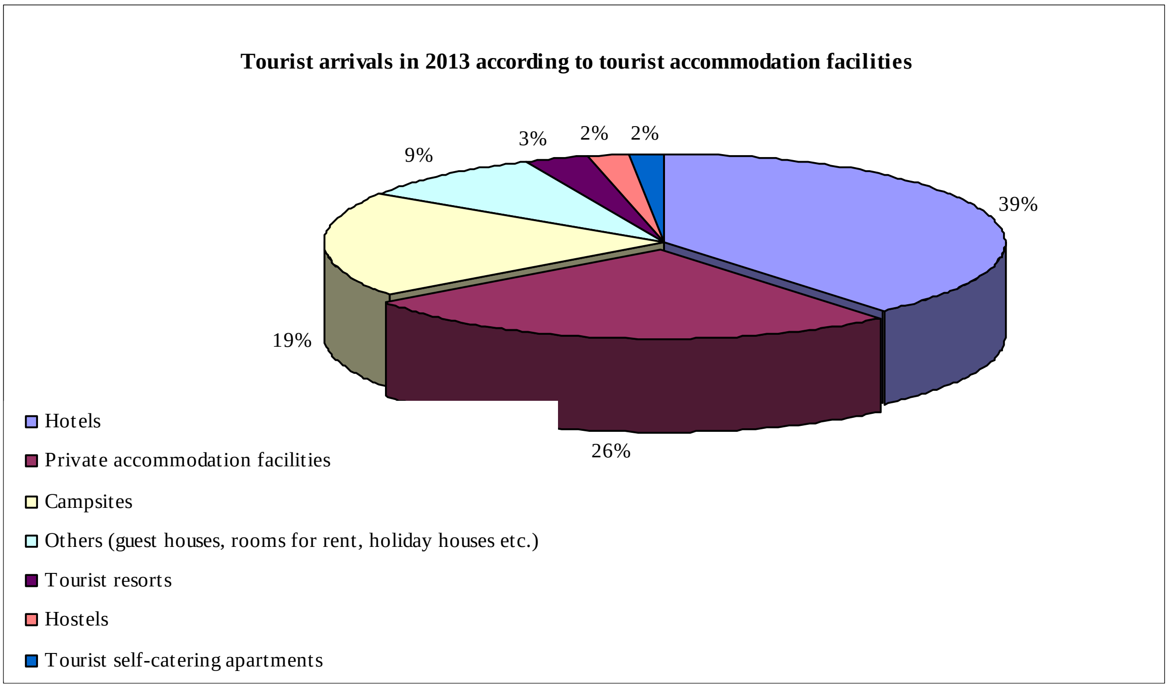
The role that transport plays in tourism is being increasingly recognized, however the precise and scientific research-based knowledge on the intensity of this correlation, i.e. on the real importance the traffic and parking as its essential component at the destination have for tourists, hardly exists. In this regard, however, it is necessary to point out the results of the research performed by the Institute for Tourism in Zagreb [Čorak et al. 2008, 2011, 2015], which on several occasions and with a time lag of several years besides exploring guests' satisfaction related to the tourist offer in Croatia, was also analyzing the degree of satisfaction related to the accessibility of the destination and also to the traffic at the destination. Regarding the transport accessibility the tourists are mostly moderately satisfied, despite the fact that the Croatian connectivity with tourism generating markets is realized through the network of newly built highways featured by the highest world standards. Among the elements that disturb tourists mostly are traffic jams and noise, which indicates a badly organized traffic in cities and probably the constant shortage of parking spaces [Maršanić 2008a].

The role of parking at the tourist destination has been a rather frequent topic in studies: from the theoretical point of view [Maršanić, 2007, 2012], applied perspective Croatian [Maršanić 2003, 2006] and related to towns of Opatija, Rijeka, etc. [Maršanić et al. 2004, 2007, 2012].

Tourists who come to Croatia largely stay in hotels. In 2013, from a total sum of 12,434,000 tourists, the hotels were visited by 4,839,000 of them, the resorts by 413,000, self-catering apartments by 200,000, hostels by 233,000, private accommodation facilities by 3,227,000 and other facilities (guest houses, rooms for rent, holiday houses, inns, rest areas for children, etc. by 1,128,000 [Bureau of Statistics of the Republic of Croatia, 2014].

Within the strategy of tourism development in Croatia great attention is paid to the quality of hotel accommodation by recognizing the possibility to increase the quality level of the tourist product, which will further motivate the process of distancing from mass tourism, in favor of various forms of the selective tourism. Hotel companies, regardless of their capacity, form of ownership and market orientation are making great efforts in tough competition encouraged by globalization, to achieve a permanent position through a quality offer.

A significant role in the strategy of tourism development plays logistics and the supply chain concept, whose features are applied by the hotel management for the purpose of an efficient business operation often unaware of its scientific and theoretical background. This background is of a modest nature. The research of the role of logistics in tourism, whose integral part is the hotel industry, has started to a certain extent only in recent years, partly because it is logistics of services [Bloomberg et al. 2006], which is mainly of secondary interest if compared to logistics of goods, and partly because the development of tourism does not decline on a global level, so that stakeholders are looking for new models which will meet the needs of the tourist demand and achieve a profitable business operation [Waters et al. 2003]. Recently, the responsible use of resources, in order to protect the environment is gaining in importance [Mrnjavac 2010].



Source: Bureau of Statistics of the Republic of Croatia, 2014 (author's interpretation)

Fig. 1. Tourist arrivals in the Republic of Croatia related to the type of accommodation in the year 2013
Rys. 1. Przyjazdy turystyczne do Chorwacji w 1993 pod względem typu zakwaterowania

The hotel industry, as a basic industry in tourism, besides the fundamental service of accommodation, food and beverages, offers a whole range of other services that position the hotel in the demanding global market. Hotel product is a logistics product [Mrnjavac, 2010] whose production involves flows of materials, goods, services, information, knowledge, capital, people, energy, waste; so that it can rightly be characterized as a product of exceptional complexity, whose production represents a major challenge for the hotel management [Mrnjavac et al. 2011].

Analyses of the supply chain and its management in tourism are also of sporadic nature and have appeared only in recent years. We think that the concept of the supply chain that is wider than the logistics, offers wider opportunities in "defining the framework" - connections and coordination of all stakeholders in the design of the product - supply and customers, aimed at achieving higher product quality and lower costs [Christopher 2011]. In the hotel company the concept of the supply chain necessarily acts as a network [Christopher 2011] whose one part comprises interrelations with suppliers for the production of a complex heterogeneous hotel product, and its second part involves the interrelations with customers directly or through intermediaries (travel agencies, tour operators), including transport undertakings and entrepreneurs [Mrnjavac et al. 2013].

From the macro perspective the supply chain is a network of companies that are participating in various activities from procurement over production to the distribution to the user [Song 2012], while from the micro perspective the network consists of nodes (places) in which the interruptions and changes in logistics processes in a hotel occur. If the supply chain in tourism (hotel industry) is observed as a network of stakeholders who provide different elements of tourism (hotel) products in a tourist destination, including a wide range of participants in the public and private sector, as air transport, accommodation ... is particularly mentioned [Song 2012]. Accordingly, parking should also be regarded as one of the elements [Mrnjavac et al. 2008].

Thus, parking belongs to the segment of services made up of the hotel product at the micro level, representing a break in the logistics process of movement of tourists due to their stay at the hotel. Efficient organization and management of the segment of the hotel supply chain, which includes parking is not possible without knowing the characteristics of the tourist demand - dynamics, seasonality [Fawcet 2000], the structure related to the means of transport, length of stay in a hotel, purchase power, age, education, special interests, etc. It should be kept in mind that the hotels open throughout the whole year round are in a great advantage in providing parking spaces for their guests, compared to hotels with a distinct seasonality in their business. Just this fact along with other mainly financial reasons could be a motivation for the hotel management to try to reduce the seasonality in their business operation.

The scientific study of the supply chain in the hotel industry that has defined the link of the logistics hotel product with the traffic in the tourist destination by pointing out the cycling tourism is especially emphasized [Kovačić 2014]. According to Kovačić [2014] the role of transport in the area, parking areas and connections with other modes of transport is of great importance because it is the only possible way to make maximum use of the available resources and to achieve value for the guest and profit for the hotel.

Due to the fact that according to the available information a scientific study of the role of parking in the hotel product has not been carried out until now, and based on the individual information that there is a certain interdependence, the scientific hypothesis was defined: parking a road vehicle (especially a guest's personal car) is an element of the quality of the hotel product. It is assumed that an adequately provided parking solution significantly contributes to the perception of the quality of the hotel product by a tourist, and that a competitive advantage is held by those hotels, which in designing a complete product for their guests, provide an adequate parking space.

MATERIALS AND METHODS

In the previous text it was pointed out that Croatia is a destination in which majority of tourists come by road vehicles, so that a considerable need for parking spaces can be expected. Due to the partial results of the research carried out in various Croatian tourist destinations, but only either related to the parking, or only to the hotel operation, two Croatian tourist destinations were chosen: Rijeka and Opatija.

Rijeka is a city with 128,624 inhabitants, a typical destination of city tourism on the rise, trying to develop event, cultural and historical tourism. Because of its geo-transport position it represents a port of departure and arrival for cruises in the Croatian part of the Adriatic Sea. Such tourist offer results in a short stay of tourists in the city, i.e. in 2013 the average length of the tourist stay amounted to 1.91 day and 2.20 days in 2014.

Located 20 km away from Rijeka, Opatija has 11,659 inhabitants, and it is a destination of bathing, conference, health, wellness, gastro and cultural tourism. It is a pioneer of tourism on the Croatian Adriatic coast, the town of exceptional architectural and landscape beauty. The average length of stay of tourists in 2014 amounted to 3 days, and it is important to point out that the average stay of tourists during the summer months (June to September) is 7 days.

These destinations were chosen because of their diversity, tourism potential, the role of the road traffic and parking problem especially during the tourist season.

The first part of the study was performed through "desk research". Recent findings in the management of the hotel chain in the hotel industry, and the interconnection of the hotel product and transport, in particular parking, were analyzed by deductive and analytic methods. This resulted in a review of findings gained until now on which this study continues. Also, based on these findings the scientific hypothesis of the study was defined.

The second part was a field research. Method of interviews included hotels, whereby a difference between a hotel and hotel company was not made, because it was assumed that it is essential for the user that his/her hotel provides a parking space close to the hotel, regardless its organizational form. In Rijeka, the managers all four hotels were interviewed, while in Opatija eight hotels were covered by the same methodology. The interdependence of the hotel product and parking was analyzed: approaches and methods typical for the organization of parking for hotel guests were the subject of the analysis as well as both guests' and management's satisfaction with the provided solution. For that purpose a questionnaire including 11 questions was written, and the answers were expected in the descriptive form.

This method was chosen because it allows that the interviewee (in this case the hotel manager) as an answer to the question presents his opinion freely and comprehensively, and also the precise information taken from the database of the hotel operation business. It was expected that such approach will allow collecting more pieces of information relevant for the logistical dimension of the research topic.

Data (in a percentage) on the number of arrivals in the hotel were collected, in order to find out if the guests come either individually (by personal car) or within the organized tour (by tourist coaches). The form of the organization of the stationary traffic (parking) was analyzed; as well as the number of available parking spaces provided by hotels in the mentioned cities and whether the parking for hotel guests is charged was or not. Exceptionally interesting are the findings that inform on the way of handling the situations when there are not enough parking spaces available for the hotel guests as well as on the type of complaints addressed to the hotel management. Managers of the hotel could prove the claim that the quality of the hotel, in addition to their accommodation facilities, price of the accommodation, hotel category, quality of food and services, the transport accessibility and many other factors also depends on a sufficient number of parking spaces available for the hotel guests. At the end of the survey managers were able to present information about the plans of the hotels and assess the cooperation with the local authorities regarding the issue of parking.

Since the method of interviews cannot avoid subjectivity of respondents, additional methods of the field research were used in order to increase the objectivity.

Results obtained through the interviews were put in correlation with the data collected by the method of direct counting of parking spaces in the area of the destination, in order to collect additional pieces of information about parking options in the selected tourist destination.

Through numerical calculations, which included the number of parking spaces and the capacity of the hotel accommodation, the interrelationship, i.e. the degree of the congruence of the respective sizes was determined, in order to provide additional data on the availability of parking spaces and guests' satisfaction regarding the hotel product as a whole.

RESULTS

The following conclusion has been made through the synthesis of responses of the hotel managers in Rijeka and Opatija:

1. To the city of Rijeka majority of guests (about 70%) come individually by personal cars, and to the city of Opatija about 60% of visitors come by car.

2. All analyzed hotels in Rijeka and Opatija dispose with organized car parks for the guests staying in the hotel. Parking places are provided in the structured garage facilities or in the closed (under the ramp) car parks, while only a small number of the hotels organize parking for their guests on street parking spaces. However, almost all hotels, especially in Opatija have an insufficient number of parking spaces.
3. All parking spaces reserved for the hotel guests in Rijeka are not charged or the car park charge is included in the price. In Opatija, unlike Rijeka, in the most of the surveyed hotels the parking service is charged, which is not negligible (for example, up to 90.00 kuna per day or 12 €).
4. If there are no available parking spaces in the hotel car park, managers of all the surveyed hotels send the guests to the public car park which is charged. It usually causes a lot of discontent among the guests, and at the same time the justification provided by hoteliers that due to the fact that the hotels are located in the city center there are limited parking spaces. Some hotels try to resolve the issue of a lack of parking spaces through encouraging conversations with the guests and by offering them some kind of compensation like certain services at a discounted price.
5. Majority of the interviewed managers believe that the quality of a hotel assessed by the guest also depends on the number of parking spaces, i.e. the possibility to park the car in front of or inside the hotel the guest is staying at. According to the managers' opinion a provided parking space is one of the most important elements of the complete offer of hotels, although not a decisive one. It is particularly important to pay attention to finding out the best solutions to ensure an adequate parking space.
6. Performed analysis provided an opportunity for managers to evaluate numerically the quality of a hotel, which means in the numbers from 1 to 10, where 1 is the lowest and 10 is the highest mark. They have evaluated the importance of parking in relation to the accommodation capacity, price, hotel category, quality of food and other services, transport accessibility and the like. The average score for the significance of parking is 7.
7. Majority of the hotel managers said they have no spatial and / or financial resources to provide a larger number of parking spaces than the number they dispose with at the moment. They are mainly not familiar with the plans of the local authorities regarding the issue of parking, which is particularly problematic during the tourist season. They mostly believe that the most likely solution is building garage facilities through a public-private partnership.

DISCUSSION

The research of the role of parking in the quality of the hotel product through interviewing hotel managers confirmed the scientific hypothesis: parking road vehicles (especially a personal guest's car) is an element of the quality of the hotel product. It is supported by the fact that in the town of Opatija the hotels of higher categories have provided parking spaces for their guests, and that the shortage of a parking space in the hotel causes the guest's dissatisfaction, even when a solution with a public car park or a garage is offered.

In such situations the hotel managers try to improve the situation through the measures of commercial compensation by offering other hotel services free of charge or at a lower price. The level of the guest's dissatisfaction with such a solution could not be assessed; it would be only possible through the method of interviewing the guests. The research has not shown that in addition to these measures also some other logistical capabilities are used.

Guest's dissatisfaction is also caused by the high charges of a daily parking inside the hotel, so that hotel management should consider the possibility of integrating the car park charges in the price of the hotel accommodation. Dissatisfaction is even higher if a high charge is paid, but the parking space is not close to a hotel, as it very often happens to be a further away public garage or a car park.

Since the average stay is longer and the car park charges in Opatija are higher, the hoteliers are often faced with the guest's dissatisfaction when there is a shortage of parking spaces. In the town of Opatija, out of totally 22 hotels, just 15 of them, which are of the highest category have their own parking spaces. When, however, the correlation between the accommodation capacities of the hotel and available parking spaces is made, just a few of the hotels can meet the parking needs in terms of the high occupancy of hotel capacities. This is especially noticeable in the summer, when the average guest's stay is longer, and the destination as a whole has a shortage of parking spaces. The vast majority of the hotels have almost a symbolic number of parking spaces in relation to their accommodation capacity. A hotel with its own garage, whose capacity is much higher than the accommodation capacity of the hotel should be emphasized as an interesting example.

When there is a high occupancy of accommodation capacities very few hotels can provide a sufficient number of parking spaces, so that the shortage of car parks is the usual practice in almost all the hotels surveyed. Newly built or thoroughly renovated hotels usually have parking garages and dispose with a higher parking capacity.

Sufficient capacity and convenient location of parking spaces increases the guest's satisfaction and herewith the quality of the hotel product. Therefore, the hotels should provide parking spaces for their guests, with a minimal divergence between the hotel capacity and adequate parking capacities. When hotels are in a process of renovation, investors should give priority to the parking spaces in relation to the number of hotel rooms and some other elements of the hotel offer. Such a concept should accept more expensive building solutions like for example the construction of the underground garages, which is often the only solution for older buildings located in the city center. Initially more expensive building solution will be paid off through a better room occupancy due to the higher quality of the hotel product. Such solution will further encourage the hotel management to adopt and implement strategies to reduce the seasonality of the business. For the analyzed destinations Rijeka and Opatija and many others, too, it presents a realistic option.

Since the construction of car parks and providing parking spaces is related to large construction projects and difficulties in the everyday operation of the destination, the hotel management should insist on the cooperation with local authorities, in order to find optimal locations and transport models of the continuous connectivity between the remote car parks and garages and the city center, either free of charge or at minimal charges.

Some hotel facilities in the old city center will not be able to accomplish a building solution that would provide parking spaces for guests in the immediate vicinity. In such situations and in others as well, the hotel management should try to find logistic and organizational solutions such as - to provide the transfer of guests, especially upon arrival and departure from the remote parking space by the own means of transport, either a rented car or a means of transport provided by a local carrier, which should be regulated by a contract; all that with no extra charges or at a symbolic price.

In this context, shuttle transport should not be ignored. Many hotels offer a shuttle service arranged for their guests, and it can always among the sites of particular interest include the car park the hotel has reserved for its guests at a symbolic price and following the adjusted timetable.

The hotel management in the town of Opatija has highlighted another problem which is the coach parking, since many tourists come by coach. It is hard to expect that the hotels, constantly complaining about shortage of space, since they are located in the old city center, will be able to provide parking spaces for coaches. In most cases a good cooperation with local authorities is mentioned or it is not established at all. The issue of transport of drivers to the coach parking, if there is any, remains still unresolved. Also, the prices that do not offer adequate services, as well as inappropriately restricted parking time and the like is mentioned.

Based on all that was mentioned in the above text it can be estimated that the topic of the study was relevant and of scientific interest. A contribution to the comprehensive findings about the role of parking in the quality of the hotel product would be a direct survey performed among the hotel guests, just in the hotels in the cities of Rijeka and Opatija, whose management was the subject of this study.

Also, the issue of coach parking in destinations with a significant share of organized arrivals can be assessed as a valuable piece of research, with a remark that along with a more detailed study of the hotel management, guests and drivers (travel agencies and/or tour operators) should also become a part of the research.

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ROLA PARKINGU W ZARZĄDZANIU ŁAŃCUCHEM DOSTAW HOTELU

STRESZCZENIE. **Wstęp**: Stosunkowo niedawno tematyka zarządzania łańcuchem dostaw w branży turystycznej znalazła swoje miejsce w pracach naukowych. Produkt hotelowy jest specyficznym produktem turystycznym, składających się z wielu różnych usług i produktów. W pracy tej skoncentrowano się na firmie hotelarskiej, która w celu stworzenia takiego produktu, buduje sieć partnerów biznesowych (firmy, współpracownicy), aby skoordynować i połączyć różne aktywności zmierzające do zbudowania produktu hotelowego.
Praca ta ma wartość naukową, gdyż do tej pory nie poddano analizie naukowej znaczenia miejsc parkingowych w produkcie hotelowym z punktu widzenia nakładów ponoszonych przez hotel oraz ich wpływu na jakość produktu hotelowego.
Celem pracy jest zdefiniowanie ogólnych ram, w obrębie których występuje zarządzanie łańcuchem dostaw w odniesienie do usług parkingowych oraz udziałów wspólników w sieci.
Metody: Potrzebne do analizy dane zostały uzyskane metodą wywiadów z menadżerami hotelów. Poprzez zestawienie liczba miejsc parkingowych z pojemnością hoteli oraz ich analizę statystyczną, spróbowano znaleźć zależność między tymi czynnikami.
Wyniki: Miasta Rijeka oraz Opatija posiadają niedobór miejsc parkingowych, szczególnie w okresie wzmożonego ruchu turystycznego. Poszukiwanie wolnych miejsc parkingowych jest charakterystyczną codzienną operacją, wykonywaną przez personel hotelu. Jedną z metod postępowania jest dzierżawa tych miejsc poza terenem hotelu. Miejsca takie znajdują się czasem w sporej odległości od hotelu, co wpływa na niezadowolenie gości. Zapewnienie odpowiedniej ilości miejsc hotelowych jest uznawane przez kierujących hotelem, za element wpływający na jakość produktu hotelowego, choć z drugiej strony w większości, nie mają oni koncepcji na rozwiązanie tego problemu.
Wnioski: Została potwierdzona postawiona hipoteza o istotności miejsc parkingowych dla jakości produktu hotelowego. Hotele powinny dążyć do zapewnienia odpowiedniej ilości miejsc parkingowych dla swoich gości. W sytuacji, gdy nie ma możliwości wygospodarowania terenu pod parking, należałoby rozważyć budowę parkingu podziemnego. Jest to drogie rozwiązanie, ale zapewniające lepsze wypełnienie hotelu przy wyższych cenach. Istotna jest współpraca z lokalnymi władzami.
Rozwiązania związane z miejscami parkingowymi w miejscach położonych daleko od hotelu, powodują niezadowolenie klientów, jednak natura tego zachowania i jego konsekwencje nie były tematem badań. W pracy wskazano również na zagadnienie parkingu dla autobusów, które także wymaga osobnych badań.

Słowa kluczowe: łańcuch dostaw, hotel, parking.

ROLLE DES PARKPLATZES IM MANAGEMENT DER LIEFERKETTE IM HOTELWESEN

ZUSAMMENFASSUNG. Einleitung: Die Thematik des Managements der Lieferkette in der touristischen Branche fand erst vor kurzem ihren Platz in Forschungsarbeiten. Das Hotel-Produkt ist ein spezifisches Produkt der touristischen Branche, das sich aus vielen unterschiedlichen Dienstleistungen und Produkten zusammensetzt. In der vorliegenden Arbeit konzentrierte man sich auf ein Hotelunternehmen, das zwecks der Etablierung eines solchen Produktes ein Netzwerk von Business-Partnern (Firmen, Kooperanten, Mitarbeiter) aufbaut.In diesem Vorahaben zielt man darauf hin, verschiedene, den Aufbau eines effizienten Hotel-Produktes anstrebende Aktivitäten zu koordinieren und zu verbinden.
Der Beitrag besitzt einen wissenschaftlichen Wert, denn es wurde bisher der Bedeutung von Parkplätzen innerhalb des Hotel-Produktes aus dem Gesichtspunkt des Aufwandes seitens des Hotels und ihres Einflusses auf die Qualität des Hotel-Produktes in wissenschaftlichen Analysen kaum Beachtung geschenkt. Das Ziel der Arbeit ist es, allgemeine Rahmen zu definieren, in denen das Lieferketten-Management in Bezug auf die Parkplatz-Dienstleistungen und auf die Anteile der an der betreffenden Lieferkette Beteiligten zustande kommt.
Methoden: Die für die betreffende Analyse brauchbaren Daten wurden anhand der Befragungen von Hotel-Managern gewonnen. Über die Zusammenstellung der Anzahl von Parkplätzen mit den Hotel-Kapazitäten und deren statistische Analyse hat man versucht, vorhandene Abhängigkeit zwischen den beiden Faktoren aufzudecken und zu verarbeiten.
Ergebnisse: Die Städte Rijeka und Opatija leiden unter Mangel an Parkplätzen, insbesondere in der Zeit intensiven Touristen-Verkehrs. Das Suchen von freien Parkplätzen ist also eine charakteristische, tagtägliche Aktivität eines jeden Hotelpersonals. Eine mögliche Lösung des Problems ist Pachten zusätzlicher Parkflächen ausserhalb der Hotelanlagen. Solche Parkflächen befinden sich allerdings meistens in einer gewissen Entfernung vom Hotel, was eine Unzufriedenheit der Hotel-Gäste hervorrufen kann. Daher ist die Absicherung der entsprechenden Parkplatz-Kapazitäten direkt am Hotel von den Hotel-Managern für ein die Qualität des Hotel-Produktes erhöhendes Element angesehen, wobei sie aber meistens kein Konzept für die Lösung des Problems besitzen.

Fazit: Es wurde die Hypothese über die gravierende Bedeutung der Hotel-Parkplätze hinsichtlich der Qualität des Hotel-Produktes nachgewiesen. Daher sollten die Hotels das Angebot der entsprechenden Parkplatz-Kapazitäten für ihre Hotel-Gäste anstreben. Wenn aber keine Möglichkeit der Inanspruchnahme einer anliegenden Fläche am Hotel für die Zwecke des Parkplatzes besteht, dann ist der Bau eines Tief-Parkplatzes zu erwägen. Die Lösung ist relativ teuer, bietet aber eine bessere Belegung von Hotel-Plätzen bei höheren Preisen. Empfehlenswert ist dabei eine weitgehende Zusammenarbeit mit Lokalbehörden.
Die Problemlösungen, die auf die weit ausserhalb der Hotel-Anlagen situierten Parkplätze zurückführen, haben eine bestimmte Unzufriedenheit der Anreisenden zufolge, die Natur eines solchen Verhaltens der davon betroffenen Hotel-Gäste und dessen Konsequenzen sind aber noch nicht ein wissenschaftlicher Schwerpunkt geworden. In der Arbeit wurde auch auf die Frage der Parkpläze für touristische Busse hingewiesen, wobei das Anliegen einer getrennten Erforschung bedarf.

Codewörter: Lieferkette, Hotel, Parkplatz

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