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USING CARBON FOOTPRINT TO EVALUATE ENVIRONMENTAL ISSUES OF FOOD TRANSPORTATION

Konieczny P.[1], Dobrucka R.[2], Mroczek E.[1]

1) Poznan University of Life Sciences, Poznan, Poland, 2) Poznań University of Economics, Poznan, Poland, Faculty of Commodity Science, Department of Industrial Products Ecology and Quality

ABSTRACT. Background: The international trade of food commodities is still growing and food products are transported sometimes for a long distance using various modes. Food transportation issues should be discussed not only in respect to quality and safety concerns but also from environmental point of view. Numerous approaches are proposed to study impacts of food transportation along typical food chain on environment. Carbon footprint based on seems to be an interesting indicator for such analysis.
Material and methods: The analysis carried out in this study is based mainly on data presented in paper and reports published in recent decade, including some opinions available on various internet websites.
Results and conclusions: The greenhouse gas emissions associated food transport along whole food supply chain. Carbon footprint can be used to study various environmental impacts on each chain stage including primary production, food processing, fuel and energy consumption in food distribution, retail issues and product use by consumer during household consumption. Adding these together all of the greenhouse gas emissions gives the total carbon footprint for a product useful to affect consumer nutritional behaviors..

Key words: food transportation, carbon footprint, environmental impact.

INTRODUCTION

Nowadays all enterprises involved in the agrifood sector, from producers, manufacturers, retailers to consumers, are required to be responsible for meeting the fundamental safety requirements for food and feed. However, according to the 'farm to fork' approach , typical food chain contains not only links connected with food processing and storing but also the transport and holding of food commodities ones. Food safety hazards characterized by different frequency and severity risk are identified across all modes of transport. Raw seafood, raw meat and poultry, and refrigerated raw and ready-to-eat foods have the highest overall risks (in descending order) in this context [Ackerley et al. 2010].

Each year, 200 billion metric tons of food are transported globally - 35 percent by land, 60 percent by sea, and 5 percent by air [Bendickson 2007]. Food transportation has a significant impact on environment because of its propensity to increase the volume of greenhouse gas emissions. In the EU countries almost 54 percent of total nitrous oxide, 45 percent carbon dioxide, 23 percent none-methane volatile organic compounds (NMVOC) and 20 percent other gases contributing to global warming are coming from this source. It results not only in the essential degradation of natural environment, but also has a strong negative effect on human health [Badyda 2010] .

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Due to opinion of experts from Eco Evaluator Inc., USA, "when it comes to food imports, air transports burn an excessive amount of fuel. A single loaded airplane can burn thousands of pounds of fuel during takeoff alone. Huge sea vessels and airplanes that are used to transport imported food use fossil fuels and produce more emissions than any other mode of transportation. Naturally, these ships and planes carrying imported goods, upon docking or landing at its destined port, will also need large trucks for the products to be delivered to its final destination. Obviously, if the food source is located a great distance away from its destination, the fossil fuel consumption of the transporting vessel will also be great" [Anonymous 2012].

To reduce the greenhouse gas impact of agri-food sector it's necessary to understand how the production, distribution, retailing and use of agri food commodities results in these emissions which contribute to global warming. One way to understand, and measure, the environmental impact of food transportation issues is to use carbon footprinting method.

The main purpose of this article is to present selected data and examples focusing on this approach to food transportation issues.

WHAT IS A "CARBON FOOTPRINT" ?

Most agro-food manufacturers and suppliers including main international players on worlds markets, are using eco-audit and eco-design principles, including Life Cycle Assessment approach, searching most environmental friendly technological and raw material solutions [Raport DIAS 2003]. Since in recent decades the environmental effects of transportation has become a topic of increasing importance around the world, also more complex LCA transportation studies have been conducted to increase understanding of pollutant emissions along with their consequences, and to develop tools for impact reduction [Fet 2001]. Some researchers have also made efforts to define the long-term direction for future transportation and environmental research from a broader perspective. These analyses provide a general framework for the concept of sustainability, defining the purpose of studying transportation and the environment, which encompasses logistics systems and their impacts. The most widely accepted definition for sustainable development was given by the World Commission on Environment and Development in 1987, and subsequently endorsed by the United Nations at the Earth Summit in 1992:"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs." As a result industry has begun to respond and make adaptations to the growing need for sustainable activities [Sathaye et al. 2006]. Therefore, developing and implementing practical and cost-effective carbon mitigation strategies for the complex logistics sector presents a great challenge of crucial importance [McKinnon, 2010, Uvarov, 2011].

Several methods and tools are used to study global impact of human activity on environment. The concept name of the carbon footprint originates from ecological footprint, which was developed by Wackernagel already in the 1990s [Wackernagel 1996] which estimates the number of "earths" that would theoretically be required if everyone on the planet consumed resources at the same level as the person calculating their ecological footprint. A carbon footprint has historically been defined as "the total set of greenhouse gas (GHG) emissions caused by an organization, event, product or person." However, a more practicable definition has been suggested, and namely : "A measure of the total amount of carbon dioxide (CO_2) and methane (CH_4) emissions of a defined population, system or activity, considering all relevant sources, sinks and storage within the spatial and temporal boundary of the population, system or activity of interest." [Wirth et al. 2011] .

To express a carbon footprint as a single number (a common currency), the emissions of greenhouse gases are converted into an equivalent amount of carbon dioxide (CO_2 equivalent or CO_2e). This conversion is based on the relative global warming impact of each gas, and the final carbon footprint is expressed as the weight of carbon dioxide. Since the Kyoto Protocol is an international treaty for

controlling the release of GHG from human activities, often this GHGs are referred as "Kyoto gases" (Table 1) [IPPC 2007] .

Table 1. "Kyoto gases" and their Global Warming Potential expressed as CO_2 equivalent
Tabela 1. Potencjał tworzenia efektu cieplarnianego dla tzw. gazów z Kyoto wyrażony jako ekwiwalent CO_2

Greenhouse Gas	**Global Warming Potential (GWP)**
Carbon dioxide (CO_2)	1
Methane (CH_4)	25
Nitrous oxide (N_2O)	298
Hydrofluorocarbons (HFCs)	124 – 14800
Perfluorocarbons (PFCs)	7390 – 12200
Sulfur hexafluoride (SF_6)	22800
Nitrogen trifluoride (NF_3)[3]	17200

Despite the reduction of LCA into a single indictor of climate change, carbon footprinting demonstrates greater appeal than LCA as it is being promoted and diffused outside the scientific community (Finkbeiner 2009).

SIGNIFICANCE OF TRANSPORTATION IN THE FOOD SUPPLY CHAIN EVALUATED BY CARBON FOOTPRINTING METHOD

There is a general agreement that the transport of food accounts for an essential portion of the environmental burden imposed by any stage of typical food chain. Transport - either during the retailing and distributing phase or in the process of household consumption has significant direct impacts on environment. Transportation processes have been shown in many LCA studies to have the largest impact in terms of energy consumption, global warming, acidification and eutrophication [Massari 2003]. The emissions associated with transportation vary by origin and type of food. Weber and Matthews, 2008 estimate that food transportation may account for 50% of total carbon emissions for many fruits and vegetables, but less than 10% for red meat products. Each year, the food system utilizes about 19 percent of the total fossil energy burned in the United States of this 19 percent, about 7 percent is expended for agricultural production, 7 percent for processing and packaging, and 5 percent for distribution and food preparation by consumers [Pimentel et al. 2006].

For example, in case of the dairy sector, it has been estimated that the distribution of dairy products to retailers requires much more energy than does the transport of the milk from farm to dairy. In the farming phase transport play a role due to the movement of animal feed and livestock, although a larger component in the overall impact of this life cycle stage seems to be the use of nitrogen based fertilizers and pesticides in the production of the cereals which generally constitute animal feed. Cows burping methane are also indicated as source of environmental problems, so, due to general assessment of problem, about 73 percent of the carbon footprint comes from dairy farming (Fig. 1) [Anonymous 2012b].

The reduction of fuel consumption of transport modes used along all food chain stages is one of critical factor influencing product carbon footprint. In respect to fuel type specific carbon dioxide emissions vary from 2.3 kg to 3,3 kg CO_2 per 1 kg of coal and gasoline, respectively [Engineering TollBox, 2012]. Fossil fuels are virtually nonrenewable natural resources. Differences in fossil fuel requirements for vegetable protein and meat protein production strongly depend on the intensity of agriculture. Depending on the relative intensities of agricultural practices and attributing all energy inputs to the production of foodstuffs, the efficiency of fossil fuel use may be a factor 2.5-50 better for vegetable proteins, if compared with animal husbandry. In European countries, this difference will usually be a factor 6-20 to the advantage of soybean-based protein food [Reijnders and Soret 2003] .

Within the developed world there are four basic transport modes for shipping large quantities of packaged products: water, rail, truck, and air. Although certain food supply chain systems require bulk transport, such as rail, barge or in water, truck transportation

dominates most logistic systems, especially toward the consumer end of the chains. Particularly for perishable foods, trucking remains cheapest and flexible mode of food transport [Ackerly et al. 2010]. To compare transport modes with regard to energy usage and resultant emissions, a ton-km as the movement of 1 metric ton of cargo over 1 km was proposed by Wakeland et al. 2012. Table 2 shows that these modes have very different energy and emissions profiles.

Life cycle stage	Raw material production	Manufacture/ processing	Logistics/ distribution	Retail	Use by consumer	Recycling and disposal
Carbon footprint	73%	9%	3%	10%	3%	2%

Fig. 1. The relative percentage of carbon footprint in raw milk production
Rys. 1. Względny udział procentowy etapów produkcji mleka surowego w tworzeniu śladu węglowego

Table 2. Energy and emissions per ton-km in dependence of transport mode
Tabela 2. Energia i emisje w przeliczeniu na tonokilometry w zależności od środka transportu

	MegaJoules per ton-km	Kg CO_2eq per ton-km
International water-container	0,2	0,14
Inland water	0,3	0,21
Rail[a]	0,3	0,18[a]
Truck[b]	2,7	1,8
Air[c]	10	6,8

Note that utilization and backhaul rates will affect all figures
[a] May depend on whether diesel or electric power is used
[b] Depends on size and type of truck, power source
[c] Includes effects from radiative forcing

Follow data reported by Ackerly et al. 2010 again in the United States, about 80 percent of all food shipments and 91 percent of all temperature-controlled freight shipments, including about 28.5 million tons of refrigerated fruit and vegetables are transported by truck. Short sea shipping, using ocean-going vessels for delivering cargo domestically, is popular in Europe and also holds promise for replacing many truck deliveries in the United States.

When it comes again to typical "farm-to-fork" food chain, environmental impacts of transportation in respect to processing phase should be taken into consideration, too. From discussion paper of Massari, 2003 it emerged that European and Japanese companies had much higher levels of production efficiency than their US counterparts. A reason for this could be that Europe and Japan both have more developed environmental management systems and , in consequence, reduce energy costs, waste disposal and treatment charges. Within the plant, key contributors to energy/carbon use include processing equipment, such as ovens, dehydrators, retorts and pasteurizers; coolers and freezers; compressed air systems; air-handling systems for clean rooms; and lighting. The processor may need to replace certain pieces of equipment to improve energy efficiency. An example would be switching some transportation volume to less CO_2-intensive modes or replacing motors with new ones that are more energy efficient and sized properly to the equipment they power. Internal transport optimization and better control systems can help reduce energy demand and thus the carbon footprint [Connolly 2012].

Transportation is an important factor, both during the retail and food distribution phases and in the process of household consumption. It has been calculated [Massari 2003] that the energy spent by household transport f. e. in the Netherlands, for shopping and eating out (assuming an average 3.5 km journey by car, once a week, for food shopping) amounts to

1280 MJ annually. The energy spent in car use for eating out has been estimated at 20 MJ per outside meal. According to DEFRA report [Forester et al. 2006], the environmental impact of car based shopping are greater than those of transport within the distribution system itself. The environmental impact of aviation is important for air-freighted products, but such product are a small proportion of food consumed. Transportation is, however, only one of the components in the overall consumption phase, which also includes conservation, preparation and final use, each one having its own direct environmental impact [Massari 2003].

To measure the full impact of a product, we measure greenhouse gas emissions across its full life-cycle, from "farm-to-fork". This includes emissions from the extraction of raw materials, direct gas emissions during the agricultural and processing stages, waste outputs, use of packaging materials, fuel consumption in distribution, energy consumption in processing, retail and product use by customers, and disposal at end-of-life. Adding these together all of the greenhouse gas emissions gives the total carbon footprint for a product. These data are used sometimes to compare plant and animal origin products in respect to its share in the total CO_2 emission. The amount of greenhouse gases caused by the production of food differs very much from one food type to the other (Table 3) [Anonymous 2011].

Table 3. Comparison of CO_2-Emissions for various food products (in g CO_2e per kg food)
Tabela 3. Porównanie emisji CO_2 dla różnych produktów spożywczych (w g ekwiwalentu CO_2 na kg produktu)

Food Group	**Food**	**CO_2 eq -Emissions (in g per kg foods)**
Meat and sausages	Beef	13300
	Raw sausages	8000
	Ham (pork)	4800
	Poultry	3500
	Pork	3250
Milk-and dairy products	Butter	23800
	Hard cheese	8500
	Cream	7600
	Eggs	1950
	Quark (curd)	1950
	Farmer cheese	1950
	Margarine	1350
	Yogurt	1250
	Milk	950
Fruits	Apples	550
	Strawberries	300
Baked goods	Brown bread	750
	White bread	650

Based on the above data some "green oriented" organizations postulate to eat only environmental friendly and "climate change friendly" food products. The growing number of publications explores the environmental burden or carbon footprint of diet and the implications of dietary recommendations for the environment [Eshel and Martin 2006, Marlow et al. 2009,]. Leading food retailers on the market footprinted own brand food products across the store to provide advice to suppliers on how they can become more resource efficient, and to advise customers on how they can reduce their household carbon footprint and save money on energy use at home. For example, in a typical 420g can of Tesco's baked beans, the energy used to cook the beans during manufacture contributes 30g CO_2e, and a further 120g CO_2e comes from the energy and raw materials used to make the tin

can [Anonymous 2012b]. Methodological issues aside, Figure 2 illustrates and summarizes well this approach as a draft categorization of food products according to their carbon footprint. On top of the pyramid, beef and dairy products are some examples of carbon intensive food products, pork and fish are less intensive, while vegetables belong to the lowest category in terms of GHG emissions [Bakas 2010]. Motivations of purchasing local, organic foods, calculating food miles for individual foodstuffs and choosing food categories with reduced carbon footprint should be issues for discussion in separate elaboration.

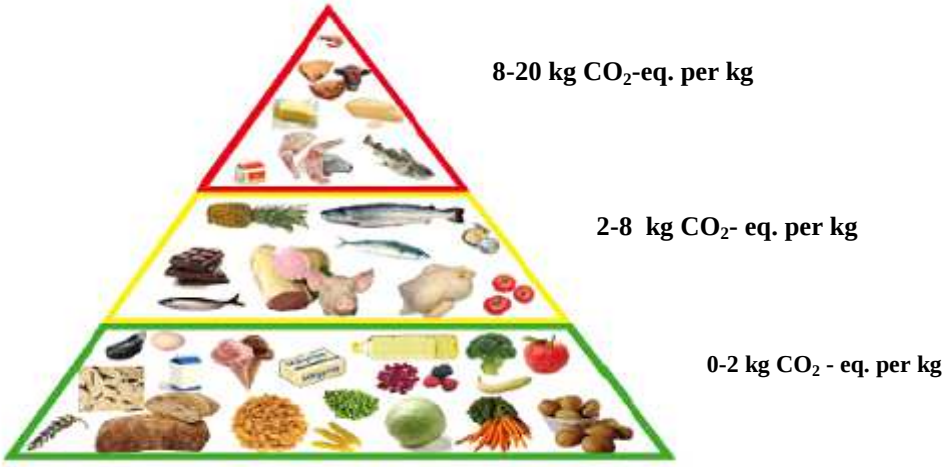

Fig. 2. Food products groups in Carbon Footprint (CF) pyramid
Rys. 2. Grupy produktów spożywczych w piramidzie śladu węglowego

CONCLUSIONS

In summary, it is demonstrated in this work that the greenhouse gas emissions associated food transport along whole food supply chain. Carbon Footprint is an issue which is continuing to grow in importance and can be used to study various environmental impacts on each chain stage including primary production, food processing, fuel and energy consumption in food distribution, retail issues and product use by consumer during household consumption. Carbon footprinting method enables to calculate global impact of foodstuffs and, in consequence, can affect significantly on food choice and purchasing decisions of consumer.

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ZASTOSOWANIA ŚLADU WĘGLOWEGO DO OCENY ASPEKTÓW ŚRODOWISKOWYCH ZWIĄZANYCH Z TRANSPORTEM ŻYWNOŚCI

STRESZCZENIE. **Wstęp:** Stale rośnie znaczenie międzynarodowego handlu żywnością, a produkty spożywcze przebywają niekiedy bardzo znaczne odległości przy użyciu różnego typu środków transportu. Zagadnienia związane z transportem żywności powinno rozpatrywać się nie tylko w aspekcie jakości i bezpieczeństwa żywności lecz także w aspekcie środowiskowym. Proponuje się liczne metody dla oceny oddziaływania transportu żywności na środowisko w całym typowym łańcuchu żywnościowym. Ślad węglowy wydaje się interesującym wskaźnikiem przydatnym do takiej analizy.
Metody: Analiza wykonana w niniejszym pracowaniu została głownie przeprowadzona w oparciu o publikacje opublikowane w ostatnim dziesięcioleciu z uwzględnieniem niektórych opinii dostępnych na różnych stronach internetowych.
Wyniki i wnioski: Emisje gazów cieplarnianych towarzyszą transportowi żywności w całym łańcuchu żywnościowym. Wskaźnik śladu węglowego można stosować do oceny różnych oddziaływań środowiskowych na każdym etapie łańcucha dostaw, włączając produkcję pierwotną, przetwarzanie żywności, zużycie energii i paliwa podczas dystrybucji żywności, handlu, a także w działaniach konsumenta w gospodarstwie domowym. Sumowanie emisji gazów cieplarnianych na wszystkich wymienionych etapach prowadzi to oszacowania śladu węglowego produktu przydatnego jako narzędzie oddziaływania na zachowania żywieniowe konsumentów.

Słowa kluczowe: transportowanie żywności, ślad węglowy, oddziaływanie na środowisko.

ANWENDUNG VON CARBON FOOTPRINT ZUR BEURTEILUNG VON UMWELTBEEINFLUSSUNGEN IM LEBENSMITTEL-TRANSPORT

ZUSAMMENFASSUNG. Einleitung: Die Bedeutung des internationalen Lebensmittehandel wird immer größer und die Lebensmittelprodukte transportiert man manchmal sehr weit unter Anwendung von verschiedenen Transportmitteln. Die Fragen, die mit dem Lebensmitteltransport verbunden sind, sollen daher nicht nur in Hinsicht auf die Qualität und Sicherheit diskutiert, sondern auch unter Berücksichtigung von Umweltbeeinflussungen erörtert werden. Man schlägt zahlreiche Maßnahmen für Beurteilung der Einflussnahme des Lebensmitteltransports auf die Umwelt entlang des ganzen typischen Food chain vor. Carbon footprint scheint ein interessanter brauchbarer Indikator für eine solche Analyse zu sein.
Methoden: Die im Rahmen dieser Publikation durchgeführte Analyse wurde anhand der im letzten Jahrzehnt veröffentlichten Publikationen und Berichte unter Berücksichtigung einiger Meinungen aus verschiedenen Internetseiten ausgearbeitet.
Ergebnisse und Schlussfolgerungen: Die Emission von atmosphärischen Gasen begleitet den Lebensmitteltransport im Bereich des ganzen Food chain. Man kann Carbon footprint als den Indikator für die Beurteilung von unterschiedlichen Umweltbeeinflussungen auf jeder Etappe des Food chain benutzen, einschließlich der primären Produktion, der Lebensmittelverarbeitung, des Energie- und Kraftstoffverbrauches bei Lebensmittelverteilung oder im Handel, ferner der Aktivitäten der Verbraucher im Haushalt. Die Summierung von Emissionen der atmosphärischen Gase auf den erwähnten Etappen führt zur Einschätzung des Carbon footprint für die jeweiligen Produkte, welchen man als brauchbares Tool für die Beeinflussung von Ernährungsverhalten der Konsumenten einsetzen kann.

Codewörter: Lebensmitteltransport, Carbon footprint, Umweltbeeinflussung.

Konieczny Piotr
Department of Food Quality Management
Faculty of Food Science and Nutrition
Poznan University of Life Sciences
Poznan, Poland
e-mail: pikofood@up.poznan.pl

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USE OF SALES AND OPERATIONS PLANNING IN SMALL AND MEDIUM-SIZED ENTERPRISES

Michał Adamczak, Roman Domański, Piotr Cyplik

Poznan School of Logistics, Poznań, Poland

ABSTRACT. Background: Increasing competitiveness in the market, customer expectations related to the shortening of the deadlines and the reduction of prices of products and services force companies to improve the efficiency of internal processes. The integration of planning process is one of possible ways to achieve this aim. The integration of planning processes by the use of SOP model (Sales and Operations Planning) is a method to implement this idea. The study allowed to identify ways to implement the process of sales and operations planning in small and medium-sized enterprises.
Material and methods: The study was conducted in companies from different industries. The research method was in-depth interviews conducted with managers of companies or persons occupying management positions in the organizational process of implementing sales and operations planning.
Results: During the survey, 10 companies were asked about the use of sales and operations planning, its elements and organizational aspects of its development, by the company.
Conclusions: The use of sales and operations plan is closely dependent on the size of the company and its localization in the supply chain. Small enterprises are not interested in the integration of the planning process due to the small scale of operations and the centralization of decision-making process. Medium-sized enterprises, due to the increased complexity of the processes of planning, see the benefits of their integration in the SOP model.

Key words: sales and operations plan, integration of planning processes, small and medium-sized enterprises.

THE ESSENCE OF SALES AND OPERATIONS PLANNING

According to APICS definition [APICS 2008] Sales and Operations Planning (SOP) is „a process of creating tactical plans to ensure company's competitive advantage, based on the continuous integration of client-orientated marketing plans (taking into account currently produced products, new products and products coming out of the market) and the supply chain management. The process integrates various plans prepared within a company: sales plans, marketing plans, research and development, production plans, purchasing plans and financial plans. The plan is prepared once a month at the level of products groups. SOP plan is a combination and a confrontation of plans fulfilling both needs of the medium-term planning of resources requirements as well as one-year business planning. This plan combines also strategic plans with the implementation, the performance measurement as well as the continuous improvement of operations".

M.Muzumdar and J.Fontanella [Muzumdar, Fontanella 2007] define SOP as a set of business and technological processes, which enable a company the most effective confrontation of market demands with production and purchasing capacities of a company.

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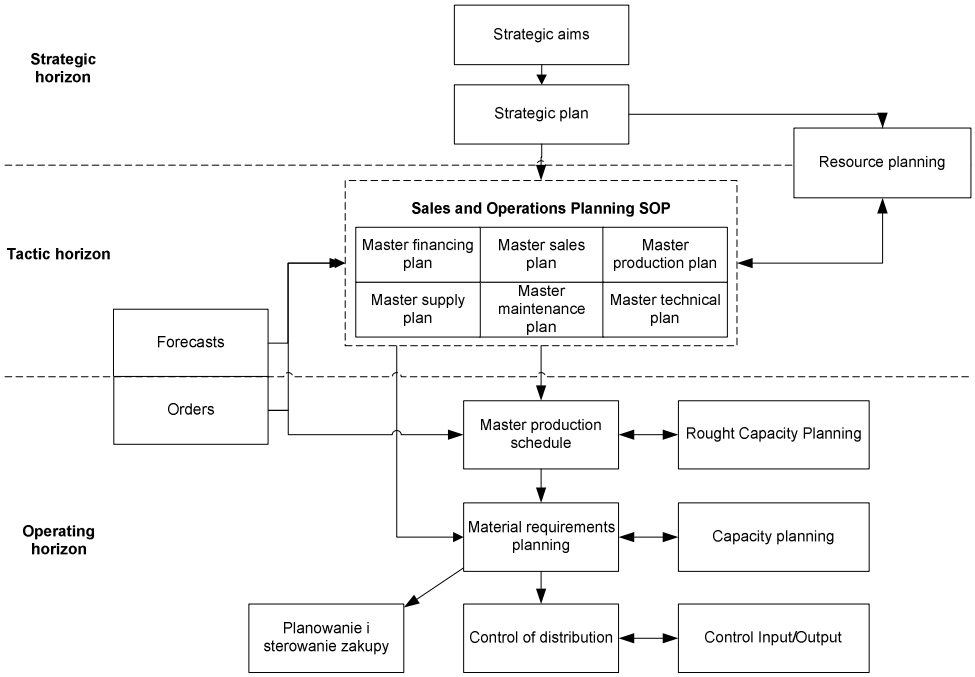
The completion of presented above definitions is the Authors' view at the structure of the planning processes, taking into account sales and operations plans. This structure is presented at the Figure 1.

According to the presented structure, SOP plan is constructed of series of plans, starting from financial one, through sales plans, production plans, supply plans up to technical and maintenance plans.



Source: own work based on [Łopatowska 2007] after [Chapman 2005]

Fig. 1. Localization of sales and operations planning in the structure of production company processes
Rys. 1. Miejsce planowania sprzedaży i operacji w strukturze procesów planowania przedsiębiorstwa produkcyjnego

Date about chosen strategy, demand estimations and long-term orders are the input date for a SOP plan.

The result of such plans is the requirement for resources, quantitative date (for each assortment) necessary to prepare the master production schedule as well as information on long-term material requirements. SOP plan incorporates tactical plans and enables the implementation of strategic objectives of a company at the operational level.

IMPORTANCE OF SOP FOR COMPANIES AND SUPPLY CHAINS

Sales and operations planning has a big importance from the point of view of the effectiveness of a company and a supply chain. The elimination of barriers in information flow is possible thanks to integrated process of plans' preparation. It enables to increase the internal and external integration level (within supply chain) [Thome, Scavarda, Fernandez, Scavarda 2012]. Overcoming obstacles takes place in a 5-step process of creating SOP plan [Tinker 2010]:

- *Step 1* - collection of data - it is particularly important both for creating the whole plans as well as its parts. Data are often gathered in companies in a non-institutionalized way, which inhibits their gathering for SOP purposes;
- *Step 2* - demand forecasting - creating the sales plans for following months based on historical data and information gathered from clients;
- *Step 3* - material flow planning - this step includes production planning, purchasing planning as well as stock levels planning;

- *Step 4* - working meetings - managers of tactical level from various departments, prepare solutions and recommendations for the company's management board. The main decisions concern the preparation of best possible sales plans, taking into consideration production and supply plans;
- *Step 5* - presentation of prepared recommendations and solutions. The choice of the best one and its approval for the further implementation is the task of management board.

The above presented steps of the preparation of the plan show the big range of operations needed in this area. The SOP plans should be created by the interdisciplinary team, consisted of specialists from various areas [Lapide 2007] such as production and logistics planning, supply chain, marketing, sales and finances. The SOP planning consists of planning of sales volumes in each distribution channels as well as adapting operational activities such as: logic of material flow, production potential, transport of individual parts of the chain and throughput of warehouses. The key data analyzed at the SOP level from the point of view of the effectiveness of a company or a supply chain are [Śliwczyński, Koliński 2012]:

- location of suppliers and formulated inquiries;
- criteria of the evaluation of tenders and offers;
- criteria of the qualification of suppliers;
- criteria of the ranking and the evaluation of suppliers.

Considering the material flow within a company or a supply chain, SOP plan allows leveling of requirements for the potential. The identification of long-term requirements for resources makes possible to organize required resources on one side, and on the other one to prepare the profitability analysis of individual material flows, their selection or changing the time of their implementation by the use of safety stocks (leveling) [Hadaś, Cyplik 2012]. The advantages of the implementation of SOP planning, having connection with a market, on which the company operates, are: increase of a market share, increase of a sale, growth of sales profits as well as advantages connected with the implementation of internal processes such as: improvement of the efficiency, reduction of losses, decrease of the needed capital, and consequently the increase of profits [Bower 2010]. Taking into consideration the above presented advantages, SOP can be one of the most powerful tools for a company operated on a competitive market, which wants to be profitable one, thanks to the ability to provide proper goods to proper clients by proper channels [Mazel 2004].

The above mentioned advantages of sales and operations planning demand various activities within a company to make possible to create plans in terms of SOP. The basic barriers to use sales and operations planning are: lack of tools for the transformation of strategic objectives into operational ones and moving the required resources for their implementation as well as the lack of tools for the control of the operational activities, which translate the results for the purposes of the correction of tactical and strategic plans [Śliwczyński 2011].

INTRODUCTION TO RESEARCHES OF SOP IMPLEMENTATION IN SMALL AND MEDIUM-SIZED ENTERPRICES

Considering the SOP planning, the attention should be paid to the area covered by this subject. There are two basic approaches of SOP: a system approach and a process approach. The system approach refers to plan's structure and allocation of resources, necessary to its realization. The process approach refers to tasks realized as a part of plans, to the involvement of resources as well as to authorities and responsibilities of individual members of a team. Taking into account the presented facts and a diversity of companies operating within a supply chain, the multivariate SOP plans should be expected, both in the system and the process approach. Due to the fact, that most of companies belong to group of micro-, small and medium enterprises as well as their big diversity (among others resulting from differences in number of employees (1-250)), the Authors attempt to define basic characteristic of SOP

planning dependence on the company size. The research problem was defined prior to empirical researches: **is there a relationship between a company size and a structure of SOP and a process of its preparation?**

The following hypotheses were assumed - while the company size increases:

- H1: task and personal scope of SOP plan will also increase,
- H2: the importance of forecasting of future activities during the SOP planning process will increase,
- H3: the degree of the delegation of the authorization in the process of an approval of SOP planning will increase.

The researches were conducted in 10 companies. Due to the small research sample, the conducted researches are only of a demonstration nature. The companies chosen for the research, belong to one of three groups: micro (3 companies), small (3 companies) and medium-sized ones (other 4 companies). The number of employees was the only criterion for this assignment. The companies operate in various areas, each of them had different production profile.

Table 1. Characteristics of companies
Tabela 1. Charakterystyka przedsiębiorstw objętych badaniem

Company	Size of company	number of employees	production profile
A	micro	5	ironwork
B		5	carpentry
C		8	gas installations
D	small	20	agricultural feed
E		30	membranes
F		to 50	elements of small appliances
G	medium	150	transport equipment
H		to 200	automotive equipment
I		200	printing articles
J		over 400	electric cables

Source: own study

The questionnaire included both open and closed questions. The aim of these researches was to identify and to learn the rules and the mechanism valid for the functional area of sales and operational activities of companies.

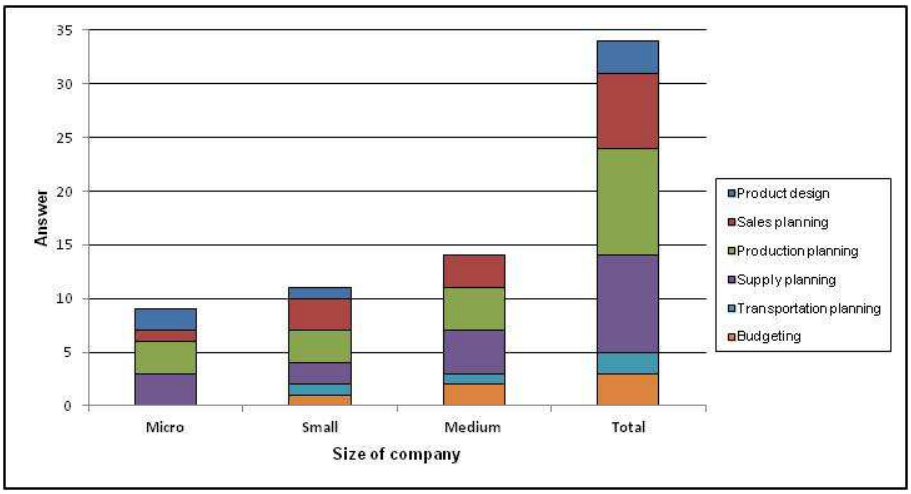
The detailed questions, for which the answers were obtained, are as follows:

- which particular functions are realized within SOP?
- which dates are used in the process of the creation of SOP?
- what activities are involved in the process of the preparation of SOP?
- what organizational cells take part in the process of the preparation of SOP?
- who accepts the SOP plan?

THE RESULTS OF RESEARCHES

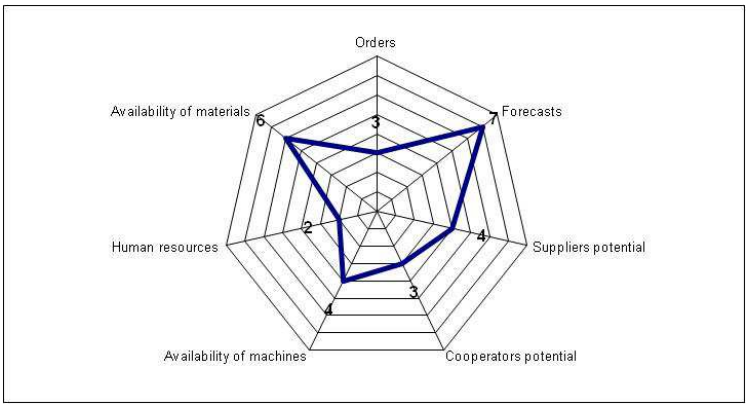
The Authors indentified six SOP elements: designing of an article, sales planning, production planning, planning of supplies, transport planning and budgeting. It should be assumed, that a number of elements depends on the company size: the bigger (more complex) a company, the higher number of analyzed elements. The key elements in small and medium-sized companies are: production planning (in 100% of companies), supply plans (in 90% of companies) and sales planning (in 70% of companies). Remaining elements (designing of an article, transport planning and budgeting) are of a minor importance (20-30%).

The highest number of small and medium-sized companies uses data covering the area of sales (70% of all cases) and goods' availability (60% of all cases). The information on workstations' load (production capacities), potentials of suppliers (40% of all companies for each of these two points) and information about orders and potentials of co-operators (30% of all companies for each of these two points) were also of the high importance. The accessibility of human resources was pointed out only in medium-sized companies at the level of 20%. The detailed analysis shows, that the micro-companies base their activities rather on orders, checking the potential of their co-operators and suppliers. The small and medium-sized companies base their activities on forecasting, paying more attention to ensure the availability of materials and production capacities.



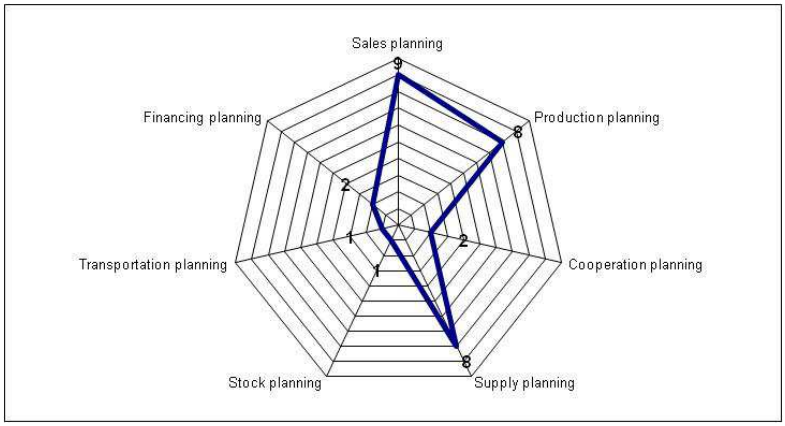
Source: own study

Fig. 2. SOP elements
Rys. 2. Funkcje szczegółowe w SOP



Source: own study

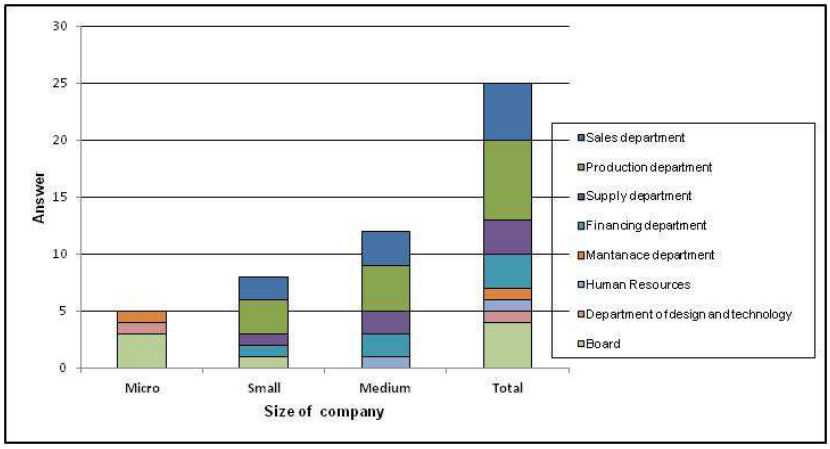
Fig. 3. SOP data
Rys. 3. Dane dla planu SOP



Source: own study

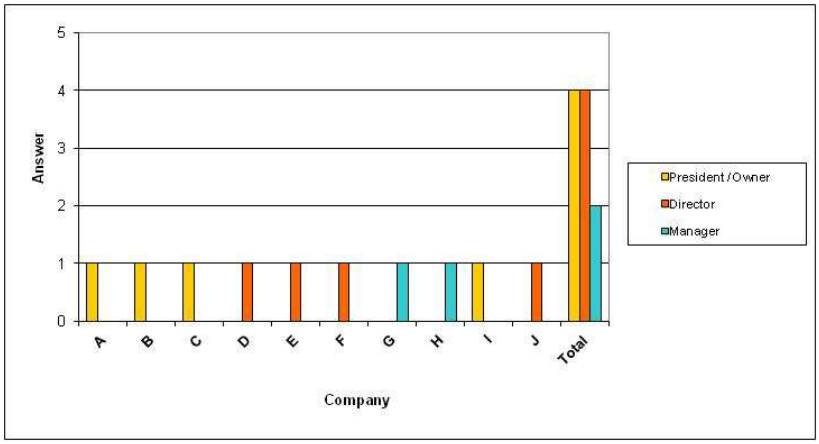
Fig. 4. Components of SOP plan
Rys. 4. Składowe planu SOP

The main tasks of SOP in small and medium-sized companies are connected with three areas: sales planning (90% of all companies), production planning (80% of all companies) and planning of supplies (also 80% of all companies), although in case of the last point it can be observed a small percentage of small-sized companies. Other functional aspects, such as: co-operation planning and financial planning (10% of all companies for each of these two points) as well as estimating safety stocks and transport planning (10% of all companies for each of these two points) showed to be of less interest (special nature of a branch, scarcity of business).



Source: own study

Fig. 5. The organizational structure and the SOP plan
Rys. 5. Struktura organizacyjna a plan SOP



Source: own study

Fig. 6. Approving the SOP
Rys. 6. Zatwierdzanie planu SOP

Considering micro-companies, SOP planning process belongs solely to the owner, who is a manager as well. The situation seems to be more interesting in small and medium-sized companies. The Production Department (100% of all companies) and the Sales Department (70% of all companies) were always engaged in the process of SOP planning in these companies. The Purchasing Department and Financial Department supported the process of SOP planning within small and medium-sized companies (30% for each of them). Occasionally such departments were mentioned like: HR, Construction and Technology and Maintenance. The specific organizational and production conditions of the organization were reasons of their input in this process. The decisions about sales and operational activities in micro-companies are made by owner/main manager (100%). The

approval of SOP plan in small companies is conducted by the manager of the department (100%). On the contrary, there are a few possible solutions in medium-sized companies, but in a half of cases, the approval is made by the manager of the department (50%). The general tendency can be observed to delegate the authority to make a decision in the down direction - from owner in micro-company, manager of a big department in small companies up to a leader of a department or a team in a medium-sized company.

Taking into consideration the presented research problem and hypothesis, the following relationships were observed - the bigger the company:

- the bigger number of components were taken into consideration,
- the higher importance of forecasting and bigger pressure put on them, as well as the bigger attention paid to accessibility of goods and production capacities,
- the key planning tasks are as follows: sales planning, production planning and planning of supplies,
- the members of Production and Sales Departments are involved in the process of the approval of plans, with the support of members from the Purchasing and Financial Departments,
- the lower level in management structure at which the plans are approved.

The above mentioned conclusions referring to the correlation between the size of the company and aspects of SOP planning are specific for small and medium-sized companies, employing between 20 and 400 people. The results of conducted researches show that the hypotheses H1, H2 and H3 should be regarded as true ones.

SUMMARY

Taking into consideration assumptions of SOP planning presented in this paper, it should be stated that micro- and small companies are not interested in the implementation of this type of planning, due to the fact, it is too labor-consuming in comparison to possible profits of its implementation. In this group of companies, the owner is responsible for taking all decisions. Additionally the range of work is small enough that one person is able to manage smoothly all processes. Due to the simple structure and limited resources, these companies restrict management activities only to manage current basic processes. The medium-sized companies acknowledge the necessity of the integration of planning processes. Due to their size and range of work, the planning process is necessary for them. The synchronization of the plan is the next step, recognized to be important by them. Therefore the medium-sized companies show more interest in planning of SOP type.

The type of SOP plan depends on the size of a company. Small companies conduct less complicated processes (both production and management ones) and therefore their plan is created only on a piece of paper. The owners of companies do not expect any changes in this process. The plans in bigger companies are prepared with the IT support and the process is carried out by many employees/departments. It should be pointed out in this case, that the sales plans and operations plans are usually prepared separately. Therefore they cannot be called a SOP plan.

Another interesting issue is the responsibility for the process of the plan preparation. In smaller companies, the owner is responsibility for the whole planning process. In bigger companies the authority is delegated and it is expected that each team is responsible for its part and will prepare its plan. At the management board level (equal to the level of SOP plan), the synchronization of plans is expected. The word “expected” should be emphasized here - this practice is not always implemented.

The companies indicate the need of the integration of sales plans with operations plans. Unfortunately each of them understands differently the operations planning process. The smaller companies shape their management process like the project process. The bigger companies notice the need to divide operation plans into smaller elements: production plans, purchasing plans, co-operation plans, transport plans and financial

plans. The presented rule influences also the structure of data needed for the planning process. The bigger the company the bigger amount of data and the more complex their structure.

ACKNOWLEDGEMENT

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WYKORZYSTANIE PLANOWANIA SPRZEDAŻY I OPERACJI W MAŁYCH I ŚREDNICH PRZEDSIĘBIORSTWACH

STRESZCZENIE. **Wstęp:** Wzrost konkurencyjności na rynku, oczekiwania klientów związane ze skróceniem czasu realizacji zamówienia oraz obniżanie ceny produktów i usług, wymagają od przedsiębiorstw poprawy efektywności procesów wewnętrznych. Jednym ze sposobów realizacji tego postulatu jest integracja procesów planowania. Metodą realizacji idei integracji procesów planowania jest SOP (Sales and Operations Planning). Przeprowadzone badania pozwoliły na identyfikację sposobów realizacji procesu planowania sprzedaży i operacji w małych i średnich przedsiębiorstwach.

Metody: Badania zostały przeprowadzone w przedsiębiorstwach reprezentujących różne branże. Wykorzystaną metodą badawczą był wywiad pogłębiony, prowadzony z osobami zarządzającymi przedsiębiorstwem lub osobami zajmującymi kierownicze stanowiska w komórkach organizacyjnych realizujących proces planowania sprzedaży i operacji.
Wyniki: W ramach przeprowadzonych badań uzyskano opinie z 10 przedsiębiorstw na temat stosowania przez te przedsiębiorstwa planowania sprzedaży i operacji, jego funkcji szczegółowych oraz aspektów organizacyjnych jego opracowywania.
Wnioski: Stosowanie planu sprzedaży i operacji jest ściśle uzależnione od wielkości przedsiębiorstwa oraz miejsca, jakie zajmuje to przedsiębiorstwo w łańcuchu dostaw. Przedsiębiorstwa małe nie są zainteresowane integracją procesów planowania ze względu na niewielką skalę prowadzonej działalności i centralizację podejmowanych decyzji. Przedsiębiorstwa średnie ze względu na wzrost skomplikowania realizowanych procesów planowania dostrzegają korzyści wynikające z ich integracji w modelu SOP.

Słowa kluczowe: plan sprzedaży i operacji, integracja procesów planowania, małe i średnie przedsiębiorstwa.

ANWENDUNG DER VERKAUFS- UND OPERATIONSPLANUNG IN KLEIN-UND MITTELSTÄNDISCHEN UNTERNEHMEN

ZUSAMMENFASSUNG. Einleitung: Wachstum der Konkurrenzfähigkeit auf dem Markte, Erwartungen seitens der Kunden hinsichtlich der Verkürzung der Ausführungszeit von Bestellungen und Senkung der Preise von Produkten und Dienstleistungen machen bei Unternehmen eine Verbesserung von innerbetrieblichen Prozessen erforderlich. Eine der möglichen Herangehensweisen an die Ausführung dieses Postulates ist eine weitgehende Integration von Planungsprozessen. Die Methode für die Ausführung der Idee der Integration von Planungsprozessen ist die SOP-Methode (Sales and Operations Planning). Die durchgeführten Untersuchungen erlaubten die Ermittlung der Methoden für die Realisierung des Prozesses der Verkaufs- und Operationsplanung in klein-und mittelständischen Unternehmen.
Methoden: Die Untersuchungen wurden in den Unternehmen, die unterschiedliche Branchen vertreten, durchgeführt. Als Forschungsmethode hat man die vertieften Interviews in Anspruch genommen. Die Interviews wurden mit den Geschäftsführern oder den Personen, die führende Posten innerhalb der für die Verkaufs- und Operationsplanung zuständigen Abteilungen bekleiden, durchgeführt.
Ergebnisse: Im Rahmen der durchgeführten Untersuchungen wurden Stellungnahmen von 10 Unternehmen in Bezug auf die von diesen Unternehmen angewandte Verkaufs- und Operationsplanung, deren detaillierte Funktionsausübung sowie organisatorische Bearbeitungsaspekte, ermittelt.
Fazit: Die Anwendung der Verkaufs- und Operationsplanung hängt mit der Größe des jeweiligen Unternehmens und mit dem Platz, welchen das Unternehmen in der Lieferkette einnimmt, eng zusammen. Die kleineren Unternehmen sind wegen des beschränkten Ausmaßes ihrer Tätigkeit sowie der von ihnen betriebenen Zentralisierung der zu treffenden Entscheidungen weniger an der Integrierung der Planungsprozesse interessiert. Die größeren dagegen nehmen in Hinsicht auf den steigenden Kompliziertheitsgrad der innerhalb des Unternehmens betriebenen Planungsprozesse die aus deren Integration innerhalb des SOP-Modells resultierenden Vorteile wahr..

Codewörter: Verkaufs- und Operationsplanung, Integrierung von Planungsprozessen, klein- und mittelständische Unternehmen.

Michał Adamczak, Roman Domański, Piotr Cyplik
Poznan School of Logistics
ul. Estkowskiego 6, 61-755 Poznan, POLAND
e-mail: michal.adamczak@wsl.com.pl,
phone +48 605 584 362
e-mail: roman.domanski@wsl.com.pl,
phone +48 603 205 275
e-mail: piotr.cyplik@wsl.com.pl,
phone +48 608 652 832

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SUPPLY CHAIN RISK MANAGEMENT

Christian Hollstein, Frank Himpel

Hochschule Anhalt, Bernburg, Germany

ABSTRACT. Background: Supply chain risk management increasingly gains prominence in many international industries. In order to strengthen supply chain structures, processes, and networks, adequate potentials for risk management need to be built (focus on effective logistics) and to be utilized (focus on efficient logistics). Natural-based disasters, such as the case of Fukushima, illustrate how crucial risk management is.
Method: By aligning a theoretical-conceptual framework with empirical-inductive findings, it may be hypothesized that logistical systems do have a positive effect on supply chain risk management activities.
Result/conclusion: Flexibility and capacity, as well as redundancy and standardization, are often viewed as being conflictionary. It shows, however, that in the light of supply chain risk management, those factors may yield a common benefit if proper logistics systems are applied.

Key words: Risk management, flexibility, capacity, redundancy, standardization.

The complexity of international value chains and supply chain logistics requires process transparency and intensified cooperation with partners and a holistic engagement with risks of logistic processes and sound evaluation of their impact on supply chains. This holds particularly true if value chain collaboration is focused on selective sourcing strategies and/or if redundancy in the allocation of activities between partners is low. In these contexts, the role of logistics may differ from classical attributions for that adequate logistics may serve as an enabler for supply chain risk management initiatives.

CONCEPTUAL CONTEXT

Risks in supply chains differ from those in individual companies. Differences especially arise in the intensity of cooperation-related risks, due to reciprocal dependencies, lower inventories and buffers, or cross-company risk interlinking and resulting effects on supply chain partners in the entire value chain. Therefore, the scope of supply chain risk is manifested in the reduction of risks for individual entities of the supply chain and the supply chain as a network entity that is related to multiple supply chain risk sources [Reh 2009]. These characteristics foster a less transparent complexity due to heterogeneous risk situations, viability and management systems of individual supply chain partners and their overall impact on the network [Kajüter 2007]. If companies act under uncertainty, flexibility and adaptability are essential. Important is that adjustments should not only be considered in the context of sales, but also in the light of logistics. Adaptive strategies especially prove to be useful for disruptions evolving over time, which enables companies to better assess changes in the long term [Tomlin, Wang 2012].

Strategies focusing on stockpile inventories can be regarded as useful and practicable to minimize risk as long as disruptions do not

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affect stocks. In this context it is important to protect stocks from internal and external disruptions e.g. by decoupling or storing them outside of the danger area or in proximity to costumers [Tomlin, Wang 2012]. Building stockpile inventory especially in post-eruptive phases may be difficult because companies are even more vulnerable to disruptions shortly after a disastrous event rather than before. Building a diversified supplier network in the context of a risk diversification strategy is a challenge that should be weighed in the light of several factors including costs, configurations, interdependencies and resilience. Significant costs due to heterogeneous supply chains often accrue for investments in plants, IT-systems, suppliers and infrastructure. Similarly, a distribution of production to multiple locations leads to shrinking economies of scale [Norman 1979]. As differentiation may also contribute to greater competition and lower unit costs, pros and cons of the different cost drivers should be weighed accordingly.

The configuration of the supply chain and the associated coordination capability of producers and suppliers probably bear the single-biggest influences on risk management. Individually tailored sourcing strategies adapted to goods and their production processes in conjunction with a sophisticated purchasing portfolio analysis and a continuous supplier monitoring form the basis for a workable and flexible network configuration in a supply chain, which additionally meets the requirements for an integrative risk management [Böger 2010]. Diversification, from the perspective of risk management, often is a balancing act between costs and risks under the compliance with technical, organizational and legal constraints.

A risk diversification is (causally considered) given if all objects are not simultaneously involved in disruptions. Serious effects mainly result from risk interdependence. If objects (e.g. plants) are in interaction with each other due to internal or external circumstances, these incidents affect all objects and can also propagate themselves in the full supply chain. In this context an exclusively object-related differentiation is insufficient as in a functional supply chain risk management there should be taken many more factors into account to successfully control dependencies in a supply chain. In this sense diversification of risk often is subdivided into temporal (temporal shifting of processes), causal (expanding the product portfolio) personnel (spreading sales volumes over multiple clients) and local (spatial separation of production) dimensions [Tomlin, Wang 2012].

In order to increase resilience of a supply chain, it is essential that all supply chain partners have access to relevant information, e.g. performance data. Furthermore they should have the necessary know-how to effectively intervene if a disruption occurs and also participate on the results so that they are motivated and willing to push improvement continuously. In addition, stress-tests are carried out to get a better and more precise understanding of the influence of different disruptive events (domestic and also externally caused) or market distortions in the supply chain performance [Chandrashekar, Narahari 2011]. The higher the data for dynamics, complexity, supply power and distance the greater the stress. If data fits in terms of resilience and stress supply chain partners should focus on keeping up the status quo or a continuously improvement process via active monitoring. If the stress is greater than the resilience the management should replace the affected chain link or the supply chain must be strengthened at this point explicitly [Pfohl 2002]. In the opposite case - if the resilience is higher than the stress - searching for saving potentials, using synergies more efficiently and rationalization efforts should be pursued since potentials and capacities will remain unused otherwise.

EMPIRICAL CONTEXT

Strategies and concepts for evaluating supply chain networks had typically not been based on geographical location of the respective suppliers. Moreover, logistical strategies and concepts had been put in place in order to support supply strategies. While proper logistics functionality typically "relaxes" the constraints put on supply chain contexts, one recent empirical example shows that even proper logistics functionality and

solid single sourcing strategic thinking may not fully substitute for adequate redundancy in a supply chain. Geographical information such as seismological, lithosperic, and geodetic data had not been fully integrated into the strategic sourcing allocation mode of a leading German car manufacturer. In 2009, employees of a leading German car manufacturer managed to apply a powerful new color (so-called "oryx white") onto its cars in the full-blown serial mode. While many customers embraced "oryx white" on their cars, only one factory of one supplier was able to produce certain color pigments needed to uphold a sparkling white effect (so-called "xirallic" - based on aluminum oxide that is surfaced with special metal oxide). Only one plant in the world produced "xirallic" - a plant located near the facility of Fukushima in Japan. When the tsunami in the Pacific and the subsequent catastrophe of Fukushima gained momentum, this plant had to be shut down. "Xirallic" could not be produced for several months, leaving customers of the German car maker without the special "oryx white". Customers of leading American and Japanese car manufacturers were affected as well. As a recommendation, companies should (in the course of a supplier evaluation or assessment) introduce "geophysical risks" as a criterion with specific relevance and incorporate it in their strategic allocation schemes to learn how to correctly interpret the results and proactively address possible (and even unlikely) disruptions. Single sourcing, combined with proper logistics, may thus be replaced by dual sourcing with evenly proper logistics functionality.

While a change of supplier providing standardized, non-critical materials can be considered as unproblematic, a change of a supplier providing complex and strategically important products is not that easy especially in long-time cooperation and interdependence by taking into account high switching costs - supplier development should be preferred over switching suppliers. In this context supplier development can also be understood as an elevation of performance and focusation of core competences to secure short and long term requirements of the sourcing enterprise. This example also showed that a tightening-up of supplier competition and the implementation of incentive contribution structures may have had a cost-cutting effect. However, these are less effective than an increase in reliability and trust - resulting from direct supplier integration in a dual sourcing context. Therefore, companies are advised to stand in direct contact with their suppliers to avoid disruptive effects in terms of quality, delivery and the security of supply. For this reason it is advisable if manufacturers limit themselves not only on the development of one single supplier, but rather to promote and develop several measures aiming at a parallel or multiple supplier development concepts. A (future) in-depth cooperation, e.g. at the level of joint R&D activities can again strengthen the interdependence by leading to a greater incentive contribution efficiency. Special incentive contribution agreements within the framework of in-house contract management should be designed to exclude any free-rider attitude of competitors with access to suppliers and their intangible assets [Meierback 2010].

It shows that standardization largely influences flexibility. While both options seem to be opposing each other, there are examples when both indicators attribute to a more resilient supply chain: A major distribution hub of a leading US-courier service in North America was exposed to heavy weather, leading to hub operations being diminished temporarily. For that the company does uphold corporate wide standards on logistical processes in any of its hubs, employees of another hub could easily replace the capacity lost due to bad weather. By means of rerouting the air-based channels, transportation and distribution flexibility could be upheld. By putting proper logistics in place, supply chain risks can be minimized. This holds true even when indicators are affected that may seem to be conflictionary at first sight.

CONCLUSIONS

Supply chain risk management is increasingly gaining significance. Its interdisciplinary character is marked by tensions and interdependencies between quantitative and qualitative factors at the company level as well as at the supply chain network level. Frequencies and effects of

disruptive events have partly developed disproportionately to the intensified networking and interaction with supply chain partners. Risk causes and their impacts often differ on a multi-dimensional level, which additionally complicates the design of new, dynamic standard strategies in complex systems, such as collaborative networks. Intensifying shortages of raw materials and problematic global allocation of resources lead to process structures on the procurement as well as the sales side that are hard to predict. The pivotal point lies in the flexibility of processes. This simple projection of the current state requires even a stronger focus on cooperative activities under the provision of a better networking and monitoring through communications and IT infrastructures in the future. There, redundancy of structures and processes come into play, too. Hence, in terms of improved supply chain risk management, standardization, flexibility, and redundancy typically have to be balanced. While those three alternatives commonly may be viewed as being opposites, it is deductible from the theoretical and empirical contexts that they actually tend to go along with each other if proper logistics is in place.

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ZARZĄDZANIE RYZYKIEM ŁAŃCUCHA DOSTAW

STRESZCZENIE. **Wstęp:** Zarządzania ryzykiem łańcucha dostaw zyskuje coraz większe znaczenie w wielu międzynarodowych branżach. W celu wzmocnienia struktur łańcucha dostaw, procesów i sieci, należy stworzyć odpowiednie potencjały dla zarządzania ryzykiem (skoncentrowane na efektywnej logistyce) a następnie je stosować (koncentrując się na wydajnej logistyce). Katastrofy naturalne, takie jak na przykład ostatnio Fukushima, pokazują jak istotne jest odpowiednie zarządzanie ryzykiem.

Metody: Zestawiając teoretyczno-koncepcyjne założenia z rezultatami emipryczno-indukcyjnymi, można postawić hipotezę, że systemy logistyczne posiadają pozytywny efekt na zarządzanie ryzykiem łańcucha dostaw.
Wyniki i wnioski: Elastyczność i wydajność, jak również redukcja i standaryzacja, są często postrzegane jako elementy konfliktowe. Aczkolwiek, rozważając zagadnienia związane z zarządzaniem ryzykiem łańcucha dostaw, czynniki te mogą przyczynić się do wspólnie osiągniętych korzyści, pod warunkiem prawidłowo skonstruowanych systemów logistycznych.

Słowa kluczowe: zarządzanie ryzykiem, elastyczność, zdolność, redukcja, standaryzacja.

SUPPLY CHAIN RISK MANAGEMENT

ZUSAMMENFASSUNG. Hintergrund: Supply Chain Risk Management gewinnt zunehmend an Bedeutung. Nicht zuletzt hervorgerufen durch Naturkatastrophen (wie z.B. die Katastrophe von Fukushima), erlangen Überlegungen zur Festigung und Stärkung von Wertschöpfungsstrukturen und -prozessen strategische Signifikanz in vielen Industrien weltweit. Damit die Potentiale des Supply Chain Risk Management adäquat aufgebaut (Fokus auf Effektivität) und genutzt (Fokus auf Effizienz) werden können, sind adäquate logistische Systeme erforderlich.
Methode: Durch einen Abgleich eines theoretisch-konzeptionellen Bezugsrahmens mit empirisch-induktiven Befunden zeigt sich, dass logistische Systeme die Leistungsfähigkeit von Supply Chains gerade auch im Kontext von Supply Chain Risk Management positiv beeinflussen können.
Ergebnis/Fazit: Flexibilität und Kapazität werden aus produktionswirtschaftlicher Sicht oftmals als dichotome Indikatoren leistungswirtschaftlicher Potentialgestaltung angesehen. Redundanz und Standardisierung sind dabei aber keineswegs konfliktionäre Zielparameter, sondern können vor dem Hintergrund adäquater logistischer Systeme einen geeigneten Beitrag zur Aufrechterhaltung produktionswirtschaftlicher Performanz in Supply Chain-Kontexten darstellen.

Codewörter: Risikomanagement, Flexibilität, Kapazität, Redundanz, Standardisierung.

Christian Hollstein
Prof. Dr. habil. Frank Himpel
Institut für Logistik
Hochschule Anhalt
Strenzfelder Allee 28
D-06406 Bernburg (Saale)
e-mail: f.himpel@wi.hs-anhalt.de

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THE EMPLOYMENT AND INCOME BENEFITS OF AIRPORT OPERATION ON THE COUNTRY IN TRANSITION

Sonia Huderek-Glapska

Poznań University of Economics, Poznan, Poland

ABSTRACT. Background: The air transport market in Poland is undergoing significant changes, which take place both on the demand and supply side. Polish airports have experienced the unprecedented growth of air traffic. However, the increase in the number of airline connections - which benefits airports, passengers, aircraft industry and, indirectly, the whole society - at the same time results in the growth of social costs reflected by the intensification of noise and environmental pollution. The benefits of airport operation are reflected in the generation of employment and income. Existing literature reveals a gap in the knowledge in respect of impact of aviation in countries in transition.
Material and methods: This paper investigates the applicability of socio-economic impact of air transport model to country in transition. In particular, it presents the employment and income benefits of airport operation. The input-output model is employed to measure the economic benefits of airport operation. The largest airport in Poland, Warsaw Chopin Airport is used as a case study.
Results: The estimation results for the income and employment effects are found to be significant. The operations of Warsaw Chopin Airport contributed to the generation of 527.8m EUR in current prices in 2011. Altogether, 19,349 jobs have been generated as the result of the direct, indirect and induced impact of Warsaw Chopin Airport.
Conclusion: The size of production in the airport expressed in the number of aircraft operations and the number of passengers and goods serviced is positively correlated with the level of economic impact. The restriction on the development of the airport reflected by the inability to meet transport needs expressed by the society may generate opportunity costs.

Key words: economic benefits, employment and income effects, input-output model, airport operation, Warsaw Chopin Airport.

INTRODUCTION

The air transport market in Poland is undergoing significant changes, which take place both on the demand and supply side. The liberalization of legal barriers has directly contributed to the increase in the range of airline services offered and to the decrease in air ticket prices, which has significantly influenced the number of passengers. Moreover, the demand is stimulated by economic changes, such as the increase in the average income of the population and the growing transportation needs resulting from the opening of the labour market.

Polish airports have experienced the unprecedented growth of air traffic. However, the increase in the number of airline connections - which benefits airports, passengers, aircraft industry and, indirectly, the whole society - at the same time results in the growth of social costs reflected by the intensification of noise and environmental pollution. Such costs are the example of hardly measurable externalities.

Several studies has been devoted to examine the relationship between air transport and economic development [OEF 2006; Button and Taylor 2006; Green 2007; Gillen and

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Hinsch 2001]. However existing literature reveals a gap in the knowledge in respect of impact of aviation in countries in transition.

The purpose of this article is to identify and measure the economic impact of airport operation on the country in transition. In studying the economic benefits the input-output model was applied. In particular the employment and income effects of an airport were measured.

AIRPORT ECONOMIC BENEFITS - INCOME AND EMPLOYMENT GENERATION

The socio-economic impact of an airport is defined as the change in economic activity within an area due to airport or airport-related activities [DeSalvo 2002].

Depending on the channel of influence, the economic effects may be divided into the demand and supply ones [Rietveld and Bruinsma 1998]. The major effects on the demand side concern the stimulation of employment and income during the operation of an airport [Butler and Kiernan 1992]. The impact of an airport and related business entities upon the level of employment and income in the surrounding area is defined as the direct impact. The companies operating within the airport include ground handling companies, airlines, air traffic control, airport service companies, freight forwarders, retail and service outlets, car park administrators, and security services. Product and service providers operating in the airport surrounding area create jobs and incomes, which represents the indirect impact. The demand reflected by the expenses of people employed in the entities directly or indirectly involved in air transport constitutes the size of the production of the induced impact.

Apart from the direct, indirect and induced impact, airport operation affects the supply side of the economy by stimulating the conditions conducive to the development of business entities and of the whole region. There are changes in the amount of resources used in the region, as well as in the productivity of those resources [Britton et al. 2005].

The main supply effects catalyzed by an airport include: the influence on enterprises' location decisions, attracting new foreign investment, the increase of competitiveness and innovation of local companies thanks to improved freight services, change in the quality of local inhabitants' living standard owing to fast transport service.

The supply effects are usually long-term and it is fairly difficult to estimate them. The demand effects are defined as the relationship between the air market and other industries. The demand effects are usually measured with the application of the input-output model or the Garin-Lowry model [Lu 2011]. In this study the former model was used.

THE INPUT-OUTPUT MODEL

The input-output model is a way of depicting economic relationship between producers and suppliers in an economy [Leontief 1936]. The advance has been made in using input-output method for cluster analysis [Pfähler 2001]. Considering the relation between air transport and economy, by using Leontief's demand-driven input-output model, one can estimated the degree to which changes in the air transport industry influence changes in the economy.

According to the input-output model, the economic benefits of airport activities are the sum of the direct, indirect and induced effects [Butler and Kiernan 1992]. The indicators which are usually measured by means of the input-output model include the income and employment generated by airport operation. These indicators reflect changes on the demand side. Revenues, incomes and fiscal effects are expressed in monetary terms and they flow in the economy as long as they are stimulated by changes in the size and structure of business activity. The employment effect results from changes in the physical labour resources. At the same time, while assessing the employment effect, technical and technological changes should be considered. The standard input-

output analysis does not allow for the effect of price changes. The demand effects are expressed in nominal values.

The total income effect related to airport operation is the sum of direct, indirect and induced income effects:

$$IE = IE_D + IE_{ID} + IE_{IN} \quad (1)$$

where IE is the total income benefit of airport operation, IE_D is the direct income effect, IE_{ID} is the indirect income effect, IE_{IN} is the induced income effect.

The income effect is measured as the gross added value generated by the activities of companies operating either on-site or in the surrounding area. These enterprises are divided into groups according to the type of their business activity. The total direct income effect is the sum of direct income effects created by companies performing a given type of activity. The equation may be recorded in the following way:

$$IE_D = \sum_{i=1}^{k} IE_{Di} \quad (2)$$

where IE_D is the total direct income effect; IE_{Di} is the direct income effect of companies of i^{th} type of business activity.

The indirect effect of companies of a given type of business activity is estimated on the basis of the number of people employed and of the average gross added value generated by one employed person:

$$IE_{Di} = L_i VAL_i \quad (3)$$

where IE_{Di} is the direct income effect of companies of i^{th} type of activity; L_i is the number of employees of companies of i^{th} type of activity; VAL_i is the average value added per employee in companies of i^{th} type of activity.

The indirect and induced impacts are usually calculated with the use of the input-output table. The table includes data concerning flows between different branches of the economy. In case there is no data at the regional level, the indirect impact is estimated as the added value generated in the economy in the chain of suppliers of goods and services to the direct activities. The total indirect income effect is the sum of indirect income effects generated by enterprises performing a given type of activity:

$$IE_{ID} = \sum_{i=1}^{k} IE_{IDi} \quad (4)$$

where IE_{ID} is the total indirect income effect, IE_{Di} is the indirect income effect of companies of i^{th} type of activity.

The expenses that business entities directly involved in airport operation incur for goods and services represent the size of suppliers' production that is dependent on airport operation. The volume of production generated on the suppliers' side is calculated as the sum of expenses for external goods and services and the costs of investment made by direct companies:

$$P_i = C_i + S_i + CE_i \quad (5)$$

where P_i is the value of the stimulated production of product and service providers for companies of i^{th} type of activity, C_i is the value of the cost of materials and energy incurred by companies of i^{th} type of activity, Si is the value of services provided by external contractors for companies of i^{th} type of activity, CE_i is the value of the total capital expenditure at companies of i^{th} type of activity.

The expenses incurred by people employed in the companies directly or indirectly involved in airport activities represent the amount of the induced demand. The induced income effect may be estimated in the following way:

$$IE_{IN} = \frac{[(L]_D + L_{ID})W}{ALP} AVAL \quad (6)$$

where: L_D is the number of employees of companies directly involved in airport operation, L_{ID} is the number of employees of companies indirectly related to airport

operation, W is the average net wage, ALP is the average labour productivity per person employed, AVAL is the average value added per employee.

The input-output model has some limitations. The existing body of literature provides numerous arguments concerning the misuse of the input-output method and the misinterpretation of research findings [Montalvo 1998, Niemeier 2001]. It is also difficult to define the area influenced by airport operation. The larger the scope of the analysis the more disperse the effects are and the higher values the indirect and induced effects assume.

The results of the input-output analysis are static as they are usually based on data gathered throughout one statistical year. Air transport is particularly vulnerable to the economic situation, thus, production in this market may considerably fluctuate in different periods. If studies are done in peak years, their results may be inflated and vice versa, research on the economic effects of airport operation done during recession may lead to the underestimation of its impact.

The input-output method is used for assessing gross effects, namely economic impact as it is produced (AIIP methodology) [Montalvo 1998]. It takes into account all effects rather than just those which are generated due to airport operation. If there is no airport, part of the resources would be used in other branches of the economy. The question is to what degree those resources would be used, i.e. the level of labour and capital productivity.

THE APPLICATION AND RESULTS - WARSAW CHOPIN AIRPORT

Warsaw Chopin Airport is the biggest airport and the main transfer node in Poland, which handled 9.3 million passengers in 2011 - almost twice more than before the liberalization of the airline market in 2004.

Warsaw Chopin Airport is a city airport, which means that it is located within the borders of the city of Warsaw. The vicinity of a large conurbation makes the airport more accessible for people, although at the same time its operations may cause some inconvenience to the local community.

INCOME AND EMPLOYMENT GENERATION

With the rapid increase in the number of airport operations and in the number of passengers at Warsaw Chopin Airport, the aircraft and non-aircraft activity has entered the stage of dynamic development. Companies involved in airport activities are rapidly developing and employing new staff, thus generating employment and income. Not only does the development of Warsaw Chopin Airport benefit passengers, but it also creates positive effects for the whole society. In order to identify and measure the generation of employment and income connected with the activities of Warsaw Chopin Airport, the input-output method was used.

Income generation

The economic impact of Warsaw Chopin Airport was measured as the gross added value generated by the operation of enterprises based within and in the close vicinity of the airport and is calculated on the income side.

The added value generated on the income side by the airport operator (PPL), the main handling agents (LS Airport Services, Warsaw Airport Services, LOT Catering) and the biggest airline (PLL LOT) was calculated on the basis of their financial statements. The 2011 was the base year. When there was no access to the 2011 data, the 2010 data was taken into account and was adjusted by the rate of the value added growth with the consideration of the type of activity. The added value generation by the other companies was calculated on the basis of the number of people employed and the average added value generated by an employee with the consideration of the type of activity and voivodeship. This data is made available by GUS (The Main Statistical Office).

As the result of the analysis, it was estimated that the companies operating on-site or in the surrounding area of Warsaw Chopin Airport have directly generated 404m EUR income in the economy of Warsaw and the region.

Direct companies through the purchase of goods and services from suppliers indirectly contribute to added value generation in the economy. The size of production generated on the suppliers' side was calculated as the sum of expenses for external products and services and the costs of investment made by direct entities. The data about the costs and investment of the airport operator (PPL), the main handling agents (LS Airport Services, Warsaw Airport Services, LOT Catering) and the biggest airline (PLL LOT) was found in their financial statements. The other entities were divided according to the type of activity and the number of people employed.

The operations of Warsaw Chopin Airport indirectly contributed to the generation of 95m EUR in 2011.

Table 1. The direct and indirect influence of companies operating within and in the close vicinity of Warsaw Chopin Airport (five dominant companies have been highlighted)
Tabela 1. Bezpośredni i pośredni wpływ przedsiębiorstw funkcjonujących na terenie i w obrębie portu lotniczego w Warszawie z uwzględnieniem pięciu największych podmiotów.

Company	**Type of activity**	**Direct impact**		**Indirect impact**		
		Number of jobs	Value added (in million Euro)	Stimulated production on the suppliers' side (in million Euro)	Number of jobs	Value added (in million Euro)
PP "Porty Lotnicze"	Airport operator	2137	83	35	294	7
Polskie Linie Lotnicze LOT	Airline	2000	44	21	180	4
Warsaw Airport Services	Airport services	473	9	11	90	2
LOT Catering	Airport services	750	8	16	132	3
LS Airport Services	Airport services	1500	6	14	116	3
Others	Security services	2571	90	13	109	3
	Airport services	2387	84	124	1 055	25
	Retail/Services	1560	55	49	415	10
	Forwarding/Logistics	460	16	49	416	10
	Airlines	211	7	143	1 214	28
	Travel agencies	66	2	6	55	1
Total		**14115**	**404**	**479**	**4 076**	**95**

Source: Own calculations

The demand reflected by the spending of incomes of people employed in the companies directly and indirectly involved in airport operation constitutes the size of production of the induced impact. The induced income impact related to the activities of Warsaw Chopin Airport amounted to 27m EUR in 2011.

The total income impact of the airport is the sum of the direct, indirect and induced effect. The operations of Warsaw Chopin Airport contributed to the generation of 527.8m EUR in current prices in 2011. As author could not precisely quantify all the data, there was a need to adopt some assumptions and use average values.

Employment generation

Employment effect is the number of jobs directly dependent on airport operation. Job places which are related to the activities of an airport are one of the most important indicators presenting the economic significance of

airports. The author takes into consideration not only the level of employment at the airport operator's, but also the number of jobs at airlines, air traffic control, including supervision services and handling agencies. The employment generated by retail outlets located within and near the airport (shops, bars, restaurants, banks, hotels, car rentals) and the civilian air industry, namely aircraft manufacturing and maintenance was taken into account as well.

In order to estimate the direct impact, data provided by the airport operator, handling companies and gathered by means of personal interviews with the other entities was used. Employment data are expressed in full-time jobs.

198 enterprises are directly involved in the activities of Warsaw Chopin Airport. Altogether, they employ 14,115 people. In case of the companies that also operate outside the area of Warsaw airport, it was taken into account only this part of their activity and those jobs which are directly related to the activities of the airport. As there were difficulties to precisely quantify all the figures, in the case of some companies employment data was estimated on the basis of regional statistics. Almost half of the jobs (47%) have been generated by the four biggest companies: the airport operator (PPL), the national airline (PLL LOT), the ground handling company (LS Airport Services) and the air traffic control (PAŻP). These companies are mainly state owned.

The direct employment per one million passenger handled amounts 1517, much above the European average. One of the reason for the size of the workforce at state owned companies operating at Warsaw Chopin Airport is the remnant of central planning economy.

Having estimated the indirect and induced income effect, the information concerning the level of employment effect was obtained.

The number of jobs related to the volume of production indirectly dependent on airport operation has been calculated on the basis of the volume of the stimulated production of product and service providers for the companies directly involved in airport activities and on the basis of the average labour efficiency. 4,076 jobs are indirectly related to airport operation.

The number of jobs created as the result of the induced impact of airport operation has been calculated on the basis of the size of production generated by the expenses of people employed by the companies indirectly and directly involved in airport activities and of the average labour efficiency of all enterprises in the country. The induced impact accounts for the generation of 1,158 jobs.

Altogether, 19,349 jobs have been generated as the result of the direct, indirect and induced impact of Warsaw Chopin Airport.

CONCLUSIONS

The influence of Warsaw Chopin Airport on its surrounding environment has both a positive and negative dimension. A lot of effects created by airport operation are hard to measure. In this article, author focused on the measurable impact.

The benefits of airport operation are reflected in the generation of employment and income. The operation of Warsaw Chopin Airport have contributed - in the direct, indirect and induced way - to the creation of 19,349 jobs and have generated the income of 527m EUR in 2011. However the direct employment per one million passengers is much above the European average. One of the reason for the size of the workforce at state owned companies operating at Warsaw Chopin Airport is the remnant of central planning economy. The size of production in the airport expressed in the number of aircraft operations and the number of passengers and goods serviced is positively correlated with the level of economic impact. The restriction on the development of the airport reflected by the inability to meet transport needs expressed by the society may reduce the negative effects of airport operation, but it may also generate economic opportunity costs.

Environmental and spatial limitations may hamper the further development of Warsaw Chopin Airport. Given the immaturity of the air transport market in Poland and the prospects for its growth, it may be justifiable to intensify works on the Central Poland Airport project. The new airport would take over the whole or part of Warsaw Chopin Airport air traffic. Bearing in mind the potential social costs and benefits, if air traffic was moved beyond the borders of the city of Warsaw, social costs connected with the loss of property value caused by aircraft noise emission would be eliminated, while positive social benefits would be maintained or increased. Environmental effects related to the pollution of air, soil and water are to a large degree independent from the location an airport.

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WPŁYW FUNKCJONOWANIA PORTU LOTNICZEGO NA ZMIANY W DOCHODZIE I W ZATRUDNIENIU W KRAJU W OKRESIE TRANSFORMACJI

STRESZCZENIE. **Wstęp:** Rynek przewozów lotniczych w Polsce ulega zmianom, które odbywają się zarówno po stronie popytu jak i podaży. Polskie porty lotnicze doświadczyły bezprecedensowego wzrostu ruchu lotniczego. Jednak wzrost liczby połączeń lotniczych, który tworzy korzyści zarówno dla portu lotniczego, pasażerów, całego rynku lotniczego oraz pośrednio dla społeczeństwa - w tym samym czasu prowadzi do wzrostu kosztów społecznych,

związanych z nasileniem hałasu i zanieczyszczenia środowiska. Korzyści z funkcjonowania portu lotniczego znajdują odzwierciedlenie w tworzeniu zatrudnienia i dochodów. Istniejąca literatura ujawnia luki w wiedzy w zakresie ekonomicznego wpływu transportu lotniczego w krajach w okresie transformacji.
Metody: Badaniu poddano możliwość zastosowania modelu społeczno-ekonomicznego wpływu portu lotniczego w kraju w okresie transformacji. W szczególności badaniu poddano zmiany w dochodach i zatrudnieniu, jakie wynikają z funkcjonowania portu lotniczego. W pomiarze społeczno-ekonomicznych efektów zastosowano model nakładów i wyników. Badanie wpływu portu lotniczego na otoczenie przeprowadzono na przykładzie największego portu lotniczego w Polsce - Warsaw Chopin Airport.
Rezultaty: Wyniki badań wskazują na znaczne zmiany w dochodzie i w zatrudnieniu w regionie, które to zmiany są efektem funkcjonowania portu lotniczego. Działalność Warsaw Airport przyczyniła się do generowania 527.8m EUR w cenach bieżących w 2011 roku. Łącznie 19.349 miejsca pracy zależały w sposób bezpośredni, pośredni i indukowany od funkcjonowania warszawskiego portu lotniczego.
Wniosek: Wielkość produkcji w porcie lotniczym wyrażona liczbą operacji lotniczych oraz liczbą obsługiwanych pasażerów i towarów jest dodatnio skorelowana z wielkością korzyści społeczno-ekonomicznych generowanych przez ten port. Ograniczenie rozwoju portu lotniczego odzwierciedlająca się w niezdolności do zaspokojenia potrzeb transportowych wyrażonych przez społeczeństwo może generować koszty utraconych korzyści.

Słowa kluczowe: korzyści ekonomiczne, efekt dochodowy i zatrudnieniowy, model nakładów i wyników, port lotniczy, Warsaw Chopin Airport.

FUNKTIONSAUSÜBUNG EINES FLUGHAFENS UND DESSEN EINFLUSS AUF DAS EINKOMMEN UND DIE BESCHÄFTIGUNG IN EINEM IM POLITISCH-WIRTSCHAFTLICHEN UMBRUCH BEGRIFFENEN LANDE

ZUSAMMENFASSUNG. Einleitung: Der Luftverkehr in Polen unterliegt tiefgreifenden Veränderungen, die sowohl auf der Angebots-, als auch auf der Nachfrageseite erfolgen. Polnische Flughäfen haben ein beispielloses Wachstum im Bereich des Luftverkehrs erfahren. Allerdings führt die Erhöhung der Zahl von Flugverbindungen, die für den Flughafen selbst, für die Passagiere, den Luftfahrt-Markt und indirekt für die Gesellschaft vorteilhaft ist - gleichzeitig zu erhöhten sozialen Kosten, die mit erhöhtem Lärm und größerer Umweltverschmutzung verbunden sind. Die Vorteile des Betreibens eines Flughafens spiegeln sich in der Schaffung von Arbeitsplätzen und Einkommen wider. Die vorhandene Literatur zeigt Wissenslücken im Bereich der wirtschaftlichen Auswirkungen des Luftverkehrs in den im politisch-wirtschaftlichen Umbruch begriffenen Ländern.
Methoden: Im Rahmen dieser Arbeit wurde die Anwendbarkeit des sozio-ökonomischen Modells von Auswirkungen eines Flughafens untersucht. Es wurden dabei insbesondere die Veränderungen innerhalb der Einkommen und Beschäftigung, welche auf die Betätigung eines Flughafens zurückzuführen sind, ermittelt. Bei der Bemessung der sozio-ökonomischen Vorteile setzte man das Input-Output-Modell ein. Die Untersuchung der Beeinflussung des Umfeldes eines Flughafens wurde anhand des größten Flughafens in Polen - Warsaw Chopin Airport - durchgeführt.
Ergebnisse: Die Ergebnisse zeigen auf signifikante Veränderungen in Bezug auf den Anstieg des Einkommens und der Beschäftigung in der Region, in welcher sich ein Flughafen etabliert hat, hin. Die wirtschaftliche Tätigkeit von Warsaw Airport trug im Jahre 2011 zur Erzeugung von 527.8 Mio. EURO in jeweiligen Preisen bei. Insgesamt wurden 19.349 Arbeitsplätze als Folge der direkten, indirekten und induzierten Auswirkungen des Warsaw Chopin Airports generiert.
Fazit: Das im Flughafen mit der Anzahl der Flugoperationen, der bedienten Passagiere und beförderten Waren ausgedrückte Leistungsvolumen ist in positiver Weise mit den sozio-ökonomischen, durch den besagten Flughafen generierten Vorteilen korreliert. Die Beschränkung der Entwicklung eines Flughafens, durch die die Unfähigkeit zur Erfüllung der Verkehrsbedürfnisse der Gesellschaft zustande kommt, kann die Opportunitätskosten, d.h. Kosten der verlorengegangenen Vorteile, erzeugen.

Codewörter: wirtschaftliche Vorteile, Effekte von Beschäftigung und Einkommen, Input-Output-Modell, Flughafenbetrieb, Warschau Chopin Airport.

Sonia Huderek-Glapska
Department of Microeconomics,
Poznań University of Economics,
al Niepodległości 10, 61-875 Poznan,
Tel: 48 61 854 3962
Fax: 48 61 854 39 62

e-mail: sonia.huderek@ue.poznan.pl

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AN EOQ MODEL FOR THREE PARAMETER WEIBULL DETERIORATING ITEM WITH PARTIAL BACKLOGGING

L.M. Pradhan[1], C. K. Tripathy[2]

[1]Silicon Institute of Technology, Sambalpur, India, [2]Sambalpur University, Sambalpur, India

ABSTRACT. Background: Business organisations are facing a lot of competition during these days. To withstand the competition and to remain in the front row, an enterprise should have optimum profitable plan for his business. Researchers in recent years have developed various inventory models for deteriorating items considering various practical situations. Partial backlogging is considerably a new concept introduced in developing various models for Weibull deteriorating items.

Methodology: In this paper an inventory model has been developed considering three parameter Weibull deterioration of a single item with partial backlogging. Here demand rate is considered to be constant and lead time is zero. During the stock out period the backlogging rate is variable and is dependent on the length of the waiting time for the next replenishment.

Results and conclusion: Optimal order quantity and total variable cost during a cycle has been derived for the proposed inventory model considering three parameter Weibull deteriorating item with partial backlogging. The results obtained in this paper are illustrated with the help of a numerical example and sensitivity analysis..

Key words: EOQ, Weibull deterioration, partial backlogging.

INTRODUCTION

It is generally observed in various markets and super markets that the demand rate is usually influenced by the amount of the stock level. When a business runs out of stock we consider it as a negative aspect, but in certain situations this shortage may actually prove beneficial for the business, because backlogging of demand allows him to order a larger lot size and hence allows for a larger cycle inventory and reduces cost for him. Partial backlogging is a function of waiting time where as complete backlogging is independent of waiting time. Looking at various situations researchers have studied in this direction and have developed various inventory models. Optimal pricing and lot-sizing under conditions of perishability and partial backordering was developed by Abad [1996] and Abad [2001]. Chang and Dye [1999] studied an EOQ model for deteriorating items with time varying demand and partial backlogging. Then Dye, C. [2007-a], developed a model of optimal selling price and lot-size with a varying rate of deterioration and exponential partial backlogging. A deterministic inventory model for deteriorating items with capacity constraint and time proportional backlogging rate was studied by Dye [2007] et. al. Then Hung, K., [2011] developed an inventory model with generalized type demand, deterioration and back order rates. Earlier Park, K.S. [1982] proposed an inventory model with partial back orders and Jalan [1996] et.al studied an EOQ model for items with Weibull distribution deterioration, shortages and trended demand.

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Ouyang et.al [2006] have established a model considering optimal ordering policy for deteriorating items with partial backlogging under permissible delay in payments. Shah, N. and Shukla, K., [2009] studied a deteriorating inventory model for waiting time partial backlogging. An EOQ inventory model with Weibull distribution deterioration, ramp type demand and partial backlogging was studied by Singh, S.R. and. Singh, T.J. [2007]. Then Singh, S.R. and Singh, C., [2008] established a Perishable inventory model with quadratic demand, partial backlogging and permissible delay in payments. Skouri, et.al [2009] developed an inventory model with ramp type demand rate, partial backlogging and Weibull deterioration rate. Teng et.al [2007], made a comparison between two pricing and lot-sizing models with partial back logging and deteriorated items. Tripathy C.K. and Pradhan L.M., [2010], developed an EOQ model for Weibull deteriorating items with power demand and partial back logging. In that paper they have allowed shortages which are partially backlogged. Tripathy, C. K., and Mishra, U., [2010] have studied an inventory model with time dependent linear deteriorating items with partial backlogging. Wu and Cheng, [2005] established an inventory model for deteriorating items with exponential declining demand and Partial back logging.

In the present paper an economic ordered quantity model has been developed considering three parameter Weibull deterioration where shortages are allowed and are partially backlogged. The holding cost and demand rate are assumed to be constant for this model. In section 2 assumptions and notations required for the development of the model are given. The optimum cycle time, holding cost, optimal ordered quantity and total average cost of the model are derived in the Section 3. An illustrative numerical example, sensitivity analysis and conclusion are given in section 4, 5 and 6 respectively.

BASIC ASSUMPTIONS AND NOTATIONS

The following are the assumptions required for development of the model:

1. The model deals with a single item.
2. Demand rate for the product is known and constant.
3. Planning horizon is infinite.
4. Lead time is zero.
5. Once a unit of the product is produced, it is available to meet the demand.
6. The backlogging rate is variable and is dependent on the length of the waiting time for the next replenishment. For the negative inventory the backlogging rate is $B(t) = \frac{1}{1+\delta(T-t)}$; $\delta > 0$ denotes the backlogging parameter.
7. Deterioration rate is a three parameter Weibull

The notations that are employed here:

A : ordering cost per order.
a : constant demand rate.
C : Purchase cost per unit.
h : Inventory holding cost per unit per unit time.
θ: Weibull three parameter deterioration rate (unit/unit time), $\theta = \alpha\beta(t-\gamma)^{\beta-1}$, where $0 < \alpha << 1$, $\beta > 0$, and $0 < \gamma < 1$, where α is called scale parameter β is called shape parameter and γ is called the location parameter.
π_b : Backordered cost per unit short per time unit.
π_l : Cost of lost sales per unit.
t_1 : The time at which the inventory level reaches zero, $t_1 \geq 0$.
t_2 : The length of period during which shortages are allowed, $t_2 \geq 0$.
T : The length of cycle time, i.e. $T = t_1 + t_2$.
$I_1(t)$: The level of positive inventory at time t, $0 \leq t \leq t_1$
$I_2(t)$: The level of negative inventory at time t, $t_1 \leq t \leq t_1 + t_2$
IM : Maximum inventory level of the product during $[0, T]$.
IB : Maximum backordered units during stock out period.

Q: Order quantity during a cycle of length T, i.e. $Q = IM + IB$.

TC : Total average cost per time unit.

MATHEMATICAL MODEL

The initial inventory level or the maximum level of inventory $I_1(0) = IM$, decreases due to the combined effect of demand and deterioration during the time $[0, t_1]$. Thus, the inventory level of the product at time t over the period $[0, t_1]$ can be represented by the following differential equation

$$\frac{dI_1(t)}{dt} + \theta I_1(t) = -a \quad , \qquad 0 \le t \le t_1$$

Using the value of $\theta = \alpha\beta(t-\gamma)^{\beta-1}$, $0 < \alpha << 1$, $\beta > 0$ and $0 < \gamma < 1$ called the scale, shape and location parameter respectively.

$$\frac{dI_1(t)}{dt} + \alpha\beta(t-\gamma)^{\beta-1} I_1(t) = -a \quad , \quad 0 \le t \le t_1 \qquad (1)$$

Inventory level reaches to zero at time t_1. After that shortages occur. During the interval $[t_1, t_1 + t_2]$, the inventory level depends on demand and a fraction of demand is backlogged. The state of inventory during $[t_1, t_1 + t_2]$ can be represented by the differential equation,

$$\frac{dI_2(t)}{dt} = -\frac{a}{1 + \delta(t_1 + t_2 - t)}, \quad t_1 \le t \le t_1 + t_2 \qquad (2)$$

Here the boundary conditions are $I_1(t_1) = I_2(t_1) = 0$

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

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

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

$$I_1(t)\, e^{\alpha(t-\gamma)^{\beta}} = \int -a\, e^{\alpha(t-\gamma)^{\beta}} dt + c \ , \quad \text{where 'c', is the constant of integration.}$$

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

$$I_1(t)\, e^{\alpha(t-\gamma)^{\beta}} = -a\left(t + \frac{\alpha(t-\gamma)^{\beta+1}}{\beta+1}\right) + c$$

Using the given boundary condition $I_1(t_1) = 0$ in the above we get the required solution of equation (1) as

$$I_1(t)\, e^{\alpha(t-\gamma)^{\beta}} = -a\left(t + \frac{\alpha(t-\gamma)^{\beta+1}}{\beta+1}\right) + a\left(t_1 + \frac{\alpha(t_1-\gamma)^{\beta+1}}{\beta+1}\right)$$

$$\Rightarrow I_1 = a\, e^{-\alpha(t-\gamma)^{\beta}}\left[t_1 - t + \frac{\alpha}{\beta+1}\left((t_1-\gamma)^{\beta+1} - (t-\gamma)^{\beta+1}\right)\right]$$

Again taking the first two terms from the series expansion of the exponential function and neglecting the higher power of α that is the power greater than or equal to 2, in the above the solution of equation (1) can be rewritten as

$$I_1(t) = a\left[t_1 - t + \frac{\alpha}{\beta+1}\left((t_1-\gamma)^{\beta+1} - (t-\gamma)^{\beta+1}\right) - \alpha t_1 (t-\gamma)^{\beta} + \alpha t (t-\gamma)^{\beta}\right],$$
$$0 \le t \le t_1 \qquad (3)$$

Similarly the solution of equation (2) can be written as

$$I_2(t) = \frac{a}{\delta}\ln\{1 + \delta(t_1 + t_2 - t)\} + c$$

Using the boundary condition $I_2(t_1) = 0$ in the above, required solution of equation (2) is

$$I_2(t) = \frac{a}{\delta}\left[\ln\{1 + \delta(t_1 + t_2 - t)\} - \ln(1 + \delta t_2)\right],$$
$$t_1 \le t \le t_1 + t_2 \qquad (4)$$

The maximum positive inventory is

$$IM = I_1(0) = a\left[t_1 + \frac{\alpha}{\beta+1}\left((t_1-\gamma)^{\beta+1} - (-\gamma)^{\beta+1}\right) - \alpha t_1 (-\gamma)^{\beta}\right] \qquad (5)$$

The maximum backordered units are given by,

$$IB = -I_2(t_1 + t_2) = -\frac{a}{\delta}\left[\ln\{1 + \delta(t_1 + t_2 - t_1 - t_2)\} - \ln(1 + \delta t_2)\right]$$

$$= \frac{a}{\delta}\ln(1 + \delta t_2) \qquad (6)$$

The order size during $[0,T]$ is

$$Q = IM + IB$$

$$\Rightarrow Q = a\begin{bmatrix} t_1 + \frac{\alpha}{\beta+1}\left((t_1-\gamma)^{\beta+1} - (-\gamma)^{\beta+1}\right) \\ -\alpha t_1 (-\gamma)^{\beta} + \frac{1}{\delta}\ln(1+\delta t_2) \end{bmatrix} \quad (7)$$

Ordering cost per cycle is

$$OC = A \quad (8)$$

Inventory holding cost per cycle is

$$IHC = h\int_0^{t_1} I_1(t)\,dt$$

$$= ha\int_0^{t_1}\begin{bmatrix} t_1 - t + \frac{\alpha}{\beta+1}\left((t_1-\gamma)^{\beta+1} - (t-\gamma)^{\beta+1}\right) \\ -\alpha t_1 (t-\gamma)^{\beta} + \alpha t (t-\gamma)^{\beta} \end{bmatrix} dt$$

$$= ha\left[\frac{t_1^2}{2} + \frac{\alpha t_1 (t_1-\gamma)^{\beta+1}}{\beta+1} + \frac{\alpha t_1 (-\gamma)^{\beta+1}}{\beta+1} + \frac{2\alpha(-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} - \frac{2\alpha(t_1-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}\right] \quad (9)$$

Backordered cost per cycle is

$$BC = \pi_b \int_{t_1}^{t_1+t_2} -I_2(t)\,dt$$

$$= -\pi_b \int_{t_1}^{t_1+t_2} \frac{a}{\delta}\left[\ln\{1+\delta(t_1+t_2-t)\} - \ln(1+\delta t_2)\right] dt$$

$$= \frac{-\pi_b a}{\delta}\left[\delta t_2 - (1+\delta t_2 + t_2)\ln(1+\delta t_2)\right] \quad (10)$$

Cost due to lost sales per cycle is given by,

$$LS = \pi_l\, a \int_{t_1}^{t_1+t_2}\left(1 - \frac{1}{1+\delta(t_1+t_2-t)}\right) dt$$

$$= \frac{\pi_l a}{\delta}\left[\delta t_2 - \ln(1+\delta t_2)\right] \quad (11)$$

Purchase cost per cycle is,

$$PC = C \times Q$$

$$= Ca\begin{bmatrix} t_1 + \frac{\alpha}{\beta+1}\left((t_1-\gamma)^{\beta+1} - (-\gamma)^{\beta+1}\right) \\ -\alpha t_1 (-\gamma)^{\beta} + \frac{1}{\delta}\ln(1+\delta t_2) \end{bmatrix} \quad (12)$$

Therefore the total average cost per time unit is

$$TC = \frac{1}{t_1+t_2}\left[OC + IHC + BC + LS + PC\right]$$

$$= \frac{1}{t_1+t_2}\begin{bmatrix} A + ha\left\{\frac{t_1^2}{2} + \frac{\alpha t_1 (t_1-\gamma)^{\beta+1}}{\beta+1} \right. \\ \left. + \frac{\alpha t_1 (-\gamma)^{\beta+1}}{\beta+1} + \frac{2\alpha(-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} - \frac{2\alpha(t_1-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}\right\} \\ \frac{-\pi_b a}{\delta}\{\delta t_2 - (1+\delta t_2 + t_2)\ln(1+\delta t_2)\} + \frac{\pi_l a}{\delta}\{\delta t_2 - \ln(1+\delta t_2)\} \\ + Ca\begin{Bmatrix} t_1 + \frac{\alpha}{\beta+1}\left((t_1-\gamma)^{\beta+1} - (-\gamma)^{\beta+1}\right) \\ -\alpha t_1 (-\gamma)^{\beta} + \frac{1}{\delta}\ln(1+\delta t_2) \end{Bmatrix} \end{bmatrix} \quad (13)$$

The necessary condition for the total average cost to be minimized is

$$\frac{\partial TC}{\partial t_1} = 0$$

$$\Rightarrow \frac{-1}{(t_1+t_2)^2}\begin{bmatrix} A + ha\left\{\frac{t_1^2}{2} + \frac{\alpha t_1 (t_1-\gamma)^{\beta+1}}{\beta+1} \right. \\ \left. + \frac{\alpha t_1 (-\gamma)^{\beta+1}}{\beta+1} + \frac{2\alpha(-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} - \frac{2\alpha(t_1-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}\right\} \\ \frac{-\pi_b a}{\delta}\{\delta t_2 - (1+\delta t_2 + t_2)\ln(1+\delta t_2)\} + \frac{\pi_l a}{\delta}\{\delta t_2 - \ln(1+\delta t_2)\} \\ + Ca\left\{t_1 + \frac{\alpha}{\beta+1}\left((t_1-\gamma)^{\beta+1} - (-\gamma)^{\beta+1}\right) - \alpha t_1 (-\gamma)^{\beta} + \frac{1}{\delta}\ln(1+\delta t_2)\right\} \end{bmatrix} +$$

$$\frac{1}{(t_1+t_2)}\begin{bmatrix} ha\left\{t_1 + \alpha t_1 (t_1-\gamma)^{\beta} - \frac{\alpha(t_1-\gamma)^{\beta+1}}{\beta+1} + \frac{\alpha(-\gamma)^{\beta+1}}{\beta+1}\right\} \\ + Ca\{1 + \alpha(t_1-\gamma)^{\beta} - \alpha(-\gamma)^{\beta}\} \end{bmatrix} = 0 \quad (14)$$

and $\frac{\partial TC}{\partial t_2} = 0$

$$\Rightarrow \frac{-1}{(t_1+t_2)^2}\begin{bmatrix} A + ha\left\{\frac{t_1^2}{2} + \frac{\alpha t_1 (t_1-\gamma)^{\beta+1}}{\beta+1} + \frac{\alpha t_1 (-\gamma)^{\beta+1}}{\beta+1} \right. \\ \left. + \frac{2\alpha(-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)} - \frac{2\alpha(t_1-\gamma)^{\beta+2}}{(\beta+1)(\beta+2)}\right\} \\ \frac{-\pi_b a}{\delta}\{\delta t_2 - (1+\delta t_2 + t_2)\ln(1+\delta t_2)\} \\ + \frac{\pi_l a}{\delta}\{\delta t_2 - \ln(1+\delta t_2)\} \end{bmatrix}$$

$$+Ca\left\{\begin{matrix} t_1+\frac{\alpha}{\beta+1}\left((t_1-\gamma)^{\beta+1}-(-\gamma)^{\beta+1}\right) \\ -\alpha t_1(-\gamma)^{\beta}+\frac{1}{\delta}\ln(1+\delta t_2) \end{matrix}\right\}\Bigg]$$

$$+\frac{1}{(t_1+t_2)}\left[\begin{matrix} \pi_b a\left\{\frac{t_2}{1+\delta t_2}+\left(1+\frac{1}{\delta}\right)\ln(1+\delta t_2)\right\} \\ +\frac{\pi_l a\,\delta t_2}{1+\delta t_2}+\frac{Ca}{1+\delta t_2} \end{matrix}\right]=0 \quad (15)$$

Provided,

$$\frac{\partial^2 TC}{\partial t_1^2}\times\frac{\partial^2 TC}{\partial t_2^2}-\frac{\partial^2 TC}{\partial t_1\,\partial t_2}>0\ ,$$

for obtained value of (t_1, t_2). (16)

The equations (14) and (15) are highly non linear. They can be solved by mathematica-5.1 software for a given set of known parameters. The obtained values of t_1 and t_2 must satisfy equation (16) to minimize the total cost per time unit of the inventory system. To illustrate these we have given a numerical example and a sensitivity analysis in the following sections.

NUMERICAL EXAMPLE

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

$$[A, C, h, \pi_b, \pi_l, a, \delta, \alpha, \beta, \gamma] = [3000, 100, 0.4, 20, 60, 12, 8, 0.08, 4, 0.4]\ .$$

Using these values in equation (14) and (15) we get, $t_1^* = 2.02662$ and $t_2^* = 7.99722$ respectively. Putting the optimum values of t_1^* and t_2^* in equation (7) and (13) we get, $Q^* = 32.7191$ and $TC^* = 1883.92$ respectively.

SENSITIVITY ANALYSIS

For study of sensitivity analysis let us change one parameter at a time keeping the other parameters unchanged. The original values of all the parameters for sensitivity analysis have been taken from the example given in section 4 above. Sensitivity analysis is performed by changing the values of all the parameters from -50% to +50%, one by one in the model which are given in the following table-1.

From the table-1 we can conclude the following:

The optimal time t_1^* increases as $A, \pi_b, \pi_l, \delta, \gamma$ increases but it decreases as C, h, a, α, β increases. Similarly the optimal time t_2^* increases as C, h, A, α, β increases but it decreases as $\delta, \pi_b, \pi_l, a, \gamma$ increases. Again the optimal ordered quantity Q^* per cycle increases as $A, \pi_b, \pi_l, a, \gamma$ increases but it decreases as $C, h, \delta, \alpha, \beta$ increases. The total average cost TC^* of the system increases as $A, C, h, \pi_b, \pi_l, a, \delta, \alpha, \beta$ increases but it decreases as γ increases.

CONCLUSION

In the present paper an economic ordered quantity model has been developed for an item with three parameter Weibull deterioration where shortages are allowed and are partially backlogged. The optimal cycle time, optimal ordered quantity per cycle and total optimal cost has been derived for the model. Sensitivity analysis shows how the different parameters affect the optimal cycle time, ordered quantity per cycle and total optimal cost. It can be concluded that to minimise the total cost, it is required to minimize the ordering cost, purchase cost, holding cost, back ordered cost, the cost of lost sales per unit, the demand rate, backlogging parameter, scale parameter and shape parameter, whereas we need to maximise the value of the location parameter.

Table 1. sensitivity analysis
Tabela 1. Analiza wrażliwości

Parameter	%change	t_1^*	t_2^*	Q^*	TC^*
A	-50	1.89117	3.63945	29.1727	1684.3
	-25	1.9731	5.74291	31.2537	1798.8
	25	2.06539	10.3503	33.8383	1951.05
	50	2.09533	12.772	34.738	2006.2
C	-50	2.54094	3.27636	44.0224	1636.46
	-25	2.2634	5.60016	37.1571	1785.84
	25	1.78866	10.3209	29.0519	1953.9
	50	1.48812	12.4773	25.0357	2006.01
h	-50	2.03057	7.98001	32.7899	1883.36
	-25	2.0286	7.98862	32.7545	1883.64
	25	2.02465	8.0058	32.6839	1884.2
	50	2.02268	8.01436	32.6487	1884.47
π_b	-50	1.6455	22.2254	28.0624	1437.75
	-25	1.8906	12.6267	30.9932	1683.57
	25	2.11579	5.38981	33.8749	2045.6
	50	2.17794	3.79444	34.6628	2174.26
π_l	-50	1.82391	10.6775	29.6568	1603.36
	-25	1.93729	9.33534	31.3401	1746.49
	25	2.09972	6.68938	33.8686	2014.54
	50	2.16055	5.43897	34.8166	2136.88
a	-50	2.13955	17.7537	18.0635	1046.59
	-25	2.07617	11.151	25.6189	1477.92
	25	1.98545	6.18381	39.48	2272.11
	50	1.95005	5.02146	45.9739	2647.08
δ	-50	2.00394	8.14827	36.5811	1846.8
	-25	2.01406	8.13586	34.0411	1863.16
	25	2.03869	7.83093	31.9329	1904.32
	50	2.04972	7.66401	31.4266	1923.33
α	-50	2.32032	7.51128	36.4918	1867.7
	-25	2.12485	7.80192	34.2163	1877.52
	25	1.94169	8.14224	31.6209	1888.57
	50	1.87552	8.25643	30.7625	1892.19
β	-50	2.99484	7.03768	47.1619	1850.9
	-25	2.29666	7.78465	37.0219	1876.94
	25	1.87709	8.16831	30.4969	1889.4
	50	1.78572	8.25674	29.0756	1892.2
γ	-50	1.83439	8.43644	30.5891	1897.78
	-25	1.93027	8.21756	31.661	1890.96
	25	2.12382	7.76999	33.7506	1876.46
	50	2.22234	7.52859	34.7362	1868.3

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MODEL EKONOMICZNEJ WIELKOŚCI PARTII DLA TRZECH PARAMETRÓW UTRATY WARTOŚCI WEIBULLA Z CZĘŚCIOWYMI ZALEGŁOŚCIAMI

STRESZCZENIE. **Wstęp:** W obecnych czasach przedsiębiorstwa musza sprostać wielu wymaganiom stawianym prze konkurencyjny rynek. Aby pokonować konkurencję pozostać liderem, przedsiębiorstwo powinno opierać się na optymalnym planie zyskowności swojej działalności. W ostatnich latach naukowcy opracowali wiele modeli dla asortymentów podlegających zużyciu praktycznie dla każdej występującej w rzeczywistości sytuacji. Częściowe zaległości są nową koncepcją wprowadzoną w rozwijanych modelach Weibulla.
Metody: Model zapasów asortymtentu dla którego występują częściowe zaległości został opracowany dla trzech parametrów utraty wartości Weibulla. Założono, że popyt jest stały oraz czas realizacji równa się zero. W okresie braków współczynnik zaległości jest zmienny i zależy od czasu oczekiwania na uzupełnienie zapasów.

Wyniki i wnioski: Optymalna wielkość zamówienia oraz całkowity koszt zmienny w czasie cyklu zostały opracowane dla proponownego modelu zapasów uwzględniającego trzy parametry zużycia Weibulla z częściowymi zaległościami. Wyniki zostały zaprezentowany przy pomocy przykładu liczbowego oraz analizy wrażliwości..

Słowa kluczowe: ekonomiczna wielkość partii, zużycie Weibulla, częściowe zaległości

MODELL DER WIRTSCHAFTLICHEN LOSGRÖßE EINER BESTELLUNG FÜR DREI PARAMETER DES WEIBULL-WERTVERLUSTES MIT TEILHAFTEN RÜCKSTÄNDEN

ZUSAMMENFASSUNG. Einleitung: Der Wettbewerbsmarkt stellt heutzutage vor Unternehmen viele wichtige Herausforderungen. Um die Konkurrenz zu überholen und die Führungsposition zu bewahren, sollten sich die Unternehmen auf den optimalen Plan der Rentabilität ihrer Betätigung stützen. In den letzten Jahren haben die Wissenschaftler viele Modelle für die Sortimente, die einem Verschleiß unterliegen, praktisch für jede in der Wirklichkeit auftretende Situation ausgearbeitet. Das Modell mit den teilhaften Rückständen stellt ein neues, in den entwickelten Weibull-Modellen eingeführtes Konzept dar.
Methoden: Das Modell der Sortimentsvorräte, bei denen die teilhaften Rückständen auftreten, wurde für die drei Parameter des Weibull-Wertverlustes konzipiert. Man hat angenommen, dass die Nachfrage konstant bleibt und die Ausführungszeit der Bestellung dem Null gleicht. In der Zeit der auftretenden Defizite ist der Koeffizient der Rückstände variabel und hängt von der Wartezeit beim Nachschub der Vorräte ab.
Ergebnisse und Fazit: Die optimale Losgröße der Bestellung sowie die variablen Gesamtkosten innerhalb eines Zyklus wurden für die Zwecke des vorgeschlagenen Vorratsmodells, welches die drei Parameter des Weibull-Wertverlustes mit teilhaften Rückständen berücksichtigt, ausgearbeitet. Die Ergebnisse wurden anhand eines Zahlenbeispiels und der Empfindlichkeitsanalyse dargestellt.

Codewörter: wirtschaftliche Losgröße, Weibull-Wertverlust, teilhafte Rückstände

Pradhan L.M.
Department of Mathematics
Silicon Institute of Technology
Sason, Sambalpur-768200, India
e-mail: lalitpradhan78@gmail.com
Tripathy C. K.
Department of Statistics
Sambalpur University
Jyoti Vihar
Sambalpur-768019, India
e-mail: c.tripathy@yahoo.com

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A NOTE ON INVENTORY MODEL FOR AMELIORATING ITEMS WITH TIME DEPENDENT SECOND ORDER DEMAND RATE

Gobinda Chandra Panda[1], Satyajit Sahoo[1], Pravat Kumar Sukla[2]

[1)] Dept. of Mathematics, Mahavir Institute of Engg. & Technology,BBSR, Odisha, India [2)] P.S College, Koksara, Kalahandi, Odisha, India

ABSTRACT. Background: This paper is concerned with the development of ameliorating inventory models. The ameliorating inventory is the inventory of goods whose utility increases over the time by ameliorating activation.
Material and Methods: This study is performed according to two areas: one is an economic order quantity (EOQ) model for the items whose utility is ameliorating in accordance with Weibull distribution, and the other is a partial selling quantity (PSQ) model developed for selling the surplus inventory accumulated by ameliorating activation with linear demand. The aim of this paper was to develop a mathematical model for inventory type concerned in the paper. Numerical examples were presented show the effect of ameliorating rate on inventory polices.
Results and Conclusions: The inventory model for items with Weibull ameliorating is developed. For the case of small ameliorating rate (less than linear demand rate), EOQ model is developed, and for the case where ameliorating rate is greater than linear demand rate, PSQ model is developed. .

Key words: Inventory model, Ameliorate rate, Economic order quantity, partial selling-quantity, second order demand.

INTRODUCTION

A number of mathematical models have been developed for these deteriorating items. To get an idea of the trends of recent research in this area, one may refer to the works Mukherjee [1987], Bhunia and Maiti [1997], Datta and Pal [1991], Giri, Pal, Goswami, and Chaudhuri [1996], Goyal and Gunasekaran [1997], Mandal and Phaujdar [1989], and Sarkar, Mukherjee, and Balan [1997] Sahu and Parida [2001], Sahu, Acharya and Tripathy [2002], Sahu and Acharya [2002], Sahu, Kalam, Sukla, and Chand [2005], Dash, Kerketa, and Sahu [2005], Sahu, Ota, Sukla, Panda [2006], Sahu, Kalam, Sukla, Dash [2006], Sahu, Dash, Sukla, [2007] and others. Moreover, it is well known that the life time of some perishable items like medicines, perfumes, cosmetics, blood, etc. is fixed and these cannot be used after the prescribed period (i.e. after the expired date). In the recent years, there are some inventory models for this type of perishable product developed by Abad [1996], Luo [1998], and Padmanabhan and Vrat [1995]. Except deteriorating or perishable items, there are other types of items made of glass, ceramic, etc. which are stored one after another in the form of heaped stock. These items break/get damaged due to the accumulated stress. Recently, Mandal and Maiti [1997] have developed some inventory models for damageable items.

Deb and Chaudhuri [1987] were the first to permit shortages for an inventory item having a linear trend in demand. In their formulation of the resulting inventory problem a cycle starts with replenishment. Sachan [1984] looked at a model that can be considered as a special case of our model. He assumed that

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the demand rates are proportional with time. In this paper, he did not suggest an optimal solution to the model but, rather, an approximate method by assumed equal replenishment periods. Goswami and Chauduri [1991] considered a model with linear demand rates. They also suggested an approximate replenishment schedule. This is concerned with the development of ameliorating inventory models. The ameliorating inventory is the inventory of foods whose utility increases over the time by ameliorating activation. This study is performed according to areas; one is an economic order quantity (EOQ) model for the items whose utility is ameliorating in accordance with Weibull distribution, and the other is a partial selling quantity (PSQ) model developed for selling the surplus inventory accumulated by ameliorating activation with linear demand. Numerical examples to show the effect of ameliorating rate on inventory polices are illustrated.

MODEL DEVELOPMENT

The notations and assumptions are used in this paper are the time dependent demand rate is $R(t) = a + bt + ct^2, a > 0, b > 0, c > 0,$ Here a is initial rate of demand, b is the rate with which the demand rate increases. The rate of change in the demand rate itself increases at a rate c.

$\alpha\beta t^{\beta-1}$ = The Weibull distribution.
C_0 = Ordering cost.
C_a = Ameliorating cost.
C_p = Purchasing cost.
P_s = Selling price.
C_h = Carrying cost.
C_s = Shortage cost.
Q = Partial ordering size.
S = Partial selling amount.
A (t) = Instantaneous ameliorating rate.
TC = Total cost/unit time.

ECONOMIC ORDER QUANTITY MODEL

When the ameliorating rate is less than the demand rate, we considered a cycle time that the amount of total demand is filled partially with the amount of ameliorated and partially with the amount of replenished amount of from an ordering quantity.

Since the inventory level at time t, I_t will change at a varying rate, it must be expressed as a differential equation. The depletion, dI, during the infinite estimate time, dt, following time t, is a function of those; the ameliorating rate, demand rate, and the remaining inventory level at the inventory system.

$$dI = IA(t)dt - (a + btct^2)dt \quad (1)$$

$$\frac{dI}{dt} - (\alpha\beta t^{\beta-1})I = -(a + bt + ct^2) \quad \text{where}$$

$$(2)\ I = e^{\alpha t^{\beta}}\left[\int_0^t (a + bt + ct^2)e^{-\alpha t^{\beta}}dt + K\right] \quad (3)$$

The value of the constant integration *K*, Using the boundary conditions. When *t=0*, *I*= I_0

$$I_0 = -\int_0^0 (a + bt + ct^2)e^{-\alpha t^{\beta}}dt + K$$

$$K = I_0 \quad (4)$$

and when *t=T* , *I=0*, solving for I_0 given,

$$I_0 = \int_0^T (a + bt + ct^2)e^{-\alpha t^{\beta}}dt \quad (5)$$

and

$$I = e^{\alpha t^{\beta}}\left[-\int_0^t (a + bt + ct^2)e^{-\alpha x^{\beta}}dx + I_0\right] \quad (6)$$

Thus, to find the total cost equation we have to consider the ameliorating cost as well as the holding cost and ordering cost.

The equation for the total cost per unit time, TC, can be obtained by

$$TC(T) = I_0\left(\frac{C_p - C_a}{T} + \frac{C_h}{2}\right) + (a + bt + ct^2)C_a + \frac{C_0}{T}$$

$$= (C_p - C_a)\left[a\sum_{k=0}^{\infty}\frac{(-\alpha)^k T^{k\beta}}{k!(k\beta+1)} + b\sum_{k=0}^{\infty}\frac{(-\alpha)^k T^{k\beta+1}}{k!(k\beta+2)} + c\sum_{k=0}^{\infty}\frac{(-\alpha)^k T^{k\beta+2}}{k!(k\beta+3)}\right]$$

$$+ \frac{C_h}{2}\left[a\sum_{k=0}^{\infty}\frac{(-\alpha)^k T^{K\beta+1}}{k!(k\beta+1)} + b\sum_{k=0}^{\infty}\frac{(-\alpha)^k T^{k\beta+2}}{k!(k\beta+2)} + c\sum_{k=0}^{\infty}\frac{(-\alpha)^k T^{k\beta+3}}{k!(k\beta+3)}\right]$$

$$+ (a + bt + ct^2)C_a + \frac{C_0}{T} \quad (7)$$

The average inventory on hand is given by

$$\frac{I_A}{T} = \frac{1}{T}\int_0^T Idt$$

$$= \frac{1}{T}\int_0^T e^{\alpha t^\beta}\left[-\int_0^t (a+bx+cx^2)e^{-\alpha x^\beta}dx + I_0\right]$$

$$= \sum_{k=0}^{\infty}\frac{(-1)^k\alpha^{2k}T^{2k\beta+1}}{(k!)^2(k\beta+1)}\left[\frac{a}{k\beta+1}+\frac{bT}{k\beta+2}+\frac{cT^2}{k\beta+3}\right]$$

$$-\sum_{k=0}^{\infty}\sum_{n=0}^{\infty}\frac{(-1)^k\alpha^{k+n}T^{k\beta+n\beta+1}}{k!n!}\left[\begin{array}{l}\dfrac{a}{(k\beta+1)(k\beta+n\beta+2)}\\ +\dfrac{bT}{(k\beta+2)(k\beta+n\beta+3)}\\ +\dfrac{cT^2}{(k\beta+3)(k\beta+n\beta+4)}\end{array}\right] \quad (8)$$

To find the optimal cycle time, T^*, it must be differentiated with respect to T, and by setting it equal to zero, gives

$$\frac{dTC}{dT} = (C_p - C_a)$$

$$\left[a\sum_{k=0}^{\infty}\frac{(-\alpha)^k k\beta T^{k\beta-1}}{k!(k\beta+1)} + b\sum_{k=0}^{\infty}\frac{(-\alpha)^k(k\beta+1)T^{k\beta}}{k!(k\beta+2)} + c\sum_{k=0}^{\infty}\frac{(-\alpha)^k(k\beta+2)T^{k\beta+1}}{k!(k\beta+3)}\right]$$

$$+\frac{C_h}{2}\left[a\sum_{k=0}^{\infty}\frac{(-\alpha)^k T^{k\beta}}{k!} + b\sum_{k=0}^{\infty}\frac{(-\alpha)^k T^{k\beta+1}}{k!} + c\sum_{k=0}^{\infty}\frac{(-\alpha)^k T^{k\beta+2}}{k!}\right]$$

$$-\frac{C_0}{T^2} = 0 \quad (9)$$

From equation $\frac{dTC}{dT} = 0$, we get

$$T = \frac{1}{C_0}\sum_{k=0}^{\infty}\frac{(-\alpha)^k T^{k\beta+2}}{k!}\left[a\left[(C_p - C_a)\frac{k\beta}{k\beta+1}+\frac{C_h T}{2}\right]\right.$$

$$\left. + bT\left[(C_p - C_a)\frac{k\beta+1}{k\beta+2}+\frac{C_h T}{2}\right]\right]$$

$$+ cT^2\left[(C_p - C_a)\frac{k\beta+2}{k\beta+3}+\frac{C_h T}{2}\right]\Bigg] \quad (10)$$

We can find the optimal cycle time, T^* by computer search.

When $\beta = 1$ in the proposed model, ameliorating rate becomes constant and the initial inventory level I_0 is

$$I_0 = \frac{a}{\alpha}\left[1-e^{-\alpha T}\right] + \frac{b}{\alpha^2}\left[1-(1+\alpha T)e^{-\alpha T}\right]$$

$$+\frac{2c}{\alpha^3}(\alpha T - e^{-\alpha T} - \alpha T e^{-\alpha T})$$

And

$$I = \frac{a}{\alpha}\left[e^{\alpha(T-t)}-1\right] + \frac{b}{\alpha^2}\left[(1+\alpha t)e^{\alpha(T-t)} - (1+\alpha T)\right]$$

$$+\frac{2c}{\alpha^3}\left[(1+\alpha t+\frac{\alpha t^2}{2})e^{\alpha(T-t)} - e^{\alpha T}(1-\alpha T) - (1+\alpha T)\right]$$

PARTIAL SELLING QUANTITY MODEL

When the amount of unit ameliorated during the infinite estimate time is greater than the depleted amount for demands the surplus amount of storages will be accumulated in the inventory system as time elapsed. On the other hand the carrying cost per unit time will increase as the surplus amount of storages increases. Hence, at a proper point of time, it will be better to sell out this surplus amount of storages, S_0, at appropriate selling price, C_s and selling process cost C_0.

Immediately after the selling points of time, the inventory level will be dropped to I_0 (base line initial inventory level). Initial inventory, I_0 and partial selling quantity, S_0, can be found from the equation (13) where k is found from the boundary conditions. When t=0, I= I_0 Thus K= I_0.

And

$$I_t = e^{\alpha t^\beta}\left[-\int_0^t (a+bt+ct^2)e^{-\alpha t^\beta}dt + I_0\right] \quad (11)$$

When t=T, I= $I_0 + S_0$

$$I_0 + S_0 = e^{\alpha T^\beta}\left[-\int_0^T (a+bt+ct^2)e^{-\alpha t^\beta}dt + I_0\right] \quad (12)$$

Thus

$$I_0 = \frac{1}{e^{\alpha T^\beta}-1}\left[e^{\alpha T^\beta}\int_0^T (a+bt+ct^2)e^{-\alpha t^\beta}dt + S_0\right] \quad (13)$$

And

$$S_0 = e^{\alpha T^\beta}\left[-\int_0^T (a+bt+ct^2)e^{-\alpha t^\beta}dt\right] \quad (14)$$

$$+ I_0(e^{\alpha T^\beta}-1)$$

$$\text{TC}=(P_s-C_a)(a+bt+ct^2)+\left[\frac{P_s-C_a}{T}-\frac{C_h}{2}\right]\left[I_0\left(e^{\alpha T^\beta}-1\right)-(a+bt+ct^2)e^{\alpha T^\beta}\sum_{k=0}^{\infty}\frac{(-\alpha)^k T^{k\beta+1}}{k!(k\beta+1)}\right] \quad (15)$$
$$-C_h I_0-\frac{C_0}{T}$$

From equation $\frac{dTC}{dT}=0$, we get

$$T=\frac{(P_s-C_a)}{C_0}I_0T\left(e^{\alpha T^\beta}-1\right)$$
$$-\frac{1}{C_0}\left[(P_s-C_a)-\frac{C_hT}{2}\right]I_0\alpha\beta T^{\beta+1}e^{\alpha T^\beta}$$
$$+(a+bt+ct^2)\alpha\beta e^{\alpha T^\beta}T^3\frac{(P_s-C_a)}{C_0}\sum_{k=0}^{\infty}\frac{(-\alpha)^k T^{(k+1)\beta-1}}{k!(k\beta+1)}$$
$$-\frac{1}{2}\alpha\beta\frac{C_h}{C_0}(a+bt+ct^2)T^4e^{\alpha T^\beta}\sum_{k=0}^{\infty}\frac{(-\alpha)^k T^{(k+1)\beta-1}}{k!(k\beta+1)}$$
$$+(a+bt)\frac{(P_s-C_a)}{C_0}e^{\alpha T^\beta}T^3\sum_{k=0}^{\infty}\frac{(-\alpha)^k k\beta T^{k\beta-1}}{k!(k\beta+1)}$$
$$-\frac{1}{2}\frac{C_h}{C_0}(a+bt+ct^2)e^{\alpha T^\beta}T^3\sum_{k=0}^{\infty}\frac{(-\alpha)^k T^{k\beta}}{k!} \quad (16)$$

We can find the optimal cycle time T^* by computer search from the equation (16).

NUMERICAL EXAMPLES

Two examples are given to illustrate the models derived: the first example illustrates the application of the EOQ model where ameliorating rate is less than the demand rate in the system, and in the second example, PSQ model is presented and partial selling quantity S_0 was obtained by the proposed procedure where the ameliorating rate is greater than the demand rate.

Example 1

A fish breeder sells raw fish in a small sea village .The average demand rate of raw fish is 1000kg/day, thus he orders fish periodically when the tank is almost empty. The fish in the water tank is almost empty. The fish in the water tank ameliorate by the rate, $\alpha\beta t^{\beta-1}$ where α and β are estimated by the historical data.

Table 1. Results of Example (Optimal Cycle Time T*, Optimal Order Level I_0, Minimum cost TC*)
Tabela 1. Wyniki przykładu optymalna czas cyklu T*, optymalny poziom zamówienia I_0, koszt minimalny TC*)

α	**β = 0.05**	**β = 0.10**	**β = 0.15**	**β = 0.20**	**β = 0.25**	**β = 0.30**
α = 0.05	0.8677 13.4148 654.3691	0.8696 13.3145 645.3895	0.8707 13.2595 640.7897	0.8788 13.2287 638.5575	08795 13.2070 638.3567	0.8854 13.1710 638.1224
α = 0.10	0.8863 12.7850 577.0362	0.8754 13.2195 532.6083	0.9917 13.0097 530.4795	1.0342 12.8575 511.4327	1.2342 12.4495 503.4782	1.5763 12.0876 490.5728
α = 0.15	1.0171 11.3444 466.4275	1.0197 11.2052 466.0275	1.0292 11.0095 465.8793	1.0497 10.9782 465.3475	1.0875 10.7775 465.1175	1.0999 10.3575 464.8792
α = 0.20	1.0417 10.0803 425.8881	1.0385 10.0203 425.8023	1.0475 9.8883 423.2372	1.0871 9.8655 .422.8873	1.0892 9.8472 421.4188	1.0922 9.8237 420.4855
α = 0.25	1.0657 8.7764 377.4221	1.0591 8.4611 355.1482	1.0676 8.1271 338.0237	1.0759 7.6488 302.1273	1.0840 7.1375 264.4525	1.0919 6.5933 257.4377
α = 0.30	1.0694 7.6472 355.0633	1.0801 7.3445 313.0663	1.0909 7.0808 285.3861	1.1015 6.5828 257.4649	1.1117 6.0353 229.6248	1.1217 5.4877 202.4027

The data needed are given as:

$$R(t)=a+bt+ct^2=1000+100t+20t^2$$
$$C_a=4{,}000W/unit$$
$$C_h=400W/kg/day$$
$$C_p=10{,}000W/kg$$
$$C_0=300{,}000W$$
$$p_s=20{,}000W/kg$$
$$\alpha=\beta=0.05\sim 0.3$$

The results of the computer program output are in Table 1.

Example 2

This example is the case that the amount of unit ameliorated is greater than demand rate. The input data for PSQ model are given as

$R(t) = 1000 + 100t + 20t^2$

$C_a = 1{,}000W / kg$

$C_0 = 30{,}000W / unit$

$C_p = 8{,}000W / unit$

$C_h = 400W / unit / time$

$p_s = 10{,}000W / unit$

$\alpha = \beta = 0.5 \sim 1.2$

When $\alpha = 0.5$ and $\beta = 0.5$, the optimal partial selling quantity and the total cost per cycle time are

$T^* = 0.0032$

$TC^* = 79.4201$

$S_0^* = 6.0018$

The results from example 1 and 2 which show different cases of ameliorating inventory models are obtained by programming with equation (8), (10), (14) and (16).

CONCLUSIONS

The inventory model for items with Weibull ameliorating is developed. For the case of small ameliorating rate (less than linear demand rate), EOQ model is developed, and for the case where ameliorating rate is greater than linear demand rate, PSQ model is developed. So the surplus amount of items accumulated in the inventory system during the time elapsed can be sold by economic conditions. In the proposed models can be used to analyze the ameliorating inventory systems well, and known to be useful practice can be done.

In the example, α and β are assumed to proper fraction (i.e. $0 < \alpha < 1, 0 < \beta < 1$) When β increases the optimal cycle time, optimal order level and the total cost will decreases. This indicates that the ameliorating rate is a decreasing function with respect to time. Generally, the fast growing animals or high speed fishes, the rate of amelioration is initially high and then it decreases over time

The present model is very importance in the developing countries like India, Pakistan, Nepal, etc. as the culture of life stocks like high breed broiler, pig, fish, etc. has been taken up now-a-days in a very large scale.

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UWAGI DOTYCZĄCE MODELU ZARZĄDZANIA ZAPASEM PRODUKTÓW PRZETWORZONYCH UZALEŻNIAJĄCEGO WIELKOŚĆ ZAMÓWIENIA OD ZMIENNEJ CZASU

STRESZCZENIE. **Wstęp:** Praca porusza zagadnienie rozwoju modeli zarządzania zapasem dla produktów przetworzonych. Dotyczy ona produktów, których użyteczność wzrasta wraz z upływem czasu poprzez zastosowanie procesów ich obróbki ulepszania.
Materiały i metody: W pracy oparto się na dwóch modelach: pierwszy z nich to model ekonomicznej wielkości zamówienia (EOQ) dla towarów, których użyteczność wzrasta zgodnie z dystrybucją Weibulla, natomiast drugi to model częściowej sprzedaży (PSQ) nadwyżek zapas nagromadzonych poprzez aktywności mające poprawę ich użyteczności i charakteryzujące się popytem liniowym. Celem tej pracy było wypracowanie matematycznego modelu dla zarządzania zapasem dla typu towarów omawianych tutaj. Praktyczne działanie modelu przedstawiono na zaprezentowanych przykładach.
Wyniki i wnioski: Wypracowano model zarządzania zapasem towarów podlegających wzroście wartości Weibulla. Dla przypadku, gdy wskaźnik poprawy przybierał niską wartość (mniejszą niż wskaźnik popytu liniowego) opracowano model EOQ, natomiast dla przypadku, gdy ten wskaźnik był większy niż wskaźnik popytu liniowego, opracowano model PSQ.

Słowa kluczowe: zarządzanie zapasem, wskaźnik poprawy, ekonomiczna wielkość zamówienia, wielkość sprzedaży częściowej, powtórne zamówienie.

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BEMERKUNGEN ZUM MODELL FÜR BESTANDSFÜHRUNG VON VERARBEITETEN PRODUKTEN IN HINSICHT AUF DIE ABHÄNGIGKEIT DER BESTELLGRÖßE VON DER VARIABLEN DER ZEIT

ZUSAMMENFASSUNG. Einleitung: Die Arbeit geht auf die Problematik der Entwicklung von Modellen für die Bestandsführung von verarbeiteten Produkten ein. Sie betrifft die Produkte, deren Brauchbarkeit durch die Anwendung von Veredelungsverfahren mit der Zeit wächst.
Material und Methoden: In der vorliegenden Arbeit stützte man sich auf zwei Modelle: das erste stellt ein Modell der wirtschaftlichen Bestellgröße (EOQ) für die Waren, deren Brauchbarkeit gemäß der Weibull-Distribution wächst dar, das andere dagegen bezieht sich auf den teilweisen Verkauf (PSQ) von Überständen der Bestandsvorräten, die sich durch die lineare Nachfrage charakterisieren und durch Anwendung von den auf die Verbesserung deren Brauchbarkeit hinzielenden Veredelungsverfahren bereitgestellt wurden. Das Ziel der Arbeit war es, das mathematische Modell der Bestandsführung der besagten Warentypen auszuarbeiten. Die praktische Funktionsausübung des Modells stelle man anhand der angeführten Beispiele dar.
Ergebnisse und Fazit: Man hat ein Modell für Bestandführung von Produkten, die dem Ansteigen des Weibull-Wertes unterliegen, ausgearbeitet. Für den Fall, in dem die Verbesserungskennziffer niedrig (niedriger als die Kennziffer der linearen Nachfrage) bemessen war, hat man das EOQ-Modell konzipiert, dagegen für den Fall, in dem die Verbesserungskennziffer als die Kennziffer der linearen Nachfrage größer war, hat man das PSQ-Modell in Anspruch genommen.

Codewörter: Bestands- und Vorratsführung, Verbesserungskennziffer, wirtschaftliche Bestellgröße, Teilverkaufsgröße, wiederholte Bestellung.

Gobinda Chandra Panda
Dept. of Mathematics
Mahavir Institute of Engg.&Technology,
BBSR,Odisha, India
e-mail: gobinda1900@gmail.com

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THE COMPREHENSIVE INTERMODAL PLANNING SYSTEM IN DISTRIBUTED ENVIRONMENT

Olgierd Dziamski

Instytut Logistyki i Magazynowania, Poznan, Poland

ABSTRACT. Background: Goods distribution by containers has opened new opportunities for them in the global supply chain network. Standardization of transportation units allow to simplify transport logistics operations and enable the integration of different types of transport. Currently, container transport is the most popular means of transport by sea, but recent studies show an increase in its popularity in land transport. In the paper presented the concept of a comprehensive intermodal planning system in a distributed environment which enables more efficient use containers in the global transport. The aim of this paper was to formulate and develop new concept of Internet Intermodal Planning System in distribution environment, supporting the common interests of the consignors and the logistic service providers by integrating the transportation modes, routing, logistics operations and scheduling in order to create intermodal transport plans.

Methods: In the paper presented and discussed the new approach to the management of logistics resources used in international intermodal transport. Detailed analysis of proposed classification of variety transportation means has been carried out along with their specific properties, which may affect the time and cost of transportation. Have been presented the modular web-based distribution planning system supporting container transportation planning. Conducted the analysis of the main planning process and curried out the discussion on the effectiveness of the new web-based container transport planning system.

Result and conclusions: This paper presents a new concept of the distributed container transport planning system integrating the available on the market logistics service providers with freight exchange. Specific to container planning new transport categories has been identified which simplify and facilitate the management of intermodal planning process. The paper presents a modular structure of Integrated Internet Planning and Scheduling system that combines in one place freight exchange with logistics service providers along with all possible clients dispersed around the world. Comprehensive integration of many participants in the intermodal transport process creates new opportunities for access to distributed logistics services. Computed complex planned routes consisting of several carriers can become an important competitor to traditional Third Party Logistics providers.

Key words: planning, intermodal planning system, containers, distribution.

INTRODUCTION

The intermodal container called also freight container rely on a standardized reusable steel box which enable safe, efficient, secure storage and movement of materials or products within a global containerized intermodal freight transport system. Invention of container facilitate possibilities to build and manage intermodal transportation system. It is the transport system whereby two or more modes of transport are used to transport the same loading unit in an integrated manner. It is integrated activities like delivery to shipper dock, load with freight and sealed, release to transportation company and transport by truck, rail or ship. On the other hand multimodal transportation is the continuous movement of goods by more than one manner. It is actually physical good movement activities like: load pallets of freight, load into a truck than unload

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from it and load onto a ship and so on. Standardisation of transportation unit support convenient move from one mode of transport to another without unloading and reloading the contents of the container. The first standardised steel shipping container has its origins in the 1950s when commercial shipping operators and the US military started developing new logistics method named Container Express or abbreviation ConEx. The first standardisation by ISO for containers were published between 1968 and 1970. Later in 1972 the International Convention for Safe Containers was established for the safe handling and transport of containers. Organization decrees that every container travelling internationally has to be compliant with CSC-Plate unifying safe and handling conditions.

Using Containers for shipping goods enables standardisation and simplification of transportation process in many stages. Every logistic operator or any player involved in handling containers is prepared for the same logistic units which create possibilities to combine more logistics services. The intermodal freight transportation utilise those handling features and enables move cargoes from origins to destinations using two or more transportation modes such as air, ocean, rail, and road. The intermodal containers services are offered mainly by third party logistics companies which manage multimodal transportation services in behalf their customers. There are number of complex interrelated operations which nowadays require support by integrated systems like NPS (Network Planning System), NOS (Network Optimization System), and DSS (Decision Support System). Since third parties companies inters are to offer as much logistic services in intermodal transportation then they are reluctant to cooperate or to integrate some transportation modes between each others. It makes some drawback for customers which have to rely only on Third Party Logistic providers.

The aim of this paper was to formulate and develop new concept of Internet Intermodal Planning System in distribution environment. The solution should supports the common interests of the consignors and the logistic service providers by integrating the transportation modes, routing, logistics operations and scheduling in order to create intermodal transport plans. In addition new solution should help resolve some inflexibilities and heaviness of container logistics, which might lead to increase its popularity.

CONCEPT OF INTERMODAL PLANNING SYSTEM

The concept of new intermodal transport planning system combine in one place several logistics process which enable to more versatile planning and better resource utilisation. The two main fields have been extended and changed which bring new quality and flexibility into multimodal transport planning. First one is the resource management. The categories of resources have been extended to three types:

- fixed resources,
- rough resources,
- on demand resources

Introduction of more versatile resources categories opens more possibilities in smooth integration of different transportation lane in multimodal transportation plan. It helps to combine resource characteristics and their availability for multimodal container transportation. Each resource category varies in service time, economics of scale, geographical restriction and so on, which might influence on resource cost, speed of services or accessibility. Application of three resources categories provide one flexible solution which can cover wide geographical service area and allow to use many transportation modes.

In addition, the new concept of multimodal planning module utilise the notion of combining benefits of multimodal transportation network with flexibility of a freight exchange platform. The conventional concept of planning activities base on assigning available resources to planed in the future tasks. All attributes of resources like cost, performance and availability have to be known at planning time. Furthermore, resources should have defined services activities which are constant during planning

process. The fundamental differences between new and old planning method lay in managing logistic resources. From the point of view of availability there are two kinds of resources:

- Estimated availability of resources in the tool's data base;
- Request for available resources through the freight exchange

Now we might assume that there is possibility of establish delivery plan for estimated resources and their availability and cost. The first category allow to define the range of services and availability of resources. It is possible that transportation resource might start anywhere in defined region and end somewhere in another region. Only certain type or resources, which have flexibility and freedom in selection of start and destination might fall in this category.

The second type of resource comes from the freight exchange portals concept and it is modified to use for multimodal container transportation. The freight exchange portal is widely used for short and medium range distance transportation for Full Truckload - FTL and sometimes is used for Less Than Truckload - LTL. The notion of the freight exchange is extended to the containerised transports that may be performed on road chassis, container trains, barges or feeders and large vessels.

The introduction of request for available resource type has substantial influence on planning concept. It divide planning process into two stages. At the first stage basing on current demand the Request for Resources - RFR is coming from the demand for transportation services. At the second stage all available resources available at the market are confirmed and converted into available for planning resources. The actual planning process integrate all demands - transportation request with all three types of resources in one planning activity. The system at one point in the time has on one side transportation request and on the second side all possible resources organized by three categories which might be assigned in order to build intermodal transportation plan.

The new concept of multimodal transport planning introduce another useful feature for Logistic Service Client. He might have opportunity to see more than one possible planning solution using different available resources types. The ICT application operator can rank proposed plan by the:

- cost category,
- delivery due time,
- CO2 emission,
- handling flexibility.

SYSTEM ARCHITECTURE OF INTERMODAL PLANNING

The intermodal Transportation Planning System is composed of five modules responsible for handling dedicated areas:

- resource,
- constrains,
- demand,
- negotiation and approval of a plan and
- execution.

Figure 1 presents schema of the multimodal transportation system. The process begins at the order management rectangle located in demand management module. This module is responsible for managing demand and calculation integrated intermodal plan. The resource constrains management deals with of all kind of constrains which need to be fulfil by calculated transportation plan.

The negotiation and approval module helps to conduct communication with service providers in obtaining additional resources form transport exchange and helps to conduct negotiations between partners involved in delivery planning. Once the plan is approved it goes to the execution module were final confirmation from resources are received.

New concept of intermodal Planning system compose of five main modules. Each one provides services for dedicated domain. There are number of interactions between modules and their sub modules.

Resource Management module - This module handle all three types of resources. The fixed and rough types that are stored in database and are ready to use. The requested

resource coming from transport exchange are obtained on demand from external services. This module helps to convert them to be ready to use by planning part of the system.

Demand Management module - is a module responsible for providing and managing the transport orders. Logistics service clients who are registered in the system can provide their transport inquiries to the system using user interface or electronic message. The transport inquiries are managed also by logistics service clients, they might be confronted with existing transport services on which the initial plan or offer is being built. Users then may choose the interesting offers for them and negotiate them or agreed with logistics service providers.

Offers and Negotiation module is a place where users may negotiate or re-negotiate the initial offers. The logistics service clients may propose changes in a few parameters like cost, service time and transport mode. This module is responsible for approval of requested resources from transportation exchange and confirmation of multimodal delivery plan for all services providers.

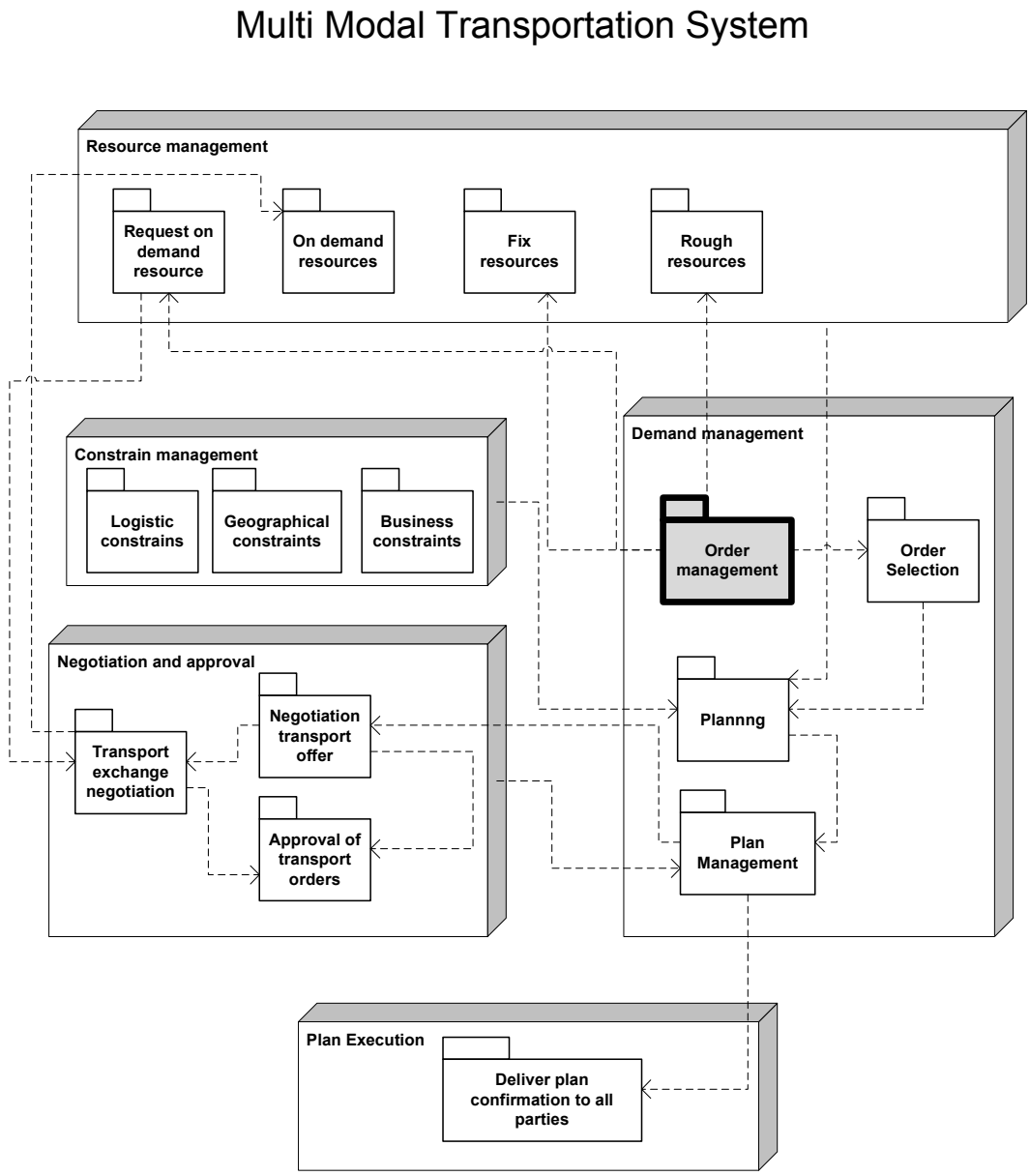

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Fig. 1. Architecture of the Intermodal Transport Planning System
Rys. 1. Struktura Systemu planowania transport intermodalnego

Constrains management - It contains subsystem responsible for handling business, logistic and geographic constrains. The first one helps to define condition and restriction for cooperation of service providers. Some logistic companies might not be open to accept all external services. The second subsystem helps to defines condition on logistic locations like service hours or available equipments. The last subsystem deals with calculation of distance between physical locations. Since system supports many resource types the distance calculation might be provided by linear equation computing cost of transportation means by covered distance. The anthers computation method rely on service area or zone of services. It does not require direct distance calculations but simple estimation of location beginning and ending of logistic services

Execution of transport plan - this module distribute message with confirmation of booking resources for multimodal transportation plan. The clients are able to trace the current status of delivery stage provided by the service providers. It can also support communications between clients and service providers for helping notify some emergency conditions and coordinate payments for rendered services.

USER PROFILES

The new concept of Intermodal Transport Planning System utilise phenomenon of Internet and enable to meet all logistics parties in transportation chain. System support the following business roles:

Logistics Service Provider (LSP)

Logistics service providers represent companies rendering logistics and transport activities with the use of all modes of transportation. That include road transport hauliers, operators of intermodal transport, owners of large container vessels as well as feeders. Beside direct carriers, owners of transport means there are numerous companies managing supply chains as freight forwarders, 4thPL integrators offering door-to door service sub-contracting selected carriers on particular sections of the route.

Logistics Service Client (LSC)

Logistics Service Client deals with all activities defining the need for transport and identifying the appropriate services (in industrial transport mostly based on pre-existing agreements especially in case of large shippers). Logistics Service Client in some cases can be Consignor in other Consignee or shipper. Always the one who pays for the transport service. Freight forwarders sub-contracting carries may also be the service client.

Transport Manager, Administration, Security (TMA)

All activities that are directed to setting up and monitoring adherence to rules and regulations in freight transport belong to this domain. One example is monitoring movement of dangerous goods. Another is customs clearance. A third task is related to security along the supply chain. Responsible for proper functioning of the system

Transportation Network Manager(TNM)

Transportation Network Manager extracts all information available regarding the infrastructure (static or dynamic) related to planning and executing transport and makes this information available to the Transport Service Client and the Transport Service Provider. The typical example may be container terminal being independent offering its handling services to the transport companies. On the other hand many inland container rail terminals are part of the intermodal operators' networks and do not offer independently handling services.

MANAGEMENT OF NETWORK RESOURCES

The new concept of intermodal planning system support all earlier mentioned type of

resources. The fixed resources like mostly ports, logistics hubs and terminals or geographical locations are managed in database of the system. They might be entered and stay in database record for long time. We assume that resource description along with services are provided to the system by service providers using the user interface or electronic messages. For the ad-hoc resources system keeps the information about logistics service providers and about the type and region of their services. We distinguish three major types of resources:

Fixed resources - long lasting connections between ports and logistics hubs. Mostly rail and sea connections but also air, in-land water and road. During planning process those resources are always in the same state and all attributes are known for planners. In the negotiation phase planer can obtain second quote for usage of those resources (next to contained in the data base).

Rough resources - in road transport there is practically unlimited number of locations that may be involved. It refers to the road transport service covering whole route as well as road pre-carriage and on-carriage of containers linking the delivery starting and final points with fixed transport hubs as sea ports or rail terminals. The problem of multitude of locations and distance calculations is simplified to new rough resources. The definition of location might be carried by zip code or by range of longitude and latitude.

On demand resources -are the resources found on an open market of transport services, the logistics service client requests transport services and he will get transport offers from logistics service providers. Before those resources are used for planning they have to be approved and converted to known services called on demand resources.

The Locations are critical part of intermodal planning system. They are geographical addresses defined in the transportation systems. Locations are needed for define fixed connections between ports and logistics hubs or city areas. Every fixed services like rail and vessels, system support storing the locations as the starting and ending point of services in the database. Besides these scheduled services there are many others, which starting or ending point might be different with the following transport orders. In addition, for any distance calculation the location defines nodes in distribution graph. Upon these distances the service costs might be calculated or determined by transport service providers.

NETWORK STRUCTURES

Transport networks are the rather fixed connections or transport corridors which exists because of geographical regions or long term business relationships and contracts. Example of that might be the transport corridor from Hamburg to Poland where most of containerized imports of Poland are coming this way. Network structure is built based on the defined services in system database of logistics services. We can have the following types of logistics services: transport services, terminal handling services, warehousing and storage, documents preparation, insurance, customs clearance services.

In the following picture below, the example of possible network structure from Hamburg to Poland is presented. This example shows the transport network with different alternative routes from Hamburg in Germany to Poznan in Poland. There are three alternatives by feeder and truck, truck and railroad and only by truck. Those solutions vary in terms of cost, delivery time and number of services. Depending on transported volume and requested speed of delivery in some case one solution might be more favourable then other.

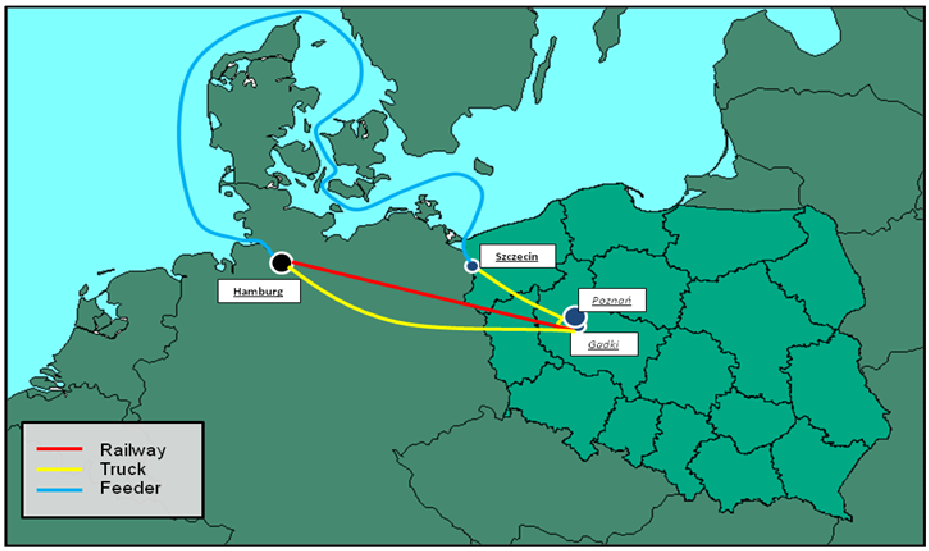

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Fig. 2. Example of transport network from Hamburg to Poznan
Rys. 2. Przykład sieci transportowej z Hamburga do Poznania

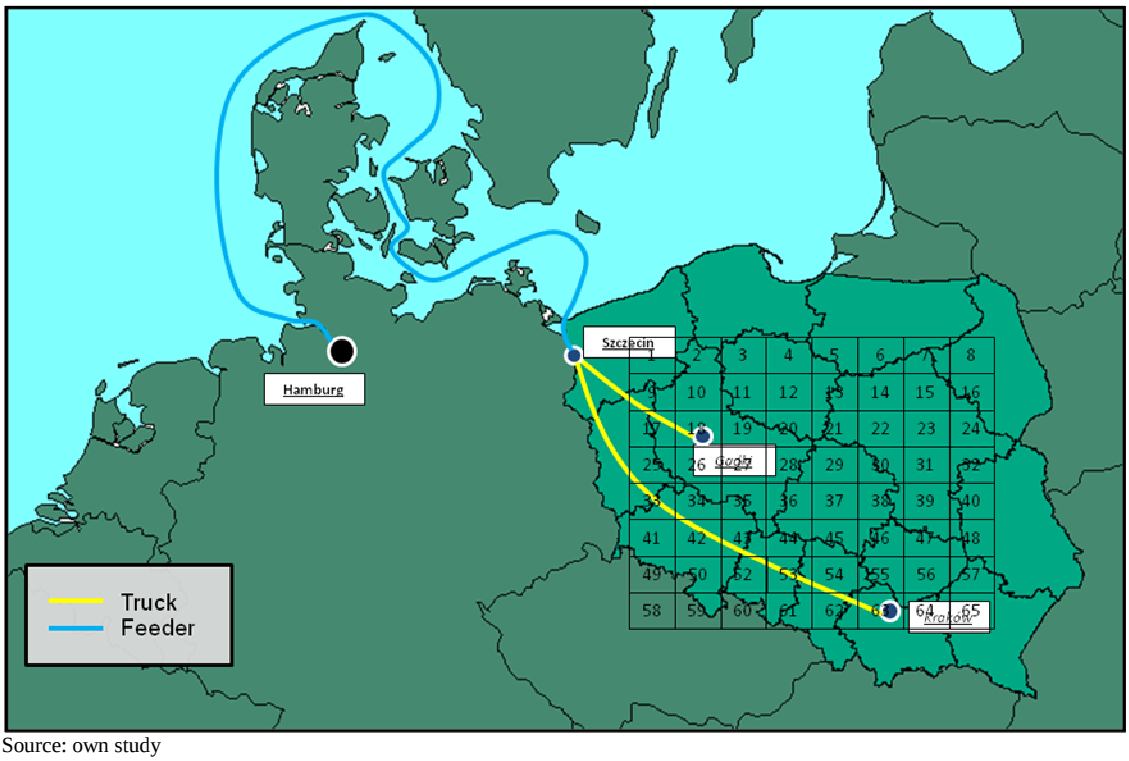

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Fig. 3. Flexible resources - zones of services
Rys. 3. Zasoby elastyczne - strefy usługowe

There are three types of service providers: fixed resources, resources on demand and rough resources. Each services provider corresponds to one of above resource type. Once he was classified the planning system will handle it differently. The railroad connections between two cities or freight transport by sea ports are typical fixed logistics resources. They are fixed by nature of geographical infrastructure which for planning horizon cannot be changed.

Handling rough resources

The notion of rough resources was introduced in order to support pickup and delivery containers form any geographical locations. It is common practice that service providers distinguish price of delivery service by regions. In the picture below there is scenario of delivery containers from Hamburg by feeder to Szczecin and then by truck to Gądki and Kraków. The truck services are provided by rough resources with different quotation for every defined region. In this example there are sixty five regions and Gądki belongs to region 18 and Kraków to 63.

In the following picture flexible resource are provided by service area. There is defined central location and range of distances from it. The further pickup or delivery place are the more expensive service are. Both types of flexible resources can help cover waste geographical area and make feasible calculate of intermodal plan for any number of customers.

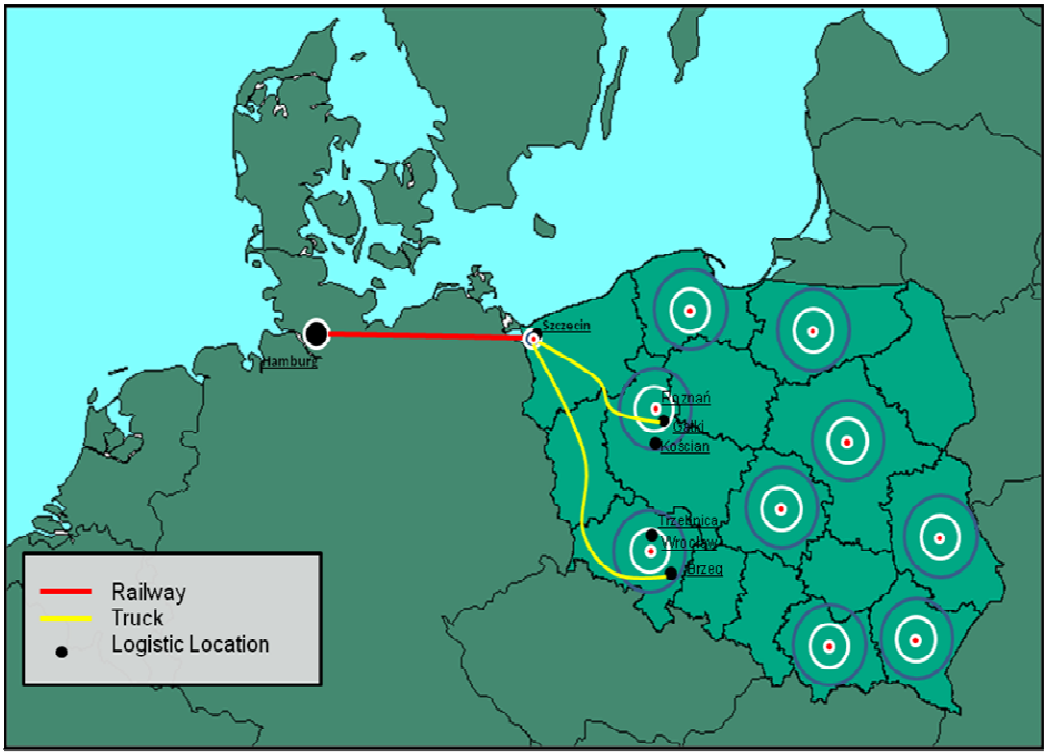

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Fig. 4. Flexible resources - service area
Rys. 4. Zasoby elastyczne - obszar usług

CALCULATION INTERMODAL TRANSPORTATION PLAN

The actual calculation process of delivery plan is executed after selection all orders, and gathering available resources. In addition system has to fulfill all defined constrains which include business, logistics and geographic conditions. Planner might decide that he has all resources to which he wants assign transport orders or he need more from market. In order to extend available logistic resources or find better alternatives he might substitute one resource by current offer from freight exchange market. After he get reply and confirm market transportation offers he can include them to planning process. Planer can even negotiation with all service providers which open possibility to request for better quotations. It can be particular useful in case of

planning bulk transportation where services provider might give lower price in this case.

Planning of intermodal transport services

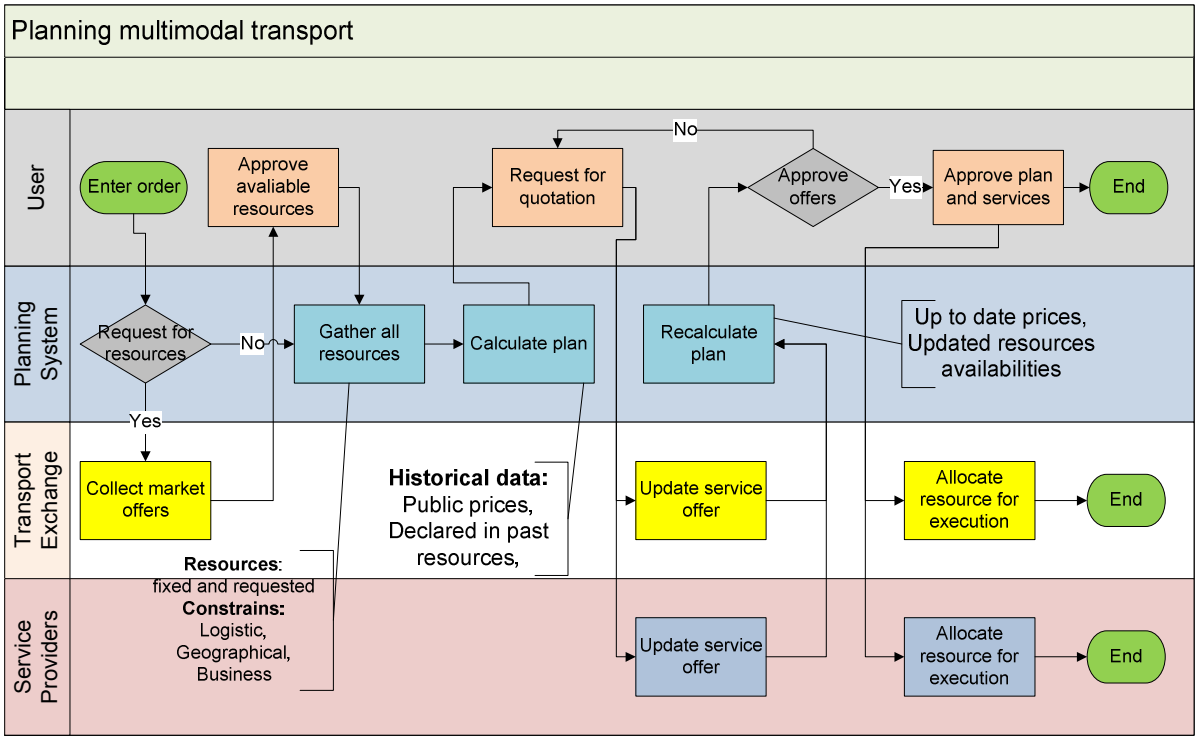
The concept of intermodal transport planning is depicted in UML sequential diagram in the picture below. It is composed of five main stages:

- collecting transportation market offers,
- gathering all system and resources constrains,
- calculate plan,
- negotiation with service provider for better transport service
- selection the best transportation plan.

The system constrains include business, geographic and logistics condition which need to be fulfilled during computation of plan. Horizontal axes correspond to four actors of the system.

- user who wants to calculate intermodal delivery plan,
- information system,
- external transport exchange system,
- service providers which can render services for this particular plan.

The process begins at user channel from entering orders and sending request for resources to Planning System. In response the external system can provide market offer which users need to approve and convert to resource used for planning. At this stage system gather all defined fixed and flexible resources from his local database and begin calculation of intermodal plan. Since the plan is computed users can began negotiation with service providers by requesting them for current quotation. He can get those information from freight exchange and from service providers. Again system compute intermodal plan. After users approve it the appropriate information about booking resources are send to transport exchange and all service providers. At this stage plan is ready for execution.



Source: own study

Fig. 5. The concept of the intermodal transport planning
Rys. 5. Koncepcja planowania transport intermodalnego

SUMMARY

The advent of new ICT systems supporting rational and well balanced decision making open new opportunities in restructuring multinational transport networks into more sustainable according to the co-modality concept. The main idea behind implementation decision support systems lay in supplying shippers with objective market information concerning all possible transport opportunities along with multimodal corridors. With on-line access to time schedules and tariffs of carriers and freight forwarders the decision makers may fully exploit intermodal container advantages.

The new concept of Intermodal Planning System comes with flexible support for all partners in intermodal container transportation network. Tanks to seamless integration of versatile logistic resources with easy access to service provider all kind of users can meet in one virtual place. They have unique opportunity to see consignors demand and available logistics services at one location. The ultimate benefits of described system comes from computation one intermodal transportation plan which is visible at the same time to all users. This plan on one side sits in virtual space but on the other is already confirmed by all services providers and accepted to execute by consignors.

The objective of the paper was presumption that there is possibilities to apply modern Internet technology in building efficient distribution plan for intermodal transportation. The research reviled the versatile of logistic resources, they characteristic in many dimensions like time, space and accessibilities. Paper comes with proposition of comprehensive integration of demand for logistics services along with available resources capable to perform requested services. Application the Internet technology to meet in one virtual place consignor, consignee and all available on the market logistic services opens new competitive market place for cheaper and better logistic services. It can lead to create new platform offering competitive services to Third Party Logistics Providers. This prove the usefulness and legitimacy to build described in paper new Intermodal Logistic Planning System both for buyers of services and all kind of logistic services providers.

Author assume that describe Internet system can create new environment and market place for wider application intermodal transportation means. It can contribute into decrease transportation cost and improve overall logistics services. In addition, it eliminates barriers to access to container transport services and enrich it with new flexible management mechanisms. Since proposed solution utilize modern Internet technology bringing customers and all involved in logistics operations players in one virtual place it will open undisputed possibilities for grow of intermodal transportation services.

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KOMPLEKSOWY SYSTEM PLANOWANIA INTERMODALNEGO W ŚRODOWISKU ROZPROSZONYM

STRESZCZENIE. **Wstęp:** Dystrybucja towarów kontenerami otworzyła nowe możliwości ich dostarczania w globalnej sieci logistycznej. Standardowe jednostek transportowych pozwalają uprościć operacje logistyczne oraz umożliwiają integrację różnych typów transportu. Obecnie transport kontenerowy jest najbardziej popularnym środkiem transportu drogą morską, ale ostatnie badania pokazują wzrost jego popularności w transporcie lądowym. W pracy zaprezentowana została koncepcja kompleksowego systemu planowania intermodalnego w środowisku rozproszonym jako propozycja bardziej efektywnego wykorzystania kontenerów w transporcie globalnym.
Celem pracy było stworzenie koncepcji Internetowego intermodalnego systemu planowania, spełniającego oczekiwania odbiorócw i dostawców usług logistycznych poprzez połączenie w procesie procesie planowania transportu takich elementów jak typu transportu, wyznaczanie tras, operacje logistyczne oraz harmonogramowanie.
Materiały i metody: Przedstawiono i przedyskutowano nowe podejście do zarządzania logistycznymi zasobami wykorzystywanymi w międzynarodowym transporcie intermodalnym. Przeprowadzona została szczegółowa analiza zaproponowanej klasyfikacji środków transportowych oraz ich specyficznych własności, które mogą wpływać na czas i koszty transportu. Przedstawiony został modułowy internetowy system planowania dystrybucji dostępny dla wszystkich uczestniczących w transporcie kontenerowym. Przeprowadzono analizę głównego procesu planowania oraz przeprowadzono dyskusję nad efektywnością nowego internetowego systemu planowania transportu kontenerowego.
Wyniki i wnioski: Praca prezentuje nową koncepcję rozproszonego systemu planowania transportu kontenerowego integrującego dostępnych na rynku przewoźników z giełdę transportową. Zidentyfikowane zostały specyficzne dla planowania nowe kategorie środków transportu, które upraszczają i ułatwiają zarządzanie procesem planowania intermodalnego. Praca prezentuje strukturę modułową zintegrowanego internetowego systemu planowania, który łączy w jednym miejscu giełdy transportowe, logistycznych dostawców usług ze wszystkimi możliwymi klientami rozproszonymi na całym świecie. Kompleksowa integracja wielu uczestników w intermodalnym procesie transportowym stwarza nowe możliwości w dostępie do rozproszonych usług logistycznych. Tak zaplanowane złożone trasy składające się z kilku przewoźników mogą stać się istotną konkurencją dla tradycyjnych operatorów logistycznych.

Słowa kluczowe: planowanie, kontener, system planowania intermodalnego, dystrybucja.

KOMPLEXES SYSTEM FÜR INTERMODALE PLANUNG IM ZERSTREUTEN WELTWEITEN UMFELD

ZUSAMMENFASSUNG. Einleitung: Die Güterbeförderung mittels der Container eröffnete neue Möglichkeiten für Warenlieferung im globalen Logistik-Netz. Standardisierte Transport-Einheiten erlauben, Logistik-Operationen zu vereinfachen und unterschiedliche Transporttypen weitgehend zu integrieren. Heutzutage stellt der Transport per Container das populärste Transportmittel im Seetransport dar, wobei die letzten Untersuchungen auf den Wachstum dessen Popularität auch im Straßentransport hinweisen. Im Rahmen der Arbeit wurde ein Konzept des komplexen Systems für intermodale Planung im zerstreuten weltweiten Umfeld als ein Vorschlag einer effizienteren Inanspruchnahme von Container innerhalb des globalen Transportes projiziert.
Material und Methoden: Es wurde eine neue Herangehensweise an das Management von logistischen, im internationalen und intermodalen Transport beanspruchten Ressourcen dargestellt und durchdiskutiert. Demzufolge wurde eine eingehende Analyse der vorgeschlagenen Klassifizierung der Transportmittel und deren spezifischen Eigenschaften in Bezug auf die Zeitdauer des Transports und die Transportkosten durchgeführt. Es wurde das Konzept

eines modulartigen Internet-Planungssystems für Warendistribution für alle am Container-Transport Beteiligten dargestellt. Der Haupt-Planungsprozess wurde einer Analyse unterzogen, wobei man sich mit der Effektivität des neuen Internet-Planungssystems für den Container-Transport auseinandersetzt hat.
Ergebnisse und Fazit: Die Arbeit präsentiert ein neues Konzept des zerstreuten Planungssystems für den Container-Transport, das die auf dem Markt bestehenden Transport-Dienstleister mit der Transport-Börse zu integrieren vermag. Es wurden dabei die für die Planung spezifischen neuen Kategorien der Transportmittel, die das Management des intermodalen Planungsprozesses erleichtern und vereinfachen, ermittelt. Die Arbeit weist eine modulartige Struktur des integrierten Internet-Planungssystems auf, das die Transport-Börsen und Logistik-Dienstleister mit allen möglichen, in der ganzen Welt zerstreuten Kunden an einem virtuellen Ort in Verbindung setzt. Die komplexe Integration von mehreren, an dem intermodalen Transportprozess beteiligten Nutzern stellt neue Möglichkeiten hinsichtlich des Zugangs zu den zerstreuten logistischen Dienstleistungen her. Die anhand des Systems geplanten Fahrrouten, die von mehreren Transport-Dienstleister bedient werden, können den herkömmlichen Transport-Anbietern gegenüber eine wesentliche Wettbewerbsfähigkeit darstellen.

Codewörter: Planung, Container, intermodales Planungssystem, Warendistribution.

Dr inż. Olgierd Dziamski
Instytut Logistyki i Magazynowania
ul. E. Estkowskiego 6
61-755 Poznań, Poland
e-mail: Olgierd.Dziamski@ilim.poznan.pl

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INFLUENCE OF THE DEMAND INFORMATION QUALITY ON PLANNING PROCESS ACCURACY IN SUPPLY CHAIN. CASE STUDIES

Natalia Szozda[1], Sylwia Werbińska-Wojciechowska[2]

[1]Wroclaw University of Economics, [2]Wroclaw University of Technology, Wroclaw, Poland

ABSTRACT. Background: Identification and analysis of factors that affect the accuracy of demand planning process across the supply chain is one of the most important problems which influence the effectiveness of its material and information flows.
Material and methods: On the basis of demand planning process investigation authors define the main elements affecting the right supply chain performance level and investigate the possible connections between demand information quality and demand planning process accuracy. Later, an overview of some recent developments in the analyzed research area is provided.
Results: Based on the literature review, there is described the defined factors impact on the accuracy of demand plan in each echelon for case companies. There are considered three cases. The examples illustrate supply chains of different manufacturing companies. The focus is placed on demand planning across the supply chains. The issue of determining the accuracy of future sales plans in each echelon of supply chains and factors affecting it are raised. Taking into account the case companies demand planning process analyses, there are defined possible quality measures, that are possible to be used when forecasting the customer demand.
Conclusions: One of the most important and difficult planning area in the companies is becoming planning demand. Errors in planning are reflected not just in the business resource planning but also in the entire supply chain. Presented cases show that many factors affect the proper demand planning process in the supply chain, like e.g. information technologies, lead-time, or number of supplied materials. As it can be seen from the case studies, the model of collecting information from the market plays an important role in the demand planning process.

Key words: demand planning, information flow quality, supply chain.

INTRODUCTION

Supply chain may be defined as an integrated process wherein a number of various business entities (like suppliers, manufacturers, distributors, and retailers) work together in an effort to: (1) acquire raw materials, (2) convert these raw materials into specified final products, (3) deliver these final products to retailers and final customers.

[Beamon 1998]. Such a logistic network is then characterized by a forward flow of materials and a backward flow of information. As a result, the reliability and efficiency of supply chain performance can be affected by many different factors.

There exist many models in the literature which are concerned with material procurement, production, transportation, and storage or distribution activities and with information flows performance. However, lot

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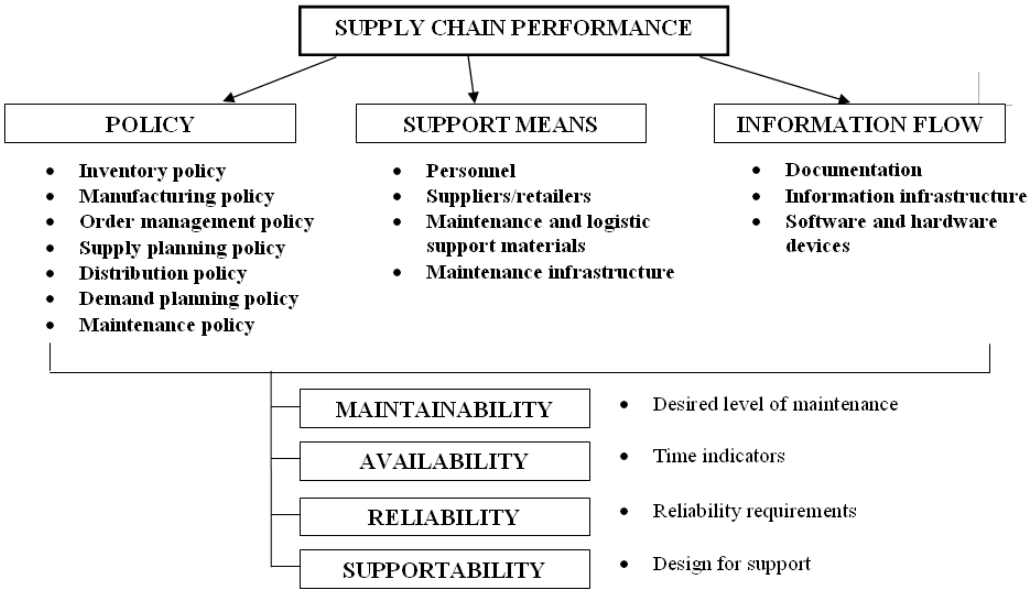
of them treats each stage of supply chain as a separate system [Cohen and Lee 1988]. As a result, many of the supply chain interactions are ignored. This may led to improper identification of elements, which may influence the proper performance of a given chain (Figure 1).

Nowadays, any system cannot perform in a satisfactory manner without reliable information flow. Thus, lots of works are focused mainly on supply chain information flow strategies definition (see e.g. [Vanpoucke et al. 2010]), supply chain information systems management (see e.g. [Gunasekaran and Nagai 2004]), reliability of information flows investigation (see e.g. [Petkova et al. 2005]), or data quality modeling problems (see e.g. [Chen and Wolfe 2011]).

As a result, the focus of this study is to identify factors that affect the accuracy of the demand planning process across the supply chain.

Following this, the rest of this paper is organized as follows: In the Section 2 authors present the main elements affecting the reliable and available supply chain performance. Later, information flow quality and demand planning process accuracy has been investigated. The paper is ended by the presentation of the obtained analysis results in comparison with the knowledge about the case companies' present conditions.

The aim of this paper was to estimate and evaluate some factors, which influence the demand process planning in companies.



Source: Blanchard 2004, Nowakowski 2006, Nowakowski and Werbińska 2006, Werbińska 2008

Fig. 1. Reliability, availability, maintainability and supportability in achieving supply chain performance
Rys. 1. Nieuszkadzalność, gotowość, obsługiwalność oraz zdolność do realizacji wsparcia logistycznego w obszarze zapewnienia funkcjonowania łańcucha dostaw

FACTORS THAT DETERMINE SUPPLY CHAIN PERFORMANCE LEVEL

Supply chain networks are vulnerable to disruptions and failure at any point in the supply chain may cause the entire network to fail. A key factor in effective supply chain management is the ability to minimize the effects of such undesired events/disruptions occurrence. As a result, understanding what disruptions may occur in a supply chain, how they will affect a supply chain system, and how far reaching these effects will be, would be of considerable benefit [Wu et al. 2007].

Treating the supply chain disruptions as unexpected events occurrence, we can describe

them as having uncertainty in supply chain operations [Wu et al. 2007]. Uncertainty in the supply chain can be seen from different aspects, such as [Vlajic et al. 2008]:

- time (in the sense of duration of activity/process, starting/ending moment of activity realization, frequency of activity/demand occurrence),
- quantity (of supply, demand or physical transfer of goods),
- location/place (where activity starts/ends),
- quality (of service/products),
- cost (fluctuation, occurrence).

For example, Landeghen and Vanmaele in their work [2002] profiled sources of uncertainty in the supply chain. They highlighted 13 sources of uncertainty across three supply chain's planning horizons (operational/tactical/strategic) and categorized them as Low, Medium and High.

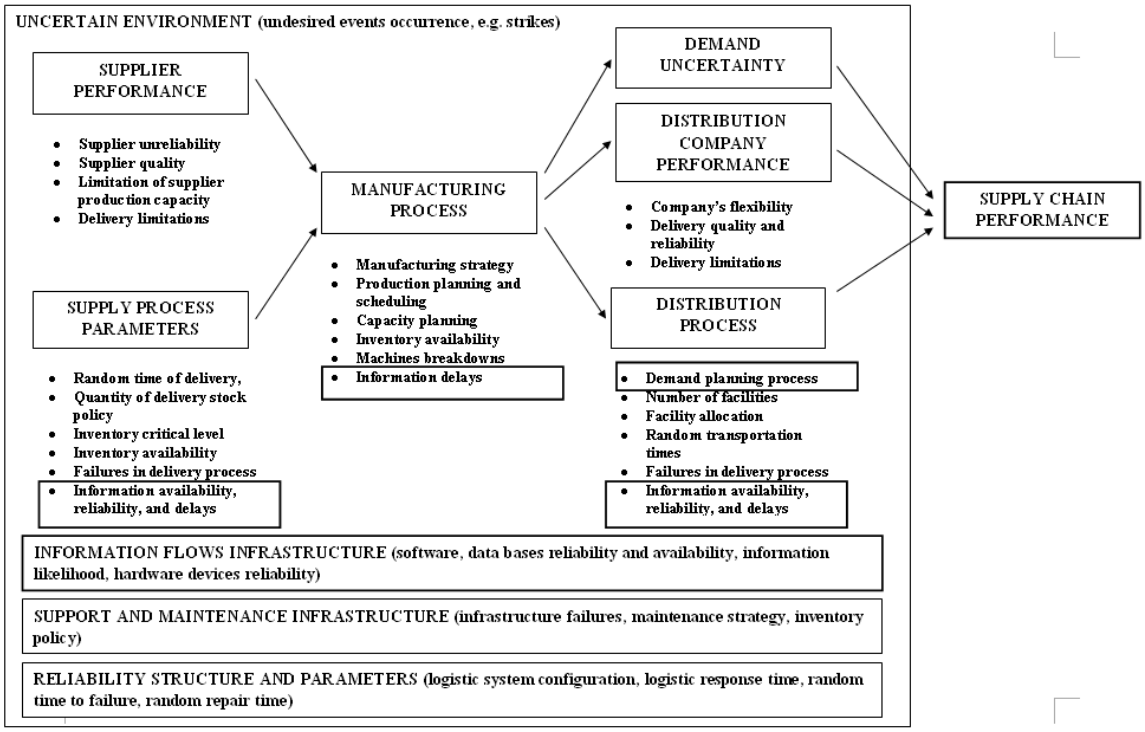


Fig. 2. Main factors which influence supply chain performance
Rys. 2. Główne czynniki wpływające na poziom funkcjonowania łańcucha dostaw

Taking the presented perspective of supply chain disruptions definition, we can identify the main factors which influence the supply chain performance (Figure 2). The factors which may affect the right supply chain performance are divided into six main groups. The first two regard to supply reliability. At the beginning of supply chain even the most reliable supplier could have a late delivery disrupting the whole production process. Moreover, improper supply process parameters could lead organizations to reschedule the regular production because running out of raw materials.

Problems with manufacturing process are the second source of supply chain unreliability. For example, a new machine could fail to work unexpectedly, even if it has just been purchased. The production process interactions, its stability, manufacturing lead time or changes in production technology are mostly unpredictable and usually hard to measure.

Finally, at the end of supply chain random customer demand is the most challenge problem, as well as the distribution process parameters and the condition of distribution company. An inaccurate forecast of customer

demand could lead to overstock or under stock, what could cause the increase of inventory costs of organization performance. Moreover, decisions made during supply chain designing process in the area of distribution process performance also have the influence on chain reliability. The variability of retailers/ distribution centers performance, quality of transportation process, quality of demand planning process or information availability and accuracy may significantly disturb chain performance and lead to fail customer satisfaction achieving.

The researchers pay the most attention on demand uncertainty [Li and Schulze 2011]. The errors in forecasting the customers' demand could be e.g. changing customers' preference, irregularity of customer orders in terms of time, quantity and quality. Thus, in this paper authors focus on demand planning process and its quality. Moreover, the proper demand planning process cannot be executed without reliable and available information. Information sharing and collaboration with trading partners is seen as a company's top logistic challenge [Vanpoucke et al. 2010]. Thus, in the next Section, authors focus on the proper information flow performance and information quality.

INFORMATION FLOWS QUALITY AND RELIABILITY

Two main problems in analysing information flows are its quality and reliability. The information quality can be determined with the use of six attributes described in [Kehoe et al. 1992]. According to them, an efficient and seamless supply chain would ensure that the relevant information on all flows within the network is accurate and comprehensive, being made accessible in the right time, in the correct format.

Many researchers have identified several important characteristics of information quality. For example, authors in [Zhou and Benton 2007] have focused on nine aspects of information quality:

- accuracy,
- availability,
- timeliness,
- internal connectivity,
- external connectivity,
- completeness,
- relevance,
- accessibility,
- frequently updated information.

Moreover, when investigating the information quality, many literature works suggest MIR- concept use [Lin et al. 2004, Molenaar et al. 2002, Petkova et al. 2005, Sander and Brombacker 2000]. The MIR-concept aims at classifying the quality of information flows taking into account their ability to measure. The issues of information quality has been intensively discussed e.g. in [Ahmad and Zailani 2007, Chen and Wolfe 2011, Gustavsson and Jonsson 2008, Suhong and Binshan 2006].

In the reliability theory, there can be found a lot of works devoted to credibility and reliability of technical and logistic systems' information flows assessment. This situation is connected with the uncertainty of operational system data, which determines the level of compatibility between real-life situations and gathered information [Klir 2004, Nowakowski 2010, Nowakowski 1999]. This problem is directly connected with disruptions occurrence during information flows performance. The mentioned disruptions are generated by the operational system itself or its environment [Lopez and Sarigul-Klijn 2010, Nowakowski 2011].

On the other hand, during the supply chain's operational processes planning performance are used historical data and forecast analysis results. Both of the mentioned information sources are also in some way uncertain, what may affect e.g. the expected cost of system performance. The types of errors, which may occur during the information gathering process, are connected with [Madanat 1993, Nowakowski 1999]:

- intentionally input of false data,
- accidentally errors connected with not proper filled documentation,
- unreadable data,
- lack of data,

- errors connected with data processing process.

In turn, demand forecasting models are strictly related with the uncertainty connected with e.g. [Madanat 1993]:

- measurement errors of model's variables,
- randomness of performed processes,
- defined model parameters (e.g. too small statistical trial).

Moreover, the main problems being investigated in the analyzed research area regard to:

- issues of information systems optimal organization (e.g. [Aarset and Ulvestad 1993, Christensen and Voytek 1975, De La Cruz et al. 2006, Durango-Cohen and Sarutipand 2009, Petkova et al. 2005]), connected with e.g. effective decision support system designing,
- reliability analysis of computer devices (e.g. [Huang and Lo 2006, Nasser 1986]),
- information flow reliability analysis, which takes into account the following issues:
  - information credibility (e.g. [Dunbar 2010, Nowakowski 1995]),
  - information incompleteness (e.g. [Bolc et al. 1991, Guidebook 1999, Pierskalla and Voelker 1976]),
  - information uncertainty (e.g. [Lin et al. 2008, Nowakowski 2010, Nowakowski 1999, Rocco et al. 2000]),
- diagnostic monitoring of disruptions occurred during information flows performance in logistics and maintenance systems [e.g. Li and Schulze 2011, Sanchez et al. 2009], or plant maintenance systems [e.g. Carnero 2006],
- optimal system reliability modelling with taking into account the uncertainty information about system elements reliability levels [e.g. Coit 2004, Lin et al. 2003, Marsaguerra et al. 2005, Rakowski 2005, Wang et al. 2004].

As a result, it is important to determine the uncertainty level of obtained results from quality and reliability analysis of given supply chain, and to define how they can be implemented in the chosen decision model application.

DEMAND PLANNING PROCESS

Demand planning is the first step of business planning. As business are moving towards a demand planning becomes the initial step to subsequent business and operations planning process such as purchasing, production, distribution and cash flow planning.

Thus, the performance of a business depends on a large extent upon the quality of the demand plan. The forecasting process is critical for the business success achieving because poor forecast can lead to insufficient or unnecessary high, finished good stocks, unused raw materials, misused production assets, and low margin. The forecasting and demand processes become more critical and difficult because of market evolving, what cause increased pressure on products life cycles, increased global competition and business turmoil. Companies that establish demand planning practice have significant competitive advantages. Every enterprise should make forecast irrelevant to their market sector, size or business activities. Appropriate demand planning process can improve the quality of forecast especially when the increase of number of customers, markets and products can be observed.

Demand planning process depends on inter alia the model of collecting information from the market. It is important to look beyond the enterprise to create correct demand planning process. Two main models can be described - information sharing and non-information sharing models [Chen and Wolfe 2011].

The initiator of the first model is the plan determined on the basis of historical data - most sales forecast. Manufacturer does not collect the information about retailer's orders and its sales data. This model is shown in the Figure 3.

The demand planning process starts when appropriate numbers of historical data are

gathered. Demand planning process starts with demand forecasting, which is a key process for maintaining efficiency throughout supply chain [Crum and Palmatier 2003]. When demand forecasting is considered as a process, the company has clear cut goals and predefined priorities towards it [Makridakis and Wheelwright 1997]. However, some problems appear to arise with demand forecasting. These problems correspond to making a forecast, which is based on pure sales historical data that could cause errors. It also causes a repetition of mistakes due to processing without understanding true customer demand [Sarang and Laxmidhar 2006]. This is the reason why demand forecasting should change or evaluate into demand planning based on multiple inputs. The forecast should be modified using information from the company such as: resources, production capacity, marketing input, product/brand management, statistical analysis, business plan and strategy etc. and environment: customers, competition, technology, economic trend etc. [Crum and Palmatier 2003].

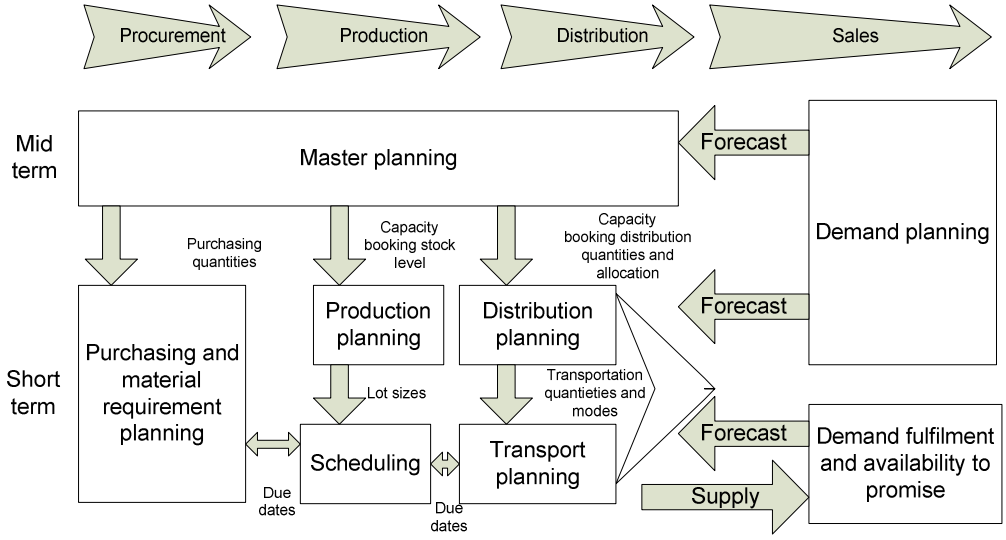


Fig. 3. Mid and short term planning process in manufacturing companies (Rohde 2002)
Rys. 3. Proces planowania średnio- i krótkoterminowego w przedsiębiorstwach produkcyjnych (Rohde 2002)

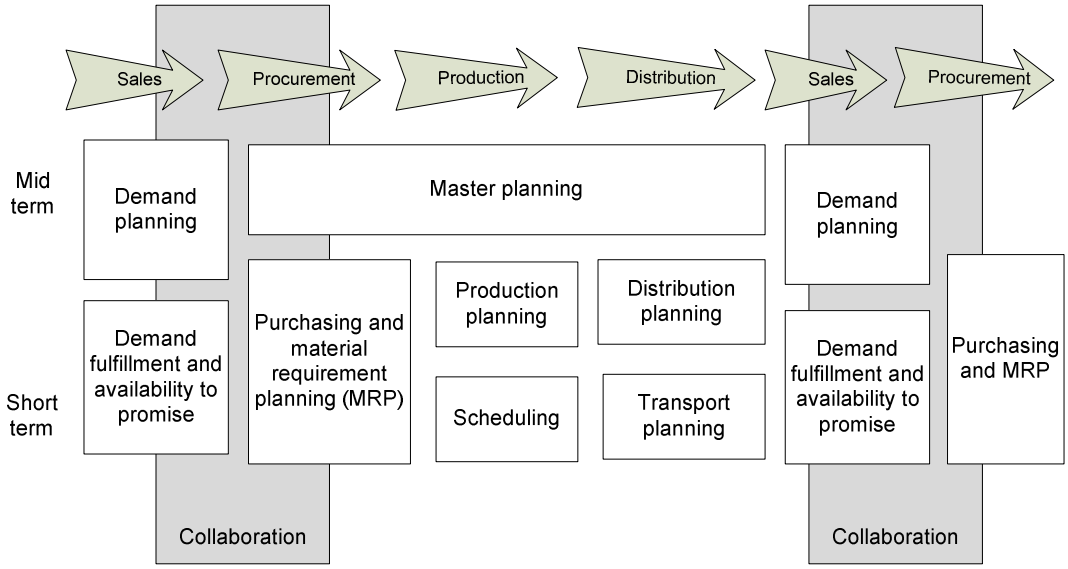


Fig. 4. Mid and short term collaboration planning process in manufacturing companies (Meyr et al. 2002)
Rys. 4. Proces planowania współpracy średnio- i krótkoterminowej w przedsiębiorstwach produkcyjnych (Meyr et al. 2002)

Favorable situation for the companies is connected with planning in the area of interaction with others. Sharing information allows determining the forecast based on the procurement and no historical data. The mid and short term collaboration planning process in manufacturing companies is shown in the Figure 4.

This model can be characterized as continuous planning process. The customers are the initiators of the process and sales collaboration is crucial. Co-operating companies share information on demand patterns, lead times, process and product configuration. If the collaborations are managed appropriately then the downstream supply chain will not lose its capability to promise lead times to customers and at the same time minimize the total costs of the supply chains [Kristianto et al. 2011]. Thus, each of the two shaded blocks in Figure 4 represents both sales and procurement collaboration to create a common and mutual agreed-upon plan [Chen et al. 2009]. Furthermore, sales and procurement collaboration should also be supported by using, for instance, vendor managed inventory (VMI) by sharing demand and inventory information amongst enterprises or factories such that it creates demand collaboration, inventory collaboration, capacity collaboration, and transport collaboration, as shown in the Figure 4 [Kilger and Reuter 2002]. In this model the demand planning process starts when customer's orders are collected. The statistical forecast is replaced by procurements. However, other sources of information are also needed to calculate accurate demand plan, such as: inventory level, business plan and strategy, product/brand management, marketing input, etc.

Although sharing information in the supply chain and the use of different data sources are not always the solution for the problems encountered with the demand planning. It depends on many different factors. Supply chains contain multiple echelons and are faced with uncertain demand and lead-times [Kian and Piplani 2003]. It also depends on the type of business, the products supplied to the market, companies size and production strategy. In the next Section, there is described the factors impact on the accuracy of demand plan in each echelon for case companies.

CASE STUDIES

In this part of the paper three cases are considered. The examples presented below illustrate supply chains of different manufacturing companies. The focus is placed on demand planning across the supply chains. The issue of determining the accuracy of future sales plans in each echelon of supply chains and factors affecting it are raised.

Case study - global car manufacturer

The first company described in this paper is a global car manufacturer. It operates in 22 countries and has more than 1 550 employees. The supply chain and demand information flow is shown in the Figure 5.

In the presented supply chain, there is provided the delivery of 9 product families with many variants in each product family. Due to the high value of final goods, the production process is organized according to the MTO (manufacturing-to-order) strategy. The lead time equals 1-3 months. Planning process bases on customer orders and manufacturer's forecasts about future demand. It is divided into two areas: strategic (capacity) and tactical (S&OP) planning. Capacity planning is a long-term decision which sets the overall level of capacity utilization. Performance decisions impact on lead time, customer responsiveness, operational costs and the company's ability to compete. The second area of planning is S&OP (Sales & Operational Planning) process. It is a common process that balances supply and demand across the extended supply chain. It aim is to maximize financial performance and customer satisfaction in a common plan. Demand planning is used to create forecasts of market demand. Forecast is based on historical sales data, customers' orders, market research, etc. Supply planning is a function of setting the general level of industrial production (production plan) and other activities related to

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capacity evaluation. As a result, there can be defined the planning quality in each echelon of analyzed supply chain (Table 1). Moreover, in the Figures 6-9, the examples of planning errors which occurred in each supply echelon are given.

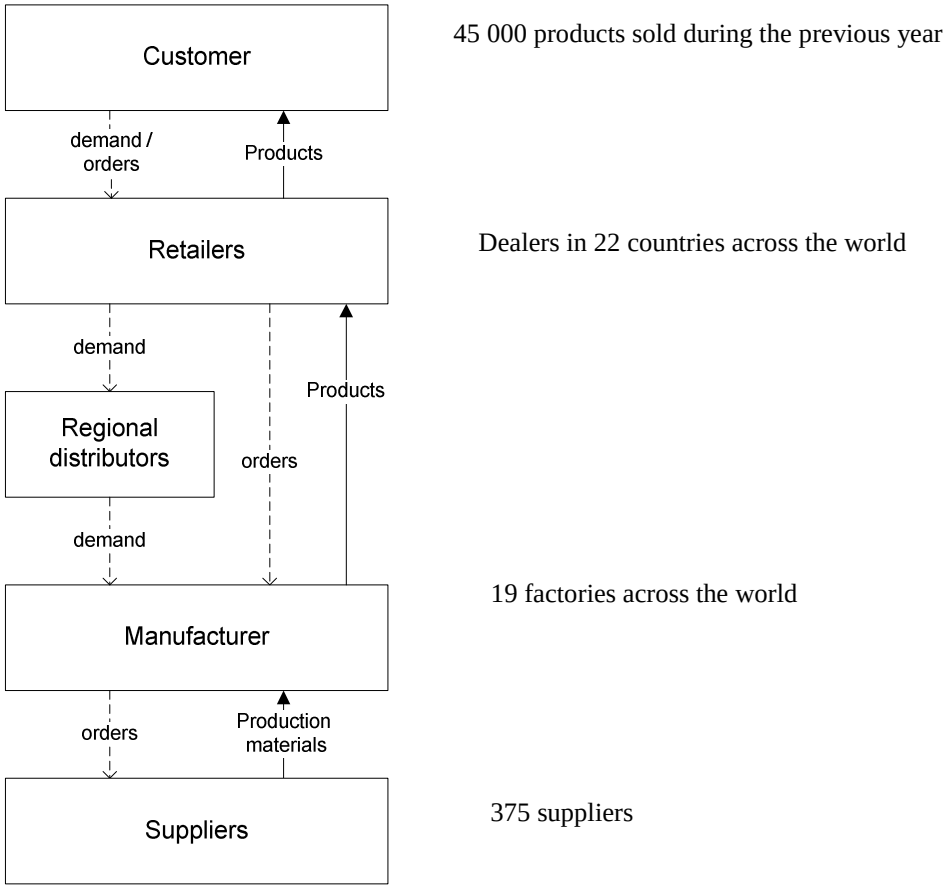


Fig. 5. Supply chain of car manufacturing company
Rys. 5. Łańcuch dostaw przedsiębiorstwa z branży motoryzacyjnej

Table 1. Planning quality in each supply chain echelon (car manufacturer)
Tabela 1. Jakość planowania na poszczególnych szczeblach łańcucha dostaw (producent samochodów)

SUPPLY CHAIN	**Planning focus**	**Collected demand information**	**Planning accuracy**	**What impact the planning accuracy**
Retailers	Demand	Customer order & lead times Sales in values and volumes Market data – customer needs	Average forecast error for the last year equals 9,79%	Targets for dealers
Regional distributors	Demand	Determine future customer needs	Average forecast error for the last year equals 16,44%	Planning is done on total volume level per product family
Manufacturer	Demand and supply	New product development data Sales history - sales in values and volumes Costs Inventory Market forecast	Average forecast error for the last year equals 20,68%	S&OP process
Suppliers	Inventory, storage capacity	Inventory The manufacturer orders	Average forecast error for the last year equals 23,19%	Inventory control

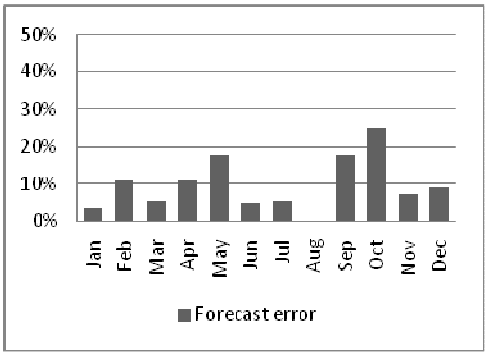


Fig. 6. Example of planning error (Retailers)
Rys. 6. Przykład błędu planowania (Dystrybutor)

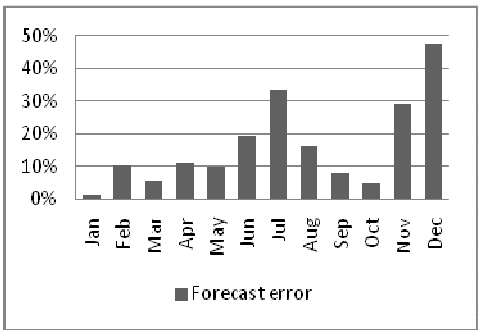


Fig. 7. Example of planning error (Regional distributors)
Rys. 7. Przykład błędu planowania (Dystrybutor regionalny)

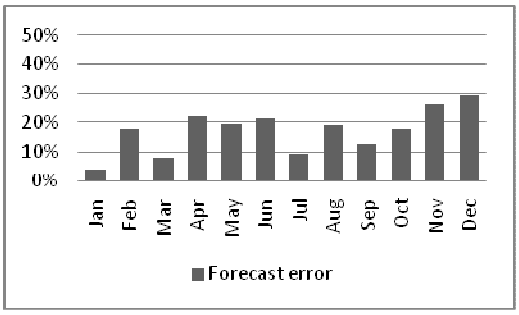


Fig. 8. Example of planning error (Manufacturer)
Rys. 8. Przykład błędu planowania (Producent)

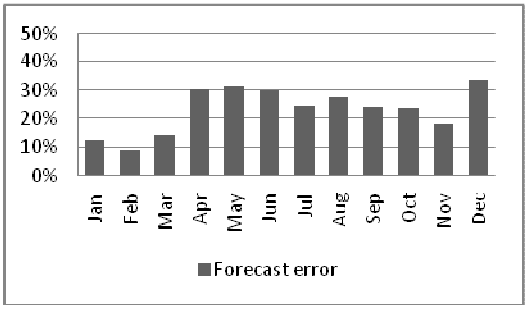


Fig. 9. Example of planning error (Suppliers)
Rys. 9. Przykład błędu planowania (Dostawca)

The strength of demand planning in the supply chain presented above is to use of S&OP process by manufacturer. The most significant fact is that it leads to the synchronization of supply and demand through collaboration between managers in the areas of sales, production and logistics.

Case study - global clothing manufacturer

The next case regards to the global clothing manufacturer from Europe, which has more than 1700 stores around the world. The supply chain is shown in the Figure 10.

In this supply chain manufacturer needs just two weeks to develop a new product and get it to the stores, compared with six-month industry average. Lead-time in Europe equals 2 weeks and 1 month around the world. It launches about 10 000 new designs (100 different product families) which 100% are changed each year. The assortments changes 70-90% each month in retail stores. It is possible by using appropriate manufacturing strategy - MTO (manufacturing to order). The pull system is based on fast reactions to retail sales. In addition to gathering POS data automatically, store manager around the world are in frequent contact by phone with product manager in the design department (Kaipia and Holmstrom 2007). The quick response strategy enables this company to be twelve times faster than its competitors. It allows the company to sell more items at full price. Only 15-20% products are sold of markdown (Table 2).

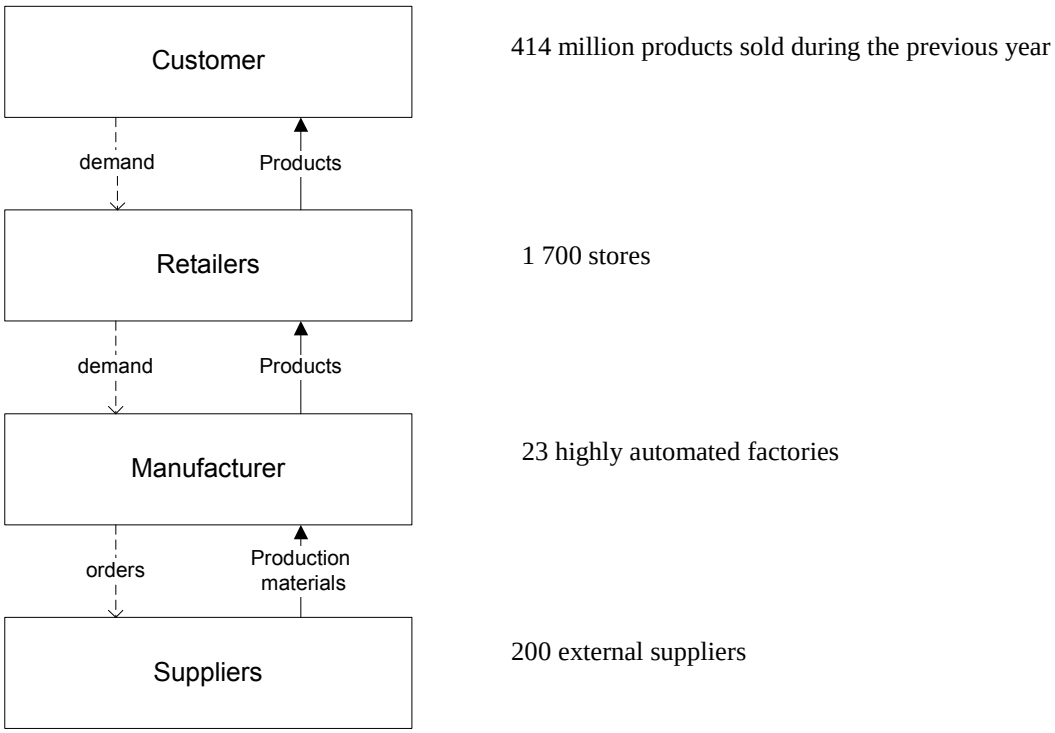


Fig. 10. Supply chain of clothing manufacturing company
Rys. 10. Łańcuch dostaw przedsiębiorstwa produkcyjnego z branży odzieżowej

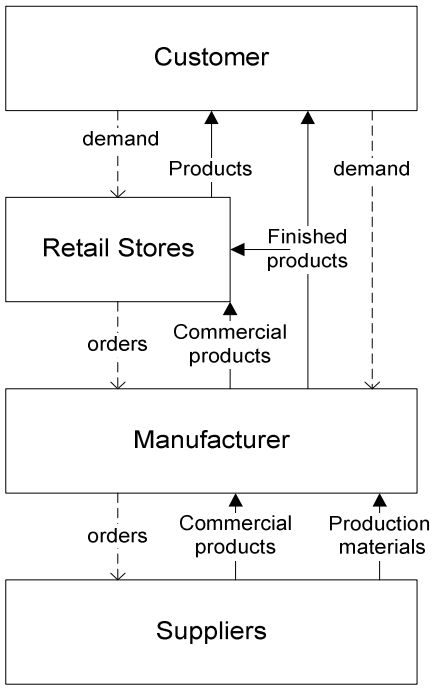
Table 2. Planning quality in each supply chain echelon (clothing manufacturer)
Tabela 2. Jakość planowania na poszczególnych szczeblach łańcucha dostaw (producent odzieży)

SUPPLY CHAIN	**Planning focus**	**Collected demand information**	**Planning accuracy – average forecast error**	**What impact the planning accuracy**
Retailers	Demand	Customers' needs	Markdown 15% - 20%	Quick response strategy, POS terminals – current information on demand transmitted to design department
Manufacturer	Demand / production plan	Customers' needs Trends in the market Market forecast	Markdown 15% - 20%	Quick response strategy; close watch on trends and buying behavior; quick decisions; reducing risk
Suppliers	Inventory, storage capacity	The manufacturer's orders - history and current orders Lack of information about customer demand	Average forecast error 25% - 30%	Inventory control

Despite a large variety of products, demand planning in that supply chain is organized in the right way. Sharing information about customer demand provides quick response and flexible manufacturing system ensures short lead times.

Case study - global furniture manufacturer

The last case shows the supply chain of medium-sized company - a furniture manufacturer, which produces and sells its products at the European market. Its supply chain is presented in the Figure 11.



13 600 products sold during the previous year

2 stores

1 factory

More than 300 suppliers

Fig. 11. Supply chain of furniture manufacturer
Rys. 11. Łańcuch dostaw producenta mebli

Table 3. Planning quality in each supply chain echelon (furniture manufacturer)
Tabela 3. Jakość planowania na poszczególnych szczeblach łańcucha dostaw (producent mebli)

SUPPLY CHAIN	Planning focus	Collected demand information	Planning accuracy – average forecast error	What impact the planning accuracy
Retail stores	Demand	Historical sales	45,17%	6 627 products are offered, lack of forecasting
Manufacturer	Production plan	Historical data	Commercial products – 53,35% Produced products – 46,82%	Production Director experience, statistical analyzes are conducted for each department, forecast for semi-products are calculated
Suppliers	Inventory, storage capacity	Manufacturer orders	Commercial products - 57,19% Production materials – 72,54%	Inventory control

Commercial products are sold from stock (MTS strategy) and furniture production takes place on the customer's order (MTO strategy). Characteristic of this supply chain is the huge number of products - 6 627 commercial products in 50 different families of products are offered and 304 products are produced (13 families). This situation causes a lot of problems. One of them is an accurate forecasting performance. A large number of products make it impossible to predict the demand without a proper predictive system. Another problem appears in the input of production process. It is a large group of suppliers, who providing 3 400 production materials.

Information between manufacturing department and trading units is not exchanged. This causes the large errors occurrence in forecasting process. Forecasts are formulated solely on the basis of available historical data. Data from previous years are updated on ongoing orders. The obtained order quantity is the forecast for future periods. In this supply chain statistical forecast is calculated only for semi-products in various production departments in order to avoid lead-time delay

of the ordered products. This allows managers to keep lead-time of 2-5 weeks (Table 3). In the Figures 12-16, there are presented the examples of planning errors occurred in the supply chain.

In this supply chain the problem is connected with the lack of integration between network echelons and inside the companies. The problem also appears on the input and output of the manufacturing process. A large number of ordered materials and manufactured products prevent effective planning without adequate information system.

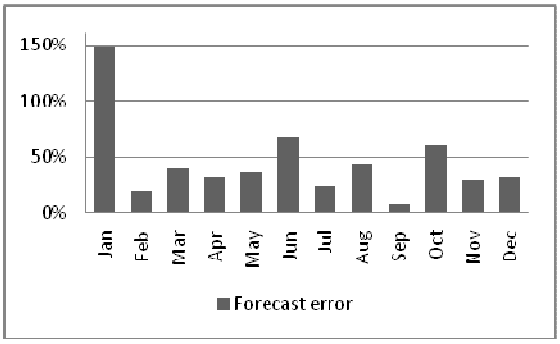


Fig. 12. Example of planning error (Retail stores)
Rys. 12. Przykład błędu planowania (Sklepy detaliczne)

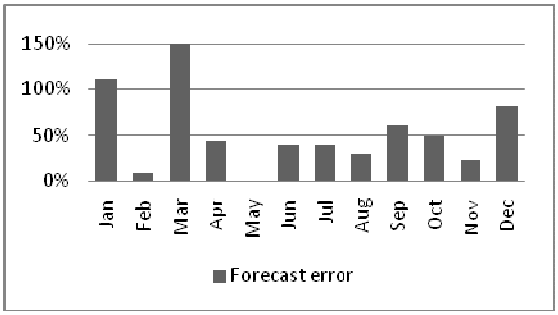


Fig. 13. Example of planning error (Manufacturer - commercial products)
Rys. 13. Przykład błędu planowania (Producent - produkty komercyjne)

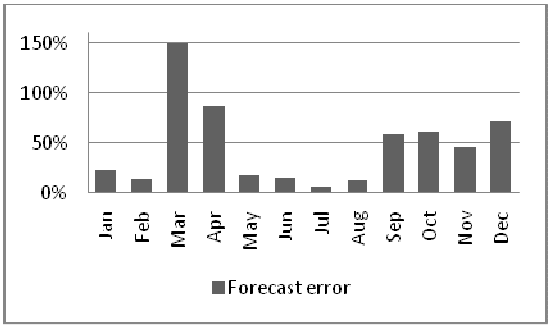


Fig. 14. Example of planning error (Manufacturer - produced products)
Rys. 14. Przykład błędu planowania (Producent - produkty wytwarzane)

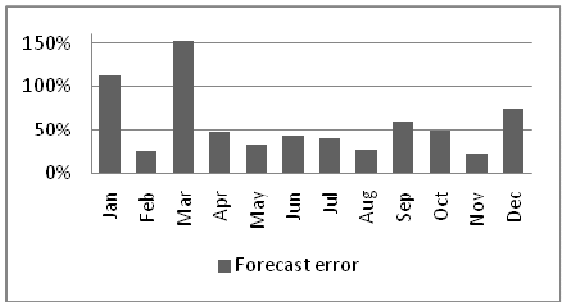


Fig. 15. Example of planning error (Suppliers - commercial products)
Rys. 15. Przykład błędu planowania (Dostawca - produkty komercyjne)

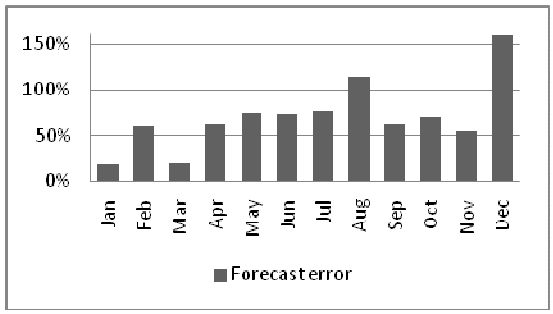


Fig. 16. Example of planning error (Suppliers- production materials)
Rys. 16. Przykład błędu planowania (Dostawca - materiały produkcyjne)

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SUMMARY

The rapid changes in consumer buying behavior change the business environment. It's very important that the company is equipped with the flexibility that allows it to adjust and adapt to changes very quickly (Palladino et al. 2010). One of the most important and difficult

planning area in the companies is becoming planning demand. Errors in planning are reflected not just in the business resource planning but also in the entire supply chain. Presented cases show that many factors affect the proper demand planning process in the supply chain. It includes inter alia: (1) level of collaboration in the relationship - integration, (2) information technologies, (3) lead-time, (4) life cycle phase, (5) demand predictability, (6) number of product variants - product variety, (7) number of supplied materials.

These factors determine the availability and inventory needs to meet demand (Kaipia and Holmstrom 2007). To improve the quality of demand planning some managerial actions are suggested. Efficient information sharing between companies is significant. Using available demand information more effectively, companies are able to predict future demand with higher accuracy. The possibility of integration in supply chain needs information technologies such as transferring data in real time about direct customers' needs. Quick response is more possible and easier to implement when vertical integration is applied. The level of collaboration in the relationship should be as high as possible. More accurate demand plans provide also reduction of product variants and supplied materials. Manufacturers and others companies in supply chains should reduce lead-time as much as possible.

As it can be seen from the case studies, the model of collecting information from the market plays an important role in the demand planning process. The main differences are: the forecast calculations and system reliability. The possible quality measures, that are possible to be used when forecasting the customer demand, are given in the Figure 17.

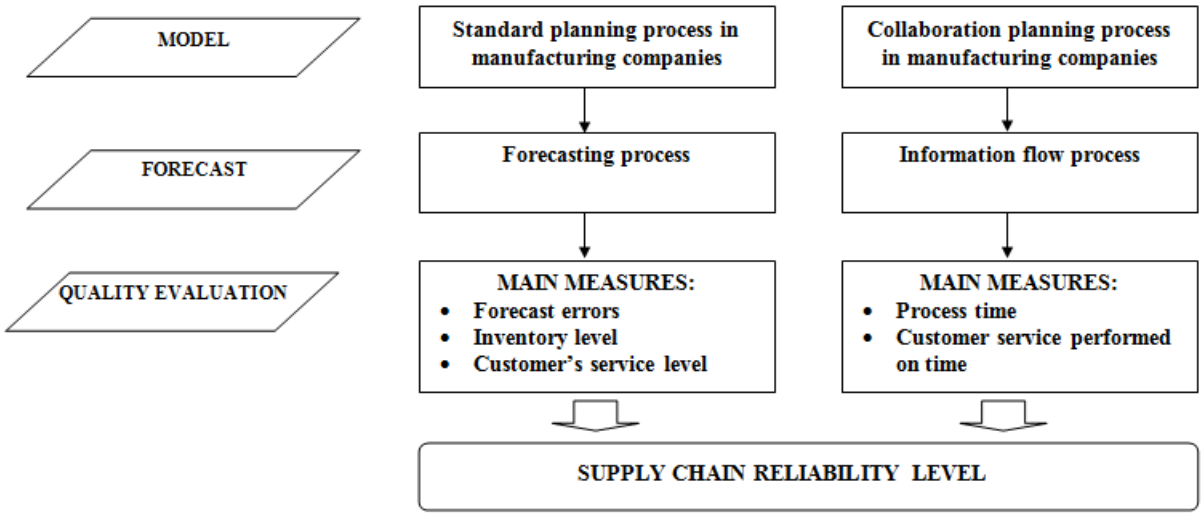

Fig. 17. Quality in the demand planning process
Rys. 17. Jakość w procesie planowania popytu

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WPŁYW JAKOŚCI INFORMACJI O POPYCIE NA DOKŁADNOŚĆ PROCESU PLANOWANIA W ŁAŃCUCHU DOSTAW. STUDIA PRZYPADKU

STRESZCZENIE. **Wstęp:** Identyfikacja i analiza czynników wpływających na dokładność procesu planowania popytu w łańcuchu dostaw jest jednym z ważniejszych problemów wpływających na efektywność przepływów materiałowych i informacyjnych.
Metody: W oparciu o badania procesu planowania popytu autorzy definiują główne elementy wpływające na poziom funkcjonowania łańcucha dostaw oraz badają możliwe zależności pomiędzy jakością informacji o popycie oraz dokładnością procesu planowania popytu. Następnie, przedstawiono przegląd literatury badanego obszaru naukowego.
Rezultaty: W oparciu o badania literatury, scharakteryzowano wpływ czynników na dokładność planu popytu w poszczególnych ogniwach łańcuchów dostaw analizowanych przedsiębiorstw produkcyjnych. Rozpatrzono trzy studia przypadków, w których rozpatrzono trzy przedsiębiorstwa produkcyjne z różnych branż. Skupiono się na procesie planowania popytu w analizowanych łańcuchach dostaw. Celem było określenie dokładności przyszłych planów sprzedaży w poszczególnych ogniwach łańcucha dostaw oraz czynników je zakłócających. W oparciu o analizę procesów planowania popytu przykładowych przedsiębiorstw produkcyjnych, zdefiniowano możliwe miary jakości, które mogą być wykorzystane podczas prognozowania popytu klienta.
Wnioski: Jednym z ważniejszych i trudniejszych obszarów planowania w przedsiębiorstwach jest planowanie popytu. Związane jest to z faktem, że błędy popełnione w procesie planowania przekładają się na funkcjonowanie całego łańcucha dostaw. Przedstawione studia przypadków pokazują, że wiele czynników ma wpływ na poprawność procesu planowania popytu w łańcuchu dostaw, jak np. technologie informacyjne, czas dostawy, czy liczba dostarczanych materiałów. Jednocześnie, można zauważyć iż model gromadzenia informacji rynkowej również jest istotnym zagadnieniem w procesie planowania popytu.

Słowa kluczowe: planowanie popytu, jakość przepływu informacji, łańcuch dostaw.

EINFLUSS DER QUALITÄT VON INFORMATIONEN ÜBER DIE NACHFRAGE AUF DIE GENAUIGKEIT DES PLANUNGSPROZESSES IN DER LIEFERKETTE. FALLSTUDIEN

ZUSAMMENFASSUNG. Einleitung: Die Identifikation und Analyse von Einflussfaktoren auf die Genauigkeit des Nachfrageplanungsprozesses in der Lieferkette ist eines der wichtigsten Probleme, die einen Einfluss auf die Material- und Informationsflusseffizienz ausüben.
Methoden: Basierend auf den Forschungsarbeiten am Nachfrageplanungsprozess definieren die Autoren die Hauptelemente, die das Funktionsniveau der Lieferkette beeinflussen. Zusätzlich werden die Zusammenhänge zwischen der Informationsqualität und der Planungsprozessgenauigkeit der Nachfrage erforscht. Anschließend wird ein Literaturüberblick aus dem erforschten Bereich präsentiert.
Ergebnisse: Basierend auf der Literaturforschung, wurde der Faktoreneinfluss auf die Nachfrageplanungsgenauigkeit in einzelnen Gliedern der Lieferketten in den analysierten Produktionsunternehmen gekennzeichnet. Es wurden drei Fallstudien, mit Produktionsunternehmen aus drei verschiedenen Branchen, betrachtet. Die Arbeiten waren auf den Planungsprozess der Nachfrage fokussiert. Das Ziel war es, die Genauigkeit der zukünftigen Verkaufspläne und Störfaktoren in den jeweiligen Gliedern der Lieferkette zu bestimmen. Auf der Grundlage der Analyse des Nachfrageplanungsprozesses in ausgewählten Produktionsunternehmen konnten Qualitätsmaße definiert werden. Diese können in der Kundennachfrageprognose verwendet werden.
Fazit: Einer der wichtigsten und zugleich schwierigsten Bereiche der Planung im Unternehmen ist die Nachfrageplanung. Dies ist aufgrund der Tatsache, dass die Fehler im Planungsprozess einen direkten Einfluss auf die

Funktionsweise der ganzen Lieferkette haben. Die vorgestellten Fallstudien zeigen, dass viele Faktoren die Genauigkeit des Nachfrageplanungsprozesses in der Lieferkette mit beeinflussen können, z.B. in Bezug auf Informationstechnologien, Lieferzeit, sowie Anzahl der gelieferten Materialien. Gleichzeitig ist zu erkennen, dass das Sammelmodell für Marktinformationen ebenfalls ein wichtiges Thema im Nachfrageplanungsprozess ist.

Codewörter: Nachfrageplanung, Qualität des Informationsflusses, Lieferkette.

Natalia Szozda
Wroclaw University of Economics, Logistics Department,
e-mail: natalia.szozda@ue.wroc.pl
Sylwia Werbińska-Wojciechowska
Wroclaw University of Technology, Faculty of Mechanical Engineering, Division of Logistics and Transportation Systems,
Wybrzeze Wyspianskiego 27, 50-370 Wroclaw, Poland
e-mail: sylwia.werbinska@pwr.wroc.pl

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DEGREE OF INTERNATIONALIZATION IN LOGISTICS SECTOR AND STRATEGIC ORIENTATIONS

İnci Polat, Hanifi Murat Mutlu

Gaziantep University, Gaziantep, Turkey

ABSTRACT. Backround: Turkey has an important transfer center among Middle East, Europe and Asia. Turkey intends to reach $ 500 billion export target in 2023. Turkish logistics sector has been rapidly grown. Both national and international companies invest their presence and service in the country. The study firstly aims to evaluate the degree of internationalization of firms in the Turkish logistics sector. The second aim of the study is to determine whether or not there is difference between international and national logistics firms' market and entrepreneurship orientation. Finally, the study is to investigate the links among market orientation, entrepreneurship orientation, and the degree of internationalization.

Material and methods: The convenience sampling method was used to send the questionnaires. A total of 91 eligible questionnaires were received. The research hypotheses are tested using data collected from questionnaire and by multiple regression analyses and independent-sample t test.

Results and conclusions: The results indicate evidences that there is a difference between the levels of strategic orientation of the international and national firms. From research findings, we offer implications for managers.

Key words: Degree of Internationalization, Market Orientation, Entrepreneurship Orientation, Turkish Logistics Sector.

INTRODUCTION

Global trade volume increased 6.6% in 2011. This volume was respectively 12.4% in 2010 and -10.6% in 2009. Therefore, World Bank has much worse expectations for 2012. The anticipated slowdown in global trade is expected to adversely affect to all the countries. The volatile in global trade directly influences to logistics sector. Turkish Logistics Sector also is affected by this volatile. However, Turkey has an important location that is crossroads between Europe and Asia. The Turkish Logistics Sector attracts attention both foreigners and domestics inventors because of high growth rates, vehicle capacity, and employment opportunities. Considering the opportunities provided by the location of the Turkey, developments in the logistics industry and Turkey's export goals, logistics firms in Turkey must compete with more capable of firms. The firms also must have more advanced strategies to be succeeded.

This study primarily aims to measure Turkish Logistics Sector's degree of internationalization. Owing to determine the degree of internationalization of firms in the logistics sector, inter-firm differences may be analyzed. In addition the sector can be compared with the other both countries and sectors. The second aim of the study is to identify whether or not the difference in terms of market and entrepreneurial orientation between national and international logistics companies. By determining of such a difference, it will be provided to become clear role of strategic orientations on the internationalization of firms. The study thirdly

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aims to examine the joint effects of market and entrepreneurial orientations on the degree of internationalization. The study also focuses on the following basic questions: (1) what is the degree of internationalization in Turkish Logistics Sector? (2) How do market and entrepreneurial orientations affect the degree of internationalization? (3) Which variable have stronger effect than other on degree of internationalization? With fulfillment of these goals, the study will contribute to both literature and business life in the managerial sense by detecting levels of relative importance that of the research variables thought to be effective on the degree of internationalization of firms. Much study in literature was relationships among market orientation, entrepreneurial orientation and firm performance or the degree of internationalization and firm performance [e.g. Chang, 2011; Geringer et al., 1989] but a few study investigated direct effects of these orientations on the degree of internationalization. Therefore previous study analyzed the degree of internationalization in manufacturer sectors [e.g. Nieminen et al., 2002; Ruzzier et al., 2007; Martin and Papadopoulos, 2006] but the study focus on service sectors. The study fills the gaps. The overall purpose of this paper is to contribute to the literature on logistic firms' internationalization processes.

LITERATURE REVIEW AND HYPOTHESES

Increasing importance of internationalization lead to a remarkable topic in both economics and business literature. In particular, Manolova et al. [2010] stated that "internationalization is vital for the continued growth and development of new-and-small ventures in transition economies such as the Central and Eastern European countries, which are characterized by relatively small domestic markets". Internationalization is also an important process for growth and development of Turkish Logistics Sector. Calof and Beamish [1995] denoted internationalization as "the process of adapting firms' operations (strategy, structure, resource, etc.) to international environments". Internationa-lization is defined as a process that increased both participation in international activities [Welch and Luostarinen, 1988] and consists of a wide variety of activities such as exports, licensing and direct investment [Liu et al., 2011]. Internationalization activities can be classified as indirect export, direct export, export through foreign agent, sales and manufacturing joint venture, sales and manufacturing company, licensing and franchising. When these activities are analyzed through resource commitment perspective, some of activities must have a higher obligations and resource for firms others have relatively lower. Hence most of the firms usually start with export activities to the internationalization and later firms go towards activities that must have more resource such as the foreign joint ventures, foreign sales subsidiaries and finally direct foreign production activities [Agndal, Chetty, 2007].

The degree of internationalization of a firm are generally evaluated the three basic indexes [Hassel et al., 2003]. Dörrenbächer [2000] indicated:

- Multinationality Index developed by UNCTAD - Transnationality Index (TNI): Ratio of foreign sales to total sales; Ratio of foreign assets to total assets; Ratio of foreign employment to total employment.
- The Transnationality Spread Index (TSI) introduced by Ietto-Gillies [1998]: Ratio of foreign sales to total sales; Ratio of foreign assets to total assets; Ratio of foreign employment to total employment; Number of foreign countries in which a company owns affiliates as a proportion of total number of countries in which foreign direct investment has occurred minus one (= home country of the company)
- The Index of Degree of Internationalization of Sullivan [1994]: Ratio of foreign sales to total sales; Ratio of foreign assets to total assets; Ratio of foreign affiliates to total affiliates; International experience of top management; Psychic dispersion of international operations.

The degree of internationalization proposed by Sullivan [1994] consists of five variables that developed to measure structural, performance and behavioral qualities of internationalization. The degree of

internationalization arises following variables: (a) such as Ratio of foreign sales to total sales (FSTS), (b)Ratio of foreign assets to total assets (FATA), (c) Ratio of foreign affiliates to total affiliates (OSTS), (d) International experience of top management (TMIE), (e) the physical distribution of international operations, (PDIO). The degree of internationalization of a firm is the sum of these five variables. It show that 0 (zero) is not internationalization, 5 (five) is the highest level of internationalization.

The degree of internationalization= FSTS + FATA + OSTS + TMIE + PDIO.

Market orientation research is largely based on the two conceptual frameworks [Grinstein, 2008]. Narver and Slater [1990] defined market orientation as the "organizational culture that most effectively and efficiently creates the necessary behaviors for the creation of superior value for buyers and thus, continues superior performance for the business". Kohli and Jaworski [1990] emphasized the behavior aspects of market orientation, conceptualizing it as the "organization-wide generation of market intelligence pertaining to current and future customer needs, dissemination of the intelligence across departments, and organization-wide responsiveness to it". Market-oriented firms have a competitive advantage to respond quickly and effectively for market opportunities and threats [Slater, 2001]. Many studies investigated the effects of market and entrepreneurial orientations on firm or export performance but little study deal with their effects on the degree of internationalization. Previous research has found a link between market orientation and export performance [Akyol, Akehurst 2003; Armario et al., 2008; Cadogan et al., 2006; Mutlu et al., 2011; Racela et al., 2007; Rose and Shoham 2002].

Kropp et al. [2006] examined the interrelationships between entrepreneurial, market, and learning orientations and international entrepreneurial business venture performance. They demonstrated a positive link between market orientation and performance, domestically and internationally. He and Wei [2011] investigated the synergistic effect of market orientation and international market selection strategy on international performance. Their findings showed that firms with a fit between market orientation and international market tend to firms' higher international success than without such a fit. Vida [2000] showed that the one of the important drivers of the internationalization process was market orientation.

Armario et al. [2008] reveal that market orientation represents an antecedent of the internationalization process for SMEs. They project that "market orientation fosters and facilitates the learning process in foreign markets and highly market-oriented companies develop stronger capabilities (market sensing, customer linking, and channel bonding) that allow the acquisition of foreign market knowledge, as well as designing a proper market response" [Armario et al., 2008: 491]. Liu et al. [2011] demonstrated that the inverse U-shaped effect of market orientation on a firm's internationalization and they explained the complex influence of market orientation on the internationalization of firms from emerging markets. As these research findings parallel, the first hypothesis of our study researched whether different levels of market orientation of domestic and international firms in Turkish Logistics Sector. The second hypothesis of the study suggested that market orientation positively affected the degree of internationalization.

H_1: The market orientation means of domestic and international logistics firms are significantly different.

H_2: Market orientation positively affects logistics firms' the degree of internationalization.

Entrepreneurial orientation reflects identifying of market opportunities for firms and the priority in the benefit process from these opportunities [Shane and Venkataraman, 2000; Baker and Sinkula, 2009] and according to Zhou et al. [2005] the tendency of firms interested in "monitoring of new market opportunities, and renewal of existing activity areas" [Hult and Ketchen, 2001]. In this context, entrepreneurial orientation plays an important role in the capture of market

opportunities and in the start of innovative activities. Entrepreneurial orientation often is considered with innovation, risk-taking tendency and proactiveness aspects in the literature.

Entrepreneurship orientation naturally is an important and key factor for the success of the internationalized firms. Empirical studies suggested that entrepreneurship orientation of the firms have an important and positive impact in on the global performance. Entrepreneurial orientation promotes the formation of brands of firms, market inputs, and market share rates and so entrepreneurial orientation strategies gives greater advantage to managers who concentrate on the profit margin, the active growth and the market boom [Lan and Wu, 2010].

Ibeh and Young [2001] have identified that entrepreneurial firms is likely to be more innovative and proactive for export and have developed a high tendency to start exporting. Kazem and van der Heijden [2006] found that it is a strong relationship between the firm' export performance with degree of entrepreneurial orientation of firm owners. According to Yeoh and Jeong [1995], exporting organizations can be differentiated in terms of their level of entrepreneurial orientation. Compared to export performance between conservative and entrepreneurial exporting firms, entrepreneurial exporting firms are expected to have higher export performance level than other firms [Yeoh and Jeong, 1995]. Okpara [2009] investigated the impact of entrepreneurial export orientation on the performance of SMEs in Nigeria. The paper findings indicated that proactive entrepreneurs were more engaged in the export market. So, a firm that want to have the higher the degree of internationalization should be more entrepreneurial firms, in other words this firm must be more proactive, innovative, and risk taker. Mavrogiannis et al. [2008] showed that entrepreneurial firms achieved higher export performance.

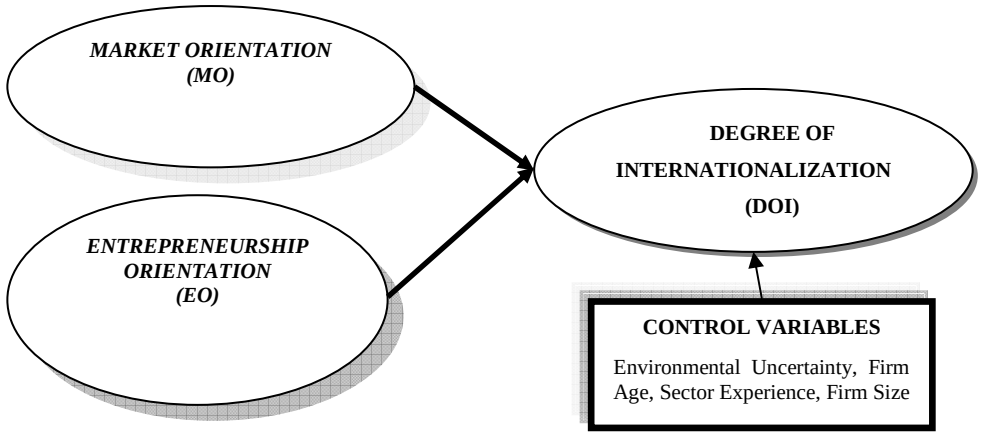

Fig. 1. Conceptual Model
Rys. 1. Model koncepcyjny

Liu et al. [2011] hypotheses that entrepreneurial orientation is positively related to the level of internationalization. They found the positive effect of entrepreneurial orientation on the internationalization of firms. Ripolles-Melia et al. [2007] discovered the direct positive relationship between entrepreneurial orientation and international degree. Clercq et al. [2005] investigated relationship between entrepreneurial orientation and internationalization intent. They found that entrepreneurial orientation is positively associated with internationalization intent. Morover, they argued that substantial and successful presence in foreign markets may partly depend on a firm's moving proactively into new markets or taking on an innovative and risk-seeking posture. As a result of all these evaluations, the third and fourth hypothesises of the study is that:

H_3: The entrepreneurial orientation means of domestic and international logistics firms are significantly different.

H_4: Entrepreneurial orientation positively affects logistics firms' the degree of internationalization.

Conceptual model in Figure 1 illustrates the relationships that established between market and entrepreneurial orientations and the degree of internationalization.

METHOD

Sampling: A self-administered questionnaire was used to collect the data for this study. The questionnaires were firstly interviewed face to face to the top executives of logistic firms in Turkey. Secondly, the questionnaires were e-mailed logistic firms. Logistic firm list was provided International Transporters Association (UND) and Logistics Association (LODER). We sent to e-mail that consist of research aims, procedures and questionnaire link. This was necessary in order to raise the response rate of the survey. The firms were given 2 weeks to respond. The end of the two weeks we repeated the same process. A total of 103 completed questionnaires were collected. Twelve completed questionnaires were found to be invalid due to missing or extreme values. 91 questionnaires were thus used for analysis.

Measurement: The scales in the measurement of market and entrepreneurial orientations concept taken up from Bulut [2007] and the scales were revised. We used Narver and Slater's [1990] scale to measure market orientation (MO). Entrepreneurial orientation (EO) scale was collected from different study by Bulut [2007, e.g. Antoncic and Hisrich, 2001; Barringer and Bluedorn, 1999; Calantone et al., 2002; Dess et al., 1997; Hornsby et al., 2002; Khandwalla, 1977; Liu et al., 2002; Lumpkin and Dess, 2001; Miller, 1983; Naman and Slevin 1993]. All items are scored on a 5-point scale in which 1 equals "strongly disagree" and 5 equals "strongly agree". Firm age (AGE) and sector experience (EXP) respectively were measured with opening year and date of starting logistics activities. Firm size (SIZE) evaluated only the number of employees. The degree of internationalization (DOI) was adapted Sullivan [1994]. The scale was used previous study [e.g. Ruzzier et al., 2007; Westhead et al., 2004]. The scale originally consists of 5 items; however the experience of export managers were excluded from. Measuring of DOI was used these items:

- Ratio of international logistic income to total logistic income-IITI (0-1)
- Ratio of international logistic operations to total logistic operations-IOTO (0-1)
- Ratio of international branches to total branches-IBTB (0-1)
- Physical Expectation of International Operations-Ratio of number of countries that operated logistic activities to total countries-PEIO (0-1)

As a result of the measurements that used these items, DOI of logistics firms will be between min. 0 and max. 4.

ANALYSIS AND RESULTS

Of the 93 respondents, 29.7% were firm owner, 20.9% were top management, 44% were department management and 3.3% were others. Respondents have professional experience between 1 and 31 years in logistics sector. The average experience is 8 years. While 29.7% of the sample worked only in domestic markets, 70.3% operated international logistics activities. Number of countries that operated logistic activities ranged between 1 and 150 country. Firms had the domestic branches between 1 and 11 while number of international branches ranged between 1 and 13.

For the measuring of DOI in logistics firms, we used the following formula:

DOI= IITI + IOTO + IBTB + PEIO

DOI ranged between 0 and 4. The average DOI in logistic sectors calculated 1.22. The zero value of DOI demonstrated that firm doesn't operated any international activate. The maximum value of DOI in the sample is 2.90.

Excluding firms that only operated domestics market, the minimum DOI value raised 0.63 and the average DOI was 2.03.

The descriptive statistics, coefficient alphas, and correlations are shown in Table 1. The reliability analysis was conducted to determine internal consistency among variables. Nunnally (1978) suggest that Coronbach's Alpha value of 0.70 is sufficient. All constructs demonstrated acceptable reliability scores. Consequently, table 1 showed that there was the positive and significant correlation coefficient of the relationship between DOI and MO / DOI and EO.

Table 1. and basic KPI
Tabela 1. Kryteria bazowe KPI

		1	2	3	4	5	6	7	Mean	S.D.	α
1.	DOI	1							1.22	1.07	-
2.	MO	.249*	1						4.15	0.65	.912
3.	EO	.293**	.627**	1					3.51	0.75	.918
4.	ENV	.192	.573**	.634**	1				3.72	0.77	.809
5	AGE	-.038	.270**	.165	.034	1			15.27	10.50	-
6.	EXP	.151	.118	.127	.038	.824**	1		12.73	9.76	-
7.	SIZE	-,148	,039	-,040	.095	.098	.171	1	36.85	42.16	-

DOI: Degree of Internationalization; MO: Market Orientation; EO: Entrepreneurship Orientation; ENV: Environmental Uncertainty; AGE: Firm age; EXP: Sector Experience; SIZE: Firm size; S.D.: Standard Deviation, α: Cronbach's Alpha Reliability Coefficient.
**: p<0.01; *: p<0.05.

Table 2. Independent samples t-test results
Tabela 2. Niezależne próbki wyników testu t

		Group Statistics				***Levene's Test***		***t-test for Equality of Means***		
		N	**Mean**	**S.D.**		**F**	**Sig.**	**t**	**df**	**Sig.**
MO	**Non-international**	36	3.93	.780	*Equal variances assumed*	5.149	.026	-2.667	89	.009
	International	55	4.29	.508	*Equal variances not assumed*			-2.448	54.426	.018
EO	**Non-international**	36	3.22	.828	*Equal variances assumed*	.972	.327	-3.123	89	.002
	International	55	3.70	.642	*Equal variances not assumed*			-2.963	61.736	.004

Independent-samples t-test procedure is applied to explore the probable effects of international activities on level of MO and EO. T-test results were summarized in Table 2. An independent-samples t-test was conducted to compare MO and EO means in domestic and international logistics firms. Hypothesis 1 assumes that there is a significantly different level of MO at international logistics firms compared to domestic logistic firms. The result of the t-test supports the assumption, there was a significant difference in the scores for domestic (mean=3.93, SD=0.78) and international (M=4.29, SD=0.50) logistics firms; t (98) =2.448, p = 0.018. Hypothesis 3 supposes that the levels of EO at domestic logistics firms compared to international logistic firms are different. The result of the t-test supports the assumption, there was a significant difference in the scores for domestic (mean=3.22, SD=0.82) and international (M=3.70, SD=0.64) logistics

firms; t (98) =3.123, p = 0.002. These results suggest that international activities really have an effect on both MO and EO. Therefore, hypothesis 1 and 3 is accepted.

Table 3. and basic KPI
Tabela 3. Kryteria bazowe KPI

Independent Variables	**β**	**$B_{(Std)}$**	**t**	**R^2**	**Adj. R^2**	**F**
Constant Term	-1.020		-1.520	0.279	0.227	5.405**
MO	0.500	0.303	2.273*			
EO	0.240	0.169	1.259			
ENV	-0.100	-0.072	-0.557			
AGE	-0.074	-0.727	-4.116**			
EXP	0.080	0.731	4.255**			
SIZE	-0.005	-0.200	-2.083*			

**: p<0.01; *: p<0.05

Multiple regression analyses were performed to further test hypotheses and these results are contained within Table 3. The regression analysis, the variables were tested significant with (p<0.01) and F=5.405. The regression tests had presented R square of 0.279. Approximately 27.9% variations of DOI can be explained by MO, EO, ENV, AGE, and SIZE. The adjusted R square value is 0.227. The multiple regression analysis indicates that MO is positively related to DOI with the beta value of 0.303, significant at p<0.0. EO is not found significant. Hypothesis 2, which predicted a positive relationship between DOI and MO, is supported but hypothesis 4 which propose a positive relationship between DOI and EO was not supported. In addition AGE and SIZE have negative and significant effects on DOI. EXP positively and significantly affected DOI.

CONCLUSION, IMPLICATIONS AND LIMITATIONS

Buckley and Casson [1976] define that internationalization is conducted research to develop and distribute of their resources for across national borders to take asymmetric advantage in the capacity and information of firms [Javalgi and Todd, 2011]. Take into account internationalization degree of the sample, Turkish logistics sector have very good score. Altintas and Ozdemir [2006] calculated internationalization degree of manufacturer firms using a sample 137 firms in Turkey. They found that internationalization degree of Turkish manufacturer was 1.622 (between 0 and 5). The degree of internationalization for Turkish exporter firms was calculated to be 0.37 (the ratio is 1.85 when converted to Likert scale) by Altintas et al. [2011]. We calculated 1.22 (between 0 and 4), therefore excluding domestic logistic firms, the score raised 2.03. The result was expected but the score could have been better. Considering the score that created factors:

- Ratio of international logistic income to total logistic income-IITI mean is 0.83.
- Ratio of international logistic operations to total logistic operations-IOTO mean is 0.85.
- The sample (65.9%) doesn't have any international branches. The sample' 10.9% have one international branches, 7.7% have two and 15.5% have three or more. The ratios show that Turkish logistics firms serve mostly domestic manufacturers. Increasing number of international branches contributes the degree of internationalization.
- The five firms have extreme physical expectation. The firms operated 50 and more country.

Eren-Erdogmus et al. [2010] showed that the relationships among different factors that influence the internationalization process of

Turkish firms. They said that above factors acted the firm to open in international markets:

- Home country characteristics
- Top management characteristics (e.g. international orientation, professional experience in international operations)
- General firm characteristics and abilities (e.g. branding, learning orientation)
- Internationalization process (e.g. market selection, entry method)
- Host country characteristics (e.g. market growth potential, intensity of completion)

Independent-samples t-test results demonstrate that international activities create signifycantly effects on level of both market orientation and entrepreneurial orientation. The results of regression analysis showed that sector experience ($\beta_{(std)}$ = 0.731; p<0.01), firm age $\beta_{(std)}$ = -0.727; p<0.01), market orientation ($\beta_{(std)}$ 0.303; p<0.05), and firm size ($\beta_{(std)}$ = -0.200; p<0.05) variables have a significant effect on the degree of internationalization. According to the results of regression analysis, the most important element that affects the degree of internationalization is sector experience. Market orientation has statistically significant effects on the degree of internationalization. The finding is consistent with previous study. However, the effects of components of market orientation must be explored. Panayides [2004] found that aggregated market orientation had not significant effect on firm performance of logistics service provides, however the interfuctional coordination component of market orientation was found to be significantly related to profitability.

We found no relationship between entrepreneurial orientation and the degree of internationalization. The finding is interesting. There has been investigated the potential moderators and/or mediators of EO and DOI.

We found that firm age and size negatively affected the degree of internationalization. The findings are unexpended. The firm age effect indicates that firms operating in the market over a longer period are more likely to achieve a lower level of internationalization. The firm size negative effect was explained that the variable was measured only number of employed. Our sample included all kind of logistics firms, for example, national or international road transport firms, maritime transport firms, railways transport firms, warehousing business, and forwarder. For each firm in the sample, the variables that measure firm size may be different. For a firm that operates only road transport, firm size may measure vehicle population, number of employment and capacity. This diversity reduces to the generalization of findings.

Our research provides managerial implications for firms. For logistics firms, the first implication is to develop market-oriented behaviors. Firm managers have a market-oriented culture, their firms will develop capabilities that promote international operates. The adaption both market and entrepreneurial orientations lead to higher the degree of internationalization. Given a firm is provided opportunities by the internationalization, firm owners and investors in logistics sector must promote market- and entrepreneurial-oriented behaviors.

As with all empirical studies, this study has some limitations. First limitation is sample method. Second, the research variables have been studied as a one-dimension concept. In future studies, they should be divided into their components. The measure of the internationalization of SMEs was proposed the multi-dimensionality of internationalization construct (e.g. product, time, performance, operational mode and market dimensions) by Ruzzier et al. [2007]. Third, this study analyzes data at a particular point in time. Finally, only direct effects among variables have been discussed in this study. In future studies, indirect, mediating, and moderator effects should be studied. In conclusion this limitation needs to be addressed in future studies.

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POZIOM UMIĘDZYNARODOWIENIA SEKTORA LOGISTYCZNEGO I ORIENTACJI STRATEGII

STRESZCZENIE. **Wstęp:** Turcja jest ważnym punktem transferowym pomiędzy Bliskim Wschodem, Europa i Azją. Zamierza ona osiągnąć poziom eksportu równy 500 bilionów dolarów w 2023 roku. Turecki sektor logistyczny charakteryzuje się gwałtownym wzrostem. Zarówno krajowe jak i międzynarodowe firmy inwestują w swój rozwój w tym kraju. Jednym z celów pracy jest ocena stopnia umiędzynarodowienia firm działających w tureckim sektorze logistycznym. Drugim celem jest zbadanie istnienia różnic w kierunkach działania firm krajowych i międzynarodowych operujących na rynku logistycznym. Trzecim celem była ocena powiązań pomiędzy orientacją rynkową, orientacją przedsiębiorstwa oraz stopień umiędzynarodowienia.

Materiał i metody: zostały wysłane ankiety do losowo wybranej grupy. 91 poprawnie wypełnionych ankiet zostało odesłanych. Hipoteza badawcza została przetestowana na podstawie danych zebranych poprzez ankiety przy wykorzystania analizy regresji oraz niezależnego testu t.
Wyniki i wnioski: Wyniki wskazują na istnienie różnicy pomiędzy poziomem orientacji strategicznej w firmach krajowych i międzynarodowych. Na podstawie wyników zostały opracowane zalecenia dla zarządzających.

Słowa kluczowe: stopień umiędzynarodowienia, orientacja rynkowa, orientacja przedsiębiorstwa, turecki sektor logistyczny.

NIVEAU DER INTERNATIONALISIERUNG DES LOGISTISCHEN SEKTORS UND DER INTERNATIONALEN STRATEGIE-ORIENTIERUNG

ZUSAMMENFASSUNG. Einleitung: Die Türkei stellt einen wichtigen Knotenpunkt zwischen dem Nahen Osten, Europa und Asien dar. Sie beabsichtigt, im Jahre 2023 das Niveau ihres Export-Volumens in Höhe von 500 Billionen Dollars zu erreichen. Der türkische Logistik-Sektor charakterisiert sich durch seinen rasanten Aufstieg. Sowohl einheimische, als auch internationale Firmen investieren in ihre Entwicklung in diesem Lande. Eines der Ziele der Forschungsarbeit war die Beurteilung des Ausmaßes der Internationalisierung der im türkischen Logistik-Sektor tätigen Firmen. Ein nächstes Ziel war es, die bestehenden Unterschiede zwischen den einheimischen und den internationalen, auf dem logistischen Markt operierenden Firmen bei ihren unterschiedlichen Betätigungsausrichtungen zu erforschen. Ein weiteres Ziel bestand auf der Beurteilung der Zusammenhänge, die zwischen der Marktausrichtung eines Unternehmens, seiner Strategie und dem Grade der Internationalisierung vorkommen.
Material und Methoden: An die ausgeloste Gruppe von Unternehmen wurden Umfragebögen zugeschickt. Die richtig ausgefüllten kamen in der Anzahl von 91 zurück.. Die Forschungshypothese wurde anhand der auf Grund der Umfragebögen gewonnenen Daten bei Inanspruchnahme der Regressionsanalyse und eines unabhängigen T-Testes durchgetestet.
Ergebnisse und Fazit: Die Ergebnisse weisen auf das Bestehen der Differenzen innerhalb der einheimischen und internationalen Firmen in Bezug auf das Niveau ihrer strategischen Orientierung hin. Auf Grund der Ergebnisse wurden entsprechende Empfehlungen für die Geschäftsführer ausgearbeitet.

Codewörter: Grad der Internationalisierung, Marktorientierung, Orientierung des Unternehmens, türkischer Logistik-Sektor.

Hanifi Murat Multu
Gaziantep University
Faculty of Economics and Administrative Sciences
Department of International Trade and Logistics
27310-Sehitkamil
Gaziantep Turkey
ph: +90.342.317 20 76
fax: +90.342.360 14 02
e-mail: mmutlu@gantep.edu.tr

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THE FUTURE OF ACTIVE AND INTELLIGENT PACKAGING INDUSTRY

Renata Dobrucka

Poznan University of Ekonomics, Poznań, Poland

ABSTRACT. Background: Innovation in food and beverage packaging is mostly driven by consumer needs and demands influenced by changing global trends, such as increased life expectancy, fewer organizations investing in food production and distribution. Food industry has seen great advances in the packaging sector since its inception in the 18th century with most active and intelligent innovations occurring during the past century. These advances have led to improved food quality and safety. Active and intelligent packaging is new and exciting area of technology which efficient contemporary consumer response.
Materials and methods: On the basis of broad review of the current state of the art in world literature, the market active and intelligent packaging is discussed.
Results: This paper shows present innovation in the market active and intelligent packaging.
Conclusion: 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. Besides, active and intelligent packaging is becoming more and more widely used for food products. The future of this type of packaging system seems to be very interesting..

Key words: active packaging, intelligent packaging.

PACKAGING INDUSTRY

Increased awareness of health and environmental consumer undoubtedly contributed to the growing requirements for used packaging. New food packaging 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 (such as market globalization resulting in longer distribution of food), or consumers way of life (resulting in less time spent shopping fresh food at the market and cooking), 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, Bilska 2011]. Innovations in packaging were up to now limited mainly to a small number of commodity materials such as barrier materials (new polymers, complex and multilayer materials) with new designs, for marketing purposes. However, food packaging has no longer just a passive role in protecting and marketing a food product. New concepts of active and intelligent packaging are due to play an increasingly important role by offering numerous and innovative solutions for extending the shelf-life or maintain, improve or monitor food quality and safety [Gontard 2006]. Food quality and shelf-life extension (e.g. for delicatessen, cooked meats etc.) Next to these, numerous others concepts such as ethanol emitters (e.g. for bakery products),

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ethylene absorbers (e.g. for climacteric fruits), carbon dioxide emitters/ absorbers, time/temperature and oxygen indicators etc. have been developed. In a general way, the field has been extended largely as a series of niche markets owing to the current approach of packaging industries looking at it in terms of new market opportunities [Rooney 2005].

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 tons of wasted food (European Commission, 2011), 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 global market is broken down into different technology applications of active, controlled and intelligent packaging; of these, CAP/MAP has the largest share of the market estimated to comprise 45.4% in 2008, probably decreasing slightly to approximately 40.5% in 2013. Also, active packaging will comprise approximately 27% of the global market in 2008 but will decrease slightly to 26.9% by 2013. This segment will be worth an estimated $4.6 billion in 2008 and should reach $6.4 billion by 2013. Intelligent packaging represented a $1.4 billion segment in 2008, increasing to $2.3 billion by 2013 [D. Restuccia et al. 2010].

ACTIVE PACKAGING SYSTEMS

In contrast to traditional packaging, active and intelligent packaging may change the composition and organoleptic characteristics of food, provided that the changes are consistent with the provisions for food. Besides the released substances will be allowed to add to food. The principles behind active packaging are based either on the intrinsic properties of the polymer used as packaging material itself or on the introduction (inclusion, entrapment etc.) of specific substances inside the polymer [Gontard 2000]. Besides, active packaging refers to the incorporation of certain additives into packaging systems (whether loose within the pack, attached to the inside of packaging materials or incorporated within the packaging materials themselves) with the aim of maintaining or extending product quality and shelf-life. Packaging may be termed active when it performs some desired role in food preservation other than providing an inert barrier to external conditions [Hutton 2003]. On the other hand, active packaging has been defined as packaging, which 'changes the condition of the packed food to extend shelf-life or to improve safety or sensory properties, while maintaining the quality of packaged food' [Ahvenainen 2003]. The development of a whole range of active packaging systems, some of which may have applications in both new and existing food products, is fairly new. Active packaging includes additives or 'freshness enhancers' that can participate in a host of packaging applications and by so doing, enhance the preservation function of the primary packaging system. Table 1 lists some of the food applications that have benefited from active packaging technology.

Oxygen scavengers are by far the most commercially important sub-categories of active packaging and the market has been growing steadily for the last several years. The development of oxygen scavenging systems was first based on self-adhesive labels, others adhesive devices or loose sachets to be included in the packaging with the food. A second concept, developed later, was based on the design of active substances for being included in the packaging material itself, using monolayer or multilayer materials or reactive closures liners for bottles and jars [Rooney 2005]. Oxygen scavengers can be used alone or in combination with MAP. Their use alone eliminates the need for MAP machinery and can increase packaging speeds. However, it is usually more common commercially to remove most of the atmospheric oxygen by MAP and then use a relatively small and inexpensive scavenger to mop up the residual oxygen remaining within the food package [Day, 2003;

Robertson 2006. Non-metallic oxygen scavengers have also been developed to alleviate the potential for metallic taints being imparted to food products. The problem of inadvertently setting off in-line metal detectors is also alleviated even though some modern detectors can now be tuned to phase out the scavenger signal whilst retaining high sensitivity for ferrous and non-ferrous metallic contaminants. Non-metallic scavengers include those that use organic reducing agents such as ascorbic acid, ascorbate salts or catechol. They also include enzymic oxygen scavenger systems using either glucose oxidase or ethanol oxidase, which could be incorporated into sachets, adhesive labels or immobilised onto packaging film surfaces [Day, 2003].

Table 1. Selected examples of active packaging systems [Day, 2003]
Table 1. Wybrane przykłady systemów aktywnych [Day, 2003]

Active packaging system	**Mechanisms**	**Food applications**
Oxygen scavengers	iron based metal/acid metal (e.g. platinum) catalyst ascorbate/metallic salts enzyme based	bread, cakes, cooked rice, biscuits, pizza, pasta, cheese, cured meats and fish, coffee, snack foods, dried foods and beverages
Carbon dioxide scavengers/emitters	iron oxide/calcium hydroxide ferrous carbonate/metal halide calcium oxide/activated charcoal ascorbate/sodium bicarbonate	coffee, fresh meats and fish, nuts and other snack food products and sponge cakes
Ethylene scavengers	potassium permanganate activated carbon activated clays/zeolites	fruit, vegetables and other horticultural products
Preservative releasers	organic acids silver zeolite spice and herb extracts BHA/BHT antioxidants vitamin E antioxidant volatile chlorine dioxide/ sulphur dioxide	cereals, meats, fish, bread, cheese, snack foods, fruit and vegetables
Ethanol emitters	alcohol spray encapsulated etanol	pizza crusts, cakes, bread, biscuits, fish and bakery products
Moisture absorbers	PVA blanket activated clays and minerals silica gel	fish, meats, poultry, snack foods, cereals, dried foods, sandwiches, fruit and vegetables
Flavour/odour adsorbers	cellulose triacetate acetylated paper citric acid ferrous salt/ascorbate activated carbon/clays/zeolites	fruit juices, fried snack foods, fish, cereals, poultry, dairy products and fruit
Temperature control packaging	non-woven plastics double walled containers hydrofluorocarbon gas Lime/water ammonium nitrate/water	ready meals, meats, fish, poultry and beverages

Another popular group of active packaging systems are moisture absorbers. Several companies manufacture moisture absorbers in the form of sachets, pads, sheets or blankets. For packaged dried food applications, desiccants such as silica gel, calcium oxide and activated clays and minerals are typically tear-resistant permeable plastic sachets. For dual-action purposes, these sachets may also contain activated carbon for odour adsorption or iron powder for oxygen scavenging [Rice 1994; Rooney 1995]. Interesting solution is the use a carbon dioxide scavenger or a dual-action oxygen and carbon dioxide scavenger system. A mixture of calcium oxide and activated charcoal has been used in polyethylene coffee pouches to scavenge carbon dioxide but dual-action oxygen and carbon dioxide scavenger

sachets and labels are more common and are commercially used for canned and foil pouched coffees in Japan and the USA [Day 1989; Anon 1995; Rooney 1995].

The development of unpleasant flavors as a consequence of food processing can be the result of thermal degradation of components, such as proteins, or of reaction such as the Maillard reaction. In 1979 Cahndler and Johnson showed that substantial quantities of limonin could be removed by acetylated paper, following earlier work involving cellulose acetate gel beads [Chandler 1968]. Franzetti et al., 2001 presented that unpleasant smelling volatile amines, such as trimethylamine, associated with fish protein breakdown are alkaline and can be neutralised by various acidic compounds.

Packaging containing natural preservatives and antioxidants undoubtedly has a high potential. Using antimicrobial or antioxidant agents in active food packaging is relatively recent, and causes consumer concerns regarding their safety due to their possible migration into foods [Vermaeiner et al. 1999, Han 2003]. For this reason, there is growing consumer preference for natural agents which have been isolated from microbiological, plant, and animal sources [Nicolson, 1998]. Active substances of biological origin have a powerful wide-spectrum activity with low toxicity, and are expected to be used for food preservation as a means of active packaging [Han, 2003]. Vojdani and Torees [Vojdani 1989a, Vojdani 1990] have examined the diffusion barrier properties of a variety of polysaccharide-based films and they have found that methyl cellulose offers the greatest potential as a substrate for the antimicrobial agent potassium sorbate. Further work established that creating multi-layer films of methyl and hydroxypropyl methyl cellulose would allow slower, thus more effective, diffusion of potassium sorbate into a potential food product. The addition of fatty acids such as lauric, palmitic, stearic and arachidic acids were also found to be effective for lowering the diffusion of potassium sorbate in cellulose-based films. To group natural antimicrobial agents belongs nisin- bacteriocin produced by Lactococcus lactis. Fang, T.J. and Lin in 1994, used nisin in combination with modified-atmosphere packaging in a study involving cooked pork which was inoculated with Pseduomonas fragi and Listeria monocytogenes. Both microorganisms were effectively reduced in number by the modified-atmosphere/ nisin combination during refrigerated storage of the cooked pork [Fang 1994].

INTELLIGENT PACKAGING SYSTEMS

Intelligent food packaging is an innovative technology which is developing in recent years [Bilska, 2008]. 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 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, 1994, 2001].

Besides, intelligent packaging systems attached as labels, incorporated into, or printed onto a food packaging material offer enhanced possibilities to monitor product quality, trace the critical points, and give more detailed information throughout the supply chain [Han, Ho, & Rodrigues, 2005]. Intelligent tags such as electronic labelling, designed with ink technology in a printed circuit and built-in battery radio- frequency

identity tags, all placed outside the primary packaging, are being developed in order to increase the efficiency of the flow of information and to offer innovative communicative functions. Diagnostic indicators were first designed to provide information on the food storage conditions, such as temperature, time, oxygen or carbon dioxide content, and thus, indirectly, information on food quality, as an interesting complement to end-use dates [D. Dainelli et al. 2008]. Indicators are called smart or interactive because they interact with compounds in the food. Microwave heating enhancers, such as susceptors and other temperature regulation methods, are sometimes regarded as intelligent methods as well. Table 2 depicts examples of external and internal indicators.

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 and 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 [Fault 1995].

Table 2. Examples of external and internal indicators and their working principles used in intelligent packaging [Ohlsson & Bengtsson, 2002]
Tabela 2. Przykłady zewnętrznych i wewnętrznych wskaźników i zasada ich działania w opakowaniach inteligentnych [Ohlsson & Bengtsson, 2002]

Indicator	Principle/reagents	Information given	Application
Time-temperature indicators (external)	Mechanical, chemical,enzymatic	Storage conditions	Foods stored underchilled and frozen conditions
Oxygen indicators (internal)	Redox dyes, pH dyes, enzymes	Storage conditions Package leak	Foods stored in packages with reduced oxygen concentration
Carbon dioxide indicator (internal)	Chemical	Storage conditions Package leak	Modified or controlled atmosphere food packaging
Microbial growth indicators (internal/ external) and freshness indicators	pH dyes, all dyes reacting with certain metabolites	Microbial quality of food (i.e. spoilage)	Perishable foods such as meat, fish and poultry
Pathogen indicators (internal)	Various chemical and immunochemical methods reacting with toxins	Specific pathogenic bacteria such as *Escherichia coli* 0157	Perishable foods such as meat, fish and poultry

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 et al. 2003].

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. 2010]. 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]. One of the latest is indicator 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 polymers (e.g. PVC). This allows the creation of indicators in the form of thin films [Mills and Thomas 1997]. One of most popular is tris(4,7-diphenyl-1,10-

phenanthroline) ruthenium(II) perchlorate, i.e. [Ru(dpp)3](ClO4)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 nbutyrate, 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 et al. 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.

SUMMARY

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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PRZYSZŁOŚĆ PRZEMYSŁU OPAKOWAŃ AKTYWNYCH I INTELIGENTNYCH

STRESZCZENIE. **Wstęp:** Innowacje w opakowaniach żywności i napojów związane są głównie z potrzebami i wymagania konsumentów pod wpływem zmieniających się globalnych trendów, takich jak wzrost długości życia, czy mniejszą liczbą organizacji inwestujących w produkcję i dystrybucję żywności. Przemysł spożywczy zrobił olbrzymie postępy w sektorze opakowaniowym od momentu jego powstania w XVIII wieku, czego dowodem jest pojawieniem się opakowań aktywnych i inteligentnych w minionym wieku. Ten rodzaj opakowań przyczynił się do poprawy jakości i bezpieczeństwa żywności. Aktywne i inteligentne opakowania są niewątpliwie nowym i ekscytującym obszarem technologii, który wychodzi na przeciw wymogom współczesnego konsumenta.
Materiał i metody: Na podstawie na podstawie obszernego przeglądu stanu badań w bieżącej światowej literaturze przedstawiono rynek opakowań aktywnych i inteligentnych.
Wyniki: Niniejsza praca przedstawia istniejące innowacje na rynku opakowań aktywnych i inteligentnych.
Wnioski: Badania i rozwój w obszarze opakowań aktywnych i inteligentnych są bardzo dynamicznie i rozwijają się w związku z poszukiwaniem opakowań przyjaznych środowisku. Poza tym opakowania aktywne i inteligentne są coraz częściej stosowane do produktów spożywczych. Przyszłość tego rodzaju opakowań wydaje się więc bardzo interesująca.

Słowa kluczowe: opakowania aktywne, opakowania inteligentne

DIE ZUKUNFT AKTIVE UND INTELLIGENTE VERPACKUNGEN INDUSTRIE

ZUSAMMENFASSUNG. Einleitung: Unter dem Einfluss der sich verändernden globalen Trends, wie Zuwachs der Lebensdauer oder die verhältnismäßig kleine Anzahl der in die Herstellung und die Nahrungsmittelverteilung investierenden Organisationen, gehen die Innovationen hauptsächlich im Bereich der Verpackungen für Lebensmittel und Getränke mit Bedürfnissen der Konsumenten einher. Die Lebensmittelindustrie hat teilweise einen riesengroßen Fortschritt seit ihrer Entstehung im 18. Jahrhundert notiert, was seine Folgen im Auftreten von aktiven und intelligenten Verpackungen schon in dem vergangen Jahrhundert hatte. Verpackungen dieser Art haben zur Verbesserung der Lebensmittel-Qualität, -Tauglichkeit und -Lebensdauer beigetragen. Die aktiven und intelligenten Verpackungen stellen zweifellos neue und spannende Technologie-Herausforderungen dar, die den Anforderungen des modernen Konsumenten entgegenzutreten vermögen.
Material und Methoden: Die Analyse der heutzutage auf dem Markt bestehenden aktiven und intelligenten Verpackungen wurde anhand eines Überblicks über die zu diesem Phänomen veröffentlichten Gegenstandsliteratur vorgenommen.
Ergebnisse: Der Beitrag stellt die gegenwärtig vorhandenen Innovationen auf dem Markt der aktiven und intelligenten Verpackungen dar.
Fazit: Die Forschung und Entwicklung im Bereich der aktiven und intelligenten Verpackungen wächst rasant und ist bei der Suche nach umweltfreundlichen Verpackungen. Darüber hinaus werden die aktiven und intelligenten Verpackungen zunehmend im Bereich der Nahrungsmittel verwendet. Die Zukunft dieser Verpackungsart scheint sehr interessant zu sein.

Codewörter: "intelligente Verpackung", "aktive Verpackung"

dr Renata Dobrucka
Uniwersytet Ekonomiczny w Poznaniu
Katedra Towaroznawstwa i Ekologii Produktów Przemysłowych
al. Niepodległości 10
61-875 Poznań
e-mail: renata.dobrucka@ue.poznan.pl

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PRODUCTION-INVENTORY MANAGEMENT MODEL FOR A WEIBULL DETERIORATING ITEM WITH LINEAR DEMAND AND SHORTAGES

Gobinda Chandra Panda[1)], Pravat Kumar Sukla[2)]

[1)] M.I.E.T, BPUT, BBSR, Odisha,India, [2)] P.S. College,Koksara,Kalahandi,Odisha, India

ABSTRACT. Background: Physical decay or deterioration of goods in stock is an important feature of real inventory systems.
Material and methods: In the present paper, we discuss an production inventory model for a Weibull deteriorating item over a finite planning horizon with a linearly time-varying demand rate and a uniform production rate, allowing shortages, which are completely backlogged.
Results and conclusions: A production inventory model is developed for a Weibull deteriorating item over a finite planning horizon with a linear time varying demand, finite production rate and shortages. The optimal number of production cycles that minimizes the average system cost is determined.

Key words: Production, Shortage, Deterioration, Inventory, Demand.

INTRODUCTION

Physical decay or deterioration of goods in stock is another important feature of real inventory systems. Ghare and Schrader [Ghare, Schrader 1963] were the first to develop an EOQ model for an item with exponential decay and constant demand. Dave and Patel [Dave, Patel 1981] extended the model of Donaldson [Donaldson 1977] to incorporate deterioration. Their model was further extended by Sachan [Sachan 1984], which permitted backlogging of items. Both these models assumed the successive cycles to be of the same duration. Keeping the reorder points fixed and increasing the order size only rather than adjusting both should result in a higher inventory cost. Bakhari-Kashani [Bahari-Kashani 1989] developed a heuristic model by relaxing the restriction of equal replenishment cycles. Xu and wang [Xu, Wang 1990] discussed the same model in discrete time. Chung and Ting [Chung, Ting 1993] developed a more general heuristic model for both finite and infinite horizons. Giri and Chaudhuri [Giri, Choudhuri 1997 discussed two heuristic models, for both finite and infinite planning horizons, in which the demand rate, deterioration rate, ordering cost, holding cost and shortage cost all vary with time; also shortages in inventory are allowed and are completely backlogged. Literature in inventory modeling for deteriorating items is extensive. All the models referred to above are economic lot size (ELS) models dealing with inventory replenishment situations only. In an ELS model, the main aim is to determine an EOQ for a cycle; the cycle starts with the EOQ as the initial stock. An economic production lot size (EPLS) model deals with an inventory-cum-production system in which procurement of inventory occurs through production within

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the cycle itself, the cycle does not start with an EOQ as in an ELS model.

The classical EPLS model assumes both the demand rate and the machine production rate to be predetermined and inflexible [Hax, Candea 1984]. However, it is usually observed in the market that the sale of many consumer goods increases rapidly after gaining consumer acceptance. It is, therefore, quite appropriate to consider time time-varying demands in EPLS models. Hong et al. [Hong, Sandrapaty, Hayya, 1990] discussed an EPLS model with a linearly trended demand and a uniform production rate. Goswami and Chaudhuri [Goswami, Chaudhuri 1991] developed such a model considering inventory shortages. Schweitzer and Seidmainn [Schweitzer, Seidmann 1991] questioned the assumption of uniform production rate and pointed out that the machine production rate should be flexible to adjust itself with the variability in the market demand.

Giri and Chaudhuri [Giri, Chaudhuri 1999] discussed a production inventory model in which the demand varies linearly with time, unit production cost is taken to be a function of the production rate and shortages in inventory are allowed and fully backlogged. Also the machine production rate, assumed to be flexible, is treated as a decision variable. Yan and Cheng [Yan, Cheng 1998] studied a perishable single item in a single period production-inventory system in which the production rate, the demand rate and the deterioration rate are all considered as a function of time; the model also allows a shortages which is partially back-logged. Several improvements to the model of Yan and Cheng [Yan, Cheng 1998] were suggested by Balkhi [Balkhi 2000], Balkhi et al. [Balkhi, Goyal, Giri 2001] and Goyal [Goyal 2001].

In the present paper, we discuss an production inventory model for a Weibull deteriorating item over a finite planning horizon with a linearly time-varying demand rate and a uniform production rate, allowing shortages, which are completely backlogged. The production inventory system in each cycle consists of four stages. The initial stock in each cycle is zero and production starts at the very beginning of the cycle. As production continues, inventory begins to build up continuously after meeting demand and deterioration. Production is stopped at a certain time. The accumulated inventory is then gradually depleted and ultimately becomes zero due to demand and deterioration. Production does not restart at this stage and inventory shortages continue to accumulate for some time. Thereafter, production starts and shortages are gradually cleared after meeting current demands. The cycle ends with zero inventory.

For every machine, there exists a critical design production rate (CDPR), which is taken as a production rate in the present model. The demand is taken to be linearly time varying and we consider case of increasing demand. The number of cycles over a finite planning horizon is determined optimally. The results are illustrated with two numerical examples with increasing demands.

ASSUMPTIONS

1. Production rate is finite and constant.
2. Weibull deterioration rate is considered.
3. Shortages are allowed and completely backlogged.
4. Time horizon is finite.
5. The finite time horizon is divided into a finite number of replenishment cycles, each of equal duration.
6. Demand rate is linear in time.

NOTATIONS

$f(t)$ $a + bt$ is the demand rate at time t where $a \geq 0, b \neq 0$. Here a is the initial demand rate and b is the rate at which the demand rate itself changes.

$\alpha\beta\, t^{\beta-1}$ Deterioration rate which is Weibull where $0 < \alpha < 1, \beta \geq 1$

P Production rate, $P > a + bt$, $t \in [0, H]$.

C_h Inventory holding cost per item per unit time

C_s Shortage cost per item per unit time

A_s Set-up cost per cycle

C_p Production cost per item

H Time horizon
n Number of cycles in $[0, H]$

THE MODEL AND ITS SOLUTION

The initial stock of the i[th] cycle (I=1,2…n) is zero and production starts at the very beginning of the cycle. As production continues, inventory begins to pile up continuously after meeting demand and deterioration. Production stops at time t_i'. The accumulated inventory is just sufficient enough to account for demand and deterioration over the interval $[t_i', t_i]$. Shortages accumulate over $[t_i, S_i]$. Production restarts at time S_i. The accumulated shortages are fully supplied during $[S_i, T_i]$. after meeting current demands. The cycle ends with zero inventory. It repeats itself. Our problem may be precisely stated as follows. "Given a linear trend in demand (either positive or negative), a uniform production rate (P) and a finite time horizon (H), divide the time horizon (H) into a number (n) of production cycles of equal periods (H/n) and within each period, determine when to produce products in order to minimize the average cost of the inventory system."

Here t_i', t_i, S_i and T_i are connected by the following relations

$$\left.\begin{aligned} t_i' &= k_i\, t_i + (1-k_i)\, T_{i-1}, \\ t_i &= rT_1 + (1-r)T_{i-1}, \\ S_i &= d_i T_i + (1-d_i)t_i, \\ T_i &= \frac{H}{n} i \end{aligned}\right\} \quad \text{(A)}$$

for i =1, 2,….., n.,
$0 < r < 1, 0 < k_i < 1, 0 < d_i < 1.$

The instantaneous inventory level $I(t)$ at any time $t \varepsilon [T_{i-1}, t_i]$ is governed by the following differential equations:

$$\frac{dI(t)}{dt} + \alpha\beta t^{\beta-1} I(t) = P - f(t),\ T_{i-1} \le t \le t_i', \quad (1)$$

with $I(T_{i-1}) = 0$;

$$\frac{dI(t)}{dt} + \alpha\beta t^{\beta-1} I(t) = -f(t),\ t_i' \le t \le t_i, \quad (2)$$

with $I(t_i) = 0$;

$$\frac{dI(t)}{dt} = -f(t),\ t_i \le t \le S_i, \quad (3)$$

with $I(t_i) = 0$;

$$\frac{dI(t)}{dt} = P - f(t),\ S_i \le t \le T_i, \quad (4)$$

with $I(T_i) = 0$;

The solution of equation (1) is

$$I(t) = (P-a)\left(t + \frac{\alpha t^{\beta+1}}{\beta+1} - \alpha t^{\beta+1}\right) - b\left(\frac{t^2}{2} + \frac{\alpha t^{\beta+2}}{\beta+2} - \frac{\alpha t^{\beta+2}}{2}\right) + c\left(1 - \alpha t^{\beta}\right)$$

By putting the initial condition, we get

$$I(t) = (P-a)\begin{bmatrix}(t - T_{i-1}) + \frac{\alpha}{\beta+1}\left(t^{\beta+1} - T_{i-1}^{\beta+1}\right) \\ -\alpha\left(t^{\beta+1} - t^{\beta} T_{i-1}\right)\end{bmatrix} - b\begin{bmatrix}\frac{t^2}{2} + \alpha\frac{t^{\beta+2}}{\beta+2} - \alpha\frac{t^{\beta+2}}{2} - \frac{T_{i-1}^2}{2} \\ + \frac{\alpha\beta}{2(\beta+2)} T_{i-1}^{\beta+2} + \frac{\alpha}{2} T_1^2 t^{\beta} - \frac{\alpha}{2} T_{i-1}^{\beta+2}\end{bmatrix} \quad (5)$$

The solution of equation (2) is

$$I(t) = -a\left[t + \frac{\alpha}{\beta+1} t^{\beta+1} - \alpha t^{\beta+1}\right] - b\left[\frac{t^2}{2} + \frac{\alpha\beta}{2(\beta+2)} t^{\beta+2} - \frac{\alpha}{2} t^{\beta+2}\right] + c\left(1 - \alpha t^{\beta}\right)$$

Substituting the value of $I(t_1')$ from equation (5), we get

$$\begin{aligned} I(t) = {} & -a\left[t + \frac{\alpha}{\beta+1} t^{\beta+1} - \alpha t^{\beta+1}\right] \\ & + a\left[T_{i-1} + \frac{\alpha}{\beta+1} T_{i-1}^{\beta+1} - \alpha t^{\beta} T_{i-1}\right] \\ & - b\left[\frac{t^2}{2} + \frac{\alpha\beta}{2(\beta+2)} t^{\beta+2} - \frac{\alpha}{2} t^{\beta+2}\right] \\ & + b\left[\frac{T_{i-1}^2}{2} - \frac{\alpha\beta}{2(\beta+2)} T_{i-1}^{\beta+2} + \frac{\alpha}{2} T_{i-1}^{\beta+2} - \frac{\alpha t^{\beta} T_{i-1}^2}{2}\right] \\ & + P\left[t_i' - T_{i-1} + \frac{\alpha}{\beta+1}\left(t_i'^{\beta+2} - T_{i-1}^{\beta+1}\right) - \alpha t^{\beta} t_i' + \alpha t^{\beta} T_{i-1}\right] \end{aligned} \quad (6)$$

The solution of equation (3) is

$$I(t) = -at - \frac{bt^2}{2} + c$$

By using initial condition $I(t_i)=0$, we get

$$I(t)=-(t-t_i)\left\{a+\frac{b}{2}(t_i+t)\right\} \qquad (7)$$

The solution of equation (4) is

$$I=(P-a)t-\frac{bt^2}{2}+c$$

$$I(t)-I(S_i)=(P-a)(t-S_i^2)-\frac{b}{2}(t^2-S_i^2)$$

Substituting the value of $I(S_i)$ from equation (7), we get

$$I(t)=-a(t-t_i)+P(t-S_i)-\frac{b}{2}(t^2-S_i^2) \qquad (8)$$

Using the initial condition $I(T_i)$=0,in equation (8), we get

$$b(T_i+t_i)+2a-2p\left(\frac{T_i-S_i}{T_i-t_i}\right)=0, T_i\neq t_i,$$

Then using (A), we get

$$d_i=1-\frac{a}{P}-\frac{bH}{2nP}(2i-1+r) \qquad (9)$$

The inventory in $[T_{i-1},t_i']$ is

$$I_{i1}=\int_{T_{i-1}}^{t_i'} I(t)dt$$

Now using (5), we get

$$I_{i1}=(P-a)\begin{bmatrix}\frac{T_{i-1}^2}{2}+\frac{t_i'^2}{2}+\frac{\alpha\beta}{(\beta+1)(\beta+2)}T_{i-1}^{\beta+2}\\ -\frac{\alpha\beta}{(\beta+1)(\beta+2)}t_i'^{\beta+2}-T_{i-1}t_i'\\ -\frac{\alpha T_{i-1}^{\beta+1}t_i'}{(\beta+1)}+\frac{\alpha T_{i-1}t_i'^{\beta+1}}{(\beta+1)}\end{bmatrix}$$

$$-b\begin{bmatrix}\frac{t_i'^3}{6}+\frac{T_{i-1}^3}{3}+\frac{\alpha\beta}{(\beta+1)(\beta+3)}T_{i-1}^{\beta+3}-\frac{\alpha\beta}{2(\beta+3)(\beta+2)}t_i'^{\beta+3}\\ -\frac{T_{i-1}^2t_i'}{2}-\frac{\alpha T_{i-1}^{\beta+2}t_i'}{(\beta+2)}+\frac{\alpha T_{i-1}^2t_i'^{\beta+1}}{2(\beta+1)}\end{bmatrix} \qquad (10)$$

Now using (6), we get the inventory in the time interval $[t_i',t_i]$

$$I_{i2}=\int_{t_i'}^{t_i} I(t)dt$$

$$=-a\begin{bmatrix}\frac{t_i^2}{2}-\frac{t_i'^2}{2}-\frac{\alpha\beta}{(\beta+1)(\beta+2)}t_i^{\beta+2}+\frac{\alpha\beta}{(\beta+1)(\beta+2)}t_i'^{\beta+2}\\ +T_{i-1}t_i'-T_{i-1}t_i-\frac{\alpha T_{i-1}^{\beta+1}t_i}{(\beta+1)}+\frac{\alpha T_{i-1}t_i'^{\beta+1}}{(\beta+1)}\end{bmatrix}$$

$$+\begin{bmatrix}\frac{\alpha}{\beta+1}t_i^{\beta+1}T_{i-1}-\frac{\alpha}{\beta+1}t_i'^{\beta+1}T_{i-1}\end{bmatrix}$$

$$-b\begin{bmatrix}\frac{t_i^3}{6}-\frac{t_i'^2}{6}-\frac{\alpha\beta}{2(\beta+3)(\beta+2)}t_i^{\beta+3}+\frac{\alpha\beta}{2(\beta+3)(\beta+2)}t_i'^{\beta+3}\end{bmatrix}$$

$$-\frac{T_{i-1}^2t_i}{2}+\frac{T_{i-1}^2t_i'}{2}-\frac{\alpha}{\beta+2}T_{i-1}^{\beta+2}t_i$$

$$+\frac{\alpha}{\beta+2}T_{i-1}^{\beta+2}t_i'-b\begin{bmatrix}\frac{\alpha T_{i-1}^2t_i^{\beta+1}}{2(\beta+1)}-\frac{\alpha T_{i-1}^2t_i'^{\beta+1}}{2(\beta+1)}\end{bmatrix}$$

$$+P\begin{bmatrix}t_i't_i-t_i'^2-T_{i-1}t_i+T_{i-1}t_i'+\frac{\alpha}{\beta+1}t_i'^{\beta+1}t_i\\ -\frac{\alpha}{\beta+1}T_{i-1}^{\beta+1}t_i+\frac{\alpha}{\beta+1}T_{i-1}^{\beta+1}t_i'-\frac{\alpha}{\beta+1}t_i't_i^{\beta+1}\\ +\frac{\alpha}{\beta+1}T_{i-1}t_i^{\beta+1}-\frac{\alpha}{\beta+1}T_{i-1}t_i'^{\beta+1}\end{bmatrix} \qquad (11)$$

Using (7), the shortage during $[t_i,S_i]$ is

$$I_{i3}=\int_{t_i}^{S_i}[-I(t)]dt=\begin{Bmatrix}\frac{a}{2}(S_i-t_i)^2+\frac{b}{6}S_i^3\\ -\frac{b}{2}t_i^2S_i+\frac{b}{3}t_i^3\end{Bmatrix} \qquad (12)$$

Using (8), the shortage during the time interval $[S_i,T_i]$ is

$$I_{i4}=\int_{S_i}^{T_i}[-I(t)]dt$$

$$=\frac{a}{2}(S_i-t_i)^2-\frac{a}{2}(S_i-t_i)^2-\frac{P}{2}(T_i-S_i)^2$$

$$+\frac{b}{6}(T_i^3-S_i^3)-\frac{b}{2}t_i^2(T_i-S_i), \qquad (13)$$

From the relations (A), we have

$$\begin{cases}t_i'=\frac{H}{n}(rk_i+i-1)\\ t_i=\frac{H}{n}(r+i-1)\\ S_i=\frac{H}{n}\{i-(1-d_i)(1-r)\}\end{cases} \qquad (14)$$

From equations (10) and (11), the total inventory in the ith cycle is

$$INV_i=-a\begin{bmatrix}\frac{T_{i-1}^2}{2}+\frac{\alpha\beta}{(\beta+1)(\beta+2)}T_{i-1}^{\beta+2}+\frac{t_i^2}{2}\\ -\frac{\alpha\beta}{(\beta+1)(\beta+2)}t_i^{\beta+2}-t_iT_{i-1}-\frac{\alpha t_i}{(\beta+1)}T_{i-1}^{\beta+1}\end{bmatrix}$$

$$+\frac{\alpha T_{i-1}}{(\beta+1)}t_i^{\beta+1}\Bigg]-b\Bigg[\begin{matrix}\frac{T_{i-1}^3}{3}+\frac{\alpha\beta}{(\beta+1)(\beta+3)}T_{i-1}^{\beta+3}\\ +\frac{t_i^3}{6}-\frac{\alpha\beta}{2(\beta+2)(\beta+3)}t_i^{\beta+3}\\ -\frac{T_{i-1}^2t_i}{2}-\frac{\alpha}{\beta+2}T_{i-1}^{\beta+2}t_i\end{matrix}$$

$$+\frac{\alpha}{2(\beta+1)}T_{i-1}^2t_i^{\beta+1}\Bigg]+P\Bigg[\begin{matrix}-\frac{T_{i-1}^{\ 2}}{2}+\frac{t_i'^2}{2}\\ +\frac{\alpha\beta}{(\beta+1)(\beta+2)}\end{matrix}\quad T_{i-1}^{\beta+2}$$

$$-\frac{\alpha\beta}{(\beta+1)(\beta+2)}t_i'^{\beta+2}+t_i't_i-T_{i-1}t_i$$

$$-\frac{\alpha}{\beta+1}t_i't_i^{\beta+1}+\frac{\alpha}{\beta+1}T_{i-1}t_i^{\beta+1}$$

$$+\frac{\alpha}{\beta+1}t_i'^{\beta+1}t_i-\frac{\alpha}{\beta+1}T_{i-1}^{\beta+1}t_i\Bigg] \qquad (15)$$

Now using (14),we get

$$INV_i=-a\Bigg[\begin{matrix}\frac{H^2(i-1)^2}{2n^2}+\frac{\alpha\beta H^{\beta+2}(i-1)^{\beta+2}}{(\beta+1)(\beta+2)n^{\beta+2}}\\ +\frac{H^2(r+i-1)^2}{2n^2}\\ -\frac{\alpha\beta H^{\beta+2}(r+i-1)^{\beta+2}}{(\beta+1)(\beta+2)n^{\beta+2}}\end{matrix}$$

$$-\frac{H^2(r+i-1)(i-1)}{n^2}-\frac{\alpha H^{\beta+2}(i-1)^{\beta+1}(r+i-1)}{(\beta+1)n^{\beta+2}}$$

$$+\frac{\alpha H^{\beta+2}(i-1)(r+i-1)^{\beta+1}}{(\beta+1)n^{\beta+2}}\Bigg]$$

$$-b\Bigg[\frac{H^3(i-1)^3}{3n^3}+\frac{\alpha\beta H^{\beta+3}(i-1)^{\beta+3}}{(\beta+1)(\beta+2)n^{\beta+3}}+\frac{H^3(r+i-1)^3}{6n^3}$$

$$-\frac{\alpha\beta H^{\beta+3}(r+i-1)^{\beta+3}}{2(\beta+2)(\beta+3)n^{\beta+3}}-\frac{H^2(r+i-1)(i-1)^2}{2n^3}$$

$$-\frac{\alpha H^{\beta+3}(i-1)^{\beta+2}(r+i-1)}{(\beta+2)n^{\beta+3}}$$

$$+\frac{\alpha H^{\beta+3}(i-1)^2(r+i-1)^{\beta+1}}{2(\beta+1)n^{\beta+3}}\Bigg]$$

$$+P\Bigg[-\frac{H^2(i-1)^2}{2n^2}$$

Using the condition $I(t_i)=0$, in equation (6) we have

$$-a\left(t_i+\frac{\alpha}{\beta+1}t_i^{\beta+1}-\alpha t_i^{\beta+1}\right)$$

$$-b\left(\frac{t_i^{\ 2}}{2}+\frac{\alpha}{\beta+2}t_i^{\beta+2}-\frac{\alpha}{2}t_i^{\beta+2}\right)+$$

$$a\left(T_{i-1}+\frac{\alpha}{\beta+1}-\alpha t_i^{\beta}T_{i-1}\right)$$

$$+b\left(\frac{T_{i-1}^2}{2}-\frac{\alpha\beta}{2(\beta+2)}T_{i-1}^{\beta+2}+\frac{\alpha}{2}T_{i-1}^{\beta+2}-\frac{\alpha}{2}t_i^{\beta}T_{i-1}^2\right)$$

$$+P\left[t_i'-T_{i-1}+\frac{\alpha}{\beta+1}\left(t_i'^{\beta+1}-T_{i-1}^{\beta+1}\right)-\alpha t_i^{\beta}t_i'+\alpha t_i^{\beta}T_{i-1}\right]=0$$

Now using (14), we get

$$-a\left[\frac{H}{n}(r+i-1)-\frac{\alpha\beta H^{\beta+1}(r+i-1)^{\beta+1}}{(\beta+1)n^{\beta+1}}\right]$$

$$-b\left[\frac{H^2(r+i-1)^2}{2n^2}-\frac{\alpha\beta H^{\beta+2}(r+i-1)^{\beta+2}}{(\beta+2)n^{\beta+2}}\right]$$

$$+a\left[\frac{H}{n}(i-1)+\frac{\alpha H^{\beta+1}(i-1)^{\beta+1}}{(\beta+1)n^{\beta+1}}-\frac{\alpha H^{\beta+1}(r+i-1)^{\beta}(i-1)}{n^{\beta+1}}\right]$$

$$+P\Bigg[\begin{matrix}\frac{H(rk_i+i-1)}{n}-\frac{H(i-1)}{n}\\ +\frac{\alpha H^{\beta+1}(rk_i+i-1)^{\beta+1}}{(\beta+1)n^{\beta+1}}\\ -\frac{\alpha H^{\beta+1}(i-1)^{\beta+1}}{(\beta+1)n^{\beta+1}}\end{matrix}\Bigg]$$

$$+P\left(\begin{matrix}\frac{\alpha H^{\beta+1}(r+i-1)^{\beta}(i-1)}{n^{\beta+1}}\\ -\frac{\alpha H^{\beta+1}(r+i-1)^{\beta}(rk_i+i-1)}{n^{\beta+1}}\end{matrix}\right)$$

$$+b\Bigg[\begin{matrix}\frac{H^2(i-1)^2}{2n^2}-\frac{\alpha\beta H^{\beta+2}(i-1)^{\beta+2}}{2(\beta+2)n^{\beta+2}}+\frac{\alpha H^{\beta+2}(i-1)^{\beta+2}}{4n^{\beta+2}}\\ -\frac{\alpha H^{\beta+2}(r+i-1)^{\beta}(i-1)^2}{2n^{\beta+2}}\end{matrix}\Bigg]=0 \qquad (17)$$

Here α,β,H,r,i,n are known, only k_i's are unknown, by tedious calculation we will get the values of k ,from equations (13) and (14), the total shortage in the i th cycle is

$$SHOR_i=\frac{H^2}{6n^2}\Bigg\{2\frac{bH}{n}(r+i-1)^3+3a(1-r)^2$$

$$-3P(1-d_i)^2+\frac{bH}{n}i^3-3\frac{bH}{n}i(r+i-1)^2\Big\} \quad (18)$$

The deteriorated stock in the i^{th} cycle is

$$\theta * INV_i \quad (19)$$

Therefore the average cost during the time horizon $(0,H)$ is

$$ATVC=\frac{1}{H}\left[(C_h+\theta C_p)\sum_{i=1}^{n}INV_i+C_s\sum_{i=1}^{n}SHOR_i+nA_s\right] \quad (20)$$

NUMERICAL EXAMPLES

Example: 1

For increasing demand rate we consider parameter values

$C_s=4.5, C_p=6.0, C_h=0.3, \alpha=0.01,$

$A_s=75, a=100, b=5, P=175, H=12, \beta=1$

in appropriate units. Then the optimal solution is:

$n^*=2, r^*=0.7912,\ INV^*=2315.9046$

and $SHOR^*=38.4928$

which are shown in the table 1.

Table 1. Parameter values for increasing demand rate
Tabela 1. Wartości parametrów dla wzrastającego popytu

n	**k_i**	***R***	**INV_i**	**Total inventory**	**Shortage**	**Average cost**
1	k_1=0.3541	0,7425	V_i=2256,9731	2256.9731	82.1032	104.7469
2	k_1=0,2681 k_i=0,2701	0,7912	V_1=125,8431 V_2= 2190,0615	2315.9046	38.4828	96.4114
3	k_1=0,2800 k_2= 0,2900 k_3=0,3001	0,8028	V_1=75,205 V_2=1204,280 V_3= 1932,558	3212.0434	25.1706	152.6029
4	k_1=0,6090 k_2=0,6942 k_3=0,2873 k_4=0,2671	0,8092	V_1= 525,7442 V_2=2320,2453 V_3=1141,9260 V_4= 1062,0520	5049.9675	18.4624	183.4224
5	k_1=0,5604 k_2=0,6686 k_3=0,7799 k_4=0,8898 k_5=0,9877	0,8069	V_1= 284,3433 V_2= 1431,417480 V_3= 2815,054199 V_4=4343,145 V_5=5834,1079	14708.0677	15.5168	478.3108

Example: 2

We have consider $\beta=2$, and all other parameters same, we get the optimum solution is

$n^*=3, r^*=0.8028, INV^*=1814.473, SHOR^*=25.1706$

Which are shown in the table 2.

Table 2. Paramter values
Tabela 2. Wartości parametrów

n	*r*	Average cost	Inventory	Shortage cost
1	0.7425	423.4493	12880.3544	82.1035
2	0.7912	85.8170	1962.7414	38.4928
3	0.8028	82.6231	1814.473	25.1706
4	0.8092	136.8056	3498.0764	18.4624
5	0.8069	88.2302	1705.3808	15.5268

CONCLUSION

The present paper deals with an production inventory model for a weibull deteriorating item having a linear time dependent demand and a uniform production rate. The model permits inventory shortage in each cycle, which is completely backlogged with in the cycle itself. The uniform production rate is actually the CDPR of the manufacturing machine. Every cycle starts with zero stock and production. As production continues, the inventory begins to accumulate after meeting current demands and adjusting for deterioration. Production stops after some time to make room for machine maintenance. To maintain the CDPR, the machine needs regular maintenance, which is ensured by stopping production in every cycle for a certain interval of time. The excess inventory accumulated during the production period is used to account for demand and deterioration in the no-production period. Due to several practical reasons, production may not restart as soon as the accumulated inventory is fully exhausted. Such practical reasons may be like a delay in machine maintenances, for example, lake of raw materials, shortage of labour, breakdown of the power unity, lake of capital, etc. due to this time lag in restarting production, shortage starts accumulating gradually. As soon as the bottlenecks in the way of restarting production are removed, production restarts and accumulated shortage are fully cleared by the end of the cycle itself. Thus each production-inventory cycle in the proposed model is self-complete in the sense that no stock of shortage of one cycle is carried to the next one. There is no carry- over effect from one cycle to another. This is a distinct departure from the classical approach to backlogging the shortage of one cycle in the next one. The finite planning horizon is divided into a finite number of production cycles of equal duration.

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ZARZĄDZANIE POZIOMEM ZAPASÓW PRODUKCYJNYCH MODELU WEIBULLA DLA LINIOWEGO POPYTU ORAZ STRAT

STRESZCZENIE. **Wstęp:** Fizyczny proces psucia się oraz obniżania wartości zapasów jest ważnym czynnikiem w realnych systemach magazynowych.
Material i metody: w pracy poddano dyskusji model Weibulla zarządzania zapasami produkcyjnymi dla skończonego okresu planowania oraz liniowego zmiennego w czasie popytu i określonej partii produkcyjnej, zezwalający na braki, które podlegają uzupełnieniu.
Wyniki i wnioski: opracowano model Weibulla zarządzania zapasami produkcyjnymi dla skończonego okresu planowania oraz liniowego zmiennego w czasie popytu, określonej partii produkcyjnej i braków. Określono optymalną ilość cykli produkcyjnych, minimalizujących średnie koszty systemu.

Słowa kluczowe: produkcja, braki, psucie się, zapas, popyt.

MANAGEMENT VON PRODUKTIONSVORRÄTEN ANHAND DES WEIBULL-MODELLS FÜR DIE BESTIMMUNG DER LINEAREN NACHFRAGE UND VERLUSTE

ZUSAMMENFASSUNG. Einleitung: Physisches Verderben und Wertsenkung von Produktionsvorräten stellen einen wichtigen Einflussfaktor in real bestehenden Lagerungssystemen dar.
Material und Methoden: Im Rahmen der Arbeit wurde das Weibull-Modell für das Management von Produktionsvorräten bei einem finiten Planungshorizont, einer linearen, in der Zeit variablen Nachfrage und einer bestimmten Produktionsgröße innerhalb eines Systems, das Auftreten von Verlusten zulässt und Vervollständigung von Fehlmengen ermöglicht, untersucht.
Ergebnisse und Fazit: Es wurde ein Weibull-Modell für das Management von Produktionsvorräten für das Management von Produktionsvorräten bei einem finiten Planungshorizont, einer linearen, in der Zeit variablen Nachfrage und einer bestimmten Produktionsgröße und Verlust-Niveau ausgearbeitet. Desweiteren wurde die optimale Anzahl von Produktionszyklen, die durchschnittliche Kosten des Systems minimalisieren, festgestellt.

Codewörter: Produktion, Verluste, Verderben, Vorrat, Nachfrage

Gobinda Chandra Panda
Dept. of Mathematics
M.I.E.T, BPUT
BBSR,Odisha,India
e-mail: gobinda1900@gmail.com
Pravat Kumar Sukla
Dept. of Mathematics
P.S. College
Koksara, Kalahandi,Odisha
e-mail: pravatsukla2005@gmail.com

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EFFICIENCY OF SUPPLY CHAIN MANAGEMENT. STRATEGIC AND OPERATIONAL APPROACH

Grzegorz Lichocik[1], Adam Sadowski[2]

[1)] Dachser sp. z o.o., Lodz, Poland, [2)] University of Lodz, Lodz, Poland

ABSTRACT. Background: One of the most important issues subject to theoretical considerations and empirical studies is the measurement of efficiency of activities in logistics and supply chain management. Simultaneously, efficiency is one of the terms interpreted in an ambiguous and multi-aspect manner, depending on the subject of a study. The multitude of analytical dimensions of this term results in the fact that, apart from economic efficiency being the basic study area, other dimensions perceived as an added value by different groups of supply chain participants become more and more important.

Methods: The objective of this paper is to attempt to explain the problem of supply chain management efficiency in the context of general theoretical considerations relating to supply chain management. The authors have also highlighted determinants and practical implications of supply chain management efficiency in strategic and operational contexts. The study employs critical analyses of logistics literature and the free-form interview with top management representatives of a company operating in the TSL sector.

Results: We must find a comprehensive approach to supply chain efficiency including all analytical dimensions connected with real goods and services flow. An effective supply chain must be cost-effective (ensuring economic efficiency of a chain), functional (reducing processes, lean, minimising the number of links in the chain to the necessary ones, adapting supply chain participants' internal processes to a common objective based on its efficiency) and ensuring high quality of services (customer-oriented logistics systems).

Conclusions: Efficiency of supply chains is not only a task for which a logistics department is responsible as it is a strategic decision taken by the management as regards the method of future company's operation. Correctly planned and fulfilled logistics tasks may result in improving performance of a company as well as the whole supply chain. Fundamental improvements in supply chain efficiency may be ensured by analysing theoretical models on the strategic level and implementing a selected concept.

Key words: efficiency, supply chain management, strategic approach, operational approach.

INTRODUCTION

The present evolution of the logistics field, including research studies relating to the exploration of the interdependencies in logistics systems, is currently at the stage of the supply chain development theories. The present scientific bases of the supply chain management constitute the main factor influencing the development of new views on the concepts of real goods and services streams management. This factor also has impact on changes in this field. Simultaneously, the dynamics of the development of the supply chain management theories includes several issues which have not been resolved or have been treated in a superficial manner.

One of the most important issues subject to theoretical considerations and empirical studies is the measurement of efficiency of activities in logistics and supply chain management. Efficiency is one of the basic problems in

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economics and management, depending on the phenomena described. There is a relatively large number of publications in the discussed fields relating to the process of defining and clarifying the term "efficiency". However, neither domestic nor foreign publications on logistics and supply chain management devote a lot of attention to the issue of efficiency, which highlights the difficulties in defining the true nature of efficiency in logistics operations.

Simultaneously, efficiency is one of the terms interpreted in an ambiguous and multi-aspect manner, depending on the subject of a study. The multitude of analytical dimensions of this term results in the fact that, apart from economic efficiency being the basic study area, other dimensions perceived as an added value by different groups of supply chain participants become more and more important.

The objective of this paper is to attempt to explain the problem of supply chain management efficiency in the context of general theoretical considerations relating to supply chain management. The authors have also highlighted the practical implications of efficiency in a process perspective by giving examples of efficiency measurements in relation to certain logistics processes within supply chains.

EFFICIENCY FROM THE POINT OF VIEW OF THE SUPPLY CHAIN THEORIES

The issues connected with efficiency were initially analysed in the context of the processes in which the field of logistics was interested in. One of the rules of logistics claiming that all activities in the logistics field must be undertaken in the most effective manner unambiguously defines the significance of thinking in terms of efficiency in logistics. Efficiency has also been analysed as a key area of company's strategic management and frequently connected with the efficiency of logistics management. Apart from strategic decisions, the following factors are of key significance for efficiency: systems, structure, mission, human resources, organisation culture or incentive systems. The above-mentioned factors are connected by certain relations resulting in synergy effects determining the efficiency of implemented logistics processes. The presented approach to efficiency mostly related to studying economic efficiency of logistics processes and operations. Lack of IT systems controlling real-time efficiency of all activities may result in the lack of synergy effects, which explains lower efficiency of logistics systems in the past. This is confirmed by the downward trend as regards the logistics expenditures observed over the last decades.

Development of the system theory and its influence on logistics resulted in common usage of formal recording of logistics processes in a form of a logistics model. The presentation of the entire logistics activity in a form of a system yields benefits consisting in the possibility of defining close relations between selected subsystems, which makes it possible to conduct in-depth studies as regard efficiency. The basis for considering efficiency of logistics systems is adoption of a correct model to be subsequently analysed. This model reflects actual processes to be analysed within a given logistics system. A correct mathematical recoding method for a logistics system is of key importance for efficiency measurements. It must take into account all dependencies, limits and boundary conditions connected with the specificity of the system studied. The least complex case in the logistics system theory is a system encompassing relations between one provider and one recipient. More complex systems include numerous providers and numerous recipients plus intermediate phases, e.g. crossdocking, which makes the system structure and relations among its elements more complex.

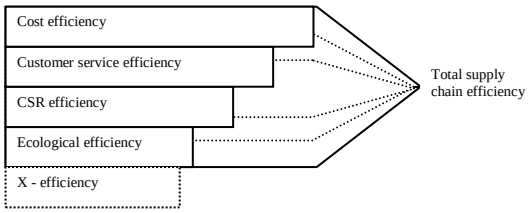
While considering the possibility of studying efficiency of logistics systems with complex structures, one must assume, a priori, static or dynamic character of the representation of the logistics processes in the system. The system dynamics provides both theoretical bases and tools facilitating elaboration of simulations regarding efficiency of both open and closed logistics systems (e.g. i-think or powersim applications).

The modern stage of logistics development, during which the studies mostly concentrate on recognition and explanation of the supply chain operation mechanisms, defines new research areas. As it has already been mentioned, the measurements of efficiency in logistics were studied in previous research work, however, due to the difficulties in selection of methods, scope and time horizon for the studies, these problems connected with supply chain management are still considered as basic and up-to-date issues. The problems regarding supply chain efficiency measurements results mostly from the characteristics of the subject of the studies, i.e. a supply chain. Modifications of an approach to a supply chain, in particular the differences in defining its scope, constitute the reason for ambiguous understanding of its efficiency. Assuming, in line with the latest definitions, that the scope of a supply chain comprises a set of processes between the provider's provider and customer's customer, the issue of the comprehensive measurement of supply chain efficiency arises. The lack of necessity to define the beginning and the end of a supply chain mostly results from the development of the supply chain organisation and transformations of its architecture, which exerts impact both on the increase in supply chain length and volume. The problem of efficiency measurements is partly resolved by referencing five main supply chain efficiency areas to defined values, i.e. a benchmark, e.g. using one supply chain reference model (e.g. SCOR, etc.) [Śliwczyński 2012]. Thus efficiency is perceived in the context of a set of indicators referring to processes within a supply chain, e.g. customer service.

Moreover, the supply chain theory does not provide exhaustive bases for comprehensive evaluation of supply chain efficiency [Khan et al 2010]. However, it describes numerous issues vital for its operation, i.e. algorithms and their properties, estimation of costs, optimisation and control theory elements [Daganzo 2003]. The formal notation describing a supply chain within the supply chain theory makes the decision-making process additionally difficult both on the strategic and operational level.

AREAS OF SUPPLY CHAIN MANAGEMENT EFFICIENCY MEASUREMENTS

The dominating approach consisting in perceiving the supply chain efficiency exclusively as economic efficiency and referring to using indicators that monitor the supply chain processes fails to provide solutions to numerous issues, e.g. environmental efficiency [Bretzke 2013]. Thus we must find a comprehensive approach to supply chain efficiency including all analytical dimensions connected with real goods and services flows. Presently, the majority of companies concentrate on studying the efficiency of areas exerting direct impact on the financial results, consciously omitting areas having negligible impact on these results. See Figure 1 for the analytical dimensions of supply chain management efficiency.



Source: proprietary compilation.

Fig. 1. Analytical dimensions of supply chain management efficiency
Rys. 1. Wymiary analityczne efektywności zarządzania łańcuchem dostaw

Thus supply chain efficiency should be perceived as a function of efficiency within the following areas: costs, customer service quality, ecology and business responsibility.

$$Esc=f(E_c,E_{cs},E_e,E_b) \quad (1)$$

The suggested comprehensive approach to the issue of measuring supply chain efficiency has been formulated from the point of view of an added value creation model. Depending on the perception of the above-mentioned areas, the contribution to the synthetic measure of supply chain efficiency will vary. Thus overestimation of areas results in deviation

from single-dimensional (purely economic) understanding of efficiency and concentrating on other areas contributing to the increase in supply chain efficiency.

In practice, we frequently encounter a situation in which a vast majority of companies participating in a supply chain mostly concentrates on measuring efficiency of a few operational elements. In order to enhance work efficiency, financial incentives are often created for the personnel (e.g. piecework systems, bonus schemes related with efficiency, etc.).

STRATEGIC DETERMINANTS OF A SUPPLY CHAIN

However, the best possibilities of improving efficiency are present on a strategic level. By elaborating different theoretical models of supply chains, a solution more effective than others may be found. According to the Pareto rule (i.e. 80% of product manufacturing cost results from its design), it may be assumed that the same rule applies to a supply chain as a whole. Thus 80% of the supply chain costs are determined during the designing stage. The following factors influence the above: distribution of facilities (warehouses, plants, selection of sub-suppliers), selection of products and locations in locations in which they are manufactured, storage, selection of distribution channels, distances from sales markets or number of links in a supply chain (employing commercial middlemen or direct access to end users). All these factors determine approx. 80% of the chain architecture costs. It means that the other systems, i.e. ERP, or enhancing personnel's efficiency may exert impact on the remaining 20% of costs. This shows why companies' managements should focus on supply chain efficiency already during its designing stage, before decisions are made on the strategic level.

While analysing activities undertaken by numerous leaders (press releases regarding closing down or relocating production) of individual industries, it may be concluded that solutions concentrating production within one or just a few plants located in each continent vital for a given business become increasingly popular. This trend consisting in minimising the number of manufacturing locations is clearly visible, particularly during the economy slowdown periods. Main sub-suppliers are frequently located in the vicinity of such plants. Another trend can also be observed here, i.e. creation of supply chains in regions, which applies both to the supply and distribution process. Among others, Poland together with its neighbours belongs to such a region. While analysing trends set by individual leaders, it may be concluded that we more and more frequently witness creation of distribution systems based on one distribution centre operating a few or even several countries located around it. In other common cases, a supply chain leader bases their production on one plant from which products are distributed all over the European market, directly to a retail network, omitting additional links in the supply chain (distributors, wholesalers, a commercial network can also be a supply chain leader). In the majority of cases, a supply chain leader is responsible for its efficiency. This entity defines conditions of cooperation which determine suppliers' activities including logistics services. Contracts concluded with suppliers usually include expectations connected with delivery methods, product quality and services in terms of their promptness, completeness of delivery in relation to orders, timeframes, etc. Such requirements have direct impact on efficiency of the entire supply chain. They make it more or less effective.

An effective supply chain should be:

- cost-effective (ensuring economic efficiency of a chain);
- functional (reducing processes, lean, minimising the number of links in the chain to the necessary ones, adapting supply chain participants' internal processes to a common objective based on its efficiency), Functionality may also be defined as correct preparation of goods facilitating their acceptance in warehouses or shops. Goods should be labelled in a manner ensuring their faultless and fast identification so that the time devoted to their acceptance is reduced to the necessary minimum. Implementation of RFID-based

technologies significantly accelerates this process;
- ensuring high quality of services (customer-oriented logistics systems);
- socially responsible (taking into account stakeholders' social interest and maximally reducing environmental impact).

When a supply chain leader implements an adopted solution, it will determine (in a perspective of at least a few years) the obtained efficiency level for the adopted model on the strategic level. Further enhancement of efficiency of the adopted supply chain is possible to be ensured as a result of operational modifications and more effective utilisation of its resources.

OPERATIONAL DETERMINANTS OF A SUPPLY CHAIN

The phrase "Efficiency improvement" seems to be a favourite buzzword for all senior managers in each organisation. However, this phrase mostly refers to improving efficiency on the operational level.

Currently, activities aimed at streamlining supply chains are mostly based on analyses of processes present within a given chain and measurements of indicators (KPI) for individual elements of this process. Even such factors as implementation of KPI measurements and correct transfer of information to interested parties result in the fact that a given process becomes more effective. This results from purposeful or involuntary evaluation of the way personnel do their work. However, to extensive number of such indicators may result in blurring the vital ones so it is necessary to concentrate on such indicators which most effectively describe processes within a supply chain. It must also be remembered that the analysed indicators should include all perspectives (e.g. BSC), but not only the ones with have impact on one of them (elements belonging to the financial or quality areas are most often evaluated). A typical example of indicators yielding contradictory results may be focusing on distribution costs, not taking into account the customer service costs (promptness or completeness). Benchmarking other teams implementing similar processes, e.g. in different locations, introduces an element of competitiveness and rivalry. As a result, personnel strive to improve their processes. Introduction of a "stop number indicator" among carriers delivering general cargo to customers has yielded similar results as introduction of an additional charge for stops. Increase in efficiency has been similar in both cases.

LOGISTICS OUTSOURCING AS A METHOD OF ENHANCING OPERATING EFFICIENCY OF A SUPPLY CHAIN

Outsourcing certain tasks to external bidders releases funds for developing areas vital for company's business. The outsourced tasks do not belong to core competencies, i.e. skills and functions being basic sources of the competitive edge. Maintaining own logistics potential results in the fact that a company generates fixed costs regardless of the current market demand or seasonal trends. Outsourcing means flexibility in shaping a logistics system used to implement supply and distribution processes, i.e. using only such a number of employees and vehicles as well as an amount of storage space that is required during a given period. Thus it results in transforming fixed costs into variable costs. Depending on operations and their complexity, different savings resulting from outsourcing may be obtained.

While taking a decision regarding cooperation with an external logistics services operator, one must decide which costs are connected with such services but also how they can influence customer service and what services they may ensure. Numerous studies show that a method employed for logistics activities has much more extensive impact on company's results than its logistics costs [Goebl, Froschmayer 2011].

Logistics operators (supply chain integrators) play the role in integration of all links of a supply chain as they are more and more frequently present in the whole chain as

one of its key elements. Thanks to effective connection networks, the provide supplied both on the local and global level. Apart from effective movement of goods, an information flow in a supply chain is also very important. Employing homogenous information exchange systems contributes to improving efficiency and allows for implementing increasingly more advanced solutions.

CONCLUSION

Efficiency of supply chains is not only a task for which a logistics department is responsible as it is a strategic decision taken by the management as regards the method of future company's operation. Decision-makers must always remember that a supply chain must first be planned in the most effective manner taking into account numerous aspects influencing its operation. Correctly planned and fulfilled logistics tasks may result in improving performance of a company as well as the whole supply chain. Disregarding the importance of the designing and strategic analysis processes will surely make a supply chain less effective. In a company aware of its importance, supply chain management may play a key role exerting the same impact on its performance as sales, marketing or production. Management itself is a success in establishing correct rapport among individual functional departments of a company. Elaboration of a correct new model or streamlining the existing supply chain may be extremely beneficial for an organisation both as regards its market position and economic results. It may be particularly important in the coming period when each, even the slightest, element can have impact on future of the organisation.

The above considerations show that fundamental improvements in supply chain efficiency may be ensured by analysing theoretical models on the strategic level and implementing a selected concept. Thus one must not disregard the importance of cooperation between science and practice in building effective supply chains and exchange of experiences resulting from observations of different existing models in comparison with theoretical considerations.

There are unique features of each supply chain which can be used as best practices in other models.

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EFEKTYWNOŚĆ ZARZĄDZANIA ŁAŃCUCHAMI DOSTAW. PODEJŚCIE STRATEGICZNE I OPERACYJNE.

STRESZCZENIE. **Wstęp:** Jednym z najistotniejszych zagadnień, które stanowi przedmiot zarówno rozważań teoretycznych jak i badań empirycznych jest pomiar efektywności działań w logistyce i zarządzaniu łańcuchami dostaw. Efektywność jest jednocześnie jednym z pojęć, które są interpretowane w sposób niejednoznaczny i wieloaspektowy w zależności od obiektu badania. Wielość wymiarów analitycznych pojęcia efektywność powoduje, że oprócz efektywności ekonomicznej, która stanowi podstawowy obszar badań coraz większe znaczenie zyskują inne wymiary postrzegane jako wartość dodana przez różne grupy uczestników łańcucha dostaw.
Metody: Celem artykułu jest próba wyjaśnienia problemu efektywności zarządzania łańcuchami dostaw na tle ogólnych rozważań teoretycznych odnoszących się do zarządzania łańcuchami dostaw. Autorzy wskazali na determinanty

i implikacje praktyczne efektywności zarządzania łańcuchami dostaw w ujęciu strategicznym i operacyjnym. W badaniach wykorzystano krytyczną analizę literatury logistycznej, metodę wywiadu swobodnego z przedstawicielami najwyższego kierownictwa przedsiębiorstw sektora TSL.
Wyniki: Istnieje potrzeba całościowego spojrzenia na efektywność łańcuchów dostaw, obejmująca wszystkie wymiary analityczne, które są związane z przepływami dóbr realnych i usług. Efektywny łańcuch dostaw powinien być optymalny kosztowo (zapewniający efektywność ekonomiczną łańcucha), funkcjonalny (redukujący procesy, lean (minimalizujący ilość ogniw w łańcuch do rzeczywiście niezbędnych), dostosowujący procesy wewnętrzne uczestników łańcucha dostaw do wspólnego celu opartego na jego efektywności) oraz zapewniający wysoką jakość obsługi (systemy logistyczne zorientowane na klienta).
Wnioski: Efektywność łańcuchów dostaw nie jest jedynie zadaniem działu logistyki, jest ona strategiczną decyzją zarządu, co do sposobu funkcjonowania przedsiębiorstwa w przyszłości. Dobrze zaplanowane i zrealizowane zadania logistyczne mogą wpłynąć na poprawę wyników nie tylko firmy, ale również całego łańcucha dostaw. Zasadniczą poprawę efektywności łańcucha dostaw można uzyskać opierając się na rozważaniu modeli teoretycznych na poziomie strategicznym a następnie wdrażaniu wybranej koncepcji w praktyce.

Słowa kluczowe: efektywność, zarządzenie łańcuchem dostaw, podejście strategiczne, podejście operacyjne.

DIE EFFIZIENZ DES SUPPLY-CHAIN-MANAGEMENTS. STRATEGISCHER UND OPERATIVER ANSATZ

ZUSAMMENFASSUNG. Einleitung: Eine der wichtigsten Fragen der Effizienz-Orientierung des Supply-Chain-Managements als des Gegenstandes der theoretischen und empirischen Forschung ist es, die Effizienz der Logistik und des Supply-Chain-Managements zu messen. Die Effizienz ist zugleich auch eines der Konzepte, die je nach dem Forschungsgegenstand als mehrdeutig und facettenreich interpretiert werden können. Die Vielzahl der analytischen Dimensionen des Konzepts der Effektivität verursacht, dass neben der Wirtschaftlichkeit, die den Grundbereich der Forschung darstellt, auch andere Dimensionen zunehmend an Wert gewinnen, und oft als eine Wertschöpfung durch verschiedene Gruppen von Teilnehmern der Lieferkette wahrgenommen werden.
Methoden: Das Ziel dieses Artikels ist ein Versuch, das Problem der Effizienz des Supply- Chain-Managements im Rahmen von allgemeinen, theoretischen Überlegungen in Bezug auf das Management von Lieferketten zu klären. Die Autoren weisen auf die Determinanten und die praktischen Auswirkungen der Effizienz-Orientierung des Supply-Chain-Managements in Bezug auf strategische und operative Ebene des Problems hin. Die Studie nimmt eine kritische Analyse der logistischen Literatur, sowie die Methode des Frei-Form-Interviews mit Vertretern des Topmanagements von Unternehmen aus der TSL-Branche in Anspruch.
Ergebnisse: Es besteht ein Bedarf an umfassender Betrachtung der Effizienz der gesamten Lieferkette, einschließlich aller analytischen Dimensionen, die mit den Bewegungen der realen Gütern und Dienstleistungen verbunden sind. Eine effektive Lieferkette sollte aus Kostenperspektive (um die Wirtschaftlichkeit der Kette zu gewährleisten) optimal, funktional (Reduzierung der Prozesse) und schlank (die Anzahl der Kettenglieder muss bis auf die Erforderlichsten minimiert werden) sein. Die internen Supply-Chain-Prozesse der einzelnen Teilnehmern müssen auf das gemeinsame, auf die Effizienz fokussierte Ziel konzentriert sein und eine hohe Qualität der Dienstleistungen (kundenorientierte, logistische Systeme) gewährleisten.
Fazit: Die Effektivität der Lieferkette ist nicht nur die Aufgabe der Logistikabteilung sondern eine strategische Entscheidung des Vorstandes für die Art und Weise der zukünftigen Funktionsausübung innerhalb seines Unternehmens. Denn gut geplante und ausgeführte Logistikaufgaben können nicht nur die Ergebnisse des Unternehmens, sondern auch den gesamten Supply Chain positiv beeinflussen. Die fundamentale Verbesserung der Supply- Chain-Effizienz kann durch die Abwägung von theoretischen Modellen auf der strategischen Ebene und die Umsetzung des ausgewählten Konzeptes in die Praxis erzielt werden.

Codewörter: Effizienz, Supply-Chain-Management, strategischer Ansatz, operativer Ansatz.

Grzegorz Lichocik
Dachser sp. z o.o.
ul. Wersalska 47/75
91-212 Łódź Poland
e-mail: grzegorz.lichocik@dachser.com
Adam Sadowski
University of Lodz
ul. Rewolucji 1905r. 37/39
90-214 Łódź Poland
e-mail: asadowski@uni.lodz.pl

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A DYNAMIC MANAGEMENT OF A PUBLIC TRANSPORTATION FLEET

Ireneusz Celiński, Grzegorz Sierpiński

Silesian University of Technology, Katowice, Poland

ABSTRACT. Background: The present paper deals with the problems of a public transportation fleet management in public transportation operators. A management concept is proposed based on a real-time acquisition of parameters of public transportation passenger exchange.
Methods: The relevant research utilised video materials documenting the processes of passenger exchange in public transportation. The proposed methodology is based on a dynamic real-time measurement of passenger streams. A characteristic feature of the measurement methodology applied is that the data is collected outside the vehicles, with a CCTV camera used per access point. Demand for the public transportation service are calculated using the image processing.
Results: The derived demand characteristics allow not only an estimation of the magnitude of traffic streams in public transportation but also their qualitative description. Such an approach permits a flexible design of the transportation offer to adapt to the demand. This allows matching the timetables to the density functions describing the demand for public transportation within the space of transportation networks. In addition, based on the results of this type of research, a public transportation operator may despatch the vehicle base in a flexible way. For each run of a bus or tram fleet, basing on the registered passenger traffic streams, it is possible to rationally despatch the vehicles with suitable capacity.
Conclusions: A system of this type is capable of determining the quality of work of the public transportation. With the ITS systems being introduced still more widely, the proposed methodology allows the design and implementation of dynamic timetables.

Key words: Public transportation, PuT Management, Image Recognition, CCTV.

INTRODUCTION

Despite the fact that the sustainable development of transportation has been a policy promoted since almost 30 years, the public transportation itself is still in recession [Our Common Future. Report of the World Commission on Environment and Development 1987], [White Paper 2001], [White Paper 2011], [Sierpiński 2012]. The results of the studies of the modal split in transportation indicate a slow but steady increase in the number of trips carried out by individual transportation [Karoń et al. 2009]. According to these authors, a fundamental problem in this context is the increase of the gap between the supply of services offered by the public transportation operators and the demand for these services. The gap exists both in the qualitative and the quantitative domain. A number of factors affecting this situation exist. One of the key ones is the increase in the mobility dynamics of the contemporary societies. On one hand, an allocation of traffic generators and absorbers within the urbanised areas has been noted (due to the socio-economic changes). On the other hand these changes are accompanied by the significant changes to the individual and group transportation-related behaviours of the population (working time, number of places of

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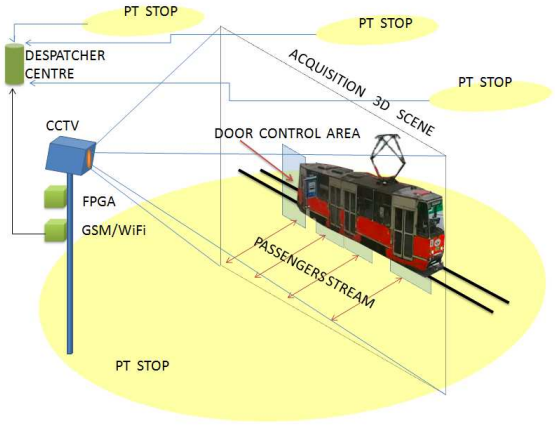
employment, forms of recreational activities, the suburbanisation processes, etc.) [Celiński and Sierpiński 2012]. Their negative effect (from the point of view of the bodies responsible for traffic management in transportation networks) is the resultant drastic increase in the time and spatial non-homogeneity of traffic streams (taking place in Poland since 1989). A non-flexible supply of the public transportation based on the timetables planned for months in advance caused the increase of dichotomy of the characteristics of the supply and demand processes in public transportation. Such a situation causes the clients of the public transportation to be 'pushed away' i.e. driven towards the purchase and use of the means of individual transportation. Such a scenario has realised itself in the US in 1950s and 1960s and the results of that are still observed in the American society [Klein 2008]. According to these authors reasonable tools exist allowing a harmonisation of the supply and demand in public transportation. The goal of the balancing of transportation should be a harmonisation of the transportation offer with the associated demand achieved through the available technical means (such as telecommunication systems, ITS, etc.). The alternatives, in the forms of soft and hard instruments of transportation policies are often too costly or misaligned with the subjective interests of specific social groups. The present paper covers the topic of a construction of a system allowing the public transportation fleet management aimed at a harmonisation of the supply and demand in public transportation. The goal of the construction of such a system is increasing the share of the public transportation in the modal split (the distribution of the transportational tasks). This goal is to be achieved by maximising the match (harmonisation) of the characteristics of passenger stream requests (raised to the service streams) at the public transportation stops (PT stops).

A MEASUREMENT SYSTEM AND THE PROJECT METHODOLOGY

A system balancing the supply and demand sides of a public transportation system should in principle be provided with two kinds of functionalities. The first one is a large flexibility in measuring the characteristics of the request streams. The other is the ability to operate in real time. An important feature of the system should be its portability and the function of wireless communication with the public transportation operator's control and despatch centre. Existing measurement systems, counting the numbers of passengers either inside the means of public transportation or at the entries of the mass service channels (such as tunnels, stations or PT stops) do not meet the above criteria (are not flexible as far as the measured characteristics are concerned, both in the qualitative and the quantitative aspect). For this reason it is proposed that a system balancing the supply and demand sides of the public transportation should be based on CCTV. As an assumption, such a system should handle the measurement of the process of passenger exchange in the means of public transportation using one or two CCTV cameras per PT vehicle. A diagram of the relevant measurement system at a single access point of a public transportation line has been shown in Figure 1.

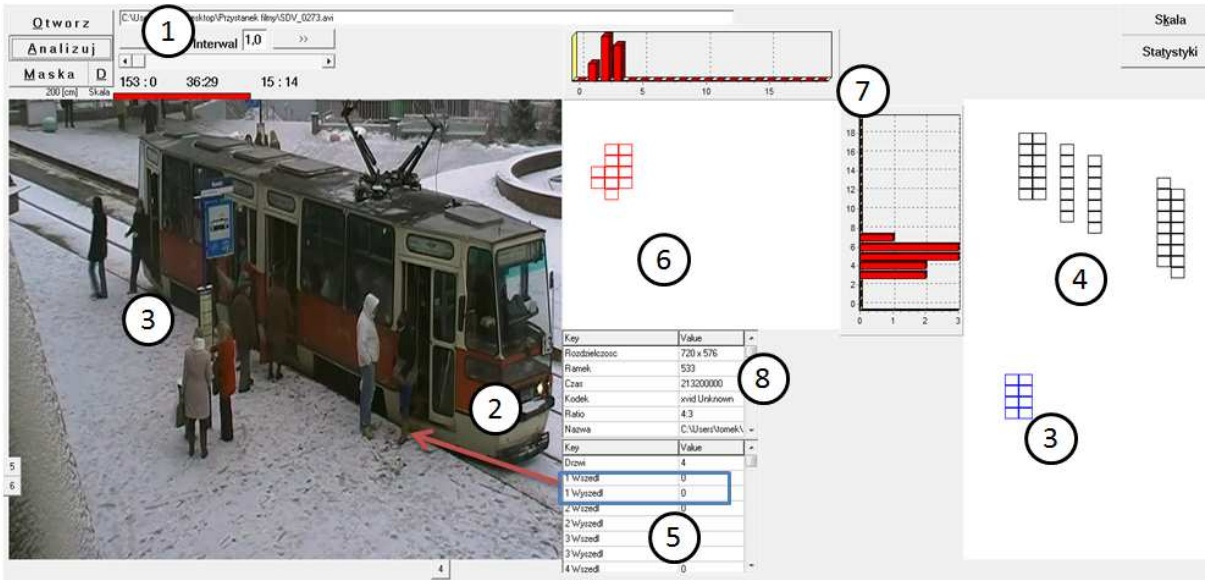


Source: Own research

Fig. 1. Measurement system diagram
Rys. 1. Schemat systemu pomiarowego

The system as presented in Figure 1 contains a set of CCTV camera (1 or 2 per one direction/platform edges) - FPGA module (in destination systems) - GSM (WiFi) module at each access point of the public transportation network. FPGA module (Field Programmable Gate Array) is responsible for the processing

of the image acquired in real time. The GSM (WiFi) module is responsible for transmitting the processed data in the form of the acquired characteristic of passenger exchange. In practice, the volume of transmitted data is minimal and may well be transmitted as an SMS message. For the basic functionality of the system and for a single service request of a means of public transportation at a service point, the data format may, for example, take the following form: date, time, point_no, relation (direction), vehicle_no, door_no (in/out), exchange_time (as sum of: clearance time, alighting time and boarding time). In practice, as it will be shown further, much more advanced characteristics of passenger exchange may be gathered and transmitted. Within the remit of the present research, due to budgetary limitations, only a stationary system for passenger exchange measurement was used. Instead of using an FPGA and a GSM module, the data was post processed (stationary processing) in a computer application. The main window of the programme is presented in Figure 2. In case of an industrial application, the programme is to be substituted by a fully-fledged FPGA module connected with an MS (GPS) unit.



Source: Own research

Fig. 2. Passenger exchange analysis software
Rys. 2. Program do analizy wymiany podróżnych

The principle of operation of the application is based on the detection of mobile objects (passengers) within a video image recorded in real time. Field 1 (number in circle on Figure 1) allows a selection and download of a file containing the video material recorded at a public transportation service point (Field 8 contains the data on the video material itself: its format, video codec name, scene size, aspect ratio, etc.) By definition, the PT vehicle in such a system stops at the service point at a marker line (in practice, these authors were positioning the cameras). Such an approach allows an automatic selection of a programme mask for the zones in which the passenger exchange takes place (the masks are shown in Field 4 in Figure 2). Any movement is detected in the image and displayed in field 6 (any movement is detected, including that in the background of the PT scene). For the purpose of the analysis of the passenger exchange parameters (in order to limit the volume of the data) traffic is only analysed in the areas (zones) defined by the "door" masks. In this way it is only the traffic in the area of the doors of a public transportation vehicle that is analysed (Field 3). Fields 3 (in fact: 2 fields) presented in Figure 2 in the scene image and in the mask image (scale 1:2) correspond to each other (the mask field is a superposition of the

scene). The so-called Block 8 of blue squares (Field 3 on the right hand side of Figure 2) corresponds to a passenger leaving through the back door of the vehicle within the scene (left side of the image - real image). The passenger exchange is registered in Field 5 with the assignment to the specific door and to the movement direction (in/out). A case with a larger number of data will be discussed further on. Based on the identified parameters of the moving objects registered in the "door" mask areas and on the results of additional statistical analyses (Field 7) the numbers of passengers getting in and out are counted and assigned to the appropriate doors of the means of transportation (Field 5). A description of the algorithms detecting the passenger exchange goes beyond the scope of the present paper. Based on the known dimensions of the objects on the scene (the height of a passenger, of the door, road sign, a shelter etc.) a user may define a scale for the registered passenger exchange scene. Applying such a procedure in the research process allows investigating the kind-related structure of passenger streams as well as more characteristics. It needs to be mentioned that the proposed system permits an investigation of a kind-related structure with the accuracy corresponding to the measurement scale accepted (e.g. taking into consideration the passenger height and taking into account the perspective-related contraction in individual exchange zones). As a result, the resultant information may be presented as shown in Table 1.

Table 1. The data obtained from the analysis of the passenger exchange scene image analysis (in the transmitted format and in a tabular format).
Tabela 1. Dane otrzymane w wyniku analizy pomiaru zmian pasażerów na obrazach (w formie transmitowanej i tabularycznej)

Transmitted format: date, time, point_no, relation (direction), PTvehicle_no, door_no (in/out), exchange_time
06_02_2013/10:01:12/11241/0/634/1(3/2)/2(1,2)/3(0,2)/4(1/1),00:17
06_02_2013/10:11:12/11241/0/841/1(1/1)/2(3,2)/3(3,0)/4(8/1),00:15
06_02_2013/10:21:12/11241/0/34/1(0/2)/2(1,3)/3(0,2)/4(0/1),00:12

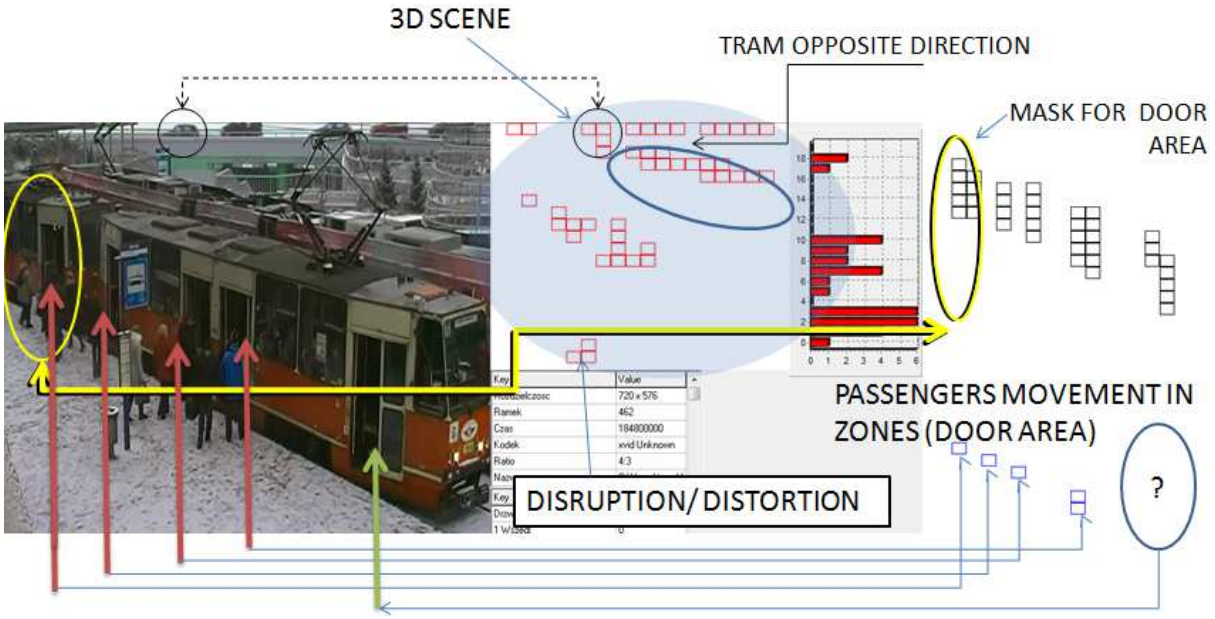
Tabular format:

date	time	point_no	relation	PTvehicle_no	door_no (in/out)	exchange_time
06_02_2013	10:01:12	11241	0	634	1(3/2)/2(1,2)/3(0,2)/4(1/1)	00:17
06_02_2013	10:01:12	11241	0	841	1(1/1)/2(3,2)/3(3,0)/4(8/1)	00:15
06_02_2013	10:01:12	11241	0	34	1(0/2)/2(1,3)/3(0,2)/4(0/1)	00:12

Source: Own research

As opposed to the classic (optoelectronic) measurements of the occupancy of the means of transportation and of the number of passengers participating in the exchange, the process itself may be monitored by a single recorder (CCTV) per vehicle/car/set. In practice, from these authors' experience, in case of the sets of vehicles, two or more CCTV cameras should be mounted because of the perspective-related contraction effect (occurring independently from the location of a camera). Compared with the technique of using the optoelectronic sensors mounted in the door area, the proposed process is less sensitive to the presence of residual passengers remaining in the door zones (in Figure 2 a passenger coming on board will remain in the door zone, leaning against the door). Such a case, with a modern vehicle monitoring system, will disable shutting the doors. In the proposed case, the system of recording the passenger flows operates from the outside and is therefore independent from the flows. A number of other parameters, such as passenger height, their speed of moving and other may be recorded in the proposed system. This allows a rough estimation of the type structure of a passenger stream. In practice, the investigated group may be divided into the sub-groups of school youth (7-13 years old), other passengers and disabled passengers on wheelchairs (the width of the wheelchairs is important in these cases). Due to the method of data acquisition the system use, as opposed to

the optoelectronic system is not limited to the door area. It is possible to evaluate the exchange processes over a larger area of a service point of a public transportation system, allowing an increase in the quality and the quantity of the observed variables. Figure 3 illustrates the mutual references of the individual acquisition areas (here: broader passenger exchange).



Source: Own research.

Fig. 3. A process of recognition of the parameters of a passenger exchange process
Rys. 3. Proces rozpoznania parametrów wymiany pasażerów

Figure 3 illustrates in a high level form a concept of operation of a passenger exchange identification algorithm at a tram stop Rondo gen J. Ziętka, Brynów direction, tram line no 6. The line is served by Tramwaje Śląskie (regional tram operator) and the tram stop located on the biggest roundabout in Katowice. Due to the perspective-related contraction of the tram in the view, the data acquisition concerns only the passenger exchange process in the first car (head of the set). Visible in the background are the vehicles (cars on the top of figure 3) going around the central island of the roundabout. The algorithm detects even smallest movements at the data acquisition scene (the resolution depends on the parameters of the camera, its settings, the distance from the registered scene, lighting etc.; it may come as high as an order of single centimetres). As a result of such a high resolution the number of events related to moving object detection may be very high (including the detection of pseudo-moves, resulting for example from the vibrations of the ground). To remediate this, exchange zone masks are defined (which may be any part of the frame of the scene but usually are set as the doors outlines). Red squares on a white background correspond to the traffic detected in a scene (the detection area is presented in the scale of 1:2 with respect to the recorded image area). Blue squares correspond to the movements detected in the area of all the doors of the public transportation vehicle concerned (in the scale of 1:2 again). The migration of the moving objects between the exchange areas is detected and processed (a statistical analysis of the data corresponding to the analysed scene) by the movement area data processing algorithm.

A CONCEPT OF A FLEET MANAGEMENT SYSTEM

The presented system of identification of the characteristics of a passenger exchange process is supposed to serve a single public transportation vehicle at a time (potentially, in the future, a single set) at a service point by means of a CCTV-FPGA-GSM set mounted on a street light pole, a dedicated mast, any near located buildings etc. The information returned is a characteristic of the passenger exchange process, including the information on the date and time of a recording, vehicle number, service point number, number of doors, number of passengers boarding and alighting (in/out in Table 1), as well as other parameters. Based on the measurements of the dimensions of the identified objects, the registered exchange stream may be categorised as to the types of passengers. This allows an identification of a share of disabled persons in the streams, of people taking cycles on board or carrying oversize luggage (all these may be achieved by proper calibration of the algorithm). In such a system the information is collated in real time as a density function of a number of requests registered in time on the territory of the transportation network monitored by that system. In this sense a timetable may be adapted dynamically so that it matches optimally the needs for transportation service requested in a specific inhabited area. By engaging flexible scheduling systems the supply of the means of transportation may be matched to suit the process. The supply is delivered JIT (just-in-time) and at a quality level adequate for a required standard of service. Apart from balancing the supply this also leads to the savings in the means of transportation (in case of observed small or decreasing demand) as well as to the increase of the quality of service (in case of high observed demand or of the increase in the demand). In case of such a methodology the dispatching system is reduced to assigning the fleet items to the extreme values of the passenger exchange density function at service points. A more detailed discussion of this problem goes beyond the scope of the present paper. It is worth mentioning that in the Polish contemporary legal system a function of dynamic adaptation of timetables goes beyond the definition of a public transportation (being: 'a universally available regular transportation service for the people, performed at specified time intervals and on a specified one transportation line, several transportation lines or over a transportation network' Dz. U. 2011, nr 5, pos. 13). Some experimental deviations from the definition (such as for example the Telebus service in Krakow) have been noted.

An added value is in this case is the passenger exchange observation process itself, related to singe door of the means of transportation. A study of the characteristics of this type allows an optimal selection of the available means of transportation related not only to the technical parameters of the infrastructure but also to the characteristics of the request stream. The described system allows also collecting the data for design and construction centres where modern means of transportation are designed.

DISCUSSION AND CONCLUSIONS

Is the passenger exchange measurement system described in the paper a rational one? Firstly, it needs to be stressed that the number of service points may be higher than the number of vehicles in the fleet. In this context, the number of measurement points mounted at the doors of the means of transportation may be lower than the number of external points (mounted on the poles and masts at the service points, at (PT stops to PT vehicle ratio ca. 4:1). Also, a cost of a CCTV-FPGA-GSM system is higher (in low series production) than the cost of optoelectronic devices mounted at the doors. From this perspective it seems to be more rational to use the optoelectronic solution. Any comparison should, however, take into account a much higher flexibility of the system based on CCTV (and of course one should remember that even such a system may also be mounted above the vehicle doors).

A system based on CCTV provides a much higher number of data allowing an identification of structures of passenger streams and covers a much wider area. Such a system allows for example to measure waiting times of passengers at the stops (a function which cannot be implemented in

the other PT vehicle system). Also other functionalities, such as security monitoring of the public transportation service points may be integrated into the proposed system (a problem of a throughput of the transmission channels). In addition, the described system allows a diversification (in theory - fully flexible) of passenger streams structures, which is important from the perspective of a carrier or a public transportation operator.

The proposed system is independent from the type of means of transportation. It may be installed on the lines served by buses, trolleybuses, underground (tube), trams or any other means of transportation of high capacity and/or occupancy. As the exchange zones may be set up freely, there is no need for the typical doors to be present. This broad range of features and capabilities makes the system an excellent complement for other instruments of improvement of the mobility in cities (described in [European Platform on Mobility Management], [Sobh et al. 2007], [Sierpiński 2011], [Sierpiński and Celiński 2012], [Toolbox for Mobility Management Measures in Companies]).

At the present moment, the dichotomy between the characteristics of supply and demand on the public transportation lines leads to a non-rational management of the vehicle base (an example has been shown in Figure 4).

Source: Own research (Katowice, 14 of November 2012, 3.47 PM).

Fig. 4. A dichotomy effect of the supply and demand characteristics in public transportation
Rys. 4. Efekt dychotomii charakterystyk podaży i popytu w transporcie zbiorowym

One more functionality of the discussed measurement system is worth mentioning. The system allows a comparison of public transportation related traffic models in a transportation network (this would be possible under the condition of a broad coverage of the system over the network concerned). The knowledge of these models in turn allows an optimization of the routes of public transportation. For example, heavily loaded passenger service points may be converted into multimodal exchange nodes due to achieved maximum seamless effect. The system also eliminates the needs for additional studies of passenger streams, contributing to the better return on investment related to the system installation and maintenance.

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DYNAMICZNE ZARZĄDZANIE FLOTĄ TRANSPORTU ZBIOROWEGO

STRESZCZENIE. **Wstęp:** Artykuł dotyczy problematyki zarządzania ilostanem środków transportu zbiorowego w przedsiębiorstwach transportu publicznego. Zaproponowano koncepcję akwizycji parametrów wymiany pasażerów w komunikacji zbiorowej w czasie rzeczywistym. Przedmiotowa akwizycja odbywa się na bazie wideorejestracji wymiany pasażerów.
Metodyka badawcza: W przedmiotowej metodyce wykorzystano materiały wideo zarejestrowane w trakcie procesu wymiany pasażerów w środkach transportu zbiorowego. Proces wymiany pasażerów rejestrowano z wykorzystaniem kamer przemysłowych CCTV w standardzie PAL. Proponowana metodyka zarządzania ilostanem środków transportu opiera się na dynamicznym pomiarze strumieni ruchu podróżnych. Pomiar wykonywany jest w punktach dostępu do infrastruktury transportu zbiorowego.
Wyniki: Tworzone charakterystyki popytu pozwalają nie tylko na szacowanie wielkości strumieni ruchu w transporcie zbiorowym, ale również na ich jakościowy opis. Tego typu podejście umożliwia elastyczne konstruowanie oferty przewozowej w celu równoważenia popytu na realizację podróży. Ponadto operator transportu zbiorowego, na podstawie tego typu badań, jest w stanie elastycznie dysponować flotą.
Wnioski: System taki może określać jakość transportu zbiorowego. W aspekcie systemów ITS zwraca uwagę możliwość wykorzystania tej metodyki w celu konstrukcji dynamicznych rozkładów jazdy.

Słowa kluczowe: Transport zbiorowy, Zarządzanie flotą, Rozpoznawanie obrazów , CCTV.

DYNAMISCHE FUHRPARK-VERWALTUNG IM MASSENVERKEHR

ZUSAMMENFASSUNG. Einleitung: Der Artikel befasst sich mit der Problematik der Fuhrpark-Verwaltung im Massenverkehr in Unternehmen des öffentlichen Verkehrs. Es wurde ein Konzept der Parametererfassung in Echtzeit beim Passagierwechsel im Massenverkehr vorgeschlagen. Die vorliegende Erfassung basiert auf Videoaufnahmen von Passagierwechseln.
Methoden: Man benutzte in der vorliegenden Methodik die Videomaterialien, die während des Passagierwechsels in Massenverkehrsmitteln aufgenommen wurden. Der Prozess des Passagierwechsels wurde mittels CCTV-Kameras in PAL-Standard registriert. Die vorgeschlagene Methodik der Fuhrpark-Verwaltung basiert auf der dynamischen

Durchflussmessung des Passagierverkehrs. Die Messung erfolgt an der jeweiligen Haltstelle mit Zugang zur Infrastruktur des öffentlichen Verkehrs.
Ergebnisse: Die erstellten Nachfrageeigenschaften machen es möglich, nicht nur die Kapazität des Verkehrsflusses im Massenverkehr zu einzuschätzen, sondern auch eine qualitative Beschreibung anzufertigen. Ein solcher Ansatz ermöglicht eine flexible Erstellung von Beförderungsangeboten, damit man den Bedarf an die zur Reisedurchführung benötigte Kapazität feststellen und deren Sicherung gewährleisten kann. Darüber hinaus ist der Betreiber des Massenverkehrs auf der Grundlage dieser Art von Untersuchungen im Stande, flexibel über einen Fuhrpark zu verfügen.
Fazit: Ein solches System kann die Qualität des Massenverkehrs bestimmen. In Bezug auf die IST-Systeme wird die Möglichkeit der Verwendung dieser Methodik empfohlen, insbesondere dann, wenn dynamische Verkehrspläne zu entwerfen sind.

Codewörter: Massenverkehr, Fuhrparkverwaltung, Erkennung von Bildern, CCTV.

Ireneusz Celiński
Grzegorz Sierpiński
Silesian University of Technology
Faculty of Transport
Department of Traffic Engineering
Krasiński 8 Str., 40-019 Katowice, Poland
e-mail: ireneusz.celinski@polsl.pl
e-mail: grzegorz.sierpinski@polsl.pl

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STUDYING CUSTOMER LOYALTY AT DAEWOO EXPRESS BUS SERVICE, PAKISTAN

Usman Yousaf [1], Javeria Yousaf [2], Mohsin Altaf [2], Mohammad Majid Mehmood Bagram [3]

[1)] Quaid Azam University, Islamabad, Pakistan, [2)] University of Sargodha, Pakistan, [3)] Allama Iqbal Open University, Islamabad, Pakistan

ABSTRACT. Background: Meeting service quality standards and striving for loyalty are two critical areas which have until now been overlooked by both the passenger transport industry and academia in Pakistan therefore the study sheds useful light on an issue hitherto untouched. Therefore increased sample size will help in increasing generalizability of study.

Methods: This paper is designed to study the level of loyalty at Daewoo Express Bus Service in Sargodha by measuring customer satisfaction. Researchers used a small sample of only 96 respondents (passengers) and only studies customer's behavior in the service quality of Daewoo Express Bus Service however it may differ in other passenger transport services.

Results and conclusions: This paper reveals that there is a positive and significant relationship between loyalty (dependant variable) and price perceptions, reliability, retrieving and smoothing (independent variables). However, the study found that reliability of services is the most important dimension among other independent variables (price perceptions, smoothing, reliability, retrieving) effecting customers loyalty at Daewoo Express. Paper under consideration would surely assist Daewoo`s management team to take care of the loopholes existing in the current service level and likely threats which Daewoo might face.

Key words: Customer Satisfaction, Service Quality, Loyalty, Smoothing, Reliability, Retrieving, Price Perceptions, Daewoo Express Sargodha.

INTRODUCTION

Customer Satisfaction is the extent to which the customers are satisfied with the goods and services of the company. It is also defined as the amount of value which customers give to the company.

Customer Satisfaction is reached when a customer is able to fulfill every desire he has in his mind regarding company's goods or services. The companies which provide their customers, every good and service according to their specification and requirement satisfy the customer.

Another important aspect of customer satisfaction is the quality of the goods and services that a company provides. Quality is the excellence a company has in its products and services. Good is the quality of the services, better is the quality of the company. According to Foster, [1917-1945] Quality cannot be achieved by chance; it is attained by high aims, sincere vigorous attempts, intelligent direction and skillful execution. Every organization keeps eyes on provision of high quality of goods and services to its

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customers. But every individual has a distinct mind and that's why he has his own perception about quality of goods and services. So, to measure the service quality and the level of satisfaction of the customers in the services of Daewoo Express Bus Service in Sargodha, this research is carried out.

Daewoo Express Bus Service is passengers' bus service nationwide, it also operates within cities through small buses and it also provides the facility of cargo in a number of cities. Daewoo Express Bus Service is a company of Sammi Group Company Korea. The company was initiated in 1954 and since 1950`s it is working in Korea. In Pakistan it started its operations in late 1990`s after completion of the first phase Motor Ways. Initially bus service was provided in big cities of country now it is provided in most cities of the country.

Daewoo Express Bus Service introduced the concepts of high quality waiting rooms, strictly following bus schedule, high quality buses, bus hostess helping passengers, refreshment during passage, good quality entertainment and non-stop traveling through bus in Pakistan. In Sargodha, company started its operations in 2000. Sargodha is a developing city and mostly youngsters are educated here so, their area of concern is that what they pay, are they receiving the services accordingly?

Ensuring quality of services is essential for the company for creating positive perception in the minds of the customers. So, the management should work closely with their customers. As there are several alternatives available for customers. With advancement in technology, companies are able to provide better services and level of customer satisfaction is increasing. To measure that increasing or decreasing level of customer satisfaction this research has been made.

LITERATURE REVIEW AND HYPOTHESIS

Service quality increases the level of customer satisfaction as according to Zeithaml et.al. [1996] when a customer makes a positive assessment about the service quality of a company, the relationship between company and the customer is tied firmly and a negative assessment lacks the relationship between the two. Where service quality, is the difference between the perceptions of the services by the customers and their expectations. [Gronroos, 1984; Parasuraman et.al. 1988, 1991]. So with the increase in the service quality the satisfaction of the customers also increases as customers satisfaction is defined as a result of comparison made by the customers of the expected performance before purchase, actual cost born and performance received [Churchill and Surprenant, 1982].

LOYALTY

Loyalty is the extent to which the customers show their faithfulness in the company or organization. The increase in loyalty increases the level of customer satisfaction. There is a positive relationship between loyalty and customer satisfaction. [Serkan Aydin 2005]. Customer loyalty is the promise made by the customers with an organization about purchasing their goods and services again and again, doing business with them and making favorable suggestions about their services and products with friends and relatives [Mcllroy and Barnett, 2000]. Customer satisfaction largely determines customer loyalty. [Anderson, Fornell 1994]. Where satisfaction is affected by loyalty directly and indirectly too by trust. [Delgado-Ballester 2003].

SMOOTHING

Smoothing means to smooth the relationship between the customers and the service providers. It refers to the ability of the employees of the company to solve or resolve any problem between the customers and the company if in case it occurs. More smoothing will satisfy the customers more.

RETRIEVING

Retrieving means to reproduce the stored data of the customers at the time of need. This

variable like smoothing is related with the abilities of the employees of the company. More efficient the employees are more satisfied the customers will be with the services of the company.

RELIABILITY

Reliability is the state of relying upon the services of the company. It is also known as dependability of the customers on the services of the company. Cook et.al. [2002] defines reliability as, the capacity or the power to perform services which the organization has promised to do in a consistent dependable way. That's why reliability is considered the most important dimension in determining the quality of services. Moreover the perfect performance of promised services by the company is the high level of service reliability. [Mirjam Galitzka 2006].

PRICE PERCEPTIONS

Price perceptions are the way how customers perceive the prices of the company. For provision of high quality services, relatively high cost incurs. Due to mistakes made by employees desired results cannot be achieved and costs cannot be controlled for provision of reliable services. [Jacob V.Simons Jr. 2004]

On the basis of literature review following hypothesis has been constructed.

H1: There is a significant, positive correlation between smoothing and loyalty.

H2: There is a significant, positive correlation between retrieving and loyalty.

H3: There is a significant, positive correlation between reliability and loyalty.

H4: There is a positive correlation between price perception and loyalty.

H5: Price Perceptions, Retrieving, Reliability and Smoothing significantly explain the variance in Loyalty.

METHODOLOGY

For carrying out research the researchers adopted two techniques of data collection. Primary data collection by going to the people and taking their interviews and also by giving them research questionnaires to fill. Also collected Secondary data by taking material from old researchers, although they were very limited. To the best of researchers` knowledge this is the first study conducted on the topic in Sargodha region. Researchers got filled 96 valid responses out of 107 questionnaires from the passengers of Daewoo Express Bus Service in Sargodha. For data collection, questionnaire from the study of Cassab and Maclachlan at, el; [2006] was adopted as that study was almost in the similar area. Questionnaire having 3 items for loyalty, 3 for smoothing, 3 for retrieving, 3 for reliability and 2 items for price perceptions was used. Scales from strongly disagree - strongly agree, very high - very low and very unlikely - very likely were used.

On the basis of literature review 5 hypotheses were developed. For checking means, descriptive statistics was used. For reliability Cronbach`s Alpha was used. And finally to test the hypotheses researchers used correlation and regression analysis.

Table 1. Descriptive Statistics (Means)
Tabela 1. Statystyki opisowe (średnie)

	N	Means
Loyalty	96	4.0556
Smoothing	96	3.6463
Retrieving	96	3.6327
Reliability	96	3.7619
Price Perceptions	96	2.4082
Valid N	96	

Table 2.1 Cronbach`s Alpha reliabilities
Tabela 2.1 Współczynnik Cronbacha Alpha

	No of items	Alpha reliability
Loyalty	03	0.714
Smoothing	03	0.724
Retrieving	03	0.508
Reliability	03	0.556
Price Perceptions	02	0.613

Table 1.1 states that most people have a positive perception about the questions asked as all means except price perceptions is more than 3.

Combined Scale:
Number of Items = 14
Alpha Reliability =0.746

Table 2.2 Total Scale Statistics
Tabela 2.2 Statystyka skali całkowitej

	Cronbach`s Alpha if item deleted
Loyalty_1	.730
Loyalty_2	.720
Loyalty_3	.695
Smoothing_1	.738
Smoothing_2	.714
Smoothing_3	.718
Retrieving_1	.734
Retrieving_2	.725
Retrieving_3	.729
Reliability_1	.763
Reliability_2	.707
Reliability_3	.705
Price Perceptions_1	.766
Price Perceptions_2	.779

Table 3. Correlations
Tabela 3. Korelacje

		Loyalty	Smoothing	Retrieving	Reliability	Price Perception
Loyalty	Pearson Correlation	1	.295*	.293*	.743**	-.118
	Sig. (2- tailed)		.042	.043	.000	.425
	N	96	96	96	96	96
Smoothing	Pearson Correlation	.295*	1	.663**	.201	-.118
	Sig. (2- tailed)	.042		.000	.166	.420
	N	96	96	96	96	96
Retrieving	Pearson Correlation	.293*	.663**	1	.243	-.062
	Sig. (2- tailed)	.043	.000		.092	.670
	N	96	96	96	96	96
Reliability	Pearson Correlation	.743*	.201	.243	1	-.147
	Sig. (2- tailed)	.000	.166	.092		.314
	N	96	96	96	96	96
Price Perceptions	Pearson Correlation	-,118	-.118	-.062	-.147	1
	Sig. (2- tailed)	.425	.420	.670	.314	
	N	96	96	96	96	96

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

The table 3 shows the correlations among all variables. It is clear from the table that there is a positive correlation among most variables. Details have been discussed in later section.

This table indicates the significant relationship between dependant and independent variables.

Table 4. Regression Analysis
Tabela 4. Analiza regresji

Model	1
R	.758[a]
R-square	.575
Adjusted R-square	.535
Std. error of the estimate	.40682
Durbin Watson	1.713
F	14.538
Sig	.000[a]

FINDINGS

This paper reveals that there is a positive and significant relationship between loyalty (dependant variable) and reliability, retrieving and smoothing (independent variables). All of the hypotheses except for H4 are supported by statistical analysis. According to Serkan Aydin, et.al. [2005]. There is a positive relationship between loyalty and customer satisfaction i.e. with the increase in loyalty customer satisfaction increases. So to the best of researchers` knowledge, in Sargodha most of the customers are satisfied with the service quality of Daewoo Express Bus Service.

DISCUSSION

Table 1.1 shows the means of all the variables used. Most of the means show that people have a positive perception about the questions asked as mostly means are higher than 3 and 3 is considered as indifferent and after 3 there is agree and strongly agree options respectively. Unlike all other variables first variable (price perceptions) has mean (2.4082) lower than 3 this means people have a different perception about this variable. This is due to the higher rates charged by the bus service as compared to other service providers. The most worth mentioning thing is the last variable's (loyalty) mean, it is higher (4.0556) than all others. This shows that people are more than loyal with the company.

Table 2.1 indicates the values of Cronbach`s Alpha for the combined scale as well as for all the variables separately. It can be observed that the Cronbach`s Alpha reliabilities are good for the combined scale (0.746) also for the individual variables (Nunnally,1978) except for retrieving and reliability which shows a bit low reliability when measured independently.

Table 2.2 indicates the alternative values of the Cronbach`s Alpha Reliability in case of deletion of any of the items. However it can be observed that there is not any meaningful improvement expected in the overall reliability of the scale even after elimination of any of the items. Therefore the study will use the current scale with a Cronbach`s Alpha Reliability of 0.746 for further statistical analysis.

Table 3.1 shows correlations among dependant and independent variables. On the basis of this the following hypothesis has been tested:

H1: There is a significant, positive correlation between smoothing and loyalty.

Table 3.1 indicates that there is a positive correlation (r =0.295) between Smoothing and Loyalty which is significant at 0.042 level. Therefore H1 is accepted.

H2: There is a significant, positive correlation between retrieving and loyalty.

Table 3.1 indicates that there is a positive correlation (r =0.293) between Retrieving and Loyalty which is significant at 0.043 level. Therefore H2 is accepted.

H3: There is a significant, positive correlation between reliability and loyalty.

Table 3.1 indicates that there is a perfect positive correlation (r =0.743) between Reliability and Loyalty which is significant at 0.000 level. Therefore H3 is accepted.

H4: There is a positive correlation between price perception and loyalty.

Table 3.1 indicates that there is negative correlation (r =-0.118) between Price Perception and Loyalty however it is not significant (0.425). Therefore H4 is not accepted.

H5: Price Perceptions, Retrieving, Reliability and Smoothing significantly explain the variance in Loyalty.

The results in Table 4.1 indicates that there is a positive correlation (R: 0.758) between the independent (price perception, retrieving, reliability & smoothing) and dependant variable (loyalty). The value of Durbin-Watson statistic (1.713) is also very near to the acceptance range which indicates that there is no autocorrelation among the variables.

In the Table the value for Adjusted R Square (0.535) shows that the independent variables (price perception, retrieving, reliability & smoothing) explain 53.5% variance in dependant variable (loyalty).

Similarly it also shows that the F statistic value of 14.538 is significant at 0.000 level. Therefore H5 is accepted.

CONCLUSIONS

However, the study found that reliability of services is the most important dimension among other independent variables (price perceptions, smoothing, reliability, retrieving) effecting customers loyalty at Daewoo Express. The impact of this research would be very positive as this study would help all and sundry who would be looking for any of the variable of the study or their impact on the customer satisfaction regarding Daewoo Express.

LIMITATIONS AND RECOMMENDATIONS

There is very limited research done in Pakistan on this topic and to the best of researchers` knowledge it is first of its kind in Sargodha. The research was carried out only in Sargodha city and a small sample of 96 respondents only was used, so on larger scale reality may differ. Increase sample size will help in increasing generalizability of study. More research should be done on the topic in Pakistan to reveal the facts. According to the research no doubt most of the customers were satisfied but there is always a room for improvement. Like quality of buses should be improved. It is also suggested to Daewoo Express Bus Service to improve their waiting rooms in Sargodha in order to retain their customers & to satisfy them more.

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OCENA LOJALNOŚCI KONSUMENCKIEJ KLIENTÓW DAEWOO EXPRESS BUS SERVICE W PAKISTANIE

STRESZCZENIE. **Wstęp:** Spełnienie standardów obsługi klienta oraz dążenie do osiągnięcia wysokiej lojalności wśród klientów są dwoma krytycznymi obszarami, którym do tej pory poświęcano mało uwagi zarówno przez przemysł transportu pasażerskiego jak i ośrodki naukowe w Pakistanie. W związku z tym przydatnym powinna być poniższa praca, jak również badania te powinny być przeprowadzone na większych próbach w celu osiągnięcia bardziej uogólnionych wniosków.
Metody: Praca bada poziom lojalności klientów Daewoo Express Bus Service w miejscowości Sargodha poprzez pomiar zadowolenia tych klientów. Autorzy przeprowadzili badania tylko na małej grupie liczącej 96 ankietowanych (pasażerów) i ograniczyli te badania tylko do Daewoo Express Bus Service, jednak wyniki podobnych badań mogą być inne w przypadku innych usług transportowych.
Wyniki i wnioski: W pracy stwierdzono pozytywną i istotną zależność pomiędzy lojalnością (zmienna zależna) a postrzeganiem ceny, wiarygodnością, dostępnością i wygoda (zmienne niezależne). Badania wykazały, że wiarygodność usług jest najważniejszym czynnikiem wśród innych zmiennych niezależnych (postrzeganie ceny, dostępność i wygoda), która determinuje lojalności klientów Daewoo Express. Praca ta pomoże z pewnością kadrze kierowniczej w wyeliminowaniu istniejących braków w obecnym systemie obsługi klientów oraz uniknięciu zagrożeń przyszłości..

Słowa kluczowe: zadowolenie klientów, jakość usług, lojalność, wygoda, wiarygodność, postrzeganie cen, Daewoo Express Sargodha.

BEWERTUNG DER LOYALITÄT VON KUNDEN DER FIRMA DAEWOO EXPRESS BUS SERVICE IN PAKISTAN

ZUSAMMENFASSUNG. Einleitung: Die Erfüllung von Standards des Kundenservices und das Streben nach Erreichen einer hohen Kundenloyalität stellen zwei kritische Bereiche dar, denen bisher sowohl seitens des Sektors des Passagiertransportes, als auch der wissenschaftlichen Einrichtungen Pakistans wenig Beachtung gewidmet wurde. Im Zusammenhang damit erscheint die vorliegende Arbeit als sehr brauchbar und daher sollten die Untersuchungen auf größeren Passagiergruppen zwecks Gewinnung von mehr allgemeinen Schlussfolgerungen durchgeführt werden.
Methoden: Im Rahmen dieser Arbeit wurde das Niveau der Loyalität von Kunden der Firma DAEWOO EXPRESS BUS SERVICE im pakistanischen Sargodha mittels der Bewertung deren Zufriedenheit untersucht. Die Autoren haben eine

ziemlich kleine Gruppe von 96 interviewten Passagieren erforscht und die Untersuchungen bis auf die Firma Daewoo Express Bus Service begrenzt. Daher können die Ergebnisse ähnlicher Untersuchungen im Falle anderer Transportdienstleistungen von den Resultaten der betreffenden Forschung abweichen.
Ergebnisse und Fazit: Im Rahmen der Arbeit wurde ein positives und wesentliches Verhältnis zwischen der Loyalität (abhängige Variable) und der Wahrnehmung des Preises, der Glaubwürdigkeit, der Zugänglichkeit und des Komforts (unabhängige Variablen) festgestellt. Die betreffenden Untersuchungen haben aufgezeigt, dass die Glaubwürdigkeit der angebotenen Dienstleistungen unter anderen unabhängigen Variablen (Wahrnehmung des Preises, die Zugänglichkeit und der Komfort) den wichtigsten, die Kunden von Daewoo Express determinierenden Faktor darstellt. Die Forschungsergebnisse helfen mit Sicherheit der Geschäftsführung, in Zukunft die im gegenwärtigen System des Kundenservices auftretenden Mängel auszuschließen sowie den zukünftigen Gefahren vorzubeugen.

Codewörter: Zufriedenstellung von Kunden, Dienstleistungsqualität, Loyalität, Komfort, Glaubwürdigkeit, Wahrnehmung des Preises, Daewoo Express Sargodha

Usman Yousaf
Lecturer, Quaid Azam School of Management Sciences
Quaid Azam University, Islamabad, Pakistan
e-mail: Usman.world@gmail.com
Javeria Yousaf
University of Sargodha, Pakistan
Mohsin Altaf
Lecturer, Department of Commerce
University of Sargodha, Pakistan
Mohammad Majid Mehmood Bagram PhD
Assistant Professor, Allama Iqbal Open University, Islamabad, Pakistan

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MARKETING IN THE BUSINESS ACTIVITY OF LOGISTICS SERVICE PROVIDERS

Marcin Świtała

University of Economics in Katowice, Katowice Poland

ABSTRACT. Background: This article is a discussion on the role of marketing in the activity of logistics service providers. The strong competition and changing purchasing preferences should motivate the transport, forwarding and logistics sector managers to apply the marketing approach in practice.
Methods: Results of direct research, conducted among a targeted group of 100 companies from the transport, forwarding and logistics sector, constitute the source basis. The sample group was divided into three categories of logistics providers: 2PL, 3PL and 4PL. The statistical analysis was based on three different non-parametric tests (Kruskal-Wallis, Chi-square and V Kramer).
Results and conclusions: Currently, marketing does not play a key role in the activity of logistics services providers. The prevailing opinion is that importance of marketing in the company is average. The respondents have assessed in a similar way their activity compared to the activities of the competition. However, it was found that with the increase of the level of specialization (2PL-4PL), the awareness of impact of marketing on the logistics services sector also increased. The logistics services providers, who offer a wide range of logistics services, asses their competitive position in a better light.

Key words: marketing, logistics services providers, 2PL, 3PL, 4PL, competitiveness.

INTRODUCTION

Dynamic changes in the logistics service market create a new playing field on the supply side. Among a number of determinants, the most influential ones include: the present sales slowdown, further consolidation of the market, intensifying competition, and particularly notable - technological progress. In addition to the development of logistics skills, an increasingly important source of competitive advantage for logistics service providers (LSPs) should also be marketing competence. This is confirmed by the example of GEFCO, which, thanks to increased investment in marketing, has strengthened its market position and increased brand awareness. Actions taken by the company show that marketing to a large extent also contributed to improved customer relations [Szreter 2012].

While in the literature of the subject much attention is devoted to logistics service providers and their new logistics concepts [e.g., Jeszka 2009; Rydzkowski 2011; Weijers, Glöckner and Pieters 2012; Graw, Daugherty and Dant 2012], the role of marketing in building a competitive advantage in the logistics service market (TSL market) remains a poorly recognised area of research [Kempny 2010; Bourlakis and Melewar 2011]. This paper is an attempt at filling the existing research gap.

The purpose of this paper is to present some results of research on the activity of logistics service providers. In particular, it focuses on assessing the significance of marketing in

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different types of logistics providers such as: 2PL, 3PL and 4PL. We also examined the tendency for LSPs to use in practice new marketing concepts, i.e. guerrilla, word-of-mouth, and experience marketing.

METHODOLOGY OF OWN RESEARCH

The research problem was analysed based on direct surveys conducted in September-October 2012. The interviews with respondents were conducted through face-to-face interviews by pollsters from the Research and Expertise Centre of the University of Economics in Katowice. The research survey consisted mainly of closed-ended scaled questions (ordinal and nominal scales were used). The study was conducted on a sample of 100 companies that had been selected in a targeted manner. The typology of the study group was based on the range of services. The following features served as the division criteria: provision of simple services without a permanent contract (2PL), customer service based on contract logistics (3PL), provision of contract logistics and supply chain management services (4PL). The study results were developed with the use of SPSS software version 20.0. The statistical analysis used: the Kruskal-Wallis, chi-square independence and Cramer's-V tests (in addition to the Chi-2 test). The methods of descriptive statistics, and most of all - measures of central tendency and dispersion, were used.

CHARACTERISTICS OF THE STUDY GROUP

In the domestic logistics service market, the studied providers offer their customers a diverse range of services. As with the previous findings, also here the LSPs' offer is dominated by transport, freight forwarding and warehousing services [Świtała 2012]. No significant changes in this area are also confirmed by research conducted by other centres, including: the Institute of Logistics and Warehousing, and the Department of International Transport and Logistics of the Warsaw School of Economics [Cudziło and Kulińska 2012, Brdulak 2012a]. It can be considered that the above-mentioned services are the major source of income in the TSL industry. Customs clearance, postal and courier services were provided by 14% and 10% of respondents, respectively. Also rarely offered by respondents were specialised logistics services. After-sales logistics (with reverse logistics support) was offered by 14% of respondents, and cross docking services - by 8%. Few also provide custom installation services (4%). 8% of respondents reported the provision of other services such as: logistics consulting, piloting oversized cargo and installation services.

The largest study group consisted of companies of the SME sector (73%). Large organisations were represented by 27% of the respondents. The surveyed companies are primarily operators of international scope. Activity in the European market is declared by 50% of the respondents, and global logistics services - by 22%. Others provide services on the domestic market. Annual revenue generated by most companies was below PLN 5 million. A considerable number of respondents declared income in the following ranges: PLN 5-10 million and PLN 11-50 million. 19% of companies said they generate revenue exceeding PLN 100 million, including 8% - more than PLN 500 million. The group of companies surveyed included 5 companies with revenues in excess of PLN 1 billion. 15% of the respondents refused to provide information about the size of their revenues.

23% of the surveyed companies were classified in the 2PL segment. It consists in cooperation with customers without a permanent contract, offering a very limited range of services ($\bar{x}$ = 1.91). 3PL providers were strongly represented in the group of respondents (61%). This group was formed by contract service providers with a more extensive range of services compared to 2PL ($\bar{x}$ = 3.44). The third segment is 4PL providers (16%). These companies offer the most comprehensive logistics outsourcing services ($\bar{x}$ = 6.12) and support the largest number of customers on the basis of contract logistics. They also have the highest competence in the field of logistics.

GENERAL ISSUES RELATED TO MARKETING IN THE TSL MARKET

Research has indicated that marketing does not play a particularly important role in the activities of logistics service providers (Table 1). Among all service providers, the average rating was 3.19 - which is slightly above the average. These results support the findings of last year's research, according to which the role of marketing is limited to supporting sales activities [Świtała 2013]. The lack of a marketing approach in the TSL market is also noted by clients in this sector. It turns out that most shippers do not see any marketing activity in the activities of LSPs [Zowada 2012].

The differences between the various types of LSPs are small and not significant - from 2.87 in the case of 2PL to 3.38 in the case of 4PL (and therefore oscillate around 3). Research has found that the respondents in the 2PL group usually attach very little importance to marketing. In the case of 3PL and 4PL providers, the mode amounted to 3 and 4, respectively. So, in the 4PL segment, the opinion of a strong position of marketing in the company prevailed.

Table 1. Types of LSPs and general issues related to marketing[a]
Tabela 1. Typ operatora a ogólne kwestie związane z marketingiem[a]

Issue	Types of LSPs						Total		KRUSKAL-WALLIS TEST		
	2PL		3PL		4PL						
	M	SD	M	SD	M	SD	M	SD	Chi-2	P	Multiple comparisons [b]
Role of marketing in the company	2,87	1,58	3,26	1,25	3,38	1,31	3,19	1,34	1,31	0,519	
Evaluation of marketing activities against activities of the competition	2,83	1,34	3,08	1,22	3,50	1,03	3,09	1,22	2,61	0,272	
Evaluation of competitive position in the TSL market	2,78	1,13	3,64	0,86	4,19	0,66	3,53	1,00	18,64	0,000**	2PL-3PL=0,002** 2PL-4PL=0,000** 3PL-4PL=0,026*

[a] the respondents used a 5-point scale, where 1 meant: very poor, and 5 - very strong
[b] only the significance of the test was presented

Similar results were obtained in the area of self-evaluation of marketing activities against the activities of the competition. The average rating among all operators was 3.09 - that is also slightly above the average. In this case, however, a more pronounced difference between 4PL operators (3.50) as well as 3PL (3.08) and 2PLN companies (2,83) was reported. It is worth noting that none of the 4PL operators has rated its activities as very poor. It can therefore be assumed that 4PL providers better assess their activity than the other test segments. These differences are not statistically significant. It was noted, however, that the above-mentioned rating is significantly correlated with the opinion of respondents on the role of marketing in the organisation (Chi-2 test = 68.54 for $p \leq 0.01$, Cramer's-V at $p \leq 0.01$ was 0.414). The results show that with the increasing importance of marketing, the tendency for respondents to positively evaluate marketing activities in the market is increasing.

Logistics service providers participating in the study were also asked to conduct a self-evaluation of their competitive position on the market. The average rating among all entities was 3.53 - meaning between an average and good position. As the results in Table 1 show, the differences in opinion between various operators are significant. From 2PL - 2.78 to 4PL - 4.19. The difference between 2PL and 3PL and between 2PL and 4PL is highly statistically significant, and the difference between 3PL and 4PL is statistically significant. Analyses show that the more

complex range of services offered by the service provider, the better evaluation of the competitive position of the company. It is worth noting that none of the 4PL providers rated their situation on the market below the average. Most respondents are convinced of a strong competitive position of their company (D = 4). In the case of 2PL and 3PL companies, the mode in a 5-point scale was 3.

Table 2. Marketing leaders on the TSL services market according to respondents
Tabela 2. Liderzy marketingu na rynku usług TSL w opinii respondentów

Item No.	Percentage of responses [%]
DHL	16.0
Raben Group	9.0
DB Schenker	8.0
UPS	3.0
Prologis, Viva Trans, Eurogate Logistics, Ceva Logistics, FM Logistic, Kurierzy.pl, Pekaes, DPD	8.0

A very large proportion of respondents who failed to indicate a brand of the operator with the most effective marketing should be assessed negatively (56% of respondents answered "do not know"). This high level of ignorance indicates that TSL enterprises do not monitor marketing activities of the competition. On one hand, it still can be explained with low popularity of marketing in the group, and on the other - with unwillingness among the respondents to conduct market research.

DHL can be recognised as the market leader in the field of marketing. The largest number of respondents who managed to identify the winning brand indicated this name (table 2). It should be noted that DHL is the most recognisable logistics brand in the Polish market. In 2009, the company was recognised as "the strongest brand in the logistics services market" [Szreter 2009]. And in 2012, the DHL brand was among top 100 most recognisable logos in the domestic market [Business Superbrands 2012]. Generally, it can be seen that the first four positions are well-known international logistics groups recognised as leaders in the market, offering customers a vast array of logistics services and solutions in the area of 3PL and 4PL.

NEW FORMS OF MARKETING IN THE ACTIVITY OF LOGISTICS SERVICE PROVIDERS

The results of research show that few LSPs use new marketing concepts in practice.

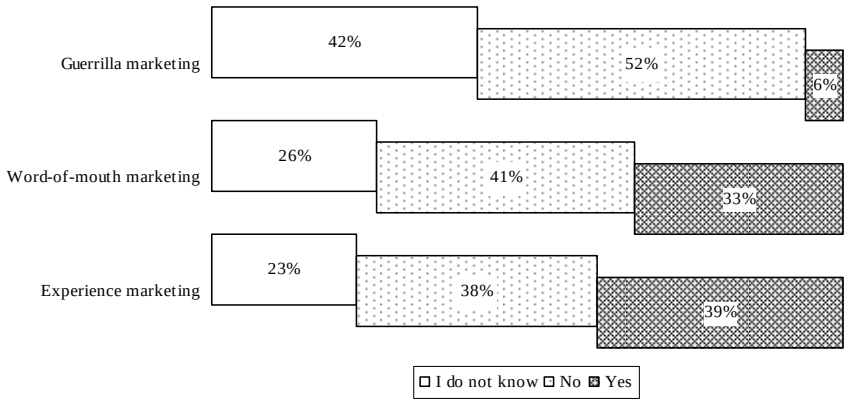

Fig. 1. The use of new forms of marketing in the TSL market
Rys. 1. Stosowanie nowych form marketingu na rynku usług TSL

At the same time, a large proportion of those declaring lack of knowledge on the subject suggests that TSL managers are not familiar with new trends in marketing (Figure 1). Only 6 respondents admitted to using guerrilla marketing techniques for promotional purposes. A good example of this form of marketing is the image campaign of

FedEx created by Miami Ad School marketing agency. As part of outdoor advertising, the front of an identical car associated with DHL was placed in the back of the FedEx vehicle. The action was accompanied by the slogan "Always First" [Adamczewski 2011]. The main objective of the campaign was to emphasise more competitive standards of service.

Every third respondent admits to the use of word-of-mouth marketing, i.e. informal channels of communication with the customers. Intermediaries that communicate the content of the message play a key role in this form of marketing. These are customers and opinion leaders in the industry. The flow of information (knowledge sharing) takes place orally or via the Internet. Currently, word-of-mouth or buzz marketing is becoming widely used in the social media. Social-networking platforms (Web 2.0) allow market participants to conduct an open debate on specific products and services. A large number of opinions should therefore encourage companies to implement innovative business solutions [Martyniuk et al. 2012]. Therefore it can be assumed that social-networking media will be an increasingly important channel of communication for the logistics services industry. Research shows that the Internet is an important source of knowledge about the offer of LSPs. Customer views are influenced by information from social networking sites, such as recommendations from other customers posted on the sites. The more that most of the market leaders have an account on FaceBook and/or Twiter (among others: Raben Group, DHL, CEVA Logistics, DB Schenker, C.H. Robinson and others). According to Brendan and Coft [2012], communications via social media is a valuable tool to strengthen B2B relations. The most useful websites include: LinkedIn, Facebook, Twitter and blogospheres.

Only 39% of service providers in the study group apply the principles of experience marketing. The CEM concept (Customer Experience Management) stipulates that any business practice affects the total customer experience from previous cooperation. Customer experience is defined as the sum of customer contacts with the brand [Pilarczyk 2011]. Most likely, the activities of operators, however, are limited to individual initiatives to increase customer satisfaction and loyalty. The results do not show that the size and class of the LSP influence the scope of responses. Customer experience related to complaint handling, especially in the case of contract logistics, is particularly important in the provision of TSL services. Previous studies indicate that customer satisfaction with the service affects their loyalty and satisfaction rates. It also shapes opinions about the quality of services [Cahill et al. 2010]. At the same time, according to Brdulak [2012b], the use of a CEM strategy in the TSL market helps strengthen synergies across the supply chain.

SUMMARY

The surveyed companies do not attach much importance to the marketing actions taken. TSL managers treat marketing as a tool to support sales. They do not see the possibilities inherent in marketing communications, including the potential of e-marketing. Paradoxically, the prevailing market situation creates favourable competition conditions for marketing-oriented service providers. It can be presumed that the majority of logistics service providers are competing in the market without specifying the style of competition.

Awareness of the importance of marketing is increasing with the level of expertise of the studied entities. The value of marketing is most appreciated by 4PL providers. These companies also better assess their activity against the activities of the competition. Generally it can be noted that the competitive advantage is determined by broad competence in logistics service. 4PL service providers (offering the most extensive and heterogeneous range of services) are more confident about their privileged market position than 2PL and 3PL service providers.

It should also be noted that the studies conducted so far should form the basis for further and more in-depth research. Increasing knowledge about marketing for logistics service providers requires doing research on a larger sample. Research efforts related to the assessment of the effectiveness of marketing

activities of the relevant market should be also made.

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MARKETING W DZIAŁALNOŚCI USŁUGODAWCÓW LOGISTYCZNYCH

STRESZCZENIE. **Wstęp:** Artykuł stanowi dyskusję na temat roli marketingu w działalności usługodawców logistycznych. Silna konkurencja i zmieniające się preferencje nabywcze powinny motywować menedżerów TSL do stosowania w praktyce podejścia marketingowego.
Metody: Podstawę źródłową stanowią wyniki badań bezpośrednich, które przeprowadzono na celowo dobranej grupie 100 przedsiębiorstw branży TSL. W badanej próbie wyodrębniono trzy klasy operatorów: 2PL, 3PL oraz 4PL. W analizie statystycznej wykorzystano trzy testy nieparametryczne: Kruskala-Wallisa, Chi-kwadrat oraz V Kramera.
Wyniki i wnioski: Obecnie marketing nie pełni kluczowej roli w działalności operatorów logistycznych. Dominuje opinia o jego przeciętnym znaczeniu w przedsiębiorstwie. Podobnie badani oceniają swoją aktywność na tle działań konkurencji. Odnotowano jednak, że wraz ze wzrostem poziomu specjalizacji (2PL-4PL) rośnie świadomość znaczenia marketingu na rynku TSL. Operatorzy oferujący szerokie spektrum usług logistycznych lepiej oceniają także swoją pozycję konkurencyjną.

Słowa kluczowe: marketing, operatorzy logistyczni, 2PL, 3PL, 4PL, konkurencyjność.

MARKETING IN DER TÄTIGKEIT VON LOGISTIKUNTERNEHMEN

ZUSAMMENFASSUNG. Einleitung: Dieser Artikel stellt einen Beitrag zum Diskurs über die Rolle des Marketings in der Tätigkeit von Logistikbetreibern dar. Der starke Wettbewerb und die wechselnden Erwerbspräferenzen sollten die TSL-Manager zur praktischen Anwendung des Marketingansatzes ermutigen.
Methoden: Als Quellen beanspruchte man die Ergebnisse direkter Untersuchungen, die an einer Gruppe von 100 Unternehmen aus der TSL-Branche durchgeführt wurden. Innerhalb der untersuchten Probe wurden drei Bedienerklassen unterschieden: 2PL, 3PL und 4PL. In der statistischen Analyse griff man auf drei nichtparametrische Verfahren zurück: den Kruskal-Wallis-Test, den Chi-Quadrat-Test und Cramers V.
Ergebnisse und Fazit: Heutzutage erfüllt Marketing keine Schlüsselrolle in der Tätigkeit von Logistikbetreibern. Die vorherrschende Meinung ist, dass das Marketing im Unternehmen eine zweitrangige Rolle spielt. Die Befragten schätzen ihre eigene Aktivität im Vergleich zu ihren Wettbewerbern ähnlich ein. Man verzeichnete jedoch, dass mit dem wachsenden Spezialisierungsniveau (2PL-4PL) auch das Bewusstsein der Bedeutung von Marketing auf dem TSL-Markt wächst. Die Bediener, die ein breites Spektrum von Logistikdienstleistungen anbieten, schätzen auch ihre Wettbewerbsposition als wesentlich besser ein.

Codewörter: Marketing, Logistikunternehmen, 2PL, 3PL, 4PL, Wettbewerbsfähigkeit.

Marcin Świtała
University of Economics in Katowice
Department of Business Logistics,
ul. 1 Maja 50, 40-287 Katowice, Poland
phone: +48/32 257 7302
e-mail: marcin.switala@ue.katowice.pl

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SIMPLIFIED PRODUCT VALUE MEASUREMENT FRAMEWORK FOR SMALL AND MEDIUM SIZED ENTERPRISES

S Parkash[1], Veerender Kumar Kaushik[2]

[1)] Singhania University, Rajasthan, India [2)] Technological Institute of Textile & Sciences, Bhiwani, Haryana, India

ABSTRACT. Background: The emergences of global markets have increased competition worldwide. For Small Medium Sized Enterprises with limited resources to sustain in what is already a very competitive market there is a need for strong and continuously increasing Product Value to reduce business risks and revenue losses and to increase market share and customer satisfaction. To fulfill this need, Product Value Measurement is necessary to characterize the current status and further improvement. It is not easy to obtain the measures about the Product Value because its many features have qualitative characteristics. We need simplified but result oriented systematic framework to measure it while considering the measurement purpose and how to measure and why do it.
Methods: How to design this is the main aim of this research paper. In this paper, GQM (Goal-Question-Metric) method as a measurement framework is introduced to measure the Product Value for Small Medium Sized Enterprises along with case study to represent that this framework was effective.
Results and conclusions: The proposed Model was effective for focusing on the essence of measurement and for avoiding extra excessive data not necessary for doing the effective measurement.

Key words: Product Value, Product Value Measurement, Supply Chain, The Goal Question Metric (GQM) Model, Small Medium Sized Enterprises.

INTRODUCTION

Small and medium sized enterprises (SMEs) are backbone of a healthy and prospering economy. Small and medium sized enterprises (SMEs) exhibit distinct characteristics that differentiate them from the majority of their larger counterparts [Storey 1994]. Research has shown that SMEs which link operations to their business strategies outperform the competition [Argument, Harrison, Wainwright 1997]. This research paper is for SMEs' entrepreneurs to sustain and grow in this global market by introducing Simplified Product Value Measurement Framework for measuring Product Value Attributes. The difference between what a customer receives from a product and what he pays is equal to 'product value'. Greater is the magnitude of this parameter, more drawn and inclined is the customer to have the offering.

The organization goodwill is heavily dependent on his products value. "However, without careful measuring of products value, a firm is unable to accurately assess whether its current products are meeting the needs of the firm and customers. A product performance expectation can be defined as "a specific statement of a business practice regarding the results anticipated or required from a product's performance in relation to the customer". Product Performance Measurement is process of choosing desired performance measures and generating a combined measurement of these. However the desired Product Value attributes

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such as Customer Satisfaction, Ease of Use and Reliability etc. are difficult to collect and quantify. Thus in case of measuring attributes which have qualitative characteristics also [Joni 2008], we need to think of the measurement purpose and the reasons why we perform this measurement to avoid the redundant and excessive measurement data. Then, it is necessary to establish measurement framework to decide what, why and how data can be collected for product value management.

After a quick view to the questions "what is product value measurement?" and "why to measure the product value?" another important question can be stated as "how to measure the product value?" In this pursuit, we need a systematic approach adequate for evaluation and improvement based on effective measurement. In this paper, the author having worked as Head Of Materials Department in one of the reputed Sports Goods Industry with in India for more than 14 years has introduced the GQM(Goal-Question-Metric) approach as a simplified measurement framework to measure product value for small and medium sized enterprises.

LITERATURE REVIEW

Products represent the tangible, market-based focus of all marketing efforts only a few studies have applied the efficiency concept to assess the performance of products. However, efficiency should not be considered a supplier-related concept only - considering the financial return on a product's manufacturing and quality costs - but first and foremost a demand-oriented one. Ultimately, creating products that fulfill the needs and expectations of customers reflects the basic idea of marketing. Consequently, the economic value a customer obtains by purchasing a product has to be investigated and optimized. This value becomes higher if a product provides a set of demanded characteristics (outputs) for given expenditures (inputs) in an efficient manner. Offering products that create superior customer value can be seen as a prerequisite to establishing profitable customer relationships, which in turn enhance corporate value. To assure a realistic product evaluation all characteristics from which utility is derived and which determine product choice need to be considered. Customer satisfaction and human resources are repeatedly cited as critical measurement areas [Eccles 1991, Kaplan, Norton 1992, Fitzgerald, Moon 1996].

Hence, product efficiency in the sense of customer value consists of a multitude of purchase-relevant components, including qualitative attributes [Zeithaml, 1988; Fernandez-Castro and Smith, 2002]. Only a few empirical attempts have been made to make such a broader construct of product efficiency operational [Staat et al., 2002; Fernandez-Castro and Smith, 2002; Bauer et al., 2003].

THE GQM MODEL

In this paper, we introduce the GQM model for measuring external, demand-side concept of marketing efficiency and investigating which return (features) a customer receives on his or her investments for purchasing and using the product. GQM handles the problem of how to decide, what to measure to reach your goals. It is a method invented by Prof. Victor R. Basili, Dr. David Weiss and Prof. Dr. Dieter Rombach. GQM is based on the idea of goal-oriented measurement and therefore it is a top-down approach. In this case, top down approach means that start with improvement goals, try to make them measurable and finally to be able to reach them.

GQM Model defines a measurement framework on three levels:

Conceptual level (goal)

A goal is defined for an object for a variety of reasons, with respect to various models of quality, from various points of view and relative to a particular environment.

Operational level (question)

A set of questions is used to define models of the object of study and then focuses on that object to characterize the assessment or achievement of a specific goal.

Quantitative level (metric)

A set of metrics, based on the models, is associated with every question in order to answer it in a measurable way.

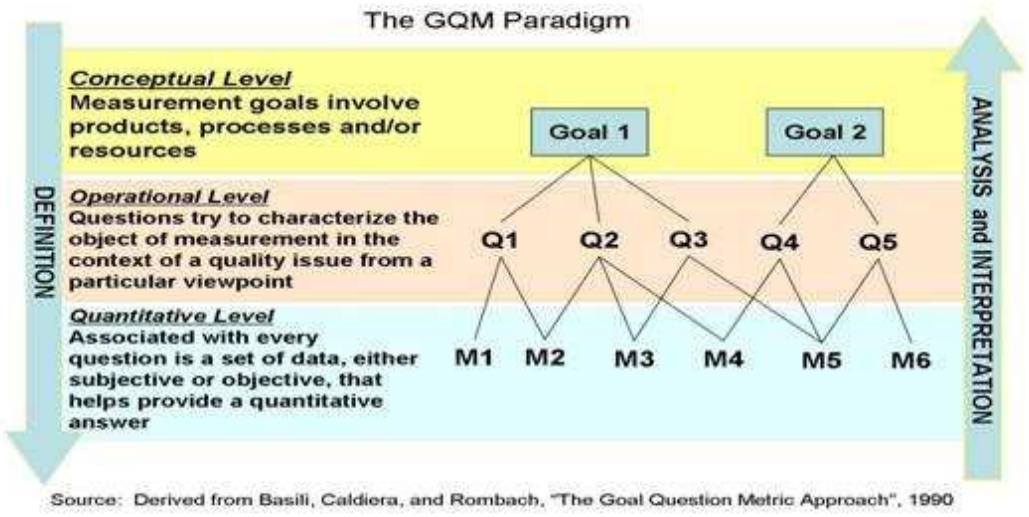

Fig. 1. GQM Paradigm
Rys. 1. GQM paradygmat

Thus GQM emphasizes the need to establish an explicit measurement goal that is specific to the process activity or product characteristics that is to be assessed, define a set of questions that must be answered in order to achieve the goal, and identify well-formulated metrics that help to answer the questions.

The GQM Model has several advantages: It helps to:

- ensure adequacy, consistency, and completeness of the measurement plan and therefore of data collection.
- manage the complexity of the measurement program. Increased complexity occurs when there are too many attributes to measure and too many possible measurement scales for each attribute.
- stimulate a structured discussion and promote consensus about measurement and improvement goals, which is a prerequisite for measurement success.

Basili described his six-step GQM process as follows:

1. Develop a set of corporate, division and project business goals and associated measurement goals for productivity and quality
2. Generate questions (based on models) that define those goals as completely as possible in a quantifiable way
3. Specify the measures needed to be collected to answer those questions and track process and product conformance to the goals
4. Develop mechanisms for data collection
5. Collect, validate and analyze the data in real time to provide feedback to projects for corrective action
6. Analyze the data in a post mortem fashion to assess conformance to the goals and to make recommendations for future improvements

MEASURING PRODUCT VALUE BY GQM MODEL

Where to start and where to focus?

Product Value: The difference between what a customer receives from a product and

what he pays is equal to 'Product / customer value'. Greater is the magnitude of this parameter, more drawn and inclined is the customer to have the offering.

- Customers buy on perceived value,
- Value is defined as Benefits relative to Cost,
- Benefits include all non-cost attributes: Product, Service, Relationship and Image,
- Benefits, costs, and value are perceived by customers relative to competition.

The current level of performance is how well product is performing now with respect to that attribute. The Desired level of Performance reflects business priorities and can be set by "shooting ahead of the competition" or by adopting improvement goals that each contributing unit commits to attain.

Product Value comprises following main components:

- Product Performance: Features, Ease of Use, Reliability, Performance, Longevity
- Product Price
- Delivery, Installation and Service
- Customer Relationships

Table 1. GQM for measuring Product Value in Cosco (India) Limited
Tabela 1. Zastosowanie GQM do pomiaru wartości produktu w Cosco Ltd (Indie)

OBJECTIVE	GOALS	QUESTIONS	METRICS
1. Measure Product / Customer Value	1.1(a) Product Features -Expected Features -Exciting Features	1.1.1(A) - Is Product fulfilling customer basic needs? - Is product offering more than its other companions?	1.1.1.1(A) - Capture and loss of new customers - Sales order cycle time response rates
	1.1(B) Performance - Quality	1.1.1(B) - How is product quality? - Is product quality changing	1.1.1.1(B) - Product return rates - Worth What paid for quality consistency
	1.1(C) Reliability -Durability -Life -Maintenance	1.1.1(C) - How often does product fail to perform?" - How is product life? - How is product maintenance requirement? - How is the availability of spare parts	1.1.1.1(C) - Mean time between failures or Mean time to repair - Customer Reported Problems - Repair Service Call - customer reported problems with availability of spare parts
	1.1(D) Ease of Use	1.1.1(D) - How often do customers complain about the Ease of Use?	1.1.1.1(D) Surveys of customers' perceptions of Ease of Use?
	1.2 Product Price -Reasonable cost	1.2.1 - How often do customers complain about Product Price?	1.2.1.1 - Reasonable cost - Service Call Rate or Warranty Repair Rates
	1.3 Delivery, Installation and Service -Availability -Ease of Installation -Ease of Service	1.3.1 - Are delivery dates slipping? - How often do customers complain about Installation? - How often do customers complain about Service?	1.3.1.1 - Surveys of customers' perceptions of availability and ease of installation? - Service call response times
	1.4 Customer Relationship -Responsiveness -Customer Satisfaction Survey	1.4.1 - Is this product is satisfying customer needs? - How quickly customer problems are being addressed?	1.4.1.1 - customer complaint levels - Speed of customer call answer and response - Customer loyalty

Translating Product Value attributes into Metrics and Measurements by the application of GQM Model based framework

To apply GQM Model for Product Value Measurement for Small Medium Sized Enterprises", the following steps are needed:

- Characterize the environment
  In this step we characterize the context in which we have to undertake improvement programs
- Identify measurement goals

Develop data user goals and associated measurement plans. This step starts by capturing the goals of the user group and using the goal template. Using this template, each goal is described.

- Generate meaningful questions
  Develop meaningful questions that define those goals as completely as possible in a quantifiable way
- Specify the metrics needed to be collected
  This step specifies the metrics needed to be collected to answer those questions. Select metrics related to defined goals. This includes defining its measurement scale and its range
- Develop mechanisms for data collection
  Here methods used for collecting data, Questionnaires, surveys, checklists, interviews, documentation review, focus groups etc. can be used.
- Data analysis and interpretation
  Analyze data from the viewpoint of the defined objective. Write down feedback regarding (under studied) objective to increase Product Value for corrective action and make recommendations for future improvements. In this step, the indicators which are measure or combination of measures that provides insight Product Value is derived.

We applied GQM Model to measure Product Value for one of the reputed Sports and Fitness Co. (Cosco India Limited, Gurgaon, Haryana, India) and the results are represented in Table 1.

CONCLUSIONS

For Small Medium Sized Enterprises with limited resources to sustain in this global market there is a need for simplified but result oriented systematic framework to measure product value attributes (including qualitative also) while considering the measurement purpose and how to measure and why do it. To design this we introduced GQM Model as a measurement framework and applied this systematic approach to know the measurement purpose and how to measure and why do it. This Model was effective for focusing on the essence of measurement and for avoiding extra excessive data not necessary for doing the effective measurement.

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UPROSZCZONA METODA OCENY WARTOŚCI PRODUKTU DLA MAŁYCH I ŚREDNICH PRZEDSIĘBIORSTW

STRESZCZENIE. **Wstęp:** Wymagania stawiane w wyniku globalizacji rynków spowodowały zwiększenie poziomu konkurencji na całym świecie. Utrzymanie się na takich rynkach przez małe i średnie przedsiębiorstwa posiadające ograniczone zasoby, oznacza potrzebę silnego i stałego zwiększania wartości oferowanych produktów, aby zmniejszonych ryzyko biznesowe jak również, aby zwiększyć swój udział rynkowy i poziom zadowolenia własnych klientów. Aby osiągnąć ten cel, niezbędne jest prawidłowe scharakteryzowanie obecnego stanu oraz koniecznych usprawnień. Ocena wartości produktu jest procesem złożonym, gdyż wymaga uwzględnienia wielu cech jakościowych. W związku z tym zachodzi potrzeba uproszczenia metody tego pomiaru.
Metody: Celem pracy jest zaprojektowanie metody pomiaru wartości produktu. Metoda GQM (Goal-Question-Metric) została zaprezentowana jako metoda pomiaru wartości produktu dla małych średnich przedsiębiorstw. Zostało również omówione studium przypadku reprezentujące zastosowanie proponowanej metody.
Wyniki i wnioski: Proponowany model jest efektywny dzięki koncentracji na istocie pomiaru jak również uniknięciu gromadzenia dodatkowych zbędnych danych, niemających istotnego wpływu na efektywność procesu pomiaru.

Słowa kluczowe: wartość produktu, ocena wartości produktu, łańcuch dostaw, model Goal Question Metric (GQM), małe i średnie przedsiębiorstwa.

EINE VEREINFACHTE METHODE ZUR PRODUKTBEWERTUNG IM KLEIN- UND MITTELSTAND

ZUSAMMENFASSUNG. Einleitung: Die im Ergebnis der Märkte-Globalisierung bestehenden Markt-Anforderungen hatten einen wachsenden Wettbewerb weltweit zur Folge. Die Aufrechterhaltung ihrer Marktposition durch klein- und mittelständische, bestandsärmere Unternehmen bedeutet eine starke kontinuierliche Werterhöhung von angebotenen Produkten zwecks der Verminderung des Business-Risikos, der Vergrößerung der Markanteile sowie der Erhöhung des Niveaus von Zufriedenstellung ihrer eigenen Kundschaft. Um dieses Ziel zu erreichen, ist die richtige Ermittlung des gegenwärtigen Zustandes und notwendiger Verbesserungen unentbehrlich. Die Bewertung des Produktes stellt einen komplizierten Prozess dar, denn sie erfordert Berücksichtigung von mehreren Qualitätsmerkmalen. Im Zusammenhang damit besteht eine Notwenigkeit, die Methoden der Bemessung von Produktwerten zu vereinfachen.
Methoden: Das Ziel der Arbeit ist es, eine Methode für die Bewertung eines Produktes herzustellen. Die GQM-Methode (Goal-Question-Metric) wurde als eine Methode für die Bewertung der Produkte in klein- und mittelständischen Unternehmen konzipiert. Bei der Gelegenheit wurde auch ein Anwendungsfall der vorgeschlagenen Methode besprochen.
Fazit und Ergebnisse: Das vorgeschlagene Modell erscheint als effektiv dank der gezielten Ausrichtung auf das Wesen der Bewertung sowie auf die Vermeidung von zusätzlichen entbehrlichen Daten, die keinen wesentlichen Einfluss auf die Effektivität des Bewertungsprozesses ausüben.

Codewörter: Produktwert, Bewertung des Produktes, Lieferkette, Modell von Goal Question Metric (GQM), klein-und mittelständische Unternehmen (KMU)

S. Parkash
Singhania University,
Pacheri Bari, Rajasthan.
e-mail: spk1972@gmail.com
Dr. Veerender Kumar Kaushik
Technological Institute of Textile & Sciences
Bhiwani, Haryana
e-mail: veerenderk_kaushik@rediffmail.com

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APPLICATION OF ACTIVE PACKAGING SYSTEMS IN PROBIOTIC FOODS

Renata Dobrucka

Poznan University of Economics, Poznań, Poland

ABSTRACT. Background: The packaging of the product has an important role in the protection of the stability of the final product. The use of active packaging system is due to play an increasingly important role by offering numerous and innovative solutions for extending the shelf-life or improve food quality and safety.
Methods: On the basis of broad review of the current state of the art in world literature, application of packaging systems in probiotics foods was discussed.
Results: In this study presented research and development in packaging systems for probiotics foods, using suitable materials with combine passive with active packaging solutions.
Conclusion: Active packages with incorporated oxygen barrier materials or films with selective permeability properties also have potential applications in the packaging of probiotic food products. This is a broad field of research for scientists and industry.

Key words: functional foods, probiotics, active packaging.

INTRODUCTION

Packaging has a significant role in the food supply chain and it is an integral part both of the food processes and the whole food supply chain. Food packaging has to perform several tasks as well as fulfilling many demands and requirements. Traditionally, a food package makes distribution easier. It has protected food from environmental conditions, such as light, oxygen, moisture, microbes, mechanical stresses and dust. Other basic tasks have been to ensure adequate labelling for providing information e.g., to the customer, and a proper convenience to the consumer, e.g., easy opening, reclosable lids and a suitable dosing mechanism. Besides, packaging has to satisfy all these various requirements effectively and economically. Some requirements and demands are contradictory to each other, at least to some extent [Ahvenainen, 2003]. In result, the demand for safe and high quality foods, as well as changes in consumer preferences have led to the development of innovative and novel approaches in food packaging technology [Puligundla et al., 2012]. Food industries uses a lot of packaging materials, and thus even a small reduction in the amount of materials and thus even a small reduction in the amount of materials used for each package would result in a significant cost reduction and may improve solid waste problems. Also, packaging technology has attempted to reduce the volume and weight of materials in efforts to minimize resources and costs. In result, innovations in packaging were up to now limited mainly to a small number of commodity materials such as barrier materials (new polymers, complex and multilayer materials) with new designs, for marketing purposes. Concept of active packaging system is due to play an increasingly important role by offering numerous and innovative solutions for

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extending the shelf-life or maintain, improve or monitor food quality and safety [Gontard, 2000].

DEFINITION OF PROBIOTICS

Consumers more and more believe that foods contribute directly to their health [Mollet & Rowland, 2002; Young, 2000]. Also, today foods are not intended to only satisfy hunger and to provide necessary nutrients for humans but also to prevent nutrition-related diseases and improve physical and mental well-being of the consumers [Menrad, 2003; Roberfroid, 2000]. Foods that affect specific functions or systems in the human body, providing health benefits beyond energy and nutrients-functional foods-have experienced rapid market growth in recent years. In response to the increasing numbers of consumers interested in maximizing their health, the food industry has developed an unprecedented variety of new functional food products [Granato et.al., 2010a]. According definition functional foods are those that contain one or more compound that provide important or limited functions in the organism, promoting welfare and health, or for reduction in the risk and protection of hypertension, diabetes, cancer, osteoporosis, and heart diseases [Arihara et.al., 2004]. Besides, functional foods present a potential to promote health through mechanisms not foreseen in conventional nutrition, with the need to be pointed out that these effects restrict them to the promotion of well-being and health by maximizing physiological functions of a person and not for the cure of illnesses [Sanders, 1998; Roberfroid, 2000]. These foods contain one or more beneficial compounds such as prebiotic, probiotic, antioxidant polyphenols and sterols, carotenoids, and others [Shah, 2001; Andlauer and Fűrst, 2002; Granato et.al., 2010b].

Table 1. Lists some of health benefits of consuming probiotics
Tabela 1. Lista wybranych zalet zdrowotnych spożywania probiotyków

Intestinal effects	– relieve effects, promote recovery from diarrhea (rotavirus, travelers' and antibiotic induced) – produce lactase, alleviate symptoms of lactose intolerance and malabsorption – relieve constipation – treat colitis
Immune system effects	– enhance specific and nonspecific immune response – inhibit pathogen growth and translocation – stimulate gastrointestinal immunity – reduce chance of infection from common pathogens (Salmonella, Shigella)
Other effects	– reduce risk of certain cancers (colon, bladder) – detoxify carcinogens – suppress tumors – lower serum cholesterol concentrations – reduce blood pressure in hypertensives – treat food allergies – synthesize nutrients (folic acid, niacin, riboflavin, vitamins B6 & B12) – increase nutrient bioavailability – improve urogenital health – optimize effects of vaccines (e.g. rotavirus vaccine, typhoid fever vaccine)

Source: Dairy Council of California, 2000.

Probiotics are defined as "live microorganisms, as they are consumed in adequate numbers confer a health benefit on the host", with ongoing controversy as to whether cultures must be viable for efficacy in all cases [Charalampopoulos et. al., 2003; Charalampopoulos et.al., 2002; Stanton et al., 2005]. Saxelin and others, [2003] defined probiotic food as a processed product that contains viable probiotic microorganisms in a suitable matrix and in sufficient concentration. Table 1 lists some of health benefits of consuming probiotics.

In order to exert health benefits beyond inherent basic nutrition, it is necessary that the activity of the probiotic culture be maintained at sufficiently high levels throughout the shelf-life of the product. This requires optimization of all phases of the manufacturing process,

including the selection of adequate materials to be incorporated into the packaging of the finished food product [Cruz et.al., 2007]. Also, role of packaging systems for functional and probiotic foods is very important.

ACTIVE PACKAGING SYSTEMS

In contrast to traditional packaging, active packaging may change the composition and organoleptic characteristics of food, provided that the changes are consistent with the provisions for food. Besides, the released substances will be allowed to add to food. The principles behind active packaging are based either on the intrinsic properties of the polymer used as packaging material itself or on the introduction [inclusion, entrapment etc.] of specific substances inside the polymer [Gontard, 2000]. Active packaging refers to the incorporation of certain additives into packaging systems (whether loose within the pack, attached to the inside of packaging materials or incorporated within the packaging materials themselves) with the aim of maintaining or extending product quality and shelf-life [Hutton, 2003]. Active packaging was developed to meet high requirements of consumers, connected among other things with an extension of shelf life of products, improvement of its organoleptic attributes and protection. In order to be able to satisfy these requirements active packaging contains several specific additives [Bilska, 2011]. Antimicrobial packaging is a form of active packaging. These types of packaging acts to reduce, inhibit or retard the growth of microorganisms that may be present in the packed food or packaging material itself [Appendini and Hotchkiss, 2002].

According to Cooksey [2001] active packaging systems aimed at quality improvement and shelf-life extension of foods can be categorized by three concepts, firstly direct incorporation of active substances into the packaging film, secondly edible films and coating with bioactive substances, and thirdly incorporation of the active substances into a sachet, patch or tablet. Most common and promising are antimicrobial packaging systems,O2 scavenging systems, and moisture-control systems, which offer significant benefits to the meat industry and consumers, and for which exist a large potential market [Han & Floros, 2007]. Also, active food packaging plays a dynamic role in food preservation and allows packages to interact with food and the environment. These packaging technique enables the regulation of various aspects that may play a role in determining the shelf life of packaged foods, such as physiological (e.g., respiration of fresh fruit and vegetables), chemical (e.g., lipid oxidation), and physical (e.g., dehydration) processes as well as microbiological aspects [Puligundla et al., 2012].

Active packaging techniques can be divided into three categories; absorbers (i.e. scavengers), releasing systems and other systems. Absorbing (scavenging) systems remove undesired compounds such as oxygen, carbon dioxide, ethylene, excessive water, taints and other specific compounds Releasing systems actively add or emit compounds to the packaged food or into the head-space of the package such as carbon dioxide, antioxidants and preservatives. Other systems may have miscellaneous tasks, such as self-heating, self-cooling and preservation. Depending on the physical form of active packaging systems, absorbers and releasers can be a sachet, label or film type. Sachets are placed freely in the head-space of the package. Labels are attached into the lid of the package. Direct contact with food should be avoided because it impairs the function of the system and, on the other hand, may cause migration problems [Ahvenainen, 2003].

Oxygen absorbing technology is based on oxidation or combination of one of the following components: iron powder, ascorbic acid, photosensitive polymers, enzymes, etc. [Cruz et al., 2007]. An appropriate oxygen scavenger is chosen depending on the O_2-level in the headspace, how much oxygen is trapped in the food initially and the amount of oxygen that will be transported from the surrounding air into the package during storage. The nature of the food (e.g. size, shape, weight), water activity and desired shelf-life are also important factors influencing the choice of oxygen absorbents [Vermeiren et al., 2003]. Oxygen scavengers must satisfy several requirements such as to be harmless to the

human body, to absorb oxygen at an appropriate rate, to not produce toxic substances or unfavorable gas or odor, to be compact in size and are expected to show a constant quality and performance, to absorb a large amount of oxygen and to be economically priced [Nakamura and Hoshino, 1983; Abe, 1994; Rooney, 1995]. At present, suitable materials combine passive with active barrier layers, e.g. oxygen consuming layers or oxygen scavengers are known.

Another popular group of active packaging systems are moisture absorbers. Several companies manufacture moisture absorbers in the form of sachets, pads, sheets or blankets. For packaged dried food applications, desiccants such as silica gel, calcium oxide and activated clays and minerals are typically tear-resistant permeable plastic sachets. In addition to moisture-absorber sachets for humidity control in packaged dried foods, several companies manufacture moisture-drip absorbent pads, sheets and blankets for liquid water control in high raw foods such as meats, fish, poultry, fruit and vegetables. Basically, they consist of two layers of a microporous non-woven plastic film, such as polyethylene or polypropylene, between which is placed a superabsorbent polymer which is capable of absorbing up to 500 times its own weight with water [Rooney, 1995]. Interesting solution in scavengers is use a carbon dioxide scavenger or a dual-action oxygen and carbon dioxide scavenger system. A mixture of calcium oxide and activated charcoal has been used in polyethylene coffee pouches to scavenge carbon dioxide but dual-action oxygen and carbon dioxide scavenger sachets and labels are more common and are commercially used for canned and foil pouched coffees in Japan and the USA [Day, 1989; Anon, 1995; Rooney, 1995]. Ethanol emitters are a sub-set of preservative releasing technologies although ethanol emitters are usually in sachet forms as opposed to impregnated preservative releasing films. The use of ethanol as an antimicrobial agent is well documented. It is particularly effective against mould but can also inhibit the growth of yeasts and bacteria. Several reports have demonstrated that the mould-free shelf-life of bakery products can be significantly extended after spraying with 95% ethanol to give concentrations of 0.5-1.5% (w/w) in the products. However, a more practical and safer method of generating ethanol is through the use of ethanol emitting sachets [Rooney, 1995; Labuza and Breene, 1989; Day, 2003].

PACKAGING SYSTEMS FOR PROBIOTIC FOODS

The oxygen level throughout storage of the product should be as low as possible to avoid toxicity and death of the microorganism and consequent loss of functionality of the product. Mattila-Sandholm et al., [2002] reported that the packaging materials used and the storage conditions are important factors for the quality of products containing probiotic microorganisms because the metabolism of this microbial group is essentially anaerobic or microaerophilic. Also, many studies in search of material for probiotics packaging.

Ishibashi and Shimamura in 1993, reported that packaging materials such as polyethylene and polystyrene are gas permeable and allow the diffusion of oxygen into yoghurt during storage. Packaging probiotic yoghurts in glass bottles has been reported to prevent oxygen diffusion and therefore result in significantly higher number of probiotic bacteria [Dave & Shah, 1997a], it suffers from some drawbacks. However, glass bottles are costly as well as hazardous and therefore this option may not be financially viable for all yoghurt manufacturers.

Cruz et.al. [2012] studied stability of probiotic stirred yogurt added with glucose oxidase in different packaging materials along the refrigerated storage. Probiotics yogurts added with glucose oxidase and packaged in different plastic packaging systems [monolayer polypropylene (PP) or PP coextruded with ethylene vinyl alcohol (EVOH) cups (100 ml) that present different oxygen permeability transfer rates (0.09, 0.2, 0.39 and 0.75 mL O_2/day) was evaluated during 28 days of refrigerated storage. The results suggested that the use of packaging systems with different oxygen permeability rates coupled with the addition of glucose oxidase presented an interesting technological option to minimize the oxidative stress in yogurts, once these conditions were able to maintain low levels of

dissolved oxygen and also to maintain the cell viability of B. longum and L. acidophilus, mainly up to the 21st day of storage. Kudełka in 2005, analyzed the effect of pasteurization and package type (of polypropylene, polystyrene and polyethylene, as well as in glass containers) on the acidity of probiotic yogurts made from goat's and cow's milk during 21 days refrigerated storage. In result, throughout the storage period studied, the yogurt with lowest acidity values was that contained in polystyrene packages as compared to the other package types evaluated, which all exhibited similar values for this parameter.

Senaka and others, [2013], studied the viability of L. acidophilus LA- 5, B. animalis subsp. lactis BB-12 and the novel probiotic P. jensenii 702 in ice cream made from goat's milk. They evaluated the physico-chemical and sensory properties during stored products in different packaging materials: polypropylene, polyethylene and glass. Packaging materials had a significant influence on the complete melting time of ice cream, and with the melting quality of the product as identified by the tasting panel, one week after production. The influence of packaging was not apparent in relation to other physicochemical properties and sensory attributes of the product, while variation in certain sensory properties such as body and texture and taste of the product was apparent after 12 weeks storage.

ACTIVE PACKAGING IN PROBIOTIC FOODS

The oxygen permeability of the packaging material used currently for probiotic yoghurts is considered a key factor in the high levels of oxygen present in yoghurt. Few current packaging techniques are capable of preventing oxygen permeation. Additional alternatives to traditional packaging probiotics include the addition of oxygen absorbers or scavengers. Active packages with incorporated oxygen barrier materials or films with selective permeability properties also have potential applications in the packaging of probiotic food products [Cruz et al., 2007]. Oxygen toxicity is considered a significant factor influencing the viability of probiotic bacteria in yoghurts [Klaver et al., 1993; Dave & Shah, 1997a-c]. While L. acidophilus is microaerophilic, bifidobacteria are categorized as strict anaerobes. Exposure to oxygen can therefore result in the intracellular accumulation of toxic oxygenic metabolites in these bacteria, leading to a loss in viability [Condon, 1987]. Alternative to HIPS such as the polystyrene-based gas barrier NupakTM [Visypac, Melbourne, Australia] has been shown to be effective in preventing diffusion of oxygen into yoghurts during storage [Miller et al., 2002]. Active packaging film, ZeroTM 2 [CSIRO, Sydney, Australia] that can actively scavenge oxygen from the product has also been developed. Dave & Shah [1997b,c] used oxygen scavengers such as ascorbate or cysteine in yoghurts to protect L. acidophilus and Bifidobacterium spp. from oxygen toxicity. They observed reduction in the oxygen content and redox potential of yoghurt, together with an improvement in the counts of L. acidophilus and Bifidobacterium spp., the incorporation of ascorbic acid in yoghurts can however reduce the amount of oxygen required for the activities of S. thermophilus, an aerobic organism used as a starter culture in the manufacture of yoghurt. This can have a detrimental effect on the textural and nutritional qualities of yoghurt and this technique may hence be undesirable in the industrial manufacture of yoghurt

Talwalkar et.al. [2004], studied effects of packaging materials on the dissolved oxygen and the survival of the probiotic bacteria in yoghurt. Oxygen adapted and non-oxygen adapted strains of Lactobacillus acidophilus and Bifidobacterium spp. were incorporated in yoghurts, which were packaged in oxygen permeable high-impact polystyrene [HIPS], oxygen-barrier material [NupakTM] and NupakTM with an oxygen scavenging film [Zero2 TM]. The studies showed packaging materials such as NupakTM and ZeroTM 2 can serve as cheaper and practical packaging for products in which it is necessary to prevent oxygen diffusion or scavenge any residual oxygen. Miller et. al. [2002] researched of dissolved oxygen content in probiotic yoghurts by alternative packaging materials. They compared high-impact polystyrene with new oxygen-barrier material and an oxygen-scavenging active packaging system. They

observed stirred-type and set-type yoghurts in each packaging material for dissolved oxygen content, over a normal shelf-life for yoghurt. In result, oxygen-barrier packaging combined with an oxygen scavenging material was found to be the most effective system, particularly when used with set-type yoghurt. Besides, set-type yoghurt was found to be more conducive to oxygen reduction using packaging methods.

Viable cell counts of S. thermophilus and B. bifidum in fermented soy milk filled into glass packages, polyethylene packages containing an oxygen absorber and a desiccant, and a laminated bag (nylon/aluminum/ polypropylene) was monitored by Wang et.al., [2004]. The product stored at 25°C exhibited higher values compared to the product kept at 4°C, with the differences being directly proportional to the temperature difference. The higher the permeability of the packaging material means the lower the number of viable bacterial cells. Hisiao et.al. [2004] studied the effect of the packaging material and the storage temperature on the viability of microencapsulated bifidobacteria. The samples in the different packages with oxygen absorbres were stored at 4 and 25°C. Using of an oxygen absorber and desiccant improved the viable cell counts, particularly at 25°C.

SUMMARY

Food package helps protect food from environmental influences, such as moisture, light, oxygen, microbes, mechanical stresses and dust. These factors lead to or enhance the deterioration of food or drink. The use of appropriate packaging materials and systems is of utmost importance to safeguard the improvements introduced in the manufacturing process as a whole and ensure that the product lives up to the expectations of the people that consume these products. An ideal food packaging material should be inert, not to allow the transfer, i.e. must have a perfect barrier property, and recyclable. Food package makes distribution easier. Apart from these, there are other important functions of packaging, including containment, convenience, marketing, and communication. The use of active packaging for this type of functional food is a broad field of research for scientists and industry. Also, active packages with incorporated oxygen barrier materials or films with selective permeability properties also have potential applications in the packaging of probiotic food products.

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ZASTOSOWANIE AKTYWNYCH SYSTEMÓW PAKOWANIA DO ŻYWNOŚCI PROBIOTYCZNEJ

STRESZCZENIE. **Wstęp:** Opakowanie pełni istotną rolę w ochronie produktu końcowego. Zastosowanie aktywnego systemu pakowania odgrywa coraz istotniejszą rolę poprzez oferowanie licznych i nowatorskich rozwiązań w celu przedłużenia okresu ważności produktu, czy też poprzez poprawę jego jakości i bezpieczeństwa.
Metody: Na podstawie szerokiego przeglądu aktualnego stanu badań w literaturze światowej, omówiono systemy pakowania żywności probiotycznej.
Rezultaty: W pracy zaprezentowano prowadzone badania w zakresie systemów pakowania dla żywności probiotycznej, szczególnie przy zastosowaniu odpowiednich połączeń materiałów pasywnych z materiałami aktywnymi.
Wnioski: Aktywne opakowania połączone z materiałami o określonej barierowości czy foliami o określonej przenikalności, mają potencjalne zastosowanie w pakowaniu żywności probiotycznej i stanowią szerokie pole do badań zarówno dla naukowców jak i przemysłu.

Słowa kluczowe: żywność funkcjonalna, probiotyki, opakowania aktywne.

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ANWENDUNG VON AKTIVEN VERPACKUNGSSYSTEMEN FÜR PROBIOTISCHE LEBENSMITTEL

ZUSAMMENFASSUNG. Einleitung: Die Verpackung spielt eine wichtige Rolle beim Schutz des Endproduktes. Die Verwendung von aktiven Verpackungssystemen gewinnt zunehmend an Bedeutung, indem zahlreiche und innovative Lösungen eingeführt werden, um durch die Verbesserung der Qualität und Sicherheit die Gültigkeit des Produktes zu verlängern.
Methoden: Basierend auf einem breiten Überblick über den aktuellen Stand der Forschung in der Fachliteratur der Welt, wurden Verpackungssysteme für probiotische Lebensmittel durchdiskutiert.
Ergebnisse: Dieser Beitrag stellt laufende Forschungen im Bereich der Verpackungssysteme für probiotische Lebensmittel dar, vor allem unter Anwendung geeigneter Kombinationen von passiven und aktiven Materialien.
Fazit: Aktive Verpackungen mit einer bestimmten Permeabilität von Materialien oder Filmen kombiniert, haben ihren möglichen Einsatz in der Anwendung von Lebensmittelverpackungen gefunden und sind somit im Falle der probiotischen Lebensmittel ein breites Feld für die Forschung und eine entsprechende Industrieentwicklung geworden.

Codewörter: funktionelle Lebensmittel, Probiotika, "aktive Verpackung".

dr Renata Dobrucka
Uniwersytet Ekonomiczny w Poznaniu
Katedra Towaroznawstwa i Ekologii Produktów Przemysłowych
al. Niepodległości 10
61-875 Poznań
tel. 508 145 440
renata.dobrucka@ue.poznan.pl

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THE IMPACT OF HRM PRACTICES ON SUPPLY CHAIN MANAGEMENT SUCCESS IN SME

Naveed R. Khan[1], Syed M. Taha[2], Arsalan M. Ghouri[1], Mustafa R. Khan[3], Chee K. Yong[4]

[1] University Pendidikan Sultan Idris, Malaysia, [2] University of Karachi, Pakistan, [3] Institute of Business and Technology, Pakistan, [4] Institute Aminuddin Baki, Malaysia

ABSTRACT. Background: Management practices are being carried out by most of the small and medium sized enterprises (SME) which substantially switched to sophisticated manner. This study aims to determine the relationship between human resource management (HRM) and supply chain management (SCM) in SME.
Methods: the data from 195 manufacturing and service sectors SME were collected. The Pearson's correlation and multiple regression were employed to examine the relationship and measure the overall impact of IV on DV respectively. This study found that SME performed moderate level of HRM and SCM practices and there is a correlation between HRM practices that proactively contributes in supply chain success. Lastly, training contributed greater to SCM success as compared to other HRM factors.
Results and conclusions: Results suggest that SCM success is activated by HRM practices. SME owners/managers should focus on enhancing the SCM success by implementing sophisticated HRM practices. This integration will allow mapping unique strategies to gain an edge over competitors. Appropriate approaches should be considered at national level to boost the national economy through SME sector.

Key words: Human resource management, supply chain management, organization structure, competitive advantage, SME.

INTRODUCTION

As the world transformed into a global village and technology integrated the processes, business environment became highly dynamic. Organizations faced higher risk and greater degree of uncertainty due to the increase in global competition. These risks and uncertainties decreased market share at national and international levels, and affected organizational efficiency. However, organizations managed to survive in this condition by continuously altered, redesigned and developed their strategies. Moreover, continuous development in the field of management enabled different functions to be integrated to produce more significant results. The 1990's decade witnessed the integration of supply chain management into the organization processes, and further with other organizational management functions, was considered as the strategic advantage for the firm around the world [Shub and Stonebraker, 2009]. However, the integration process may vary among firms, sectors and industries around the region. Similarly, human resource management function also emerged as a dominant organizational function, which has a significant effect on organizational functions and performance [Zheng, 2009]. Likewise, other organizational functions in human resource management proactively contributed to the emergence of supply chain success

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[Wellins and Rioux, 2000]. On the other hand, supply chain management has direct and indirect effects on human resource management practices [Kinnie, et al, 1999]. However, few studies have been available which reported the relationship between human resource management practices and supply chain management success, especially in the context of SMEs.

As elsewhere Pakistan's business environment also faces higher risk and greater degree of uncertainty. Moreover, economic meltdown in 2008 also affected SMEs along with large scale firms. Escalating inflation and slow economic growth in Pakistan further worsened the situation for SME growth. Our focus in this study is not the external environment of SME, but rather we focus on human resource and supply chain management strategies.

Human resource and supply chain management are recently adopted strategies in Pakistan's SME sector. Albeit, these practices have already existed in SME in a very informal and casual manner, there is a need to revamp these practices under separate departments of HR and supply chain management SCM which are responsible for performing these practices. During the last decade, SME expanded their market share by focusing on competitive advantages in the booming economy of the country. In this period, Government of Pakistan had taken a number of initiatives for supporting SME growth, for example, Small and Medium Sized Enterprises Development Authority (SMEDA), SME Bank, Agriculture Support Fund, Business Support Fund, and Competitive Support Fund. The State Bank directed private banks for soft collateral policies for microfinance grants.

SME are identified as the leading employment generation sector nationwide. In the context of Karachi city which contributes 30% in manufacturing sector of Pakistan and 90% in Sindh's GDP and around 20% of the total GDP of Pakistan, SME sector plays pivotal role and have potential for further growth [Khan, 2011]. Moreover, extensive trade activities at Karachi's ports and industrial zones increase the significance of Karachi city, hence is called the financial and business hub of Pakistan, providing millions of economic opportunities.

SME contribute in export and generate foreign exchange that boosts the national economy. In terms of percentage for the period between 1990s and 2006, in the total export of SME, China stood at the top with 60% share, followed by Taiwan (56%), Thailand (46%), India (40%), and Pakistan (25%). This data indicates that in the worst economic conditions, SME's performance in Pakistan is commendable and better than Malaysia and Indonesia and it has great potentials to increase its share in the total [Tambunan, 2010].

HRM philosophy emphasizes employees' efficiency, effectiveness and productivity and employees' needs. Employees' satisfaction motivates employees for capacity building and learning new technology required in the production process. The extensive use of HR practices indicates a significant investment in human capital. Basic microeconomics suggests that investments in human capital (employees) are justified when such investments are more than offset by future returns in the form of increased productivity. Thus, firms will make greater use of such practices when employees are viewed as particularly vital to firm success [MacDuffie, 1995]. Traditional literature on human resource activity identified and classified human resource activities into four categories, which includes: Staffing, training, evaluation and compensation [Dessler, 2008; Mathis and Jackson, 2008; Fisher, et al., 2006]. In a few cases, these categories are aggregated in a slightly different manner, and certainly there is overlap and interrelationship among them (Shub and Stonebraker, 2009). Generally, the relationship-based approaches to staffing, training, evaluation, and compensation are shown in the literature to be directly associated with greater supply chain integration and performance [Shub and Stonebraker, 2009].

Supply chain as a formal concept is not understood and practiced in Pakistani SME. Harland [1996] described supply chain structure as a dynamic, inter-connected supply network. In practice, supply chains form a complex interdependent network of suppliers, manufacturing facilities and stockist linking multiple organizations. This trend is

getting more popular day by day in the firms which operate globally. Moreover, Cox [1999] considered supply chain management as a technique that is linked to the adaptation of the lean production system. The supply chain management (SCM) philosophy stresses supply chain integration that links a firm with its customers, suppliers, human resource and other channel members [Young, 2005]. Scholars in the field of SCM have revealed that a major source of cost savings and enhanced service performance in the supply chain is through increased collaboration [Sheth and Sharma, 1997] and integration among supply chain participants [Morash and Clinton, 1998]. The cross-functional coordination in SCM involves multiple business functions that span departmental and firm boundaries [Young, 2005]. The typical structure of supply chain of firms organizes the conventional functional of a firm with emphasis on individual functions like suppliers, logistics, operation and customers. However, recent improvements in Internet and Information Technology applications have facilitated rapid flow of information for real time coordination with supply chain to match demand [Eng, 2004].

This study aims to find the correlation between HR practices and SCM. The research location of this study is the city of Karachi, a port city of Pakistan, hub of huge SME and focal point of export-import activity at national and international levels. SME functioning in different industrial zones of Karachi have a mixture of formal and informal set up of HRM and Supply Chain. This study designs the research to evaluate HR practices and its overall impact on the functioning of supply chain. In addition to that the study gauges the rate of interaction among various activities of HRM and SCM.

LITERATURE REVIEW

Human resource and supply chain management importance has been recognized as a means of competitive advantage in industry. Hence integration of HR and SCM functions enable organizations to craft a unique strategy, and will increase the firm's performance. In this study, these concepts are reviewed in the perspective of Pakistani SME.

Many studies conducted in different working conditions reveal a strong correlation between HRM and SCM [Gowen and Tallon, 2003]. McAfee et al. [2002] emphasized the necessity to create a fit between supply chain and human resources strategies. Bulk of literature has been produced on HRM and SCM separately. Very few of them investigate the relationship between human resource practices and supply chain process which is the focus of this study.

Pakistan's SME sector is very different from SME in the industrialized world. Here, small and medium size businesses are usually not documented mostly with the purpose of tax evasion. Pakistan has also a unique culture of not sharing information with others. Organizations are not willing to share any information regarding their businesses. Business profiles are not uploaded onto the website, and it is so difficult for field researchers to collect basic information through interviews. Limited academic studies are conducted so far on HRM and SCM in Pakistan's SME environment. This study is thus dependent on earlier researches conducted in environment other than Pakistan for conceptual understanding and theory development. Selected literature is reviewed for this study whose results are generalizable to any other environment.

Human Resource Management Practice and Supply Chain Management Success

Human resource is the backbone of every organization; likewise supply chain management is also playing a significant role in the organization performance. Therefore, human resource and supply chain management (HRSCM) system has evolved to play an integrated supporting role in the creation of value chain system of an organization. The new integrated model of HRSCM would combine suppliers, information systems, finance, employees, manufacturing and operations, sales and marketing, research and development, inventory management and customer relations, and integrate them into a single unified model which can be divided into different modules according to the flexibility of an organization [Kureshi et al, 2009].

Gowen and Tallon [2003] found a link between managerial and employee support as well as employee training to enhance the SCM practice success. This research demonstrates that SCM has a substantial competitive advantage in four dimensions: value added, rareness, imitation cost barrier and organizational structure. All these four dimensions are activated by HRM factors such as employee training and employee support. In brief, HRM enhances the value added chain by providing more effective resources in terms of trained and enthusiastic employees. Hence, organizations could achieve a greater competitive advantage by directing more resources toward managerial and employee support while marinating employee training (Goldstein and Ford, 2002). However, there is little literature that describes the relationship between human resource activities or organization variables and supply chain success [Shub and Stonebraker, 2009].

The success of the SCM system depends on adopters who develop specific capabilities [Chandra and Kumar, 2000]. Attaining these capabilities requires employees, who are flexible in their role to have a broad set of skills, adaptable to recognition, able to work in boundary-spanning responsibility and are innovative [Othman and Ghani, 2008]. Moreover, companies said to be effective in their SCM practices put a lot of emphasis on developing their human resource through training and retraining of employees [Gowen and Tallon, 2003]. In addition, Shadur and Bamber [1994] pointed out that effective SCM practices also rely on teamwork and continuous improvement. Basu and Miroshnik [1999] explained that such collaboration also requires high trust among employees and with suppliers. The study by Othman and Ghani [2008] provided evidence that there was a positive relationship between HRM practices and the SCM success. Moreover, they found some support for the contention that the adoption of SCM needs to be supported by specific forms of HRM practice.

Another study on SCM and electronic information relationship by Hussain and Subramoniam (2009) demonstrates the positive benefits of integrating the Internet into management of the supply chain. It also suggests that firms which have completed such integration hold a current competitive advantage over those that have not. Ramos [2004] also examined the relationship between managerial accounting and SCM and found positive significance between these two approaches. She focused on the potential role that management accounting information can play a significant role in supply chain management.

Concepts Related to Supply Chain Success and Human Resource Management in SME Sector

In recent years the small and medium sized enterprises (SME) have come under "public policy limelight" [Schlogl, 2004]. Researchers focus their intentions on this sector to identify the employment potential and the number of firms as the major concern of their research. Moreover, this shift has been even more profound in Pakistan [Bhutta et al., 2007]. SMEDA was established in October, 1998 under SMEDA ordinance promulgated by the President of Pakistan on August 12, 2002 with the aim to develop Small & Medium Enterprises (SME) in Pakistan [SMEDA, 2010]. Moreover, in the mid-nineties, Government of Pakistan established an SME bank to provide financial assistance. Moreover, many commercial banks in the country have set up their SME departments to cater for the SME sector [Bhutta et al., 2007].

While analyzing the human resource management practices in Pakistan, Sabeen Jamil [2005] concluded that the economies and business activities were facing latest development of globalization and free market worldwide. The human resource management practices in Pakistan were adopted in response to face these challenges. However, HRM concept is in a developmental phase in Pakistan. Business seems inclined to introduce the HRM practices to manage and retain their workforce but companies' desire to invest and to accept the real essence of HR development is needed. Kinnie et al. [1999] described the direct and indirect effects of supply chain management have on human resource activities which are practiced in SME.

METHODOLOGY

This study aims to identify the relationship between HRM practices and SCM success in SME of Karachi, Pakistan. This study is quantitative in nature because this method is most appropriate to measure the relationship between the constructs. The cross-sectional survey was carried out to collect the primary data from manufacturing and service sectors SME. It covers eight sub-sectors, which include textile, engineering/construction, leather goods, chemical/pharmaceutical, education, financial institutions, hotels/ restaurants and logistics.

The HRM items in the questionnaire were adopted from the study of Chew [2004]. However SCM items were developed through existing literature. All items were based on five point Likert scale, from strongly disagree to strongly agree. In this study, it is hypothesized that human resource management practices are associated with supply chain management; and human resource management practices have significant positive effect on supply chain management success.

Sampling and data collection

Initially the survey questionnaires were sent through courier along with the introductory letter and paid return envelope. However, due to very low response rate, the survey was then self-administered. Three groups of researchers administered the survey and collected the data. Each group comprised of three members, i.e. a researcher and two degree level students who were asked to volunteer their services for data collection. The sample of the study was randomly selected from different areas of Karachi, Pakistan. The manufacturing SME were selected among the members of Korangi Association of Trade and Industry (KATI). However, service sector SME were selected from the Phonebook Yellow Pages of Pakistan since the database of Phonebook is more categorized and updated. A total of 300 survey questionnaires were distributed. However, only 195 fully-filled questionnaires were found eligible for further analysis. It showed 65% response rate.

Reliability Testing

Cronbach's alpha was employed to measure the reliability of the items used in this study. The internal consistency reliability coefficients (Cronbach's alpha) for the items used in this study are found well above the level of 0.7. The alpha value should be greater than 0.7 to enable the instrument to be accepted for data collection and analysis [Sekaran, 2005]. Thus, the instrument is acceptable for the analysis purpose. The summary of alpha scores is given in table 1.

Table 1. Reliability Coefficients of the variables (n = 195)
Tabela 1. Współczynniki wiarygodności zmiennych (n = 195)

Constructs	No. of Items	Cronbach's Alpha
Selection	4	.650
Training	6	.792
Compensation	6	.845
Evaluation	5	.624
Supply Chain Management	5	.756

FINDINGS

Background of Respondents

The background of the respondents in this study analyzes the different demographic variables which present the respondent's responses, clearly and logically. The demographic characteristics of respondents summarized in table 2.

Descriptive Statistics of Main Variables

The descriptive statistics of the main variables of the present study, i.e. selection, training, compensation, evaluation and supply chain is summarized in the table 3, presented below. The results showed that the SMEs generally practiced the HRM, selection is moderately practiced in the organization (mean = 3.49, SD = 1.10) along with training (mean = 3.35, SD = 1.081), compensation (mean = 3.68, SD = .975), evaluation (mean = 3.69, SD = 1.34).

With respect to supply chain management, the SMEs responded in this study are generally inclined towards the supply chain management success (mean = 3.66, SD = .95). See table 3.

Table 2. Summary of Respondents(n = 195)
Tabela 2. Charakterystyka respondentów (n = 195)

Variable (S)	Frequency	% age	Variable (S)	Frequency	% age
Gender			Marital Status		
Male	167	85.6	Married	130	66.7
Female	28	14.4	Unmarried	64	32.8
			No response	1	0.5
Age			Departments		
20-25 yrs	29	14.9	Supply chain / operations	83	42.5
26-30 yrs	48	24.6	HR / Administration	112	57.4
31-35 yrs	40	20.5	Management Level		
36-40 yrs	32	16.4	Junior	14	7.2
41-45 yrs	16	8.2	Middle	108	55.4
46-50 yrs	21	10.8	Top	70	35.9
Over 50	9	4.6	No Response	3	1.5
Education			Working Experience		
Intermediate	3	1.5	< 1 Years	3	1.5
Bachelors	77	39.5	2 - 4 Years	39	20
Masters	103	52.8	5 – 7 Years	37	19
M. Phil	7	3.6	8 - 10	45	23.1
PhD	0	0	11 - 13	20	10.3
Other	5	2.6	14 – 16	19	9.7
Business Sectors			> 17	32	16.4
Financial Institution	18	9.2	No of Employees		
Engineering/Construction	23	11.8	10 to 50	45	23.2
Leather goods	5	2.6	51-100	16	8.2
Chemical/Pharmaceutical	18	9.2	101-150	26	13.3
Education	15	7.7	151-200	73	37.4
Textile	19	9.7	201 - 250	35	17.9
Hotels / Restaurants	18	9.2	Type of Business		
Logistics	17	8.7	Manufacturing	89	45.6
Others	62	31.8	Services	106	54.4
Total	**195**	**100.0**	**Total**	**195**	**100.0**

Table 3. Descriptive Statistics of Variables (n = 195)
Tabela 3. Opisowe statystyki zmiennych (n = 195)

Items	Mean	SD
Selection	3.497	1.10
Training	3.352	1.081
Compensation	3.683	.975
Evaluation	3.682	1.349
Overall HRM Practices	3.553	1.126
Supply chain management	3.661	.956

Selection

Out of the four items of selection, "only the best people are hired to work in this organization" (mean = 3.74, SD = 1.07) has the highest mean score, followed by "the values and beliefs of this organization are discussed in interviews with potential employees" mean value of 3.69 (SD = 1.054), "when new employees are hired, they must go through an extensive hiring process in which they are interviewed a number of times" (mean = 3.44, SD =1.153), and "employees of this organization are involved in the hiring of their peers" (mean 3.11, SD = 1.152). In general, the

SMEs appeared to have moderate selection practices in their organization.

Training

The descriptive statistics for each training items showed that "people are properly oriented and trained upon joining this organization" has the highest level of training practice (mean = 3.67, SD =1.042), followed by "the company provides enough training for the employees to learn new ways to do their job" (mean = 3.59, SD = 1.037). "This organization does provide regular opportunities for personal and career development" (mean = 3.43, SD = 1.045). "Training provided by the firm often consists of both classrooms teachings and On-Job-Training (OJT)" (mean = 3.27, SD = 1.168); "This organization subsidizes, assists or reimburses employees for training they get outside the organization", mean = 3.22, SD = 1.097). However, "employees in this organization receive additional compensation" have the lowest level of practice in the variety of activities (mean = 2.90, SD =1.099).

Compensation

Out of the six items "Employees are given positive recognition when they produce high quality work" showed the highest level of compensation practice (mean = 3.89, SD =. 965), followed by "This organization pays well" and "This organization offers good opportunities for promotion" (mean = 3.723, SD = .927) and (mean = 3.723, SD = 1.018) respectively. "The way in which employees in this organization are compensated" (mean = 3.65, SD = .920). "This organization values individual excellence over teamwork" (mean = 3.61, SD = 1.015); "This organization offers a good benefits package compared to other organizations", mean = 3.49, SD = 1.007). The overall mean score showed a moderate level of compensation practiced followed in SMEs.

Evaluation

Results found that SMEs are highly intended to let its employees know, how they are performing (mean = 4.08, SD = 2.98). The item vise analysis showed that the measurement of an employee's performance on the job is a priority in this organization, it received the highest mean value (mean = 3.77, SD = .895), followed by the measurement of turnover and absenteeism is a priority in this organization" and "when evaluating the employees for promotion, seniority is one of the criteria taken into account" (mean = 3.517, SD = .937) and (mean = 3.517, SD = .970) respectively. However, "this organization makes a point of keeping track of factors that it considers critical for success" receive the lowest mean value (mean = 3.50, SD =. 959).

Supply Chain

Five items were used to measure the supply chain management success in SMEs. Out of the five items, "our organization is involving in establishing continuous improvement teams" received the highest mean value (mean = 3.86, SD =.934), followed by the "our organization is creating substantial customer satisfaction evaluation" received the second highest mean value (mean = 3.83, SD= .939), followed by "Our organization is creating substantial supplier quality evaluation" (mean = 3.65, SD= .931); "Our organization is involving in substantial competitive benchmarking advantage" and "Our organization is establishing substantial supplier partnerships" (mean = 3.57, SD= .956) and (mean = 3.38, SD= 1.02) respectively.

The overall mean for supply chain management success (Mean = 3.661, SD = .956) suggests that SMEs in this study are generally effected by the HRM practices.

Correlation Matrix

To determine the relationships amongst the variables Pearson correlation were employed. As a result, a correlation matrix is presented in table 4.

Analysis showed that out of four, three human resource management variables show a positive and significant relationship to supply chain management. This means that the SMEs practiced training; compensation and evaluation have the higher tendency for supply chain management success. However, selection

practice does not seem to have any bearing on supply chain success in SMEs.

The results reveal a significant and positive relationship between supply chain management and (a) Training (r = .510, p = .000), (b) Compensation (r = .654, p = .000) and (c) Evaluation (r = .556, p = .000). However, there is no significant relationship between selection and supply chain management success (r = -.033, p =.730).

Table 4. Correlations Matrix (n = 195)
Tabela 4. Macierz korelacji (n = 195)

HRM Practices	Training	Compensation	Evaluation	Selection	SCM success
Training	1				
Compensation	.459**	1			
Evaluation	.509**	.698**	1		
Selection	-.067	-.100	-.021	1	
SCM success	.510**	.654**	.556**	-.033	1

**Correlation is significant at p<0.01

Table 5. Overall Effects of HR practices on SCM success
Tabela 5. Ogólny wpływ działań HR na sukces łańcucha dostaw

R	*R* square	Adjusted *R* square	Std. error of the estimates	*F*	Sig.
.585	.342	.315	.94421	12.56	.000

Table 6. Effect of each HRM Practice variables on SCM success
Tabela 6. Wpływ poszczególnych działań HR na sukces łańcucha dostaw

Variables	**Std. error**	**Std. Beta**	**t**	**Sig.**
Selection	.196	-.099	-.984	.327
Training	.250	-.386	-3.763	.000
Compensation	.163	-.181	-2.262	.025
Evaluation	.167	-.106	-.906	.366

Multiple Regression Analysis

To test the overall impact of HRM practices on SCM success multiple regression was employed. The idea here is to estimate the variance explained in SME's supply chain management success by four dimensions of human resource practices. Four components of HR practices i.e. selection, training, compensation and evaluation were included in the regression model using a default enter method, to calculate the effects of variance caused on the supply chain management success. The results are shown in table 5.

The results from Table 10 indicated that the multiple regression coefficients (R) of the four independent variables of HRM practices in the SCM success model is .585 and the R square is .342. The value of F is 12.56 at (p =.000). This means that 34.2 percent of the variance in SCM success has been significantly explained by the four factors of HR practices. Thus the results in this study support the hypothesis that SME's HR practices have significant bearing on SCM success. However in the regression analysis beta values of each independent variable signify the significant contribution

and influence on the SCM success was addressed and the results are shown in table 6.

From the result presented above, training appeared to be the strongest explanatory variable to predict SCM success followed by compensation. However selection and evaluation did not able to predict significantly on SCM success in SMEs.

The summary of results of hypotheses examined in this study is presented in the table 7.

Table 7. Summary of Hypotheses Testing Results
Tabela 7. Wyniki testowania hipotez

	Hypotheses	**Result**
H1:	Selection has a significant positive effect on supply chain management success.	Rejected
H2:	Training has a significant positive effect on supply chain management success.	Supported
H3:	Evaluation has a significant positive effect on supply chain management success.	Supported
H4:	Compensation has a significant positive effect on supply chain management success.	Supported
H5:	Four factors of human resource practices have significant positive effect on supply chain management success.	Partially supported

CONCLUSION

During the data collection process, we encountered a number of people, trends and policies that gave a vivid picture of HRM practices and SCM. Our ethnographic survey of other SME working in areas other than the sample revealed that the infrastructure for SME support is critically lacking and Pakistan's unstable economy further discouraged the owners of SME to run the business in traditional style. Despite Pakistan's resilience economy, policy makers have failed to formulate SME policy at national, provincial and even local government levels that could exploit the full potential of human resource in Pakistan. Law and order situation also unprovoked the local investors to invest and bring foreign direct investments.

The findings revealed that SME practiced the HRM and SCM at a moderate level. However, it also indicated that HRM and SCM functions were not practiced fully in SME. The research demonstrated that SCM success is activated by HRM practices. Hence it proved the contention that HRM significantly amplified the level of supply chain success. Moreover, trained and motivated employees and managers contributed effectively under these practices.

This study found that by applying HRM practices at modest level and if linked with SCM, an organization can enhance SCM effectiveness. This would provide an edge to lead in the competitive market(s). Moreover, the integration of best HRM practices with SCM has significant effects on SME's performance as well [Souviron and Harrison, 2007; Shub and Stonebraker, 2009; MacDuffie, 1995]. Indeed this integration provides an edge over those who either focus on human resource management or supply chain management. The finding clearly indicated a unidirectional effectiveness of HRM on supply chain, which is not vice versa. It means that organizations need to focus more on HRM not only to improve the performance of employees but also to enhance the supply chain management success. Moreover, this study also demonstrated that employee training and compensation contributes the most significant value in SCM success. We safely conclude that human resource practices are the activators of all non-human resources and are means for developing competitive advantages in the market place.

This study further found that HRM practices such as training, compensation and evaluation were the key factors for either supply chain success or failure in SME. Therefore, it is clear that SCM success is highly dependent upon HRM practices which were confirmed by Othman and Ghani (2008) and they found some support for the contention that the adoption of SCM needs to be supported by specific forms of HRM practices.

This study demonstrated the relevance of considering the effects of integrated HR practices which includes: selection, training, compensation and evaluation rather than considering individuals. The central role of HR practices in shaping supply chain has been

advocated in other researches [Souviron and Harrison, 2007]. However, effects of individual HR practices are also contingent on other HR practices and therefore require an approach to those practices working as a set or "bundle" rather than independently [Delery, 1998].

The development of SME needs clustering of products and networking that can only be improved through effective governmental assistantship programs such as industrial incubators, industrial parks for SME, and industrial apartment. Effective cluster environment synergized various shortages and helps in the production processes. Further SME owners/manager should implement HRM and SCM functions by considering them as an investment rather than expenses, which in return enhance the organizational performance. It is further observed that the existing HRM and SCM structure in Pakistani SME is fragile and still there is ample room for improvement.

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WPŁYW PRAKTYK ZZL NA SUKCES ZARZĄDZANIA ŁAŃCUCHEM DOSTAW W MAŁYCH I ŚREDNICH PRZEDSIĘBIORSTWACH

STRESZCZENIE. **Wstęp:** Metody zarządzania są stosowane przez większość małych i średnich przedsiębiorstw. W miarę upływu czasu metody te stają się coraz bardziej złożone. Celem pracy jest określenie związku pomiędzy zarządzaniem zasobami ludzkimi (ZZL) a zarządzaniem łańcuchem dostaw w małych i średnich przedsiębiorstwach.
Metody: zebrano dane od 195 przedsiębiorstw, zarówno produkcyjnych jak i usługowych. Wyliczono współczynnik Pearsona oraz regresję wielokrotną w celu zbadania zależności. W wyniku badań stwierdzono, że małe i średnie przedsiębiorstwa stosują średnio zaawansowane metody zarządzania zarówno zasobami ludzkimi jak i łańcuchem dostaw. Stwierdzono korelację pomiędzy metodami ZZL, które pozytywnie wpływają na sukces w łańcuchu dostaw. Największy wpływ wśród wszystkich stosowanych metod ZZL miały szkolenia.
Wyniki i wnioski: Otrzymane wyniki potwierdzają pozytywny wpływ metod ZZL na sukces łańcucha dostaw. Właściciele i managerowie małych i średnich przedsiębiorstw powinni skupić się na szerszym wprowadzeniu zaawansowanych metod zarządzania ludźmi w celu osiągnięcia lepszych wyników w obszarze łańcucha dostaw. Takie działanie pozwala na osiągnięcie większej przewagi nad konkurencją.

Słowa kluczowe: zarządzanie zasobami ludzki, zarządzanie łańcuchem dostaw, struktura organizacyjna, przewaga konkurencyjna, małe i średnie przedsiębiorstwa.

EINFLUSS VON HRM-PRAKTIKEN (HUMAN RESOURCES MANAGEMENT) AUF DEN ERFOLG IM MANAGEMENT VON LIEFERKETTEN IN KLEIN- UND MITTELGROßEN UNTERNEHMEN

ZUSAMMENFASSUNG. Einleitung: Ausgewählte Methoden der Unternehmensführung werden von den meisten klein- und mittelgroßen Unternehmen angewendet. Im Laufe der Zeit werden die Methoden immer komplizierter. Das Ziel der Arbeit ist es, den Zusammenhang zwischen dem Human Resources Management (HRM) und dem Management von Lieferketten in klein- und mittelgroßen Unternehmen zu bestimmen.
Methoden: Als Material-Bezugsquelle wurden 195 sowohl Produktions-, als auch Dienstleistungsunternehmen ermittelt. Zwecks Prüfung der Abhängigkeit wurden der Pearson'sche Korrelationskoeffizient und die mehrfache Regression berechnet. Im Ergebnis der Forschungen stellte man fest, dass die klein- und mittelgroßen Unternehmen nur mittelmäßig fortgeschrittene Methoden der Unternehmensführung im Bereich des HRM wie auch im Management von Lieferketten in

Anspruch nehmen. Es wurde dabei eine gegenseitige Korrelation zwischen den HRM-Methoden, die den Erfolg innerhalb der Lieferkette positiv beeinflussen, festgelegt. Unter allen angewendeten HRM-Methoden haben Schulungen den größten Einfluss ausgeübt.
Ergebnisse und Fazit: Die ermittelten Ergebnisse bestätigen den positiven Einfluss der HRM-Methoden auf den Erfolg einer Lieferkette. Die Geschäftsführer und Manager von klein- und mittelgroßen Unternehmen sollten eine breitere Anwendung von den fortgeschrittenen HRM-Methoden zwecks Erzielung von besseren Ergebnissen innerhalb der Lieferketten anstreben. Solch eine Ausrichtung der betreffenden Aktivitäten erlaubt, eine bessere Wettbewerbsfähigkeit des Unternehmens zu gewinnen..

Codewörter: Human Resources Management, Management von Lieferketten, Organisationsstruktur, Wettbewerbsfähigkeit, klein- und mittelgroße Unternehmen

Naveed R. Khan
No 10-3-B, Bahtera Arked,
Jalan Bahtera 2,
Taman Bahtera, 35900,
Tanjong Malim, Perak, Malaysia.
Mobile: +60176331172
Email naveed.r.khan@gmail.com

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PERFORMANCE MANAGEMENT SYSTEM IN SALE AND DISTRIBUTION: A CASE OF SERBIAN COMPANY

Aleksandar Jankulović[1], Milan Stamatović[1], Dragan Čović[1], Vladimir Škorić[2]

[1] Belgrade Metropolitan University, Belgrade, Serbia, [2] London School of Commerce in Belgrade, Belgrade, Serbia

ABSTRACT. Background: Performance management system (PMS) is the process of quantifying action which leads to organizational efficiency, competitiveness and growth. Performance measurement is the vital element of quality management system (QMS). Innovative companies have a strong culture, clear sense of mission and purpose, a well thought out strategy and business philosophy of continuous improvement, driven by QMS. Implementation of QMS ISO9001 standards has encouraged many organizations to develop and implement performance management system. Statement of quality objectives and Measurement, analysis and improvement as a part of QMS which leads to continual improvement is a vital part of success of company. Therefore PMS influence on sale, distribution and logistics companies with a complex processes and great number of subjects in supply chain are of great importance for their success.
Methods: In our research we analyse measures and measurement approaches and frameworks that exist in logistic management and based on that we present results from one SME from eastern European country. We use case study research and therefore we conduct interviews with managers, employees and QMS/PMS implementation staff in sale and distribution company.
Results: The aim of this study was to estimate the value of various metrics of the evaluation of QMS implementation. The study was based on case study in one Serbian sale and distribution company specifically in measurement part and metrics that are essential for their business and to compare them with approaches existed in literature. We reveal some obstacles in collecting data for measurement and benchmarking in Serbian market. Different metrics for efficient management of company are implemented in this company based on sales results and customer satisfaction.
Conclusion: The importance of the research is in the fact that implementation of QMS reveal the need for PMS implementation and therefore results in certain performance measures implementation and further continuous tracking of these parameters. We made conclusion that higher business results were reached after PMS implementation and that after implementation of QMS and PMS top managers understand the importance of implementation. We reveal also the fact that in former eastern European socialism countries like Serbia, exist resistance of performance measurement implementation and publication of these data as well as the implementation of benchmarking among companies.

Key words: Quality management, Logistics, Performance Management System (PMS), Serbia.

INTRODUCTION

Implementation of Quality Management System (QMS) is of great importance for effective and efficient work of companies. Very important part of QMS is performance measurement, control and improvement. Performance management system (PMS) is the process of quantifying action, where measurement as a process of quantification and action leads to performance [Neely et al., 1995]. Therefore PMS influence on sale, distribution and logistics companies with a complex processes and great number of subjects in supply chain are of great importance for their success. Given the volume of information that logistics professionals must consider to make sound decisions, selecting performance measures that report timely and relevant information is critical for effective

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management of logistics activity. [Griffis et al., 2007]. The aim of this study was to present results of QMS implementation in one Serbian sale and distribution company specifically in measurement part and metrics that are essential for their business and to compare them with approaches existed in literature. According to QMS standard which put customer on primary position and the interest of managers and owners of companies to gain higher financial results, we focus our work on two groups of parameters: customer satisfaction and sales results. The study was initiated in order to raise the level of importance of performance measurement implementation for countries in transition and for understanding that the first step toward this implementation could be QMS implementation.

Every organization needs to use a proper combination and selection of quality tools, methodologies and techniques for implementing continuous quality improvement process [Parkash and Kumar Kaushik, 2011]. The competitive and innovative companies had a strong culture, a clear sense of mission and purpose, a well thought out strategy and a business philosophy of continuous improvement, driven by Total Quality Management (TQM) which is successfully realised by PMS [Neely et al., 2001]. Therefore TQM and implementation of ISO9001 standards have encouraged many organisations to develop and implement PMS. Some of the basic principles of TQM are strongly related to the use of measures. Within ISO9001, developing a method of measurement, analysis and improvement is an integral part of the quality management system [chapter 8 of ISO9001]. TQM and technology play important and complementing roles in improving the performance. Brah and Lim (2006) shows for logistics company that both high technology firms and high technology TQM firms perform significantly better than their low technology peers.

In Serbia QMS implementation in domestic companies is still on very low level especially in Small and Medium Enterprise's (SME's). The lack of financial funds for implementation as well as owner's and management willingness for implementation and their misunderstanding of QMS importance are the most common reasons for low level of QMS implementation. Also the influence of previous period of planned economy neglected the importance of performance measurement, KPIs, success factors and improvement of business processes. Considering the transition to market economy and competition with highly efficient companies from all over the world, domestic companies has to be more proactive and improve the level of their efficiency and competitiveness toward customers' satisfaction.

Sliwczynski B. and Kolinski A. [2012] confirm the relation of company's processes efficiency to the processes of material flow and logistic processes which together create a complex decisional system. Such important processes have to be measured. Logistics management has many measures and measurement approaches and frameworks. Most firms' priorities change over time due to market and competitive dynamics and therefore new or different measures are used in accordance with priorities and situation. According to analysis of academic literature some of the proposed sample measures are: On-time delivery percentage; Logistic costs as a percentage of sales; Days order late; Inventory turnover ratio; Complete order fill rate; Average order cycle time; Order cycle time variability; Items picked per person per hour; Average line item fill rate; Weeks of supply; Average backorder fill time; Sales lost due to stock out; Percent error pick rate; Logistics cost per unit [Griffis et.al., 2007]. In their work Griffis et.al. [2004], proposed measurement framework with dimensions: measures based on efficiency or based on systems responsiveness; measures support operational decisions versus strategic decisions; measures suited for process orientations versus measures suited to functional orientations; measures monitor performance versus measures for functional orientations. According to research of Lichocik and Sadowski [2013] an effective supply chain must be cost-effective (ensuring economic efficiency of a chain), functional (reducing processes, lean, minimizing the number of links in the chain to the necessary ones, adapting supply chain participant's internal processes to a common objective based on its efficiency) and ensuring high quality of

services (customer oriented logistics systems). Januszewski [2011] stated that not all customers are equally important for the company, that the aim of the identification of key customers is to facilitate the optimal allocation of resources of the company and to use combination of methods for the evaluation of the customer value in logistic companies.

As an indicator of how many strategic supply network performance measures are actively in use the Supply Chain Operations Reference (SCOR) model provides a clue of 144 defined supply chain operation reference measures (SCOR) (Supply Network Council, 2006) identify approximately 19 strategic measures which can be classified as strategic, managerial or operational in nature [Morgan, 2007]. According to Morgan [2007], instead effort needs to be expended to reduce the number of performance measures, the goal is to design simpler and more effective performance measurement systems throw management involvement and that whichever methodology is chosen, the key task must be to focus on the central relationship between culture and performance measurement and how this varies in different countries. Sliwczynski [2010] concluded in his research that developing such a number of operating solution variants within a supply chain in practical management of material, information and financial flows that would make it possible to conduct a comprehensive analysis at the accepted level of costs and execution time is the optimal number of variant analysis measures.

The experience from, and the review of, industry standards and best practices in supply chain performance measurement suggest that "less is better" as to developing performance metrics. Companies should focus on only a small list of Key Performance Indicators (KPIs) which are critical for their operations management, customer service, and financial viability. Potential KPIs should be developed for each of the SCOR model's four meta-processes (plan, source, make, and delivery) and need to be hierarchically grouped such as primary and secondary metrics [Chae, 2009].

Performance measures that are focused on financial metrics are used for a long period of time to provide operational control and external financial reporting in private sector organisations [Kuwaiti, 2004]. New market development and globalisation force companies to consider their performance in terms of quality of service, flexibility, customization, innovation and rapid response (Neely, 1999).

METHODOLOGY

The chosen research methodology was case study of sale and distribution company of construction products which is suited to the interpretive research approach. Multiple sources of data are embraced and engaged in a recursive, sense-making process, in which results and discussion are compared and contrasted as suggested by Yin [2003]. Data were gathered with semi-structured interviews that were held with the top managers, sales managers and outlet managers responsible for the leading processes in company. Key questions and issues were raised in order to define implementation of performance measures in company. The managers were allowed to freely give their opinions and answers [Simon et al., 1996].

RESULTS AND DISCUSSION

Company was issued an ISO9001 certificate by an internationally acknowledged certification company, which made a significant contribution in introducing process approach, defining and measuring business parameters, as well as additional analysis and improvements. After ISO 9001 have been implemented, performance measures were established. Before ISO9001 implementation, performances were just on the level of bookkeeping considering domestic low requirements. Measurement, analysis and improvement as indispensable parts of ISO 9001, were valuable tools for the establishing of PMS in company. Performance measures have been developed in company on the basis of financial metrics and reporting mechanism. All parameters were stored both in spreadsheets and in bookkeeping software developed commercially on domestic market. Both tracking systems were used for parallel

control and comparison. Such monthly reports have become available to the manager stuff.

Every month on meeting outlet managers present their result in previous month. Outlets are organized as income units and their results are tracked individually. Payment of outlet managers is connected with outlet results. Data were prepared by managers of outlets (existing 8 outlets all over Serbia), technical director, specialists responsible for technical support and sales of products according to different groups and bookkeeping department. The stated parameters serve for internal comparison between sales points which makes a solid competition between them. A number of business decisions is made through these regular monthly meetings, a set of proposed measures towards suppliers is established, a position about sales of certain product on a given territory is taken, the questions of quantity of stocks is reviewed, trends are followed, problems and causes are established and possible ways of their removals, as well as business improvement are defined. Certain parameters are followed and compared with regard to received parameters in companies which are part of the international shareholder from the region, which deal with the same business. Benchmarking within domestic market and competition is on very low level since it is very hard to provide results from competition and statistical state institutions.

In the next part of paper we will present performance measures that are used in this company. We uncovered two groups of performances:

- Sales results,
- Customer satisfaction.

Sales results based on financial parameters analysed monthly on meetings are based on performance measures of outlets. They are:

- Retail sales information (invoiced, paid invoices, number of invoices, average value of the invoice, rebate amount, amount and list of unpaid invoices),
- Wholesale information (pro-invoices, date, invoice number, customer's name, value of pro-invoice and invoice, unpaid amount, discount, name of salesman),
- Information of net amount of income in comparison to previous years (so called diagram "to know where we stand")
- Information of goods groups (retail sales and wholesale, quantity of sold goods by goods groups, participation in the total sales of specific important suppliers), comparison with previous years and to the competitors),
- Year turnover plan, control and analysis of realization in sales outlets totally and by goods groups, comparison with previous years, pre-tax profit/total income, income and profit by employee
- Total inventory turnover and inventory by goods groups, inventory turnover ratio, expenses of inventory per product, number of days in inventory and unit inventory costs (in total, for sales outlets and by goods group).
- Expenses (workforce, utilities, vehicles used for goods transport to customer and from supplier or central distribution center, logistic cost in relation to sales, other material costs).

Performance measures connected with customer satisfaction are:

- Number of objections/complaints of buyers about sold goods, value of products subject of complaint in relation to the total income;
- Price of products with relation to competition for the same quality;
- Order cycle time, on-time delivery;
- Fill rate, in stock, stock out, backorder

Company takes a lot of care to stock of material available for customers and high level of in stock probability despite high expenses of high inventory level. Company doesn't take evidence about sales lost due to stock out as one of the very important parameters for customer satisfaction which directly leads to lost sale and income.

According to research of Griffis et.al. [2004], dimensions used in analyzed company within performance measures of sales result and customer satisfaction are measures based both on efficiency and system responsiveness, measures that support both operational and strategic decisions of management, measures

suited for process orientations and measures for monitor performance.

Performance measures in company serve for process and business improvement and corrective measures which include improvement level of customer services, proposed measures toward suppliers in order to raise the level of sales, own stock optimization in relationship with high customer satisfaction and sales rise in outlets. Implementation of ISO9001 initiated every month meetings, establishment of performance measures which are discussed on these meetings, improvement and corrective measures according to gained parameters. Business results within all parameters are better controlled and raised within implementation of management analysis of performance measures.

CONCLUSION

Important aspect of the implementation of PMS according to our presented findings is to establish a quality management system ISO9001, since it demands system of measurement, analysis and improvement with corrective measures. After implementation PMS in analyzed company, according to interviews with managers, business controllability, efficiency and user satisfaction were raised on the higher level and therefore better results were gained throw higher level of sale and income. In our research we presented different metrics within two group, sales results and customer satisfaction which appropriate to performance measures analysis of academic literature. These company parameters mostly comply with studies which classify measures as strategic, managerial or operational in nature and that are suited for process measurement and company efficiency and responsiveness. Some other specifics of PMS are due to culture, country and company uniqueness. Further research should include analysis of PMS implementation in a larger number of logistic companies in Serbia and further research of implementation other group of performance measures other than customer satisfaction and sales result.

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SYSTEM ZARZĄDZANIA EFEKTYWNOŚCIĄ W SPRZEDAŻY I DYSTRYBUCJI: STUDIUM SERBSKIEGO PRZEDSIĘBIORSTWA

STRESZCZENIE. **Wstęp:** System zarządzania efektywnością to proces ilościowego działania, prowadzącego do efektywności w zakresie organizacji, konkurencyjności i rozwoju. Pomiar wyników jest istotnym elementem systemu zarządzania jakością. Innowacyjne firmy charakteryzują się silną kulturą, przejrzystym poczuciem misji i celów, posiadaniem dobrze przemyślanej strategii i filozofii ciągłego doskonalenia swojej działalności, kształtowanej poprzez system zarządzania jakością. Wdrożenie standardów ISO9001 SZJ stymuluje wiele firm do opracowania i wdrożenia systemu zarządzania efektywnością. Jasne określenie celów jakościowych oraz sposobów pomiaru stanowi ważną część systemu zarządzania jakością, umożliwiającą ciągłe doskonalenia działania i w rezultacie osiągnięcie sukcesu przez firmę. Dlatego też wpływ systemu zarządzania efektywnością w przedsiębiorstwach działających w obszarze sprzedaży, dystrybucji i logistyki, charakteryzujących się złożonością procesów i dużą liczbą ogniw w łańcuchu dostaw, jest bardzo istotny dla osiągnięcia sukcesu przez te przedsiębiorstwa.
Metody: W badaniach przeanalizowano środki i metody pomiarowe, które są stosowane w zakresie zarządzania logistycznego. W oparciu o tą analizę zaprezentowano wyniki analizy reprezentanta wyłowionego wśród grupy małych i średnich przedsiębiorstw z Europy Wschodniej. Przeprowadzono studium przypadku, w trakcie którego przeprowadzono rozmowy z zarządzającymi, pracownikami oraz osobami wdrażającymi systemy zarządzania jakością w przedsiębiorstwie działającym w obszarze sprzedaży i dystrybucji.
Wyniki: Celem niniejszej pracy była ocena przydatności wyboru wskaźników dla oceny wdrażania systemu zarządzania jakością. Badania przeprowadzono w jednym z serbskich przedsiębiorstw, działającym w obszarze sprzedaży i dystrybucji. Szczególny nacisk położono na system stosowanych wskaźników i porównanie tego systemu z opisywanymi w literaturze fachowej. Stwierdzono parę trudności w uzyskaniu odpowiednich danych dla przeprowadzenia pomiarów i benchmarkingu dla serbskiego rynku. W analizowanym przedsiębiorstwie stosowano różne mierniki, oparte na pomiarze wyników sprzedaży oraz poziomu zadowolenia klienta.
Wnioski: Znaczenie przeprowadzonych badań wynika z faktu, że wdrożenie systemu zarządzania jakością ujawniło potrzebę wdrożenia systemu zarządzania efektywnością. To z kolei jest związane z koniecznością wdrożenia sytemu wskaźników służących do pomiaru i monitorowania działań przedsiębiorstwa. Osiągnięcie lepszych rezultatów przez przedsiębiorstwo, dzięki wdrożeniu tych systemów, spowodowało lepsze zrozumienie konieczności takiego wdrożenia przez zarządzających firmą. Stwierdzono istnienie oporu w przeprowadzaniu badań pomiaru efektywności oraz publikacji tego typu danych dla celów benchmarking w krajach postsocjalistycznych Europy Wschodniej.

Słowa kluczowe: zarządzanie jakością, logistyka, system zarządzania, Serbia.

EIN EFFEKTIVITÄTSMANAGEMENT-SYSTEM IN VERKAUF UND DISTRIBUTION: FALLSTUDIE EINES SERBISCHEN UNTERNEHMENS

ZUSAMMENFASSUNG. Einleitung: Ein Effektivitätsmanagement-System stellt einen Prozess des quantitativen Wirkens, das zur Steigerung der Effektivität im Bereich der Organisation, der Wettbewerbsfähigkeit und der Entwicklung

eines Unternehmens führt, dar. Die Berechnung von betreffenden Ergebnissen bildet daher ein wesentliches Element des Qualitätsmanagement-Systems. Innovative Firmen charakterisieren sich durch eine ausgebaute Organisationskultur, transparente Zielsetzung und Gefühl ihrer Mission, ferner durch den Besitz einer gut durchdachten Strategie und Philosophie der ständigen Vervollkommnung ihrer Tätigkeit, die mittels des Qualitätsmanagement-Systems gestaltet werden. Die Einführung von den Standardnormen ISO9001 SZJ stimuliert viele Firmen zur Bearbeitung und Einführung des Effektivitätsmanagement-Systems. Die klare Bestimmung von Qualitätszielen und Berechnungsmethoden stellt einen wichtigen Bestandteil des Qualitätsmanagement-Systems dar, das die permanente Vervollkommnung der wirtschaftlichen Aktivität und somit die Erzielung eines kommerziellen Erfolgs durch die Firma ermöglicht. Daher ist das Effektivitätsmanagement-System in den Unternehmen, die im Bereich von Verkauf, Distribution und Logistik tätig sind und sich durch eine Kompliziertheit von Prozessen und eine große Anzahl von Gliedern in den Lieferketten charakterisieren, sehr wesentlich für die Erzielung des Erfolgs durch die Unternehmen.
Methoden: Im Rahmen der Forschungen wurden die Mittel und Methoden, die im Bereich des Logistik-Managements angewendet werden, analysiert. Gestützt auf diese Analyse wurden die Ergebnisse einer unter klein- und mittelgroßen Unternehmen ausgewählten, repräsentativen, in Ost-Europa lokalisierten Firma präsentiert. Anhand dieser im Bereich des Verkaufs und der Distribution tätigen Firma wurde eine Fallstudie realisiert, in deren Rahmen Gespräche mit den Geschäftsführern, Mitarbeitern und den für die Einführung von Qualitätsmanagement-Systemen im Unternehmen zuständigen Personen durchgeführt wurden.
Ergebnisse: Das Ziel der vorliegenden Arbeit war es, die Brauchbarkeit der für die Bewertung der Einführung des Qualitätsmanagement-Systems ausgewählten Kennziffern einzuschätzen. Das Forschungsvorhaben wurde in einem serbischen, im Bereich von Verkauf und Distribution aktiven Unternehmen durchgeführt. Einen besonderen Druck legte man auf das System der dabei angewendeten Kennziffern und den Vergleich des betreffenden Systems mit den in der Fachliteratur beschriebenen Systemen. Dabei stellte man einige Schwierigkeiten bei der Ermittlung von entsprechenden Daten für die Durchführung der Bemessung und der Benchmarking-Bewertung für den serbischen Markt fest. Im betreffenden Unternehmen wendete man unterschiedliche Messwerte an, die hauptsächlich auf die Bewertung der Verkaufsergebnisse und des Niveaus der Kunden-Zufriedenstellung zurückzuführen waren.
Fazit: Die Bedeutung der durchgeführten Forschungen beruht auf der Tatsache, dass die Einführung des Qualitätsmanagement-Systems auch die Notwendigkeit der Einführung des entsprechenden Effektivitätsmanagement-Systems offenlegte. Dies ist folglich verbunden mit der Notwendigkeit der Einführung eines Kennziffer-Systems, das zur Bewertung und zum Monitoring der Betätigung dieses Unternehmens dienen sollte. Die dank dieser Systeme durch das Unternehmen erzielten, besseren Resultate hatten auch eine bessere Akzeptanz für die Notwendigkeit der Einführung solcher Systeme seitens der Geschäftsführer zur Folge. Bei dieser Gelegenheit wurden auch zurückhaltende Stellungnahmen zur Durchführung von Effektivitätsberechnungen sowie zur Veröffentlichung solcher Daten für die Zwecke des Benchmarkings in den Ländern des postsozialistischen Ost-Europas festgestellt.

Codewörter: Qualitätsmanagement, Logistik, Management-System, Serbien.

Dr Aleksandar Jankulović, assistant professor
Belgrade Metropolitan University
Faculty of management
Tadeusa Koscuska 63
11000 Belgrade, Serbia
e-mail: aleksandar.jankulovic@metropolitan.ac.rs

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MODELLING OF THE OPERATION OF THE MULTI-STOREY AUTOMATED GARAGE WITH A BIG CAPACITY

Czesław Pypno, Grzegorz Sierpiński

Silesian University of Technology, Katowice, Poland

ABSTRACT. Background: The paper presents the issues of parking in the cities. The idea of multi-storey, overground garage with the capacity of 400 cars per hour has been proposed in the paper. The main focus is on analyzing loading and unloading as well as trans-shipment of the cars on the storeys of the garage.
Methods: The queuing theory has been used in the modelling process of the vehicles operation. The theory may enable to draw up general methods which let us indicate basic factors describing the process of the operation and the evaluation of the quality of work of the queuing theory system.
Aims: The subject of the paper is to check the influence of stochastic effects on the effectiveness of the parking operation in multi-storey garage.
Conclusions: The garage could be a solution to parking problems in the city centres, in the vicinity of factories, office buildings, academic centres and the like. Furthermore the research method may support and speed up a decisional process while choosing the optimal structure, organization and first of all the construction of the parking.

Key words: overground automated garage, queuing theory, modelling of transportation processes.

INTRODUCTION

The increasing need for supplying the necessary amount of parking spaces for motorized vehicles is the reason for the development of different parking structures. Analyzing the situation [Michalak 2006] we can say that parking structures enable the growth and disperse of the urban building development. The need to provide a sufficient number of stopping and parking places in the immediate vicinity of newly-erected buildings, offices, bureaux, shopping centres, large, industrial plants, academic centres, stadiums and airports, results from regulations and is one of the elements of city spatial development politics. It is important to have knowledge about real needs of travelling persons. It will help to construct better transportation system because if a constructed system of sustainable urban transportation is adapted to the transportation-related needs of the inhabitants, then the system will be truly implementable and effective operationally [Sierpiński 2011, 2012, Sierpiński, Celiński 2012]. The choice of the most favourable solution in order to meet the parking space needs, depends on numerous factors, of which particularly important, in the urban conditions because of high costs of land, is the absorption of land area to create one stopping space. The right decision about the car park and garage issue is of a vital importance for the proper functioning of the city or otherwise the wrong decision may become an obstacle in its development. [Biedrońska et al. 2010, Michalak 2006]. The subject of the study report is the multi-storey, aboveground, automated garage built on the base of the rectangle and of the huge capacity

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of 400 cars an hour, both ways [Pypno 2008]. In currently, rarely built aboveground, fully automated garages, mechanical parking systems enable, depending on the storey, parking and retrieving of the car within 40-120 seconds, which means 90-30 cars an hour. Presumably the average is 60 cars an hour. This cycle starts the moment the driver drives his/her car onto the pallet and gets out of it and the system takes the car into the lift, the lift transports it to a given storey, there the car is moved to a proper box and the lift returns to the ground floor for the next car (Fig. 1). However, automated FATA Skyparks parking system has an efficiency of only 24 cars per hour with the capacity of 3000 cars! (Fig. 1b). In the description of the American patent referring to this issue, you can find remarks about problems connected with cars` slow storage and retrieval in automated garages. The being designed garage is not likely to have these inconveniences, and thanks to the advanced mechanical-automatic system, it will be able to store coming cars straightaway.

At present, in European countries, especially in Germany, they created the database with current filling of city garages. The driver who wants to park his/her car, equipped with the onboard computer with the suitable navigation software is directed to the nearest garage with available, vacant places [Bogenstattet 2006].

Source: www.wired.com/science/discoveries/news/2007/12/dayintech_1205#; www.fataic.com/gallerymain.php 14.11.2008

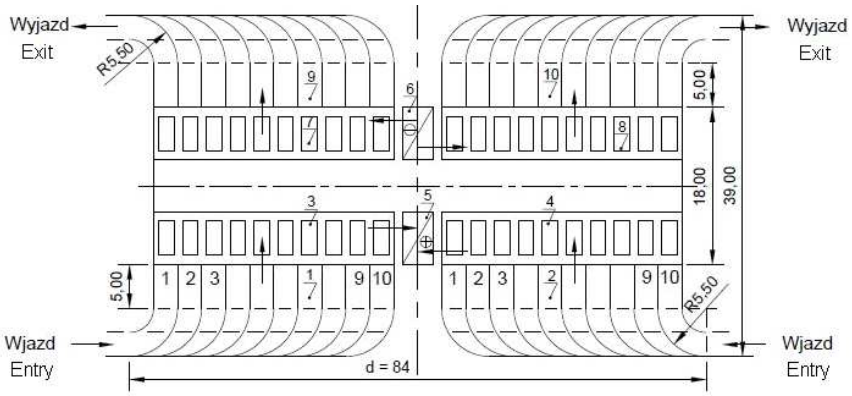
Fig. 1. The automated multi-storey garage - a) circle view ,b) rectangular view
Rys. 1. Garaż zautomatyzowany wielokondygnacyjny; a) na rzucie koła, b) na rzucie prostokąta

THE IDEA OF THE AUTOMATED GARAGE WITH THE CAPACITY OF 400 CARS PER HOUR

It is assumed that the garage built on the rectangle projection will have 17 storeys with 60 cars on each storey what gives a total capacity of 1020 cars (Fig. 3). The area demand for the being designed garage considering the access and exit roads. Designing this area a convenient access to the garage was assumed and right before the entering the garage cars stop at road lights (red/ green) placed in front of the building. The surface occupied by the garage equals 39m x 84m = 3276m^2.

An urban parking with the capacity of 1016 cars occupies the area of 21 375m^2 (Fig. 2).

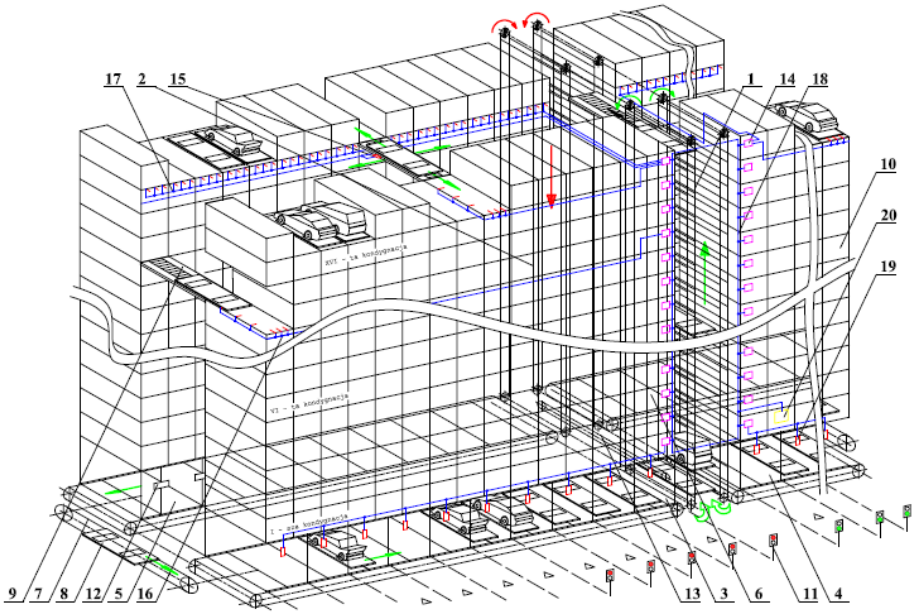
In the mechanical section on the ground floor there are, among other things, pallet conveyors for taking and returning vehicles. First, from the loading zone, vehicles are transported on pallets, onto particular storeys by the first electrical lift. On the level of every storey, vehicles are transferred from the lift by storey platforms to the parking spaces in boxes. Vehicles are transported downstairs to their owners by the other electrical lift (Fig. 3).



Source: own research

Fig. 2. Total demand for the area of the garage: 1,2 - the entrance zone, 3,4 - cars on take-in conveyors, 5 - electrical lift for transport of cars upwards, 6 - electrical lift for transport of cars downwards, 7,8 - cars on give-out conveyors, 9,10 - the exit zone.

Rys. 2. Całkowite zapotrzebowanie na powierzchnię dla prezentowanego garażu: 1, 2 - strefa oczekiwania na wjazd, 3, 4 - samochody na przenośnikach odbierających, 5 - dźwig elektryczny transportujący samochody do góry, 6 - dźwig elektryczny transportujący samochody w dół, 7, 8 - samochody na przenośnikach wydających, 9, 10 - strefa wyjazdu dla samochodów z garażu.



Source: own research

Fig. 3. The diagram of automated garage; 1- chain hoisting lift, 2- chain lowering lift, 3 - taking conveyor left, 4 - taking conveyor right, 5 - returning conveyor left, 6 - returning conveyor right, 7 - reserving conveyor, 8 - pallet, 9 - storey platform, 10 - boxes, 11 - lights red/green, 12 - electronic display, 13 - emergency conveyor, 14 - local S1 drive controlling half of the storey, 15 - controlling of the storey platform, 16 - positioning system with a vehicle in the box, 17- local network of ultrasound/magnetic sensors positioning storey platforms, 18 - annular network of the exchange of data between drivers S1, 19 - network of the system controlling the process of taking and returning vehicles, 20 - central controlling system S2.

Rys. 3. Schemat zautomatyzowanego garażu; 1- dźwig łańcuchowy podnoszący, 2- dźwig łańcuchowy opuszczający, 3- przenośnik przyjmujący lewy, 4- przenośnik przyjmujący prawy, 5- przenośnik wydający lewy, 6- przenośnik wydający prawy, 7- przenośnik odwodowy, 8- paleta, 9- platforma kondygnacyjna, 10- boksy składowania, 11- światła czerwone/ /zielone, 12- wyświetlacz elektroniczny, 13- przenośnik awaryjny, 14- lokalny sterownik S1 sterujący połową piętra, 15- sterowanie platformy kondygnacyjnej, 16- system pozycjonujący paletę z pojazdem w boksie, 17- lokalna sieć czujników ultradźwiękowych/ magnetycznych pozycjonujących platformy kondygnacyjne, 18- pierścieniowa sieć wymiany danych pomiędzy sterownikami S1, 19- siec systemu sterującego przyjmowanie i wydawanie pojazdów, 20- centralny system sterujący S2.

Taking vehicles from the owners of the cars to the garage

We assume that in the first stage of the analysed case there are no vehicles in the garage. On the ground floor there are 2 x 10 vehicle taking conveyor, left (3) and right (4), entrances, where drivers leave their cars. Maximum and safe, drive in and admission time of 10 vehicles onto receiving conveyors, e. g left one, takes 90 seconds. After that time, during the subsequent 90 seconds the lift (1) carries vehicles upstairs, where on storeys, they are successively transported on platforms (9) to the boxes. At the same time, during the same 90 seconds of the garage work, next 10 vehicles go onto the right (4) receiving conveyor, then they are transported upstairs by the same lift during the subsequent 90 seconds and at the same time, 10 further vehicles will get onto the conveyor (3) and will be transported by the lift upstairs within the time of subsequent 90 seconds of the garage work etc.

It can be seen here that on "zero level" in the take-in zone the work of the conveyors (3,4) is alternating, only the lift works continuously.

Trans-shipment from the lift and storing cars on the storeys of the garage

The lift hoisting the cars upwards works for three seconds and moves by the distance of one storey h = 2.032m, then it stops for three seconds. During this time a harpoon pulls out the car onto the platform and the platform transports the car into the empty box. Cars can be pulled out onto the platform simultaneously on many storeys of the garage.

Returning vehicles to their owners

Car owners come to the garage passageway and declare to retrieve their cars using e.g. magnetic cards or introducing their car registration number onto the proper panel.

The steering system works in this way that first a storey platform comes to a proper box, next the car is pulled by the harpoon from the box onto the platform and now the platform transports the car to the lift and the car is placed onto the lift. All transport and trans-shipment actions into the boxes on the storey take place independently of the work of the lift. The cars places on the lift are transported downwards in the cycle as previously namely the lift moves down for three seconds and then it stops for six seconds. This time is necessary for moving subsequent cars from platforms onto the lift. On the " zero level" during the lift stop cars are unloaded from its shaft onto the returning conveyor (5) or (6).

There are 10 entrances for each returning conveyor in the passageway. Over each entrance you can see lighting notice boards showing the registration numbers of retrieved cars.

Simultaneous taking and returning of the cars

Theoretically, the actions described here can take place at the same time, and in this way working, computer-operated garage is able to take and return 400 vehicles, nonetheless, it is hardly possible to occur.

MODELLING THE PROCESSES OF ENTERING AND EXITING SERVICE IN A GARAGE

Basic assumptions

The proposed model is supposed to describe the process of entering and exiting service in an automatic multilevel garage. The basic assumptions of the model are as follows:

1. A garage treated as a complex system of mass service (a queuing system).
2. Particular queue systems of a complex system of mass service is the process of entering and leaving the vehicle at rest and the process of moving the vehicle from the "box", placing the vehicle in a lift and exiting. These processes are considered separately.
   In defining the queuing system three ideas should be characterized: the stream of

applications, the way of servicing and the number of servicing channels. Another two assumptions stem from this:

3. The exponential shifted schedule of intervals between the applications was adopted.
4. Times of service have got a free shifted schedule.
5. In the proposed garage there is one basic channel of service, a lift with elements which assist the vertical and horizontal translocations.

The description of the process of entering and exiting using the queuing theory

Time intervals between the notifications of other vehicles are fate variables. Assuming the full fate of the occurrence - Poisson's schedule is restricted due to necessity of having a minimum space between the vehicles - vehicles have a finite length. Assuming the above, the exponential shifted schedule of intervals between the notified vehicles was used and it is often used in reflecting the models of vehicle traffic (as e.g. in [Krystek 1980, Tracz 1990, Kuwahara et al. 2002]):

$$F(t_{ij}) = 1 - e^{-\frac{(t_{ij} - t_{\min})}{(\bar{t} - t_{\min})}} \qquad (1)$$

where:
t_{ij} - time interval between given vehicles *i j* (when j = i +1 is the interval between another vehicles) [s]
t_{min}- the minimum time interval between the vehicles in one lane [s]
t - average time interval between the vehicles [s]

The minimal interval makes a constant shift of the exponential schedule. So the given time interval is the sum of the fate variable t_{los} and the minimal interval t_{min} (fig. 4):

$$t_{ij} = t_{los} + t_{\min} \qquad (2)$$

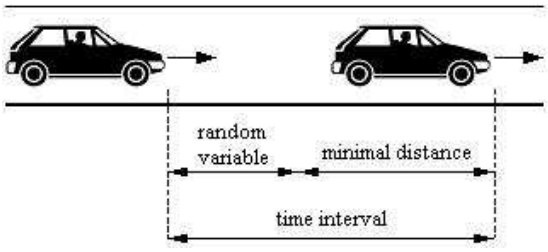


Fig. 4. Time interval between appearances of vehicles
Rys. 4. Odstęp czasowy między kolejnymi zgłoszeniami pojazdów

Because the concept assumed vehicles standing on independent positions waiting for entering, the possibility to change the position from the moment of appearance of the vehicle was omitted.

A traditional queuing model described in the Kendall's classification by symbols M/G/1 is characterized by Poisson's process of appearances (3), exponential intervals between the appearances (4) and one service channel; times of service have got a free schedule.

$$p_n(t) = \frac{(\lambda t)^n}{n!} e^{-\lambda t}, \quad n = 0,1,2,\ldots; \qquad (3)$$

$$f(t) = \lambda e^{-\lambda t}, \quad t \geq 0; \qquad (4)$$

Service time schedule is described by two quantities:

– the expected value (average) - m

$$m = E(X) = \sum x_i \cdot P(x_i); \qquad (5)$$

where:
x_i - observed values of the occurrence
$P_{(x\ i)}$ - probability of a given value of the occurrence

– variance □□²

$$\sigma^2 = V(X) = E(X^2) - (E(X))^2 = \sum x_i^2 \cdot P(x_i) - m^2 \qquad (6)$$

M/G/1 does not belong to Markow's systems what makes the analysis more

difficult. Not Markow's processes are usually studied with the approximation through the Markow's model. In this case the method of Markow's build in chains was used (among others in [Kleinrock 1975, Rajski and Tyszer 1986, Adan and Resing 2001]). In order to achieve this, the system was to be observed in chosen discreet moments - at times when other vehicles finish servicing (and are moved to the place of "rest"). If one assumes that is the number of vehicles in the system in the moment of finishing servicing by vehicle "k" and X k is the number of vehicles which came in the time of servicing the vehicle "k" two things can be seen (7):

- in the moment of finishing the service of the vehicle k-1 there was no queue (no waiting vehicles) $L_{k-1} = 0$,
- in the moment of finishing the service of the previous vehicle k-1 there was a queue $L_{k-1} > 0$.

$$L_k = \begin{cases} X_k & ;\ L_{k-1} = 0 \\ L_{k-1} + X_k - 1 & ;\ L_{k-1} > 0 \end{cases} \qquad (7)$$

Defining additional random variable $U(L_{k-1})$, which takes 0 when $L_{k-1} = 0$, and in the case when U = 1 was replaced by the formula (7):

$$L_k = L_{k-1} - U(L_{k-1}) + X_k \qquad (8)$$

In this way a built in Maslow's chain was created. Next making a series of changes a Pollaczek-Khintchina's formula is obtained [Kleinrock 1975]:

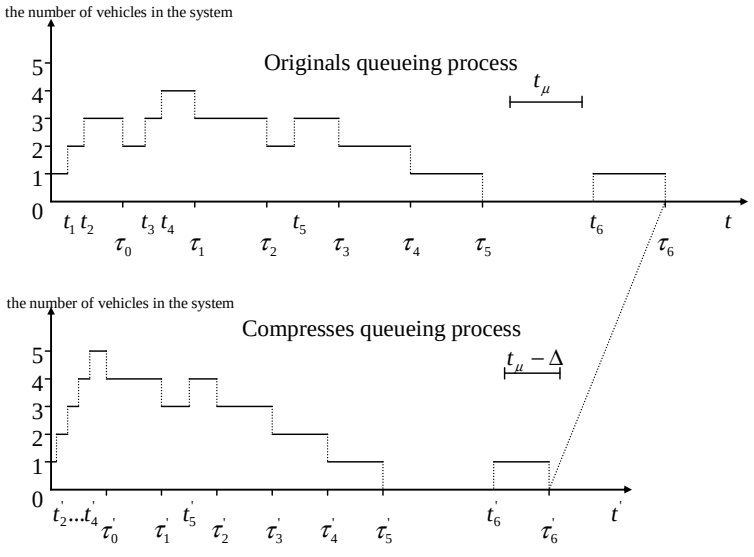
$$\bar{L} = \rho + \frac{\lambda^2 \cdot \sigma_\mu^2 + \rho^2}{2 \cdot (1 - \rho)} \qquad (9)$$

However, one should remember about the necessity of taking into account a finite length of a vehicle which means shifts in the intervals between the appearances and the times of service. Joining processes of Woch's queues were used for that matter and adopted to the model $M_{+\Delta}/G_{+\Delta}/1$.

If $\frac{1}{\mu}$ is the average operation time. And Δ is the minimal time distance between the vehicles. Then $\frac{1}{\mu'}$ will be the equivalent of the average factor after the separation of the constant part in the form of Δ, namely:

$$\frac{1}{\mu'} = \frac{1}{\mu} - \Delta \qquad (10)$$

Figure 5 presents the graphic interpretation of the joining process.



Source: Woch 1998

Fig. 5. Exemplary accomplishment of original and joining processes
Rys. 5. Przykładowe realizacje procesów oryginalnego i zlepionego

The average interval between the appearance of vehicles in the system, that is the inverse of intensiveness of appearances λ may be the sum of a random and constant element (the minimal time interval):

$$\frac{1}{\lambda} = \frac{1}{\lambda'} + \Delta \tag{11}$$

which can be shown differently:

$$\lambda' = \frac{\lambda}{1 - \lambda \cdot \Delta} \tag{12}$$

If the system is stable (the only one to be considered), according to the queuing theory intensiveness of appearance must be less frequent than the operation performance.

$$\rho' = \frac{\lambda'}{\mu'} < 1 \tag{13}$$

and the following relation occurs:

$$0 < \Delta < \frac{1}{\mu} < \frac{1}{\lambda} \tag{14}$$

From the above-mentioned formulae we can get the dependence ρ' presented in the following quantities:

$$\rho' = \frac{\lambda \cdot \left(\frac{1}{\mu} - \Delta\right)}{1 - \lambda \cdot \Delta} < 1 \tag{15}$$

Having applied appropriate transformations we can obtain a formula for the average queuing time for the queuing system M/G/1:

$$\overline{W_q}' = \frac{\lambda'^2 \cdot \sigma_\mu^2 + \left(\frac{\lambda'}{\mu'}\right)^2}{2 \cdot \lambda' \cdot \left(1 - \lambda' \cdot \overline{t_\mu}'\right)} = \frac{\lambda' \cdot \left(\sigma_\mu^2 + (\mu')^{-2}\right)}{2 \cdot \left(1 - \lambda' \cdot \overline{t_\mu}'\right)} \tag{16}$$

Whereas the appropriate formula for the original system $M_{+\Delta}/G_{+\Delta}/1$ is:

$$\overline{W_q} = \frac{\lambda \cdot \sigma_\mu^2 + \lambda \cdot \left(\frac{1}{\mu} - \Delta\right)^2}{2 \cdot (1 - \rho)} \cdot (1 - \mu \cdot \Delta) \tag{17}$$

In the above-mentioned formula factor $(1 - \mu \cdot \Delta)$ has been added in comparison with the previous formulae. This factor shows the value of operation time variability, $\mu \cdot \Delta$ namely, it is a quotient of the constant time operation to the expected value of time operation while elevator moving ($\Delta / \overline{t_\mu}$).

Another explanation is the fact that in the described process another vehicle does not have to wait till the previous one has been serviced. For a single vehicle the minimal time after which its driving in begins equals $\frac{1}{\mu} - \Delta$. Generally this value is multiplied by the intensiveness of operation μ, which equals $(1 - \mu \cdot \Delta)$. This assumption is applied for reallocated layout of probability [99].

With the following formula (17) and formulae:

$$\overline{L} = \lambda \cdot \overline{W};$$

$$\overline{L} = \overline{L_q} + \frac{\lambda}{\mu};$$

$$\overline{L_q} = \lambda \cdot \overline{W_q};$$

$$\overline{W} = \overline{W_q} + \frac{1}{\mu} \tag{18}$$

one can achieve four main basic dimensions of productivity and efficiency for a chosen queuing model :
L - an average number of clients in a system,
L_q - an average number of clients in a queue,
W - an average time of waiting in the system and
W_q - an average time of waiting in a queue.

The process of exiting the automatic multilevel garage can be described using

similar model conditions. The service runs in the same way, but in the opposite direction. Notifications show schedule of applications of people coming to collect a vehicle. Naturally depending on the character of a garage and its purpose the full chance of notifications can change. It can happen in the case of a garage ,servicing vehicles of a given company, with regular times of work. The process of notifications of both vehicles as well as people coming to collect a vehicle may in certain times have a similar form to a deterministic arrangement. In other instances the use of model $G+_{\Delta}/G+_{\Delta}/1$ can be considered. However, it goes beyond the topic of this article.

DISCUSSION AND CONCLUSIONS

Present transport systems focus on problems with being overcrowded. It is especially visible in the centres of towns. At the same time attention should be paid to the fact that transport absorbs space. Parking in street lanes takes additional space, which can be used in a different way, more friendly to the inhabitants. The proposed construction makes it possible to limit the space taken by cars in a town (at the moment of parking).

The automatic garage, described in the article, can be one of the solutions to the problem with fast parking in the centres of towns, next to factories, large buildings, universities etc. It is worth noticing that a garage of this type can be part of a transfer junction of the type Park and Ride and in this way help the activities of sustainable transport development [White Papers, Bruntland Report]. The research method showed in the article through the description of the process using the queuing theory can on one hand help in defining the efficiency of that solution and on the other assist the decision about the choice of the structure and organization of the service, but most of all about the choice of the parking construction.

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MODELOWANIE OBSŁUGI ZAUTOMATYZOWANEGO GARAŻU WIELOKONDYGNACYJNEGO O DUŻEJ PRZEPUSTOWOŚCI

STRESZCZENIE. **Wstęp:** Artykuł dotyczy problematyki parkowania w miastach. Zaproponowano koncepcję projektu wielokondygnacyjnego nadziemnego garażu o przepustowości 400 samochodów na godzinę. Skupiono się na analizie systemu załadunku, rozładunku oraz na analizie systemów przeładunku samochodów na kondygnacjach garażu.
Metody: Do modelowania procesów obsługi pojazdów zaproponowano użycie teorii kolejek, która może pozwolić na opracowanie ogólnych metod umożliwiających wyznaczenie podstawowych wskaźników charakteryzujących proces obsługi i ocenę jakości pracy systemu kolejkowego.
Cele: Celem artykułu było zbadanie zjawisk stochastycznych na efektywność obsługi garażu wielokondycyjnego.
Wnioski: Opisany garaż byłby rozwiązaniem problemów z szybkim parkowaniem samochodów w centrach miast, obok fabryk, dużych biurowców, uczelni itp. W dalszej pracy wskazana metoda badawcza może wspomagać proces decyzyjny dotyczący wyboru optymalnej struktury i organizacji obsługi, a przede wszystkim wybór konstrukcji parkingu.

Słowa kluczowe: zautomatyzowany garaż wielokondygnacyjny, teoria kolejek, modelowanie procesów transportowych.

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URL: http://www.logforum.net/vol9/issue3/no8

STEUERUNGSMODELLIERUNG DER AUTOMATISIERTEN MEHR-GESCHOSSIGEN GARAGE VON HOHER UMSCHLAGSKAPAZITÄT

ZUSAMMENFASSUNG. Einleitung: Der Artikel betrifft die Parkplatzproblematik in den Städten. Es wurde ein Entwurfskonzept einer mehrgeschossigen oberirdischen Garage vom Umschlagsgrad von 400 Autos/Stunde vorgeschlagen. Man hat sich auf eine Analyse sowohl des Verladungs- und Ausladungssystems als auch der Umladungssysteme von Autos in den Garagengeschossen konzentriert.
Methoden: Zur Modellierung der Prozesse der Fahrzeugsteuerung wurde die Theorie der Warteschlangen vorgeschlagen, die erlauben kann, allgemeine Methoden auszuarbeiten. Sie ermöglichen folglich, die den Bedienungsprozess charakterisierenden Grundrichtwerte zu bestimmen und die Qualität der Arbeit des Warteschlangensystems zu beurteilen.
Ziele: Das Ziel der Arbeit war es, den Einfluss der stochastischen Erscheinungen auf die Effektivität der Bedienung eines mehrgeschossigen Garage zu erforschen.
Ergebnisse und Fazit: Die beschriebene Garage wäre eine Lösung der Probleme mit schnellem Parken in Stadtzentren, in der Nähe von Fabriken, von gro?en Bürohäusern, von Universitäten usw. Die in anderen Arbeiten gezeigten Untersuchungsmethoden können den Entscheidungsprozess, der die Auswahl der optimalen Struktur und Organisation der Steuerung und vor allem die Auswahl einer geeigneten Garagenkonstruktion anbetrifft, weitgehend unterstützen.

Codewörter: Automatisierte oberirdische Garage, Theorie der Warteschlangen, Modellierung von Verkehrsprozessen.

Czesław Pypno
Grzegorz Sierpiński
Silesian University of Technology
Faculty of Transport
Krasiński 8 , 40-019 Katowice,
POLAND,
e-mail: czeslaw.pypno@polsl.pl, grzegorz.sierpinski@polsl.pl

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REALTIME OBSERVATION, IDENTIFICATION AND TRACKING FROM DANGEROUS PERSONS IN AIRPORTS - A LOGISTICS SYSTEM ROIT

Bernd Hentschel, Zbyszko Pawlak, Karol Górski

Poznań School of Logistics, Poznań, Poland

ABSTRACT. Background: The aim of this paper is to present and analyze a new method of the logistics disaster management and concentrates particularly on terrorist attacks of CBRN type (C - chemical attack/weapon, B - biological attack/weapon, R - radiological attack/weapon, N - nuclear attack/weapon) at the airports. Each of the aforementioned is an issue of great importance and high priority for the airport communication.
Methods: The research of a ROIT project (Realtime Observation, Identification and Tracking from dangerous people in airports) has been conducted in a way that enables the application of the three-step computer system. The program has been configured to identify, observe and protect from undesired actions of people suspected of involvement in CBRN.
Results: The main results of applying the device in different scenarios are: enabling reliable automatic identification and classification of potentially hazardous materials and substances, association of the materials with their owners or distributors.
Conclusion: Simultaneous passing information to the airport security guards, police and expert team guarantees that further purposes involve the independent opportunity to observe in real time the CBRN suspects as well as to eliminate them secretly and quickly from the rest of airport passengers after thorough and credible identification.

Key words: disaster management, logistics of security solutions, protection of critical infrastructure, passenger.

INTRODUCTION

Research and practical applications of systems of logistic management of terrorist threats constitute an underexplored field, and largely limited to the issues of direct identification of radioactive substances. Thus authors suggest a novel method of identification with the aim of providing a comprehensive solution encompassing various types of possible terrorist attacks, such as chemical, biological, radiological, and nuclear. The realisation of the assumed research objectives involved conducting analysis based on a three-stage computer system configured for the purpose of a reliable and automatic real-time identification of substances and people suspected of creating terrorist threats.

Nowadays the issue of safety faces challenges concerning efficient cooperation between all the public institutions, local authorities and administration offices. Additionally, their actions need to be supported by modern and integrated methods of management in case of crisis, which involves inter alia the exploitation of technical equipment and information system enabling monitoring and identification. Others include prevention of crisis occurrence and fast and effective rescue action. Realization of the aforementioned points is dependent on

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ongoing improvement of technology, forecasting events that may happen in the future, computer data processing and elimination of risk results. These technologies are strictly connected with research problem concerning safety engineering consisting of civil safety and technological safety. There is currently much research done in order to invent and implement new strategies of passengers' protection. Modern techniques increasing the level of safety involve:

- antiterrorism protection (including so-called bio-terrorism and application of hazardous biological, chemical, radioactive, nuclear, high-energetic materials etc.),
- processes of management in case of crisis, safety and protection of network systems,
- integration of information system and connectivity,
- education; increasing the awareness of the danger.

In these areas the technologies assumed to be of the greatest importance for security are the following: sensor technology, observation, detection and spying technology, information, modeling and simulation systems. The aforementioned can be found in priorities of 6th and 7th CapTechprogramme as well as in technological priorities of European Defence Agency. It indicates the similarity between Polish priorities in terms of safety and the ones stated by European Union. Thus, it creates the opportunity to extend and continue the research using European fund and cooperating with foreign research centers in order to invent create innovative mutual projections [EDA Annual_Report 2011]. The topic scrutinized in the following article concerns the Disaster Management and concentrates particularly on terrorist attacks of CBRN type (C - chemical attack/weapon, B - biological attack/weapon, R - radiological attack/weapon, N - nuclear attack/weapon) at the airports. Moreover, it touches the topic mainly from the logistical point of view. It emphasizes the importance of application of various systems in order to increase the safety in the international airport transport and communication.

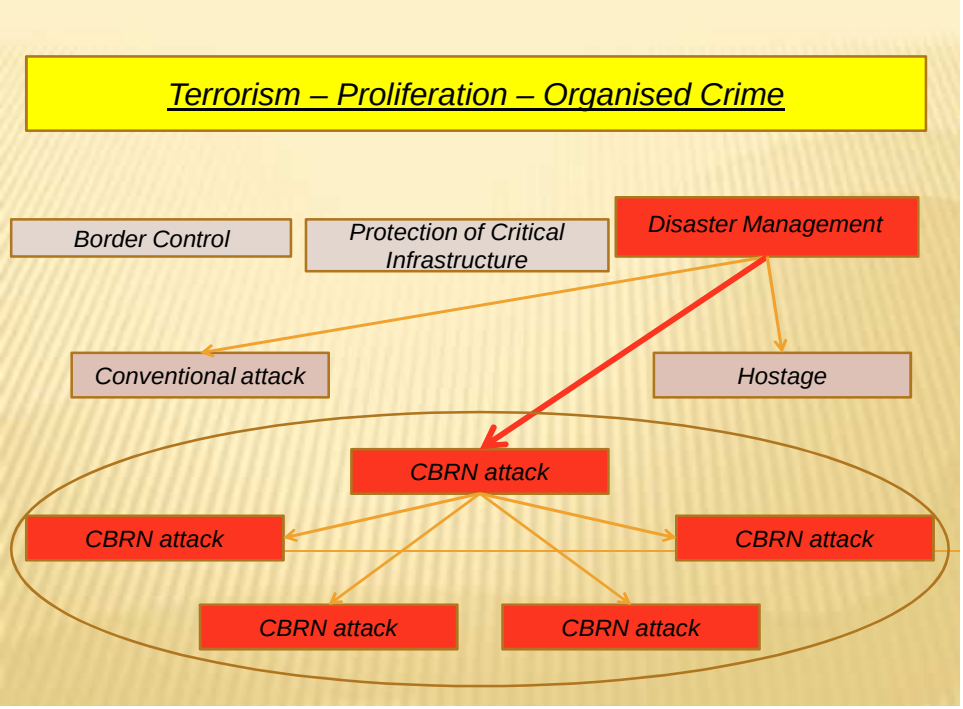
SOURCES OF THREATS IN AIRPORTS

Issues of guarding against terrorism and of early detection of threats from dangerous people at border checks in airports constitute the main focal points for which a variety of solutions are being proposed today. They are characterized by different cycles of processes and logistical operations. The supply chains constitute the "backbone" of modern economy. These cover manufacturers, logistics hubs, operators, platforms and control points. Protection of these elements requires an integrated approach to monitoring and assessment of risk, tracking of goods, to safe exchange of goods between countries and operators, and to fast and efficient control of goods and platforms. On the whole, it could be said that projects aimed at improving passenger safety target these three areas. The first include border control, then come protection of critical infrastructure, while the third covers disaster management - in case of identified dangers. Graphical presentation of all three components with the extraordinary complexity of the relationships emerging from presented correlation is illustrated in Figure 1.

According to what goes on within the international space of management of airports, taking into account all systems Interoperability, the authors of the article have outlined adopted solutions for the protection against class CBRN hazardous substances, their detection, decontamination and the logistics systems operating in this area. In this context, trends in the development of improved security at airports and implementation of specific solutions in Germany constitute an interesting aspect. Valuable resolution, assigned to individual sectors with regard to potential threats in 2015 appears to be of great significance (Figure 2). It could, therefore, be assumed that software programs for IT solutions in security, equipment and facilities connected with this software programs, as well as identification systems are strongly strengthening their position in the market, and in some cases, it would come to a concentration or drastic shifts in emphases. Modern airports are equipped with a range of alarm systems and technical systems that secure the safety and reliability of their

operations. Building Management Systems - BMS incorporate:

a) safety systems (fire alarm, burglar alarms, access control and CCTV systems),
b) information technology security (security system for computer resources, data transfer security system, systems for physical protection of telecommunication equipment),
c) building automation and control systems (air conditioning, elevator operations, lighting, supply of utilities - water, gas, electricity).



Source: own elaboration

Fig. 1. Exemplary relations between threats, capabilities and technologies
Rys. 1. Przykłady relacji pomiędzy zagrożeniami, możliwościami i technologiami

Source: www.sicherheit.berlin-brandenburg.de (18.12.2012)

Fig. 2. The market for security solutions in Germany in 2015 (in millions of Euro)
Rys. 2. Rynek systemów bezpieczeństwa w Niemczech w 2015 (w mln Euro)

BMS provides technical tools for management of security and comfort at work inside buildings under everyday conditions and during emergency situations. However, BMS cannot guarantee the safety of the airport under crisis situation, since damage to infrastructure and technical equipment result in breakdown of the system. Under such circumstances, outside help in form of crisis management is needed, which is a set of previously developed procedures, data recorded on an ongoing basis, based on information from the search and rescue services, and procedures designed to minimize the effects of terrorism (chemical, biological, radiological, etc.). This requires management and coordination of work from many areas, the study of operation systems as well as selection and testing of suitable sensor base [Valera and Velastin 2005].

ROIT SYSTEM'S LOGISTICS SOLUTIONS IN REAL-TIME TRACKING, IDENTIFICATION AND OBSERVATION OF DANGEROUS PERSONS IN AIRPORTS

Comprehensive equipping of emergency response services with all kinds of devices, and creation, on their basis, of systems of detection and notification constitute an initial and necessary condition of actions to ensure protection against effects of threats [Jane 2001]. Monitoring of security risks can logistically be conducted in a constant measurement network or in mobile measurement points.

Methods used in CBRN monitoring risks, in terms of method of drawing of samples for analysis, may be divided into two groups: sampling at the site of danger, remote detection and identification and measurement of concentration of dangerous substance. Accuracy and clarity of the measurements might not be very precise for first group of methods due to separation in space and time of the places of drawing samples and their analysis. Remote methods are free of these shortcomings and, depending on the measurement technique used, they allow for monitoring of the environment even at very long distances. In the remote detection, methods and optoelectronic technologies that, being very precise tool at detecting and determining the concentrations of gaseous air pollution, are increasingly displacing traditionally used methods (e.g., wet chemistry methods, chromatography) in monitoring the environment, play a special role. The major advantages of optoelectronic methods include the possibility of full automation of the measurement, the uniqueness of the results, possibility of taking measurements without drawing samples, as well as integration of different electro-optical systems in the acquisition, processing and transmission of data.

There are two types of remote monitoring systems: a "stand-off" and a "remote"[Harig and Matz 2001]. The "stand-off" systems, for example optical sensors, can detect threats from a significant distance without coming in contact with the observed area. These are, for example, active laser systems - Difference Absorption Lidar DIAL or passive thermal imaging systems [Kovalev and Eichinger 2004]. A single "stand-off" station can cover a wide area, whose size depends on the coverage, field of view and scanning speed. "Remote" systems use various types of minute spot "in situ" sensors, where the data from these sensors are transmitted to the emergency centers via wire or wireless links. These centers analyze the data coming from the sensors' network and then determine the level of threat.

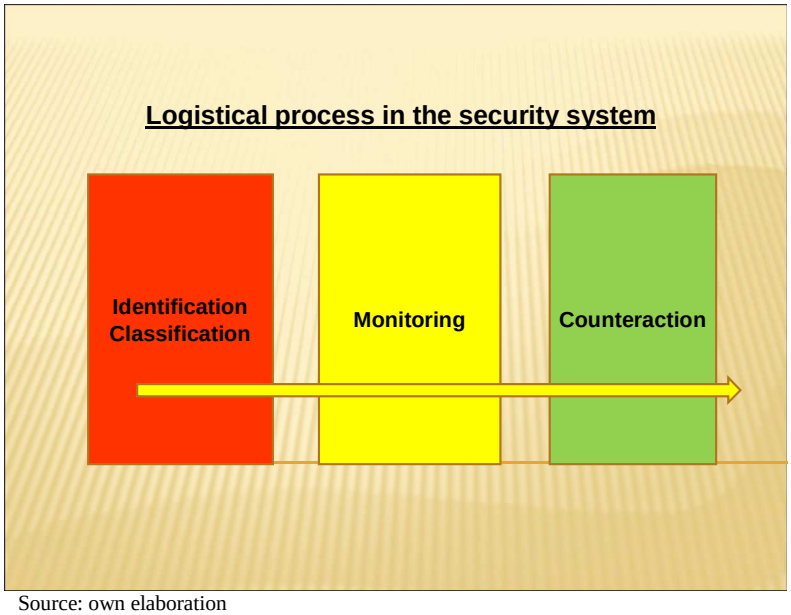
The proposed, in the research tests conducted by the authors, project of logistics solution of ROIT (Real-time observation, identification and tracking of dangerous persons in airports) system, has been designed in such a way that application of three-tier IT system, configured for identifying, tracking and protection against threats from people suspected of generating CBRN threats, is possible.

Practical application of the system is:

1. enabling of reliable, automatic identification and classification of potential hazardous materials and substances by

linking them to their owners or administrators,
2. creating the possibility of parallel transfer of relevant information to relevant airport services, expert teams, as well as to security officials and the police,
3. providing of possibility of real-time independent observation of persons suspected of generating CBRN threats, after picking relevant information from jointly acting services and partners,
4. enabling discreet and efficient removal of this type of persons from the general flow of passengers in the airport, after their effective and reliable identification.

Sequence of logistic processes under the proposed system is shown in Figure 3.



Source: own elaboration

Fig. 3. Logistic process under the proposed security system
Rys. 3. Proces logistyczny w ramach proponowanego systemu bezpieczeństwa

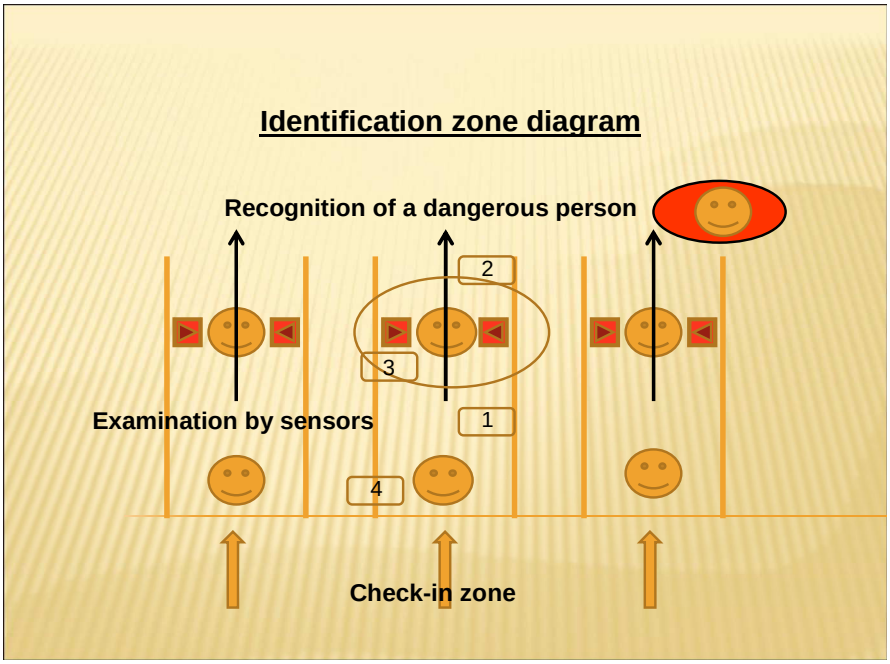
The different sequences of the process will be discussed separately, to illustrate the scope and content of the product constituting the objective of a solution within the above project.

Identification / Classification

Automatic detection and the classification of persons suspected of generating CBRN threats should be implemented based on an intelligent detection system. To this end, each passenger must be subjected to a separate control for eventual possession of dangerous materials, without the need to generate excessive costs and burdens for the other passengers and the staff. This action should not affect on-going, efficient handling of passengers, and should not create congestion or other complications. Therefore, the process of identification and classification of passengers, in terms of prevention of dangers, is carried out with use of innovative detection system in correlation with appropriate logistics system, independently and unnoticed by the object of such examination, or by the observed individual. The operation of the system may be described as follows: identification sensors continually "keep watch" over a specific area where controlled persons enter. This takes place within a single throughput neck within the check-in area and other similar places, they constitute narrowing bottle-necks designed for carrying out these activities. In the case of activation of sensors by one or more hazardous materials, the system classifies them according to the alarming level of activity and, after this classification set in motion appropriate intervention measures.

The pattern of Action of the system (Figure 4) explains the principle of

identification, during which time a person (4) is forced to pass through a specially shaped narrowing in the shape of a bottle neck (1). At the moment of crossing the narrowing, identification takes place in the active zone (2) as a result of activation of device (3). If identification tests come with positive result (if a person is in possession of Class CBRN dangerous goods), relevant classification will takes place and situation is assigned to appropriate alert level.



Source: own elaboration

Fig. 4. Diagram of the traveler identification system in the check-in zone
Rys. 4. Schemat działania systemu identyfikacji podróżnych w obrębie punktów odpraw

Table 1. Possible alert levels
Tabela 1. Możliwe poziomy alarmowania

Alert level	Hazardous material
0	No detected of hazardous material
1	Poisonous and intoxicating material
2	Chemical/explosive material
3	Radioactive material
4	Radioactive and explosive material

Source: own elaboration

Based on five levels of alerts (Table 1), it is possible to generate different described actions aimed at protecting against potential threats, in addition to stopping and removing suspicious persons and hazardous materials from the airports (in the framework of multi-level management of emergency situations). Based on this management system, all security link stakeholders (police, federal police, customs and private security providers) can adequately respond to the threat and plan joint action preventive measures appropriate to the situation (as part of the operational management of emergency situations).

Monitoring

After identification and classification, the next step is discreet observation of a person or object (through a coordinated monitoring combined with visualization as an image on a monitor). To do this, sensor-based IT system, which, depending on the level of alert assigned after screening, will be able to identify and observe these people or objects, should be designed. Screen monitoring is used for visual identification of persons and objects by the controlling staff with the help of the color classification corresponding to each level of alert.

Table 2. Possible alert levels
Tabela 2. Możliwe poziomy alarmowania

Alert level	Color classification
0	Green
1	Yellow
2	Orange
3	Red
4	Violet

Source: own elaboration

Every object bearing signs of the potential threat is monitored as an image. Every image is accompanied by additional information corresponding to assigned level of alert. This visual aid is necessary equipment for the monitoring staff, which, based on an image from the camera can send a more detailed description to the concerned air traffic security services. Therefore, a detailed characteristic of the person is based on the image from the control camera and provides information to facilitate accurate identification of a person perceived as potentially dangerous. The computer software and equipment should be able to limit tracking and observation functions to one particular room. The purpose of this restriction is to be able to configure, between operations, the linkage of used sensor systems and software, for "detection", to eliminate losses in information. In addition, an extremely important thing is to ensure the continuity of the information chain to consistently protect against any potential threats.

Source: own materials of Karp GmbH / Technische Hochschule Wildau / Projektlogistik GmbH

Fig. 5. Marking of an observed person experiment
Rys. 5. "Oznaczenia osoby" w ramach doświadczenia laboratoryjnego

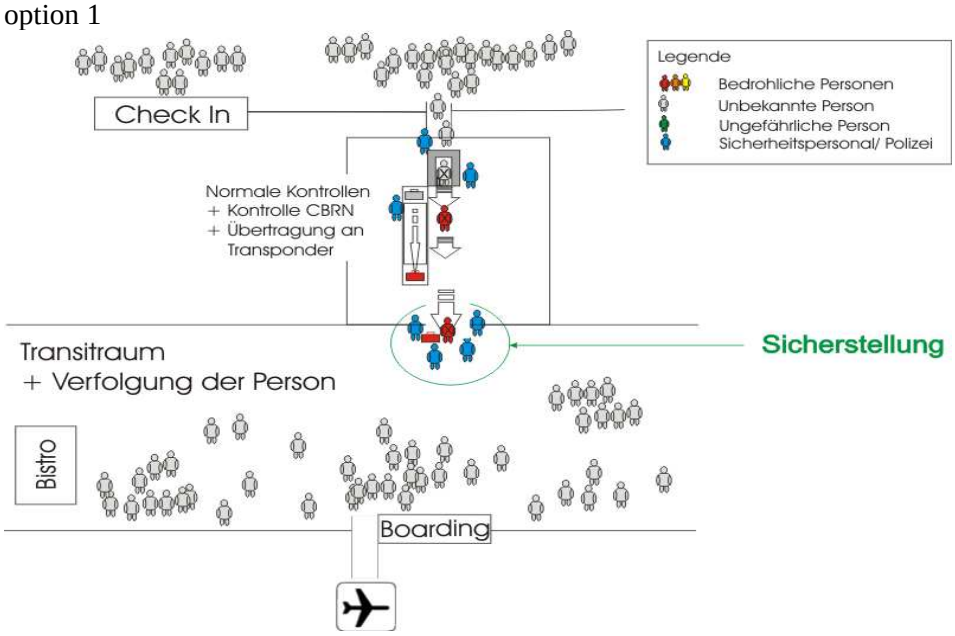
Such a solution should therefore be configured in the form of information chain, connecting series of rooms and should enough the latest innovations in the field of detection and monitoring of risks. In summary, two partial aspects, namely: "determination of the control object" and "constant control of facilities that are crucial for the safety of air traffic by several watch zones", it can be said that they constitute the focus of the system of detecting and monitoring of potential threats. In this respect, a detection system has already been developed under the name "CASTAF" (Computer Aided Screening, Tracking and Fixing) [ZLUR-Projekte 2012]. The following figure shows the action of marking of an

observed person and the result of such marking within conducted laboratory experiment, containing the overall picture of the path of movement within the airport area of the monitored person.

Isolating of the person constituting a threat and securing of dangerous materials

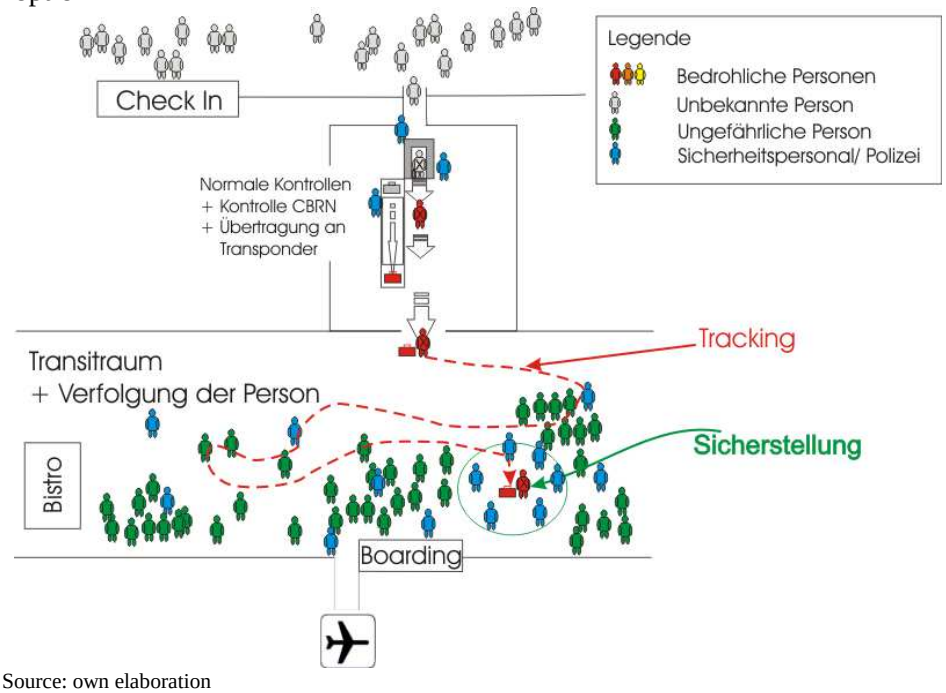
The final segment of the product is the ability to carefully isolate the person identified as constituting potential threat and to secure dangerous materials, and thus effectively prevent danger. Alone the operations of securing (intercepting) hazardous materials and substances are individually correlated with a given level of alert, as well as with the spatial conditions of the room. Below different scenarios of detection operations and operations of securing dangerous materials in the following options (1-4) are presented:

– option 1



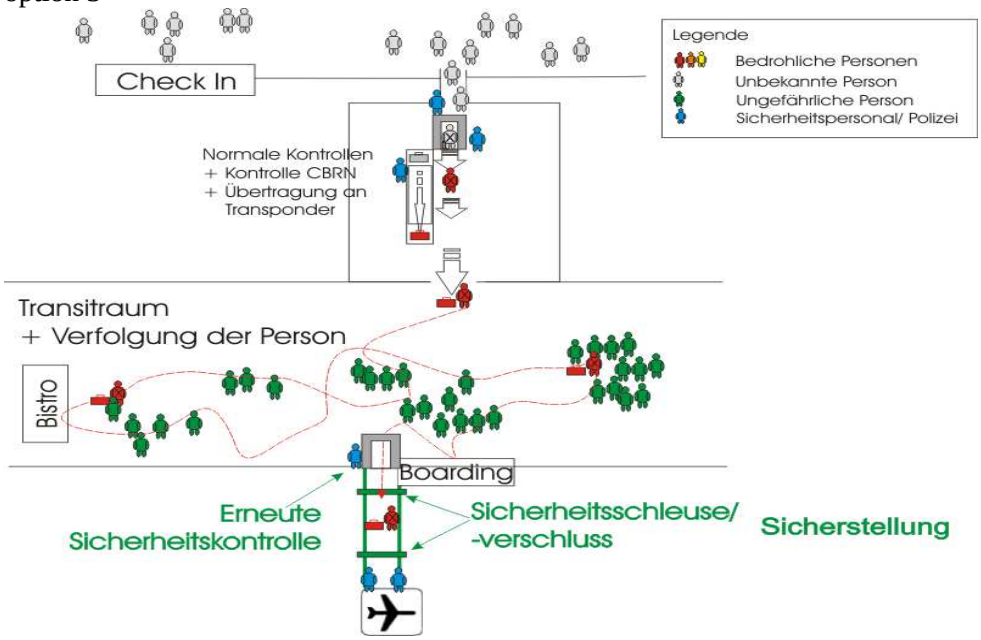
Source: own elaboration

– option 2



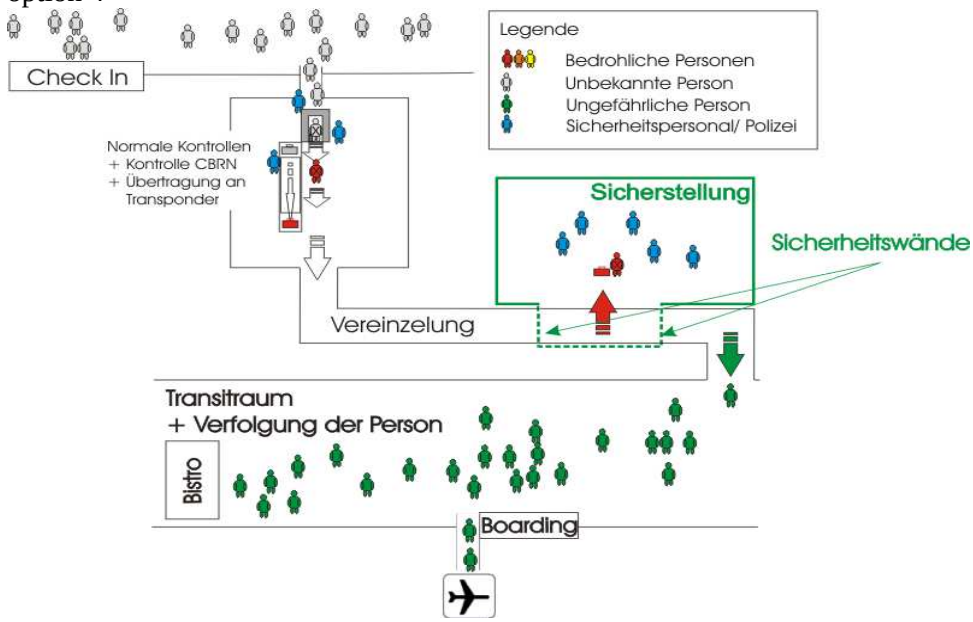
Source: own elaboration

– option 3



Source: own elaboration

– option 4



Source: own elaboration

All of these options are basically achievable, however, they have their advantages as well as disadvantages. In conjunction with the emerging detection system and computer-aided, through appropriate software program, system of controlling the activities of monitoring of persons suspected of possessing dangerous materials and substances, a broad field of research and development has been outlined. In this regard, partial scenarios are already in operation and they will be outlined below.

Alert Level1: Toxic substances and intoxicants (narcotics)

The potential threat posed by the person carrying such substances is assessed as low, as usually the objective is to prevent further transfer. As seen from many years of

observation of drug couriers, they do not carry weapons due to the small amount of substances being smuggled. For this reason, securing (intercepting) may take place anywhere.

Possible scenario securing (intercepting)

Alert Level 1: Detailed features of the person, their actual position and direction of movement are transferred to preventive services on site. A relevant preventive unit would, in a discreet manner, approach the indicated person and request the control staff for confirmation whether the intercepted individual is the one indicated. Intervention takes place smoothly and quietly as is only possible. Interrogation and securing narcotics or other substances take place in nearest office of preventive services.

Alert Level 2: Explosive / chemical / biological materials

This level is a potentially high risk for all those present at the scene (airport security services, passengers and the person creating the danger), due to existence of many hidden aspects of illegal transportation or of accomplishment of specific criminal intent:
Are explosive / chemical / biological materials only transported?
Does explosive material already constitute an element of a bomb?
In case of detection of a bomb, how is the bomb detonated?

In view of the above airport aspects, the prevention services must always start from the worst-case scenario and to subject all actions this scenario. The basic element of these activities is the creation of a narrowing, in form of artificial bottle neck, which should allow for isolation of the object of potential risks from freely accessible airport space, thereby extracting the source of danger from the surrounding.

Possible scenario of securing (intercepting)

The idea and objective of installing a bottle neck channel is to separate the source of the threat and the object bearing potential threats from the surrounding. To effectively accomplish this isolation, the person/object must be separated from the larger group of passengers. Intervention team of the airport security authority receives information on the level of alert, detailed features of the person as well as the location of potentially dangerous object. Due to the fact that bottle-neck channels constitute a fundamental part of the concept of security protection in airports, an isolated and monitored object must pass through such channel. In the meantime, SWAT team members take positions in a predetermined safety channel and its adjacent isolation space. Both the safety channel as well as the isolation space must be able, in case of an explosion, to absorb the pressures and forces arising explosion, in order, to suppress the effects of detonation to the greatest extent possible. Intervention, as far as possible, should not interfere with the normal passenger traffic.

Alert level 3: Radioactive materials

In fact, the procedure of conduct in this case is based on principles similar to alert level 1. Due to the fact that presence of radioactive material has been detected, it is assumed that it is case of pure smuggling. Therefore, the risk is focused only on the radioactive radiation. In addition to adhering to the rules of conduct of level 1 alert, the intervening officers must be equipped with protective gear, with this that their contact with radioactive material should be kept at minimum needed to carry out this function. The type of action to be taken while securing and intercepting radioactive materials, shall always depend on the management actions at the scene.

Alert level 4: Explosives with radioactive materials

The combination of explosives with radioactive material (dirty bomb), as well as combination with biological materials constitute the highest level of terrorist threat, due to the fact that an eventual explosion would cause a wide dispersal of radioactive /biological material, and thus resulting in high contamination of the environment - this produces significant damage accompanying the explosion. For the need of protect against such type of threat, course of action similar to alarm level 2 should be adopted, and complemented by additional protective measures for the

airport security personnel and the passengers themselves. To minimize the risk, efforts should be made to bring to partial stoppage or relatively slowing down of incoming stream of other passengers - but for the success of operations, the person being monitored should not sense that they and their intentions have been detected.

SUMMARY

The assumed research objectives have been fulfilled from research as well as practical perspectives. The proposed method guarantees the feasibility of comprehensive real-time observation of people of whom there exists a suspicion of creating threats of a CBRN nature.

Additionally, the system enables a discreet and efficient elimination of this type of people from the passenger streams (e.g. in an airport area), after their successful and reliable identification. The development of modern technology assisting government agencies in accomplishing strategic tasks of protection against terrorist threats, is interdisciplinary and involves many sectors of the economy and state agencies. In terms of logistics, use of IT and decision processes in crisis management, selected technologies the development of which research effort should be concentrated (as strategic and could be a future Polish specialty), should be supported by long-term programs funded by the state and the industrial sector. Based on experience from international attempts made in the past by persons transporting dangerous goods and materials by air, different scenarios of identifying, monitoring and stopping such people have been presented in this paper. The system of prevention currently being developed in a comprehensive way, and logistics system supporting it are at present the main focus of research efforts undertaken in this direction in the European countries. Hence a good opportunity has presented itself so as to include research institutions and institutions of higher learning in international innovation and research works. One of the possibilities of running this type of projects appears in actions partially funded through one of the European framework programs, and this undoubtedly will facilitate development of a wide range of appropriate solutions in the above specified area.

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ROIT - LOGISTYCZNY SYSTEM NAMIERZANIA, IDENTYFIKACJI I MONITORINGU W CZASIE RZECZYWISTYM OSÓB NIEBEZPIECZNYCH W PORTACH LOTNICZYCH

STRESZCZENIE. **Wstęp:** Celem artykułu jest przedstawienie i poddanie analizie nowej metody zarządzania logistycznego zagrożeniami (Disaster-Management), w zakresie ataków terrorystycznych typu CBRN (C - atak chemiczny, B - atak biologiczny, dla R - atak radiologiczny i dla N - atak nuklearny) w portach lotniczych. Każda z tych form działalności terrorystycznej stanowi na całym świecie problem o najwyższym, priorytetowym znaczeniu w komunikacji lotniczej.

Metody: Proponowany w przeprowadzonych przez autorów badaniach projekt logistycznego rozwiązania systemu ROIT (Realtime Observation, Identification and Tracking from dangerous persons in airports), został opracowany w ten sposób, że możliwa jest aplikacja trójstopniowego systemu informatycznego, skonfigurowanego na potrzeby identyfikacji, obserwacji i zabezpieczenia przed niepożądanym działaniem ze strony osób, co do których istnieje podejrzenie o generowanie zagrożeń typu CBRN.
Wyniki: Praktyczna aplikacja systemu w różnych scenariuszach, co umożliwia niezawodną i automatyczną identyfikację oraz klasyfikację potencjalnych materiałów i substancji niebezpiecznych przy powiązaniu ich z właścicielami lub dysponentami.
Wnioski: Stworzenie możliwości równoległego przekazywania stosownych informacji do odpowiednich służb portu lotniczego oraz zespołów eksperckich i służb bezpieczeństwa, gwarantuje możliwości samodzielnej obserwacji w czasie rzeczywistym osób, co do których istnieje podejrzenie o generowanie zagrożeń typu CBRN, oraz umożliwia dyskretną i sprawną eliminację tego typu osób ze strumienia przepływu pasażerów w przestrzeni portu lotniczego po ich skutecznej i wiarygodnej identyfikacji.

Słowa kluczowe: zarządzanie zagrożeniami, logistyka systemów bezpieczeństwa, ochrona infrastruktury krytycznej, monitoring ruchu pasażerskiego, systemy zarządzania lotniskowego.

LOGISTIKSYSTEM ROIT ZUR ECHTZEIT-ERFASSUNG, IDENTIFIZIERUNG UND VERFOLGUNG GEFÄHRLICHER PERSONEN IN FLUGHÄFEN

ZUSAMMENFASSUNG. Einleitung: Im vorliegenden Artikel wurde eine neue Methode des logistischen Gefahrenmanagements (Disaster-Management) im Bereich terroristischer CBRN-Angriffe (C - chemischer Angriff, B - biologischer Angriff, R - radiologischer Angriff, N - nuklearer Angriff) in Flughäfen analysiert und erörtert. Jede von den genannten Formen der terroristischen Aktivität stellt auf der ganzen Welt ein Problem von höchster, prioritätsmäßigen Bedeutung im Flugverkehr dar.
Methoden: Ausgearbeitetes Projekt des logistischen Gefahrenmanagements ROIT (Realtime Observation, Identification and Tracking from dangerous persons in airports) wurde durch von den Autoren durchgeführten Forschungen so konzipiert, dass die Anwendung eines Dreistufen-Informatiksystems zustande kommt, das zwecks der Echtzeit-Erfassung, Identifizierung und Verfolgung der gefährlichen, der CBRN-Gefährdungen verdächtigten Personen in Flughäfen systematisch konfiguriert wurde.
Ergebnisse: Praktische Anwendung des Systems innerhalb von unterschiedlichen Szenarien ist es, eine einwandfreie automatische Identifikation sowie eine Klassifikation potenzieller Gefahrmaterialien und -stoffe in Verbindung mit deren Inhabern oder Disponenten.
Fazit: Möglichkeit einer parallelen Weiterleitung der betreffenden Informationen an die zuständigen Flughafen-Sicherheitsdienste, Experten-Teams und staatlichen Sicherheitsdienste garantiert die Möglichkeit einer selbstständigen Echtzeit-Verfolgung der Personen, die der Herbeiführung von CBRN-Gefährdungen verdächtig sind, zu gewährleisten sowie eine diskrete und reibungslose Aussonderung solcher Personen und Objekte aus dem Material- und Passageierfluss im Flughafenraum nach deren effektiver und glaubwürdiger Identifikation zu ermöglichen.

Codewörter: Gefahrenmanagement, Logistik von Sicherheitssystemen, Absicherung von kritischer Infrastruktur, Verfolgung des Passagierverkehrs, Managementsysteme in Flughäfen

Bernd Hentschel, Zbyszko Pawlak, Karol Górski
Wyższa Szkoła Logistyki
ul. Estkowskiego 6
61-755 Poznań
e-mail: bernd.hentschel@wsl.com.pl
zbyszko.pawlak@wsl.com.pl
karol.gorski@wsl.com.pl

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MODELLING OF CONTACT PROBLEMS INVOLVED IN ENSURING THE SAFETY OF RAIL TRANSPORT

Edward Rydygier [1], Zygmunt Strzyżakowski[2]

[1)] Kazimierz Pulaski University of Technology and Humanities in Radom, Radom, [2)] Municipal Office of Capital City of Warsaw, Poland

ABSTRACT. Background: Mathematical modelling aids diagnostics the track and rolling stock, as it often for technical reasons it is not possible to obtain a complete set of measurement data required to diagnose the rail and wheel deformation caused by the impact of a rail vehicle on the track. The important issue in a railway diagnostics is to study the effects of contact wheel and rail. Diagnostics investigations of track and rolling stock have a fundamental role in ensuring the safety of transport of passengers and goods.
The aim of the study presented in the paper was to develop simulation methods of mathematical modelling of the wheel-rail system useful in the diagnostics of the track and a railway vehicle.
Methods: In the paper two ways of modelling were presented and discussed. One of these ways is the method which consists in reducing the contact issue to field issue and solving the identification of the field source in 2-D system. Also presented a different method designed on the basis of the methods using one period energy concept. This method is adapted for modelling the dynamics of the contact wheel-rail for the normal force. It has been shown that the developed modelling methods to effectively support the study on the effects of mechanical and thermal of contact wheel-rail and contribute to the safety of operations.
Results and conclusions: In the case of field sources identifications two specific issues were examined: the issue of rail torsion and the identification of heat sources in the rail due to exposure the rolling contact wheel-rail. In the case of the method using one period energy concept it was demonstrated the usefulness of this method to the study of energy processes in the contact wheel-rail under the normal periodic force. The future direction of research is to establish cooperation with research teams entrusted with the diagnostic measurements of track and rolling stock.

Key words: contact wheel-rail, diagnostics of tract and rolling stock, numerical methods, one period energy.

INTRODUCTION

Diagnostics investigations of track and rolling stock have a fundamental role in ensuring the safety of transport of passengers and goods. The important issue in a railway diagnostics is to study the effects of contact wheel and rail [Strzyżakowski 2007]. Because often due to technical reasons it is not possible to obtain a complete set of measurement data required to diagnose the rail and wheel deformation caused by the impact of a rail vehicle on the track, the mathematical modelling is needed to support experimental research. [Rydygier and Strzyżakowski 2009b]. One of the methods of mathematical modelling of the wheel-rail is the Simulation Method of identification which consists in reducing the contact issue to field issue and solving the identification of the field source in 2-*D* system. Another way of modelling the contact wheel-rail is the method based on the methods used in the study of electrical circuits using one period energy concept. This method was adapted for modelling the dynamics of the contact wheel-rail on the assumption that in the vertical plane of the rail the normal force has

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a character of periodic signal. The aim of the study described in the paper was to develop simulation methods of mathematical modelling of the wheel-rail system useful in the diagnostics of the track and a railway vehicle.

THE SIMULATION METHOD

Simulation Method of identifying the sources of the field is a numerical method that uses computational tools taken from the combinatorial analysis [Rydygier and Strzyżakowski 2009a]. In the design of algorithms used computational tools in the form of monic power polynomials $T_n(q)$ and $P_n(q)$ and in software procedures used modified numerical triangles generating power polynomials. The investigated system was described by Poisson equation with known boundary conditions $u|_\Gamma$ at the edge of the area Γ in the form [Potter 1980]

$$\frac{\partial^2 u(x,y)}{\partial x^2} + \frac{\partial^2 u(x,y)}{\partial y^2} = f(x,y) \ , \qquad (1)$$

where $x \in (0, l_x)$, $y \in (0, l_y)$, $u = u(x, y) \in R^2$ is a field function, and $f = f(x, y) \in R^2$ is a function of field sources distribution (a sources' function).

The task of identifying the sources of the field in the system (1) consists in determining the sources' function $f(x, y)$. In order to solve this task in a numerical way a continuous description of the system was approximated by discrete model. After replacing continuous variables x and y to discrete variables using the formula $x = ih$, $i = 0, 1, 2, \ldots, M$, $y = jh$, $j = 0, 1, 2, \ldots, N$, $M = l_x/h$, $N = l_y/h$, h is a length of a step of discretization for a rectangular grid on the area of dimensions l_x x l_y and next approximating the differential equation (1) using a finite difference scheme, the algebraic equations system was obtained which maintains values of the field function u with values of the source function f in nodes of a rectangular grid as follows [Potter 1980]

$$u_{i+1,j} - 2u_{i,j} + u_{i-1,j} + u_{i,j+1} - 2u_{i,j} + u_{i,j-1} = h^2 f(i,j) = q_{i,j}$$

$i = 1, 2, \ldots, M$, $j=1, \ldots, N$, (2)

where $u_{i,j} = u(i, j)$, $q_{i,j} = q(i, j)$.

Border conditions for equation (2) have the form

$$u(0, j) = U_0(j), \quad u(M, j) = U_M(j), \quad j = 0, 1, \ldots, N,$$

$$u(i, 0) = U_0(i), \quad u(i, N) = U_N(i), \quad i = 0, 1, \ldots, M.$$

For a discrete model (2) the solution of the identification problem based on the evaluation which involves the values of source function $q(i, j)$ in the nodes of the grid. Field function as well as the sources' function were approximated by a discrete Fourier series [Potter 1980]

$$f_{m,n} = \sqrt{2}\sum_{k=1}^{N-1} F_m(k) \sin\frac{k\pi n}{N} \ ,$$
$$f_{m,0} = f_{m,N} = 0 \ , \qquad m = 0, 1, 2, \ldots, M \ ,$$

$$u_{m,n} = \sqrt{2}\sum_{k=1}^{N-1} U_m(k) \sin\frac{k\pi n}{N} \ ,$$
$$u_{0,n} = u_{M,n} = 0 \ , \quad n = 0, 1, \ldots, N, \qquad (3)$$

where $F(k)$ and $U(k)$ means coefficients for $k = 1, 2, \ldots N$-1.

Equation (2) can be transformed to the form

$$\frac{1}{h^2}\left[(U_{m+1}(k) - 2U_m(k) + U_{m-1}(k)) - (4\sin^2\frac{k\pi}{2N})U_m(k)\right] =$$

$$= F_m(k), \ m = 1, 2, \ldots, M, \qquad (4)$$

with boundary conditions defined by $U_0(k) = 0$ and values $U_M(k)$ from a equation $u_{M,n} = 0$, $n = 1, \ldots, N$.

After substituting the monic power polynomial $P(q_k)$ for $q_k = 4\cdot\sin^2\frac{k\pi}{2N}$ to the equation (4), a solution of direct problem takes the form

$$U_m(k) = P_m(q_k)U_1(k) + \sum_{l=1}^{m-1} P_{m-l}(q_k)h^2 F_l(k) \ , \ m = 2, 3, \ldots, M\text{-}1. \qquad (5)$$

The values $U_1(k)$ in the equations (4) can be determined from the boundary conditions. For

$N = M$ from system of M-1 equations the set of coefficients $U_M(k)$, k = 1, 2, ... , M-1 can be determined. Next substituting these coefficients to the equation (4) for $m = M$, the set of coefficients $U_1(k)$ for k = 1, 2, ... , M-1 can be determined. The field function u can be obtained from formula (3). Solving the inverse problem the source function is obtained in the following form

$$F_l(k) = \frac{U_{l+1}(k) - P_{l+1}(q_k)U_1(k) - \sum_{i=1}^{l-1} P_{l+1-i}(q_k)h^2 F_i(k)}{P_l(q_k)h^2} \quad (6)$$

The sources function f can be obtained by formula (3). The issue of identification the sources of the field is the inverse problem and therefore its solution requires the use of stabilization procedures [Tikhonov et al. 1995]. Therefore Simulation Method has been extended by a specific numerical approximation procedure developed on the bases of a inverse distance method for smoothing data in the 2-*D* systems. This method of stabilization is a kind of self regularization procedure [Rydygier and Strzyżakowski 2012a]. It should be noted that computer simulations had an important contribution in testing the effectiveness, accuracy and stability of the Simulation Method as well as they were used to improve the processing of the measurement data and testing some regularization procedures and fixing various regularization coefficients.

RESULTS

With the help of the Simulation Method the problem of torsion of a rail can be solved. This problem is the contact issue because the wheel of railway vehicle causes a deformation of a rail [Rydygier and Strzyżakowski 2010]. Rail was described by the Timoshenko model. Results of calculations are shown in the Figure 2 whereas in the Figure 1 there are shown the input data which correspond to the auxiliary function ψ (x, y) associated with a twisting angle in a cross-sectional plane.

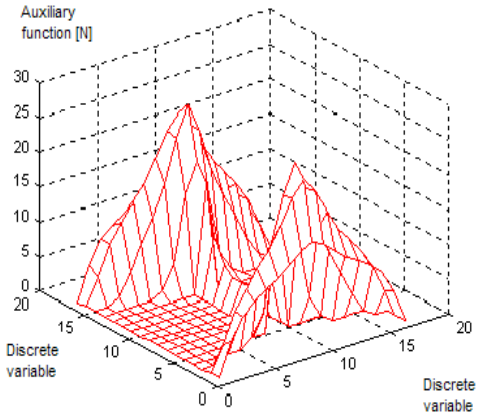

Fig. 1. Input data
Rys. 1. Dane wejściowe

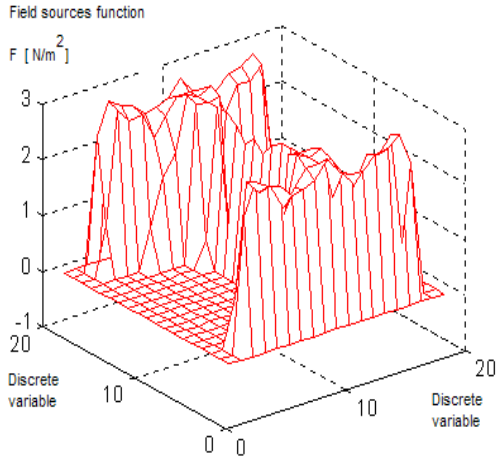

Fig. 2. The sources function for a torsion of rail
Rys. 2. Funkcja źródłowa dla skręcenia szyny

It is noticed that the form of computed source function corresponds with the analytical solution of a inverse problem described by the Poisson equation with constant source function.

The established Simulation Method was also used to identify heat sources caused by a rolling contact wheel-rail [Rydygier and Strzyżakowski 2010]. The temperature distribution in a heat trace of the rail as the input data is shown in the Figure 3. Results of calculations are illustrated in the Figure 4 in a form of heat density distribution.

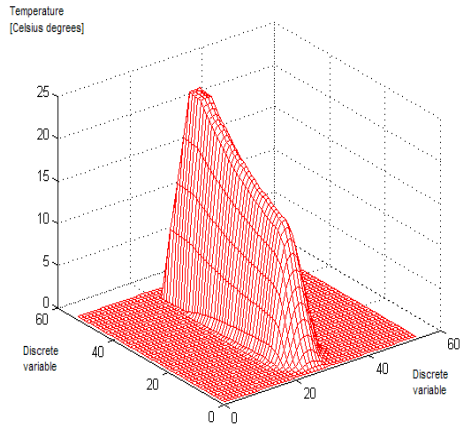

Fig. 3. Temperature distribution in a heat trace
Rys. 3. Rozkład temperatury w śladzie cieplnym

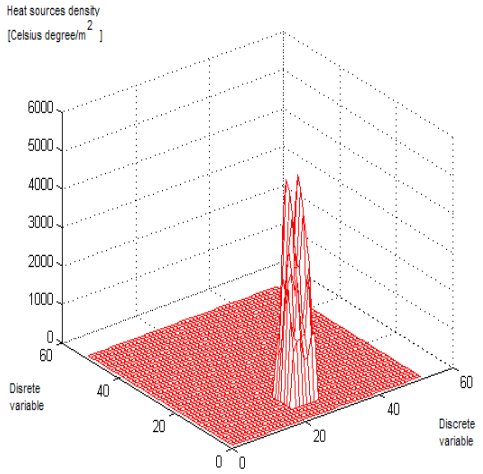

Fig. 4. The calculated sources function
Rys. 4. Wyznaczona funkcja źródłowa

It should be pointed that the identification of sources in the heat trace can be used to identify the dynamical parameters of the track-vehicle. These results allow the verification of the mechanical properties of the contact and next the appointment of local stress, slip, friction power density. Since the rolling contact wheel-rail produces thermal effects on the surface of the rail, so the mechanical quantities causing the temperature field can be determined [Szolc et al. 2002].

ONE PERIOD ENERGY METHOD

To modelling of a wheel-rail system is also used the method using the concept of one period energy [Rydygier and Strzyżakowski 2011]. The one period energy concept is used in the analysis of real-time energy processes in electric circuits in periodically non sinusoid states. Energy process can then be examined for the energy phase plane and evaluated by a change in the instantaneous voltage and current of the circuit in the one period T. Considering the dynamical circuit operating in a non sinusoidal state for the excitation signal as a voltage $v(t) = v(t + T)$ and the response as a current $i(t) = i(t + T)$, the energy transferred from the source $v(t)$ to the receiver in the time interval $\Delta t = nT$, $n \in N$, can be defined by the following term [Trzaska 2008]

$$W(\Delta t) = nW_T\,, \tag{7}$$

where W_T means the one period energy, i.e. the energy supplied to the receiver during one period of excitation and response.

For the examined circuit the one period energy W_T can be written as

$$W_T = \int_0^T v(t)i(t)dt = \int_0^T v(t)\frac{d}{dt}\left(\int i(\tau)d\tau\right)dt = \int_{q(0)}^{q(T)} v(t)dq(t) = \int_{\psi(0)}^{\psi(T)} i(t)d\psi(t)\,, \tag{8}$$

where $q(t) = \int i(t)dt$ means a load and $\psi(t) = \int v(t)dt$ means a magnetic flux.

The form of expression (8) shows that one period energy W_T collected by the receiver from the source defines a limited area in the phase loop in the phase plane of the coordinates ($v(t)$, $q(t)$) or equivalently ($\psi(t)$, $i(t)$). Considering the contact wheel-rail it is assumed that the studied system is in a steady state and that the vertical force which acts from a wheel on a rail has the nature of a periodic signal [Rydygier and Strzyżakowski 2012b]

$$F(t) = f(t + T), \tag{9}$$

where the period T corresponds to the arrival time for a wheel in the next carriage, $T = \Delta x/v$, v - velocity along the track.

In the vertical plane perpendicular to the railway track the rolling contact dynamical system can be described by the following set of equations

$$m\frac{d^2y_1}{dt^2}+b_2\frac{d(y_1-y_2)}{dt}+k_2(y_1-y_2)+b_1\frac{dy_1}{dt}+$$

$$+k_1y_1=0 \qquad (10)$$

$$M\frac{d^2y_2}{dt^2}+b_2\frac{d(y_2-y_1)}{dt}+k_2(y_2-y_1)=F(t),$$

where $y_1 = y_1(t)$ and $y_2 = y_2(t)$ mean displacements, m - the replacement mass of the track, b_1, k_1 - dynamic parameters of the track, while the mass M and the dynamic parameters b_2, k_2 correspond to the rail.

The one period energy in the case of the study effects of acting normal force on the rail can be presented on the basis of the equation (8) by the following formula

$$W_T=\int_0^T Fwdt=\int_{y(0)}^{y(T)}Fdy_2\ ,$$

$$w=\frac{dy_2}{dt}. \qquad (11)$$

The form of the expression (11) shows that the the energy W_T transferred in one period cab be defined by the area enclosed by a loop in power phase plane with coordinates ($y_2(t)$, $F(t)$). Basing on the electrical circuits analogy, the force $F(t)$ corresponds to source voltage $v(t)$, and the displacement $y(t)$ corresponds to an instantaneous load $q(t)$. After transforming the second order set of differential equations with two variables (10) to the first order set of differential equations with four variables with the use of following substitution

$$\frac{dy_1}{dt}=y_3(t),\quad \frac{dy_2}{dt}=y_4(t), \qquad (12)$$

and then using the *ode23* function from MATLAB library for numerical solution of ordinary differential equations, the displacement $y_2(t)$ was determined. The data for masses and dynamic parameters of damping and elasticity were taken from [Kisilowski et al. 1991]. Timing displacement $y_2(t)$ and the normal force $F(t)$ in one period are shown in the Figure 5 and the Figure 6. It is noted that the Figure 5 shows a solution for a zero value of the normal force, while the Figure 6 shows a solution for a fixed value of strength. For the period T = 1s it can be estimated the time of acting the normal force from the equation $\Delta x = v\Delta t$. Assuming the vehicle speed v = 80 km/h and estimating the length of contact for 10^{-2} m it was obtained the time of duration of signal as Δt = 5 ms.

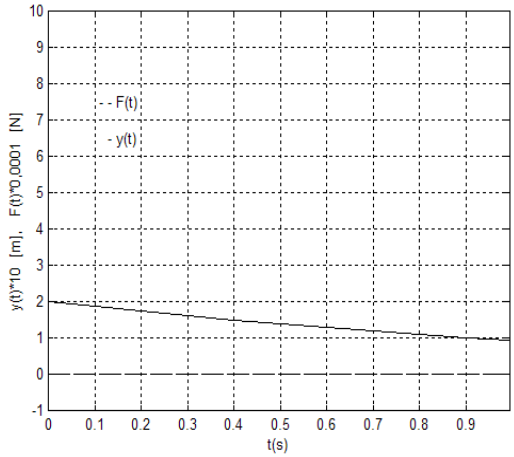

Fig. 5. Displacement and force for $F(t) = 0$
Rys. 5. Przemieszczenie i siła gdy $F(t) = 0$

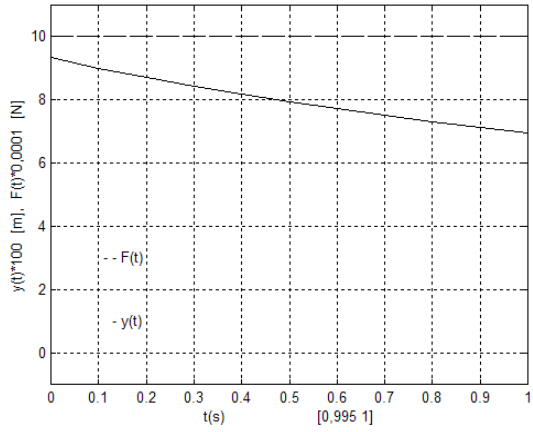

Fig. 6. Displacement and force for $F(t)$ = 100 kN
Rys. 6. Przemieszczenie i siła gdy $F(t)$ = 100 kN

In the system of coordinates ($y_2(t)$, $F(t)$) the one period energy loop takes the form shown in the Figure 7.

From a plot of the loop shown in the Figure 7, it can determine the value of one period energy as the area covered by this loop.

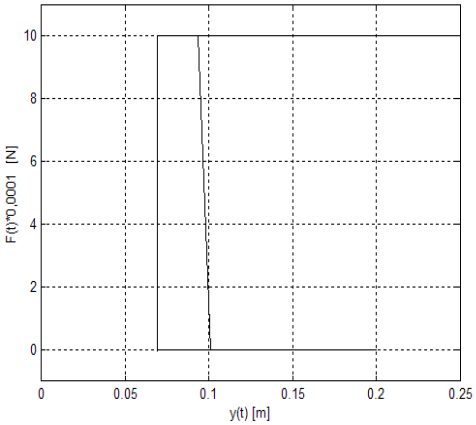

Fig. 7. One period energy loop
Rys. 7. Pętla energii jednookresowej

CONCLUSIONS

In the paper it was showed that two computer simulation methods, one using field sources identification and the second using one period energy concept, are useful in modelling the wheel-rail system and can support the diagnostics of a rail vehicle and the track. The future direction of research is to apply established methods by a cooperation with teams engaged the diagnostic measurements of track and rolling stock.

Modelling studies of track and rolling stock not only support the diagnostic measurements, but they serve to ensure the transport safety of passengers and goods. Without adequate research model may be appeared the case that the wheels of new trains in the old rails will be deformed, which not only causes discomfort of transport and will be a source of noise nuisance to the environment, but it can also be the cause of the train crash. This situation appeared at the beginning of this year in Poland according wagons manufactured by 'Pesa' company and purchased by the Warsaw Access Railway Company (WKD). As a result passengers must still ride the old, rickety warehouses trains that were produced in the 70's of last century. Board of the WKD does not preclude the charging of penalties for the manufacturer that purchased the trains are not suitable for use. Similar incident occurred 10 years ago when the Warsaw underground trains were renewing. Italian manufacturer, the 'Alstom' company, after some months of disputes finally agreed to replace the defective wheel sets.

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UDZIAŁ MODELOWANIA ZAGADNIEŃ KONTAKTOWYCH W ZAPEWNIENIU BEZPIECZEŃSTWA TRANSPORTU SZYNOWEGO

STRESZCZENIE. **Wstęp:** Modelowanie matematyczne wspomaga diagnostykę toru i taboru kolejowego, gdyż często z przyczyn technicznych nie jest możliwe uzyskanie pełnego zestawu danych pomiarowych wymaganych do zdiagnozowania deformacji szyny i koła powstałych w wyniku oddziaływania pojazdu szynowego na tor. W diagnostyce toru i taboru kolejowego ważnym zagadnieniem jest badanie skutków kontaktu koła pojazdu i szyny. Badania diagnostyczne toru i taboru kolejowego odgrywają istotną rolę w zapewnieniu bezpieczeństwa przewozów pasażerów i towarów.
Celem pracy było opracowanie symulacyjnych sposobów modelowania matematycznego układu koło - szyna kolejowa użytecznych w diagnostyce toru i pojazdu kolejowego.
Metody: Przedstawiono i przedyskutowano dwa sposoby modelowania układu koło - szyna kolejowa. Jednym z tych sposobów jest metoda polegająca na sprowadzeniu badanego zagadnienia kontaktowego do zagadnienia polowego i rozwiązaniu zadania identyfikacji źródeł pola w układzie 2-D. Drugim sposobem jest metoda wykorzystująca koncepcję energii jednookresowej. Ten sposób obliczeń został zaadaptowany do modelowania dynamiki kontaktu koło - szyna dla siły normalnej. Wykazano, że opracowane metody modelowania efektywnie wspomagają badania skutków mechanicznych i cieplnych kontaktu koło - szyna oraz przyczyniają się do zapewnienia bezpieczeństwa przewozów.
Wyniki i wnioski: W przypadku metody identyfikacji źródeł pola rozpatrzono dwa zagadnienia szczegółowe: zagadnienie skręcania szyny kolejowej oraz dokonano identyfikacji źródeł ciepła w szynie kolejowej spowodowanego kontaktem tocznym koło - szyna. Natomiast w przypadku metody wykorzystującej koncepcję energii jednookresowej wykazano przydatność tej metody do badania procesów energetycznych kontaktu koło - szyna kolejowa pod działaniem siły normalnej o charakterze periodycznym. Przyszłym kierunkiem badań jest praktyczne wykorzystanie opracowanych metod przez nawiązanie współpracy z zespołami badawczymi dokonującymi pomiarów diagnostycznych toru i taboru kolejowego.

Słowa kluczowe: kontakt koło - szyna kolejowa, diagnostyka toru i taboru kolejowego, metody numeryczne, energia jednookresowa

BEITRAG DER MODELLIERUNG VON KONTAKTPROBLEMEN RAD-SCHIENE ZUR GEWÄHRLEISTUNG DER SICHERHEIT IM SCHIENENVERKEHR

ZUSAMMENFASSUNG. Einleitung: Die mathematische Modellierung hilft, die Gleise und Schienenfahrzeuge zu diagnostizieren, zumal es aus technischen Gründen oft nicht möglich ist, einen vollständigen Satz von Messdaten, die für die Feststellung der wegen der Einwirkung des Schienenfahrzeuges auf die Gleise verursachten Verformung von Schiene und Rad erforderlich sind, zu gewinnen. Die Diagnostik von Gleis-und Rollmaterial ist ein wichtiges Thema, um die Auswirkungen des Kontakts zwischen den Rädern und Schienen zu studieren. Untersuchungen des Gleis-und Rollmaterials spielt eine große Rolle bei der Gewährleistung der Sicherheit der Beförderung von Personen und Gütern.
Das Ziel dieser Studie war es, eine Simulations-Methode für die mathematische Modellierung des Rad-Schiene-Systems zu konstruieren, die bei der Beurteilung von Bahnstrecken und Schienenfahrzeugen brauchbar wäre.

Methoden: Es wurden zwei Möglichkeiten der Modellierung des Rad-Schiene präsentiert und diskutiert. Eine der möglichen Herangehensweisen ist die Methode, wonach das Kontaktproblem auf die Feldkontaktfrage zurückgeführt und die Lösung der Identifikation der Feld-Quelle im 2D- System erreicht wird. Die andere Methode ist eine Methode, die das Single-Cycle-Energie-Konzept in Anspruch nimmt. Diese Berechnungsmethode wurde an die Modellierung der Dynamik des Kontaktes zwischen dem Rad und der Schiene bei normaler Kraft angepasst. Es hat sich gezeigt, dass die entwickelten Modellierungsmethoden zur effektiven Unterstützung der Studie über die Auswirkungen vom mechanischen und thermischen Kontakt innerhalb des Rad-Schiene-Zusammenstoßes dienen und zur Gewährleistung der Sicherheit im Güter-Eisenbahntransport beitragen können.
Ergebnisse und Fazit: Im Falle der Methode für die Ermittlung der Feld-Quellen wurden zwei detaillierte Fragen untersucht: die Frage der Schienenverdrehung und die Frage der Identifizierung von Wärmequellen innerhalb des rollenden Kontaktes, die zwischen der Rad- und Schienenoberfläche entsteht. Dagegen im Falle des Verfahrens mit Anwendung des Single-Cycle-Energie-Konzeptes zeigte man die Nützlichkeit dieser Methode für die Untersuchung von energetischen Prozessen im Kontakt innerhalb des Rad-Schiene-Systems unter Einwirkung der Kraft vom periodischen Charakter auf. Die künftige Ausrichtung der Forschung ist die Aufnahme einer engen Zusammenarbeit mit Forschungsteams, die sich mit den diagnostischen Messungen von Gleisen und rollenden Schienenfahrzeugen beschäftigen.

Codewörter: Kontakt Rad-Schiene, Diagnostik von Schienen und Schienenfahrzeugen, numerische Methoden, Single-Cycle-Energie

Zygmunt Strzyżakowski, Dr. Sc., Eng., Prof. UTH
Kazimierz Pulaski University of Technology and Humanities in Radom
ul. Malczewskiego 29,
26-600 Radom, Poland
e-mail: zstrz@data.pl
Edward Rydygier, Ph. D., EurPhys
Municipal Office of the Capital City of Warsaw
ul. Kondratowicza 20
00-083 Warszaw, Poland
e-mail: erydygier@gmail.com

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SELECTION AND APPLICATION OF THE TOUCHABLE ELEMENTS FOR BLIND AND PEOPLE IN THE WARSAW UNDERGROUND

Poliński Janusz, Ochociński Krzysztof

Railway Institute, Warsaw, Poland

ABSTRACT. Background: The aim of this work was to design a warning belt for blind people as well as an inclusion of the requirements in the normative document.
Methods: A diagnostic survey using the questionnaires and the interviews with disabled people (especially with blind and visually impaired people).
Results and Conclusion: As a result of the research and a participation of the blind and visually impaired people, the tactile elements were chosen and parameterized for use in the underground buildings in Warsaw. The relevant information in this filed, which should correspond to Warsaw underground buildings, were included in the regulations of the Minister of Infrastructure. On this basis, all the edges of the Warsaw underground platforms were indicated.

Key words: underground platform, danger zone, touchable element.

INTRODUCTION

A human vision plays an essential role in the process of exploring reality, surrounding objects and occurring events. A visual analyzer receives up to 80% of all information coming from the surrounding. This includes a spatial orientation and safe movement for example with the use of different modes of transport. A lack of vision significantly reduces or even eliminates an independent movement and an orientation in the space around. The phenomenon of a compensation endeavors to avoid such situation by replacing the damaged sensory with others. In the case of vision loss by hearing, smell and touch.

With regard to the people who are blind and visually impaired, in addition to the sense of hearing, it is necessary to make greater use of the touch sense. While recognizing objects, a major role plays the sense of touch located in the upper limbs. In the case of spatial orientation the most important role plays the sense of touch in lower limbs. The touch provides information for blind people whether the space is free or blocked with the obstacles. It lets the visually impaired or blind people to know the specificity of an area. A special role is played by the indirect touch, for example by means of walking sticks.

A unified information system of the understandable colors has a great importance for the visually impaired people. The colors and contrasts fulfill an important function related to the orientation and the warnings for impaired people. They are selected on the basis of the color impact on the eyes.

A design of all infrastructure facilities available for the blind people should be on the one hand a process of a consistent implementation of the danger warning, and on the other hand, should be the process of

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drawing safe roads and of elimination of any obstacles that may be placed on them. The tactile warning strips have a great importance as a danger warning. They are placed in front of dangerous places such as: the stairs and an edge of the platform. [Poliński 2012], [Guidebook 2009].

A construction of the first metro line in Warsaw did not consider placing the warning touchable elements along the edges of platforms and in the front of other dangerous places. Such markings were not required by any law act. A series of terrible accidents involving the blind people, were the reason to equip Warsaw Underground with touchable marks.

The objective of the study was to design a warning belt on the platform and to include the related requirements in the normative document. It was assumed, that the realization of this objective will lead to apply the touchable warning belts on the platform edges of Warsaw Underground stations.

OBJECTIVE AND PLACE OF RESEARCH

Currently there is no common global system for the use of touchable elements for the blind people. In one group of countries, such as Japan, Australia, United Kingdom and France, there are internal regulations ordering this issue. In the second group, which includes Poland, these issues are not settled yet.

The research subject was the assessment and the analysis of the single touchable elements ("nodules"). It included:
- the choice of a suitable material and a shape for touchable element,
- the selection of a deployment mode of the touchable elements,
- the determination of the correct width of the warning belt.

Considering the large traffic on the metro platform, high resistance to abrasion was required from a single element, and a relatively large non-interference in the existing pavement during the installation. The choice was guided by the characteristics of the individual elements of touch, set in an analysis of the world solutions [Bentzen L. 2000], [Terauchi F.2000]. For the research purposes two types of nodules were selected (Figure 1a, b), they were made of stainless steel.

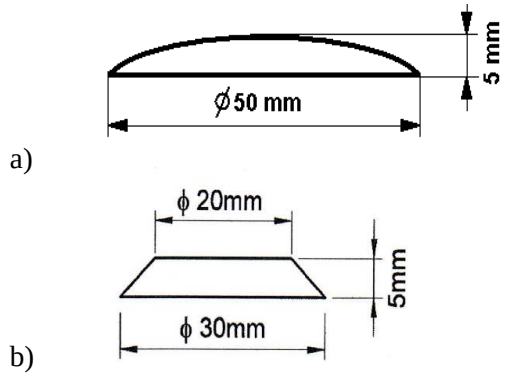


Fig. 1. Tactile elements tested
Rys. 1. Elementy dotykowe poddawane badaniom

The study was conducted in three areas, namely:
- Metro Kabaty station (tested tactile elements placed on the "1" level before the gates, at the southern exit of the subway, a tactile path led from the elevator on the"-1" level to the entrance gates),
- Wilson Square metro station (tactile elements mounted on "-1" at entresol before the gates, at the southern exit of the subway on Wilson Square, the tactile path was placed between the elevator at the "-1" level and the entrance gates; the belts with the touchable elements were placed in the front of the hallway towards the exit to the Krasinski Street).
- Warsaw Central Station (warning belts installed in the main hall at the "O" level . The warning belts arranged at a distance of ca. 3 meters from the stairs leading to the"-1" level, the tactile path has been placed between the warning belts and ticket office and an exit to the bus depot at the Golden Terraces.

The selection of the locations to install tactile elements was agreed with Warsaw Metro, PKP SA Branch Railway Stations, the Polish Blind Association, Associations Friends

of Integration with the participation of the Railway Institute.

METHOD

The lack of legislative act in Poland for using the warning stripes consisted of the tactile elements in public areas initiated a literature analysis of a specific designations. The available normative documents were examined and the application of such signs was analyzed in over 40 companies operating on the underground railway.

In order to study the tactile elements, they were mounted in the places with very intense pedestrian traffic. With a view to ensuring the safety of the research, the places along the edge of the platforms were abandoned which were the places of the future use of tactile elements.

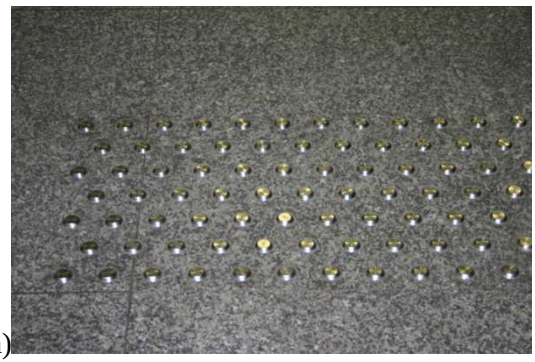
Diagnostic survey method was used during a few weeks of research. It has allowed the analysis of the documents related to the applicable regulations, including: ensuring adequate safety zones and adequate technology of making tactile elements. In the study, a questionnaire for travelers was used, including travelers with diverse disabilities. The questionnaire method was supplemented by the interviews, mainly on passengers with disabilities.

The study involved people with disabilities in the age between 15 to 65 years old, as well as the elderly persons. Among people with disabilities were both the blind persons and the persons with reduced mobility: moving with a walking sticks or wheelchairs.

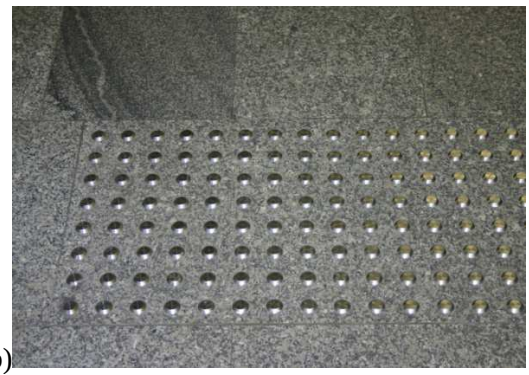
THE COURSE OF STUDY

On the subway Wilson Square Station tactile elements were used according to Figure 2 a) and c), while on the Kabaty Station - according to the Figure 2 b) and d). On the Central Warsaw Station all kinds of samples were installed - in front of the stairs leading from the main hall to the gallery on "-1".

a)



b)



c)

d)

Fig. 2. Patterns of tested warning belts with tactile elements
Rys. 2. Wzory ocenianych pasów ostrzegawczych

The path consisted of a flat with an oval cross-section and trapezoidal touchable elements. The path was made from stainless steel and was glued to the ground - Figure 3.

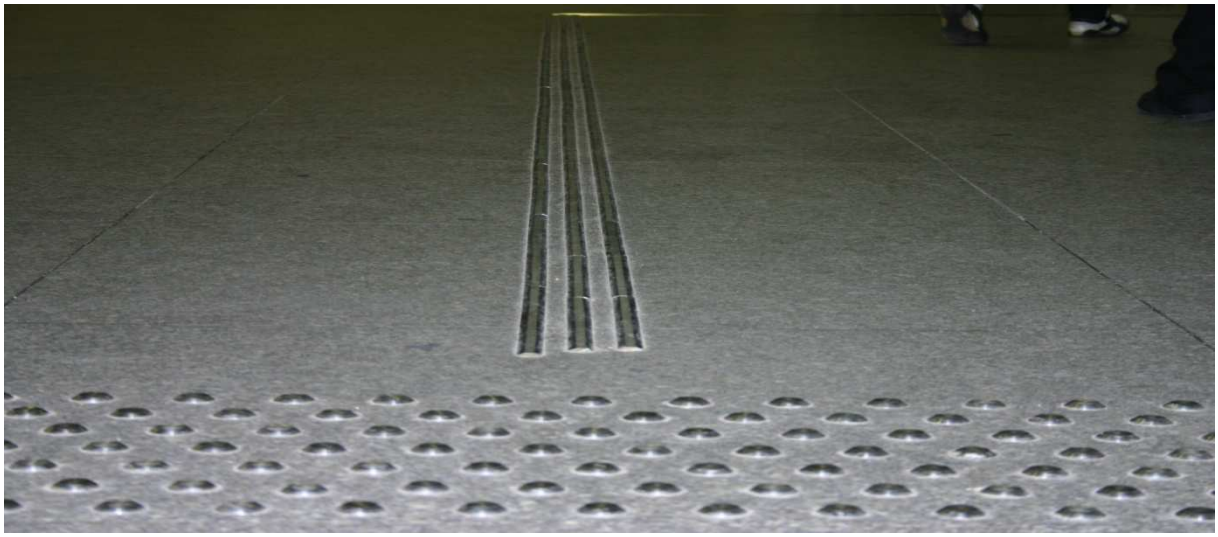


Fig. 3. Pattern of tactile path made of the flats with trapezoidal cross section
Rys. 3. Wzór ścieżki dotykowej wykonanej z płaskowników o przekroju trapezowym

The tests were conducted in the summer and lasted for five weeks. During a supervised exploitation of the signs the opinions were collected from:

- People who are blind and visually impaired, who in testing places gave their opinions on sensing by feet (in shoes with thick soles). Their opinions were related to the types of tactile elements and their placement relative to each other (pattern). During the study four groups of blind people were organized at the Warsaw Central Station and several meetings with blind individuals were performed on subway stations.
- People moving on wheelchairs (two meetings with users of wheelchairs - both manual and electric
- Elderly people who have difficulty in moving independently without the walking sticks or crutches (several meetings fruiting many opinions)
- Sighted and physically fit people of all ages

For all people a questionnaire was prepared with the following issues: sensibility of the tactile elements; their placement relative to each other and evaluation of the ease of walking on the elements. More than 200 interviews were conducted on various possible solutions. Thanks for providing monitoring provisions by the Warsaw Metro the passengers' behaviours were analyzed on the different sections of tested areas during different traffic intensities.

TEST RESULTS, EVALUATIONS AND ANALYSIS

Analysis of the collected test results, the observations and the interviews, on the background of the current rules allowed us to formulate the following requirements:

a) **Selection of the tactile elements from the set of tested solutions**

As the result of analysis of the information gathered, it was found that 69% of respondents have chosen the tactile elements in the form of a truncated cone (fig. 1b), and 31% indicated a better detection of a lens nodule (fig. 1a). In the group of blind people, 82% indicated the nodules in the form of truncated cones as better detected by the foot, as well as using a white walking stick, and 18% better recognized lenticular nodules.

With regard to the placement of nodules relative to each other, the vast majority of the

people participated in the test indicated a very good shape of nodules shown in Fig.2b. This solution also advocated disabled people moving in wheelchairs and with walking frames. Wheels of equipment used by these persons can move freely between the rows of nodules, which does not result in shock and does not interfere with the uniformity of driving.

b) **General requirements for tactile elements**

As the result of testing and observations, it was found that the solutions should be safe for all types of visitors, durable in use and perform the expected information functions (you can feel surface even in the winter footwear).The individual elements should not be slippery. At the same time they must be easy to keep clean. They cannot be flammable and cannot release toxic chemicals in contact with high temperatures, such as during fire. In addition, it should be easy to clean (the possibility of using chemical and mechanical cleaning method). The tactile elements should contrast with the surface of the platform. These requirements concern both the warning belts and tactile paths.

c) **Requirements for warning belts**

The warning belt should be placed along the edge of the underground platform, before the security zone, at the end of the platform, and in the distance of 0.6 m before the first ascending stair and 0.6 m before the first stair down. The warning belt width should be not less than 400 mm and not more than 600 mm. Consumption of the touch elements cannot cause a reduction in the height of the item less than 4 mm. In the case of the achievement of the nodules height limit, it is necessary to use appropriate techniques to adjust their desired size and the assumed information functions.

During operation, tactile signs should be illuminated with light of intensity min. 50 lux (an important condition for all passengers including visually impaired people.

d) **Expectations for tactile paths**

Tactile path should be an element of each passenger platform. It should be free from obstacles and possibly the shortest. It connects entrances and exits available for people with limited movement abilities with the platform. The minimum width of the tactile path should not be less than 330 mm. Each path should be terminated with the warning belt or an attention field. The dimensions are shown in Figure 4.

The attention field should be also located in those places where tactile path changes its direction. The height of the tactile elements should be within the range 4,0 - 5,0 mm.

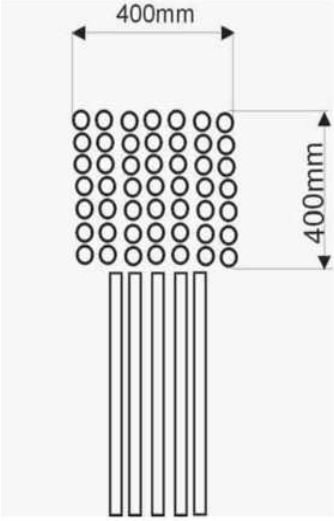


Fig. 4. Dimensions for an attention field of the tactile path
Rys. 4. Wymiary pola uwagi ścieżki dotykowej

e) **Indication of the danger zone on the platform**

A boarder of the danger zone of the Underground's passenger platforms extends the entire length of the platform, 0.65 m from the edge of the platform on the side of subway track. The edges of the platform should be highlighted with the visual warning signs (for the visual impaired people) and the tactile signs. The visual signs should contrast with the color of the floor surface. A first sign should be a continuous line of minimum 0.1 meters placed directly along the edge of the platform. Second sign should be0,05 m wide placed on

the entire length of the platform, in the distance of 0,6 m from the platform edge. The visual warning signs should be antiskid and contrast with the surface of the platform.

The warning belt should be placed outside the danger zone. Figure 5 shows the location of visual and tactile warning signs along the edge of the underground platform.

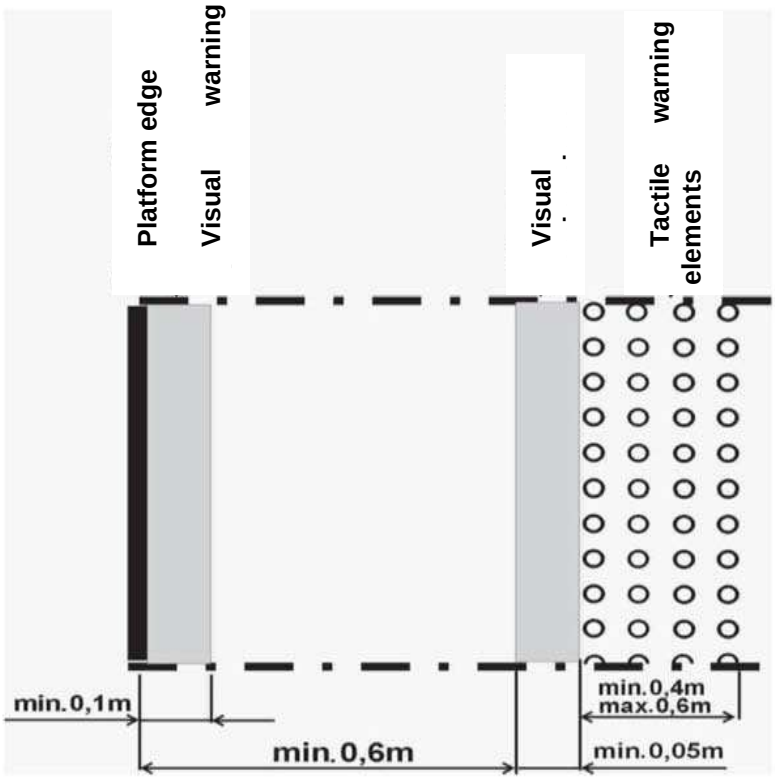


Fig. 5. Indication of the danger zone on the underground platform
Rys. 5. Oznakowanie strefy zagrożenia na peronie metra

IMPLEMENTATION AND OBTAINED RESULTS

As a result of the conducted researches with the participation of blind and visually impaired people, the tactile elements are chosen for implementation in the area of Warsaw Underground. They were carefully selected and parameterized. The relevant information in this field was given to the Ministry of Infrastructure, where work regarding the preparation about legislation on the technical infrastructure underground was conducted. An implementation of the research results was determined by the existence of a legal basis for labeling the danger zone with the visual and the tactile sign as well as highlighting the potentially dangerous places.

The visual and tactile singling is specified in a document defining the technical conditions which has to be met while building underground facilities [Regulation, 2011].

The legal law regulations allowed appropriate signaling of all platform edges of Warsaw Underground, as well as all other danger zones and places such as: the stairs or the ramps. Examples of the applied results of are shown in Figure 6.

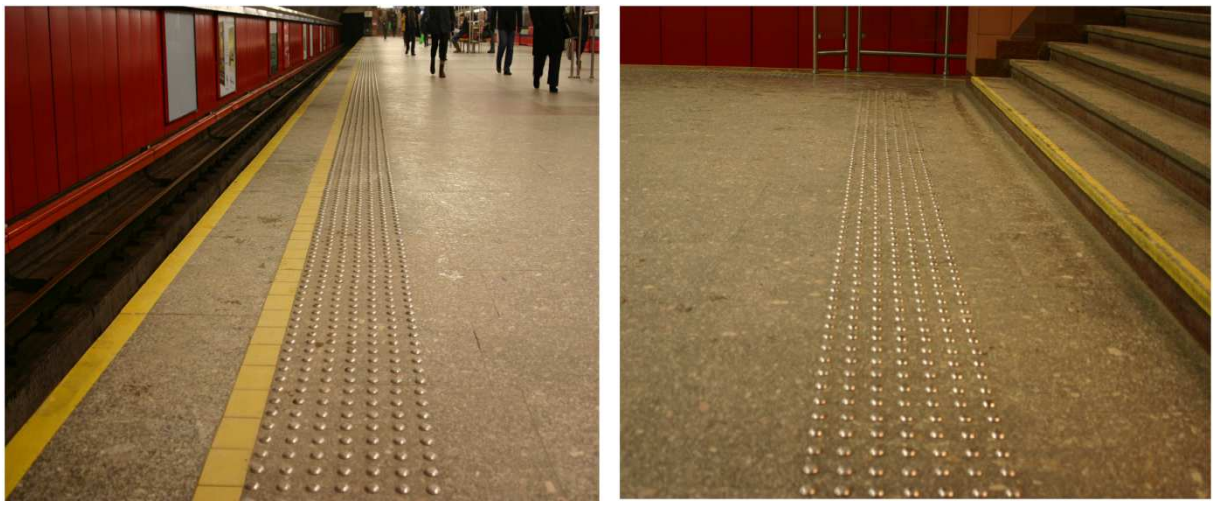


Fig. 6. The examples of the visual and tactile indication of the danger places for blind and visually impaired people of Warsaw Underground, a) on indication of platform edge, b) on indication of the stairs
Rys. 6. Przykłady oznakowania wizualnego I dotykowego niebezpiecznych miejsc dla osób niewidomych i słabowidzących w Metrze Warszawskim, a) oznaczenie krawędzi peronowej, b) oznaczenie schodów

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Rozporządzenie Ministra Infrastruktury z dnia 17 czerwca 2011 roku w sprawie warunków technicznych jakim powinny odpowiadać obiekty budowlane metra i ich usytuowanie. (Dz. U. 2011 nr 144, poz. 859) Regulation of the Minister of Infrastructure from 17th of June, 2011 on the technical conditions to be met by building underground facilities and their location.

WYBÓR I ZASTOSOWANIE ELEMENTÓW DOTYKOWYCH DLA OSÓB NIEWIDOMYCH W METRZE WARSZAWSKIM

STRESZCZENIE. **Wstęp.** Celem pracy było zaprojektowanie pasa ostrzegawczego dla osób niewidomych i zamieszczenie wymagań z tym związanych w dokumencie normatywnym.
Metoda: sondaż diagnostyczny z wykorzystaniem ankiet i wywiadów z osobami niepełnosprawnymi.
Wyniki i wnioski. W wyniku przeprowadzonych badań i udziału w nich osób niewidomych i słabowidzących, wybrano i sparametryzowano elementy dotykowe do stosowania na obiektach Metra Warszawskiego. Stosowne informacje z tego zakresu, którym powinny odpowiadać obiekty budowlane metra, znalazły się w rozporządzeniu ministra Infrastruktury.

Słowa kluczowe: peron metra, strefa zagrożenia, element dotykowy

DIE AUSWAHL UND DIE ANWENDUNG DER TAKTILEN ELEMENTE FÜR BLINDE MENSCHEN IN DER WARSCHAUER U-BAHN

ZUSAMMENFASSUNG. Einleitung: Ziel der vorliegenden Arbeit waren der Entwurf eines Blindenleitsystems und die Veröffentlichung der entsprechenden Erfordernisse im normativen Dokument.
Methode: Meinungsforschung mithilfe von Fragebögen und Interviews mit behinderten Menschen.
Ergebnisse und Schlussfolgerungen: Im Ergebnis der durchgeführten Studie und dank der Teilnahme der blinden und sehbehinderten Menschen wurden die taktilen Elemente zur Anwendung in den Anlagen der Warschauer Metro ausgewählt und parametrisiert. Die Zusammenstellung von Informationen zu diesem Thema, denen die Anlagen der Warschauer Metro entsprechen sollen, wurde in der Verordnung vom Minister für Infrastruktur erfasst. Im Hinblick darauf wurden alle U-Bahnsteigkanten der Warschauer Metro mit Leitsystemen ausgestattet.

Codewörter: U-Bahnsteig, Gefahrenzone, taktiles Element.

Dr inż. Janusz Poliński,
mgr inż. Krzysztof Ochociński
Instytut Kolejnictwa
Zakład Dróg Kolejowych i Przewozów
ul. Chłopickiego 50
04-275 Warszawa
e-mail: kochocinski@ikolej.pl
e-mail: jpolinski@ikolej.pl

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OPTIMIZING SALES AREAS OF COMBINED TRANSPORT CHAINS

Philip Michalk

Technical University of Applied Sciences Wildau, Wildau, Germany

ABSTRACT. Background: Combined transport chains (such as intermodal transport), have certain advantages. The main advantage from customer points of view is the possibility to bundle freight and thereby decrease transport costs. On the other hand, a combined transport chain can cause longer transport times, due to the necessary transshipment processes.
Methods: The area around a terminal, in which a combined service has favourable properties to a customer in comparison to a direct transport, can be understood as a sales-area, in which a combined transport product is marketable. The aim of this paper was to find a method to determine the best shape and size of this area.
Results and conclusions: The paper at hand lined out a method in order to calculate such a sales area and determine which geographical points around a terminal have an advantage in comparison to a direct transport service.

Key words: sales area, intermodal transport, marketing.

INTRODUCTION

Combined transport services (such as intermodal transport), have certain advantages. The main advantage from customer points of view is the possibility to bundle freight and thereby decrease transport costs. On the other hand, a combined transport chain can cause longer transport times, due to the necessary transshipment processes. The area around a terminal, in which a combined service has favourable properties to a customer in comparison to a direct transport, can be understood as a sales-area, in which a combined transport product is marketable.

DETERMINING THE ECONOMIC CATCHMENT AREA OF A TERMINAL OR FREIGHT VILLAGE

In the study at hand, the catchment area of a terminal or freight village shall be defined as an area around a terminal from within which a combined transport chain is superior to the pure road transport alternative. Superiority shall be defined in three possible ways: economically (cost superiority), environmentally (lower CO_2 emissions) and over time (transport duration superiority).

A combined chain can be describes as a system, consisting of several subsystems. In the paper at hand, a shuttle train connection (or long haul truck connection), as well as a pre-/post-carriage-truck-connection constitute such subsystems, which are combined by the transshipment process.

Each subsystems is described by the distance it covers and - due to the framework conditions - each subsystem has certain features in regards to operational costs, CO_2-emissions, and transport time. If a load factor is assumed, these features can be calculated as a value per load unit and trip:

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$$C_{CRi}(d_i) = \frac{1}{2} * \frac{C_{Ri}(d_i)}{\square} l_{Ri}$$

$$E_{CRi}(d_i) = \frac{1}{2} * \frac{E_{Ri}(d_i)}{\square} l_{Ri}$$

with:

C_{CRi}: Transport costs per load-unit at a distance d of a train- or truck-transport-relation i in TEU.

$C_{Ri(di)}$: Costs per roundtrip at a distance d of a train- or truck-transport-relation i.

$E_{CRi(di)}$: CO_2 emissions per load unit at a distance d of a train- or truck-transport-relation i.

$E_{Ri(di)}$: CO_2 emissions per roundtrip at a distance d of a train- or truck-transport-relation i.

l_{Ri}: Average load of a train or truck on a train- or truck-transport-relation i in TEU.

In the case of a "one-rail-leg" intermodal port hinterland connection, the port would be connected with a hinterland terminal by train. From there on a load unit would be transported by truck to its final destination. Alternatively a truck could run directly from the port to the final destination in question.

As an intermodal shuttle train bundles freight for numerous final destinations, these final destinations could be located anywhere around the terminal in different distances. In order to ascertain if a given destination should still be served through an intermodal chain or if a direct connection by truck would be more feasible, the distance dilation when switching from the pure road transport to the intermodal chain needs to be calculated.

When the geometrical structure of the intermodal chain is known, the alternative straight line distance between the port and the final destination can be calculated through the law of cosine (in a simplified model, where all connections are represented by straight lines and no bendiness exists):

$$d_{RO} = \sqrt{d_{RA}^2 + d_{PPC}^2 - 2 * d_{RA} * d_{PPC} * \cos(\gamma)}$$

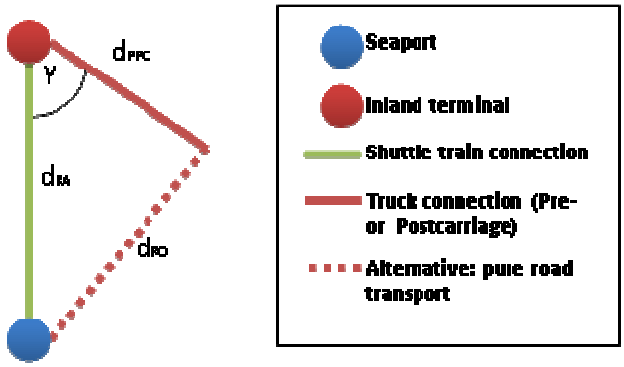

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Fig. 1. Simplified distance-relations between an intermodal port-hinterland transport chain and the alternative of pure road transport

Rys. 1. Uproszczone zależności odległości pomiędzy intermodalnym węzłem łańcucha na odcinku port-wnętrze lądu a alternatywnym czystym transportem drogowym

With:

d_{RO}: Road-distance (in this model also straight line distance) between the port and the final destination

d_{RA}: Rail-distance between the port and the inland terminal.

d_{PPC}: Road-distance between the inland terminal and the final destination

γ: Angle between the straight line distances of a rail-connection and the pre-/post-carriage-connection.

Transport costs and transport time are highly important competition factors for any transport service. With the environment conscious of retail customers on the rise, CO_2 emissions are as well becoming a competitive factor. The aim of optimizing a transport chain

is to create a chain, were at least one factor is superior to an analogue factor in pure road transport, e.g. costs, transport time and/or CO_2 emissions of an intermodal chain are lower, than those of an alternative truck transport. In case of a superior intermodal transport chain, the quotient of the road-transport-feature-value and the intermodal-transport-feature-value would be larger than one:

$\frac{C_{CRiT}}{C_{CRiI}} > 1$ *indicates cost superiority of an intermodal chain towards pure road transport.*

$\frac{E_{CRiT}}{E_{CRiI}} > 1$ *indicates* CO_2 *emission superiority of an intermodal chain towards pure road transport.*

$\frac{t_{CRiT}}{t_{CRiI}} > 1$ *indicates transport time superiority of an intermodal chain towards pure road transport.*

With:

C_{CRiT}: Transport costs per load-unit on a truck.

C_{CRiI}: Transport costs per load-unit on an intermodal chain

E_{RiT}: CO2 emissions per load-unit on a truck.

E_{RiI}: CO2 emissions per load-unit on an intermodal chain

t_{RiT}: Transport time per load-unit on a truck.

t_{RiI}: Transport time per load-unit on an intermodal chain

The larger the quotient for a given covered distance is, the more competitive an intermodal chain would be. If the quotient is one, a point of equilibrium is reached, where road and intermodal transport would be equal.

The set of all points of equilibrium constitute the rim of the set of all points of superiority (with the rim not being a part of this set).

A larger area of this set (i.e. a larger area of the terminal) would imply a potentially larger possible demand for intermodal transport. In conclusion, to maximize this area would lead to a larger demand - and thereby potentially larger revenue - for an intermodal transport operator.

Theoretically it could be possible, that direct transport is superior in all points. This case shall be excluded, as the aim of this study is to find superior combined services.

A point of equilibrium can be formally defined as follows:

$$C_{CRi}(d_{RAi}) + C_{tj} + C_{CRi}(d_{PPCi}) = C_{CRi}(d_{ROi})$$

$$E_{CRi}(d_{RAi}) + E_{tj} + E_{CRi}(d_{PPCi}) = E_{CRi}(d_{ROi})$$

$$t_{CRi}(d_{RAi}) + t_{tj} + t_{CRi}(d_{PPCi}) = t_{CRi}(d_{ROi})$$

With:

$C_{Cri(dRAi)}$: Transport costs per load-unit at a distance d of the rail leg of an intermodal chain.

$C_{Cri(dPPCi)}$: Transport costs per load-unit at a distance d of the pre-/post-carriage leg of an intermodal chain.

C_{tj}: Transshipment costs per load unit in an intermodal chain.

$C_{Cri(dROi)}$: Transport costs per load-unit at a distance d of the road transport alternative.

$E_{Cri(dRAi)}$: CO_2-emissions per load-unit at a distance d of the rail leg of an intermodal chain.

$E_{Cri(dPPCi)}$: CO_2-emissions per load-unit at a distance d of the pre-/post-carriage leg of an intermodal chain.

E_{tj}: Transshipment CO_2-emissions per load unit in an intermodal chain.

$E_{Cri(dROi)}$: CO_2-emissions per load-unit at a distance d of the road transport alternative.

$t_{Cri(dRAi)}$: Transport time at a distance d of the rail leg of an intermodal chain.

$t_{Cri(dPPCi)}$: Transport time at a distance d of the pre-/post-carriage leg of an intermodal chain.

t_{tj}: Transshipment time in an intermodal chain.

$t_{Cri(dROi)}$: Transport time at a distance d of the road transport alternative.

The catchment area can be calculated as the sum of all triangles Fl, whereby one triangle is determined by the distances of the pre-/post-carriage dPPC, as its sides, of two different angles? The angle γ between these two sides can be calculated as:

$$\alpha = \gamma_l - \gamma_{l-1}$$

The area of one triangle could then be calculated as:

$$F_l = \frac{d_{PPCl} * d_{PPCl+1} * sin\alpha}{2}$$

The total catchment area C can then be approximated as the sum of all triangles F_l:

$$C = \sum_{l=1}^{n} F_l$$

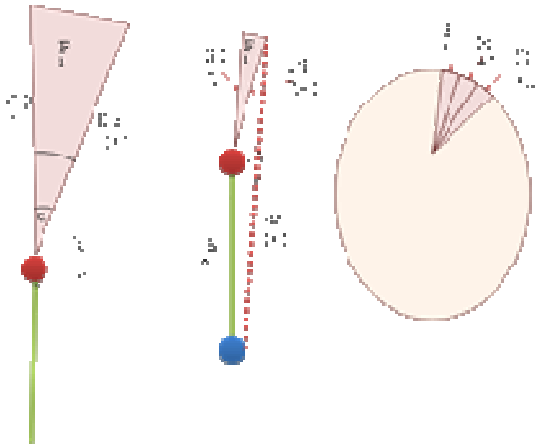

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Fig. 2. Catchment area of a terminal as the sum of triangle Fi
Rys. 2. Powierzchnia oddziaływania terminal jako suma trójkata Fi

COMBINING DEMAND EFFECTS

Differently designed combined transport services and alternative road transport services - over equal given distances - do have different features. In this case: differently designed intermodal chains and pure road transport services on a given distance. The intermodal chains mainly differ in the ratio of rail- and road-share (e.g.: does an intermodal chain over a total distance of 500 km, consist of 450 km rail transport and 50 km road transport or alternatively consist of 300 km rail transport and 200 km road transport?). In the model at hand these features are transport times and transport costs. Customers will decide if they should use a certain service (or a competing service), based on how well these features meet their own requirements.

The reaction of customers to alterations of one feature in a given service can be described with an elasticity function [Bücker 1998]:

$$\varepsilon = \frac{\Delta x}{\Delta y} * \frac{y_1}{x_1} \qquad (1)$$

With:
ε: Elasticity
Δx: Absolute change of demand
Δy: Absolute change of demand-factor
x_1: Demand before change of demand factor.
y_1: Demand factor before change of demand factor.

The above equation can be transformed in order to calculate a change of demand based on a given elasticity:

$$\Delta x = \varepsilon * \Delta y * \frac{x_1}{y_1} \qquad (2)$$

The demand factor could be a price or transport time, i.e. changing the price would change the demand.

In the study at hand, changes of transport costs, shall be equated with changes of service

prices, e.g. an increase of the operational costs by 5% would lead to an increase of the service price of 5%. This assumption is quite realistic, as expert knowledge implies that the transport market is a buyer market. Different intermodal transport operators have explained, that they aim at prices, which allow for a return on sales of about 4%, which means, that they indeed orientate prices on the operational costs.

In the study at hand, the possible transport modes a shipper can choose between shall be pure truck transport or intermodal transport. Transport prices and transport time are assumed to be the most important decision factors for a shipper, when deciding for a transport mode, this assumptions is backed up by a number of studies, such as the studies of Bühler [2005] Beute [2003] or Geiger [2011].

By inserting cost and time factors into equation (2), demand changes can be calculated based on transport-cost and transport-time changes:

$$\Delta x_c = \varepsilon_c * \Delta c * \frac{x_1}{C_1} \qquad (3)$$

$$\Delta x_t = \varepsilon_t * \Delta t * \frac{x_1}{t_1} \qquad (4)$$

With:
x_1: Demand before change of demand factor.
Δx_c: Demand change based on transport cost change.
Δx_t: Demand change based on transport time change.
Δc: Absolute Change of transport costs.
Δt: Absolute Change of transport time.
c_1: Initial operational costs.
t_1: Initial transport time.
ε_c: Transport cost elasticity.
ε_t: Transport time elasticity.

In the study at hand, demand effects of transport cost and transport time changes, which occur through changing from one transport system to another, shall be calculated by adding the demand changes:

$$\Delta x_{Total} = \Delta x_t + \Delta x_c \qquad (5)$$

A demand indicator shall be defined as:

$$A = 1 + \Delta x_t + \Delta x_c \qquad (6)$$

Furthermore, a Baseline Indicator $A_{Base}=1$ shall be defined for a given baseline transport service. A transport service superior to the baseline transport service would be indicated by a demand indicator A>1.

The optimization Problem can be described as follows:

$$Maximize \left\{[A]_{Inter} \left(d_{PPCk}, d_{RAj}\right) = 1 + \Delta x_t + \Delta x_c\right\} \qquad (7)$$

whereby:

$A_{Base}(d_{Ro}) = 1$
$d_{Ro} = d_{Inter}$
$d_{Inter} = d_{PPCk} + d_{RAj}$
$d_{RA1} = dI_{nter} - d_{PPC1}$ with: d_{PPC1} = 5 km,
$d_{RA2} = d_{Inter} - d_{PPC2}$ with: d_{PPC2} = 10 km,

…etc.
until: d_{RAi} 5 km

With:
A_{nter}: Demand indicator for an intermodal chain.
d_{Inter}: Transport distance in an intermodal chain
d_{PPC}: Pre-/post-carriage distance from a terminal in an intermodal chain.
d_{RA}: Rail distance between a port and an inland terminal in an intermodal chain.
$c_1(d_{Ro})$: Initial transport costs, based on pure road transport on the given straight line distance.
$t_1(d_{Ro})$: Initial transport time, based on pure road transport on the given straight line distance
d_{Ro}: Straight line distance for pure road transport between the port and an inland destination, with an intermodal terminal on this straight line.

The optimum A found trough this algorithm, is defined through a d_{PPC} and a d_{RA}.

This optimum A however is based on the assumption that a terminal lies on the straight line distance between a port and the final destination of the consignment. In all cases where the terminal does not lie in the straight line distance dInter is longer than d_{Ro}, so A

also becomes smaller for a given d_{Ro} in most cases, as costs and transport time increase with increasing transport distances. This also means, that the AInter calculated through function (7) is the maximum AInter possible for the given straight line distance. Most AInter for destinations that do not have the terminal considered on a straight line between them and the departure point are necessarily smaller.

However, as long as these Anter are larger than 1, the associated transport chain can still be deemed superior.

Due to necessary drivers breaks, some distances are more attractive (measured by indicator A) than others [Michalk 2012]. This leads to "holes" in a catchment area. This can be seen in figure 3, which shows a scatter plot of all points around a terminal in a distance d and an angle γ (compare figure 2). Each point in the scatter plot represents a point with A>1.

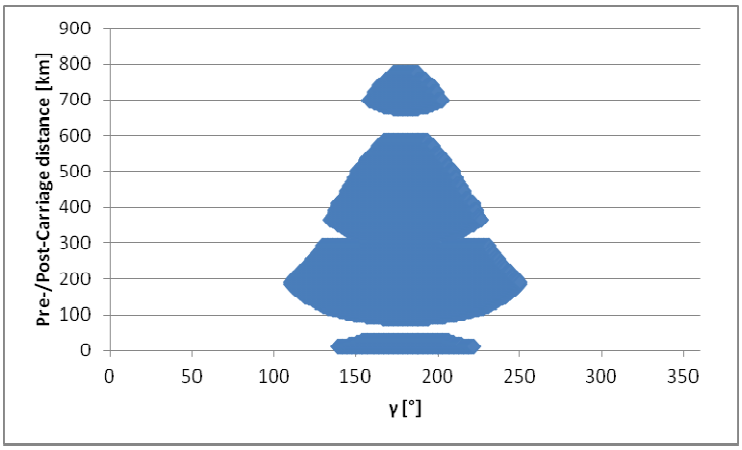

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Fig. 3. Scatter plot of a terminal catchment area with a 500 km long rail connection
Rys. 3. Obszar oddziaływania terminal połączonego 500 km odcinkiem kolejowym

Using Bühlers elasticity values with equation (7) is not without problems; as the elasticity values have been determined independently from each other. A customer that would not ship his goods with a given service when the price increases, might be completely insensitive towards a change in transport time when his shipment is not time-sensitive and vice-versa.

This indicates the necessity for further examinations in this area, in order to determine true more-dimensional demand patterns of shippers. Such an examination should be designed in order to lead to a multi-attribute compositional model. Such an analysis would present survey participants with a number of possible services, each consisting of different combination of features, which constitute different tradeoffs to each other.

However, it can be argued, that these elasticity values still depict the different importance of the features "transport-time" and "transport-price". Also the demand estimation does aim at a large number of potential shippers, thus meaning, that for any customer who would not ship his goods after the transport price increases, another customer might just choose this service because of a simultaneous decrease in transport time. A high importance of lower transport prices would then lead more customers to use a different service, while the number of customers attract by the now changed service would be smaller, which is implied by the lower transport-time-elasticity. In conclusion, the demand indicator might not be a reliable parameter to estimate exact demand-developments, but it still can be used to make qualitative statements about the superiority of a service as compared to a competing service.

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OPTYMALIZACJA POWIERZCHNI OBSŁUGI PRZEZ ŁAŃCUCH TRANSPORTU KOMBINOWANEGO

STRESZCZENIE. **Wstęp**: Łańcuch transportu kombinowanego (takiego jak na przykład transport intermodalny) ma szereg zalet. Z punktu widzenia klienta najważniejszą zaletą jest możliwość łączenia różnych przewozów i w efekcie obniżenie kosztów transportu. Z drugiej strony transport kombinowany wymaga często dłuższego czasu realizacji, ze względu na potrzebne czasy przeładunków.
Metody: obszar położony wokół terminala, na którym realizacja dostaw poprzez transport kombinowany jest korzystniejsza od transportu bezpośredniego, jest określany jako obszar sprzedaży. Celem tej pracy było znalezienie metody wyznaczania takiego obszaru.
Wyniki i wnioski: Przedstawiono metody obliczania obszaru sprzedaży oraz wyznaczania punktów geograficznych ograniczających ten obszar..

Słowa kluczowe: obszar sprzedaży, transport intermodalny, marketing

OPTYMALISIERUNG DES BEDIENUNGSAREALS DURCH KOMBI-VERKEHR-KETTE

ZUSAMMENFASSUNG. Einleitung: Die Kette des Kombi-Verkehrs (wie beispielsweise des intermodalen Transportes) besitzt viele Vorteile. Aus dem Gesichtspunkt des Kunden ist die Möglichkeit von Anbindung unterschiedlicher Beförderungstypen und damit der Verminderung von Transportkosten der größte Vorteil solcher Ketten. Zum anderen verlangt aber der Kombi-Verkehr des Öfteren eine längere Ausführungszeit wegen der nötigen Zeiten für Verladung.
Methoden: Das um einen Terminal gelegene Areal, auf dem die Ausführung von Lieferungen mithilfe des Kombi-Transportes günstiger als der direkte Antransport ist, wird als Verkaufsareal bezeichnet. Das Ziel der Arbeit war es, eine Methode für die Bestimmung eines solchen Areals auszuarbeiten.
Ergebnisse und Fazit: Es wurden die Methoden für die Berechnung des Verkaufsareals und die Bestimmung von geographischen, dieses Areal konturierten Punkten dargestellt..

Codewörter: Verkaufsareal, intermodaler Transport, Marketing

Philip Michalk
Research Group Transport Logistics
Technical University of Applied Sciences Wildau
Wildau, 15745 Germany
e-mail: michalk@th-wildau.de

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THE TOOLS FOR EVALUATING LOGISTICS PROCESSES

Michał Adamczak, Roman Domański, Piotr Cyplik, Żaneta Pruska

Poznan School of Logistics, Poznan, Poland

ABSTRACT. Background: The growing importance of business process approach and dynamic management is triggered by market expectations for lead time reductions and the pressure for cost cuts. An efficient process management requires measurement and assessment skills. This article is intended to present the tools used in evaluating processes and the way in which they work together under simulated conditions.
Methods: The project's Authors believe that a process can be assessed by measuring its attributes: cost, time and quality. An assessment tool has been developed for each of those attributes. For costs - it could be activity based costing, for time - value stream mapping; for quality - statistical process control. Each tool allows for evaluating one of the attributes, any element in the process hierarchy. The methods presented in the paper have been supplemented with process modelling and simulation.
Results: In order to show how process assessment tools are combined with process simulation the Authors show a sample process in three versions (serial, parallel and mixed). A variant simulation (using iGrafx software) allows for determining the values of attributes in the entire process based on the data set for its components (activities). In the example under investigation the process variant has no impact on its quality. Process cost and time are affected.
Conclusions: The tools for identifying attribute values, in combination with process modelling and simulation, can prove very beneficial when applied in business practice. In the first place they allow for evaluating a process based on the value of the attributes pertaining to its particular activities, which, on the other hand, raises the possibility of process configuration at the design stage. The solution presented in the paper can be developed further with a view to process standardization and best variant recommendation.

Key words: process assessment, process modelling, process simulation, process management.

INTRODUCTION

This paper is intended to present the tools for performance evaluation of processes and linking them to modelling and simulation methods. The Authors of this publication believe that a process can be assessed by measuring its attributes. The publication has added value - it links the evaluation of the attributes pertaining to process elements (activities) with modelling and simulation. Such a solution provides an opportunity for building various process configurations and for evaluating those configurations without putting them in practice.

A growing importance of process approach for business entities and the orientation of those entities on such processes have been the underlying reasons for selecting such an area of research. This phenomenon is driven by market requirements, such as: growing importance of customer service, shortening order lead times, price reductions. To live up to those requirements companies must dynamically change - not only in terms of how they are organized, but how they function - by opting for dynamic management rather than static (structural) management. The management and continuous improvement of processes (their adaptation to meet customer

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expectations) requires obtaining control information in order to analyse and evaluate the performance of processes that take place.

Measuring performance efficiency of process is a pivotal issue in both theory and practice. Apart from economic efficiency also other types of efficiency start to gain in importance in this respect (added values generated by various groups of participants). G. Lichocik and A. Sadowski [Lichocik, Sadowski 2013] emphasize the need for taking a broad and holistic view on the performance efficiency of supply chain processes - taking into account all analytic dimensions related to the flow of goods and services. According to those authors a supply chain should be optimum in terms of costs (economic efficiency), functions (reduction of processes, lean - reduction of the number of links to an indispensable minimum), adapting internal processes of the chain's actors to a common objective and ensuring top quality of service (reliable customer-oriented systems).

The use of process modelling and simulation method in research allows for making predictive analyses which look into project variants of processes. According to the Authors process evaluation at its design stage makes a major contribution to the research in the area of process approach.

PROCESS - DEFINITION

Process orientation requires a broader view on processes within an organization - an organization is a sequence of interleaving processes. Process identification, their evaluation and streamlining allow for increasing the efficiency and the competitive position of an organization [Nowosielski 2007]. What is a process in a business organization? Plenty of definitions can be found in literature.

Table 1. Process definitions
Tabela 1. Definicje procesu

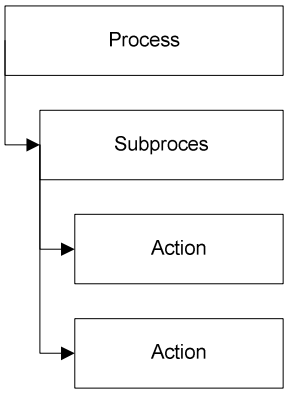
Author	Definition
PN-EN ISO 9000:2001	A process is a collection of interrelated and interdependent activities, which transform input into output [ISO 9000:2001].
K. Perechuda	A process is a series of parallel, conditional or sequential activities, which transform input resources of the enterprise into output - a product or service [Perechuda 2000].
M. Manganelli, M.M Klein	A process is a series of interrelated activities that lead to transforming process input into a product [Manganelli, Klein 1998].
M. Hammer, J. Champy	A process is a set of activities involving one or more types of input, as a result of which the customer receives a product that is of value for him [Hammer, Champy 1996]
APICS	A planned sequence of activities, operations (mechanical, electrical, chemical, control, test activities) which increases the value-added content of a product or a service [Blackstone, Jonah 2008] .
J. Peppard, P. Rowland	A continuous and regular activity or a sequence of activities taken in a prescribed manner and aimed at achieving a specific result [Peppar, Rowland 1997]
A.G. Rummler, A.P. Brache	A process is a value chain. Each activity participates in creating or producing a product or a service and should hence add value to the preceding activity [Rummler, Brache 2000]

Source: own study

The definition put forward by M. Manganelli and M.M Klein is the most interesting for the Authors. It provides a very concise description of the nature of a process with the focus on product input and output. This definition fits best into the subject matter of this study. Evaluating the process implementation is undoubtedly linked with the input and output analysis.

The requirements imposed by performance evaluation of processes bring process hierarchy into focus. Processes can be classified into elements called sub-processes and activities.

A sample process hierarchy is presented in the figure 1.



Source: own study based on Nowosielski ed. [2007]

Fig. 1. Process hierarchy
Rys. 1. Hierarchizacja procesów

Process hierarchy allows for creating their structure. Thus particular process elements (components) can be evaluated and the evaluation results can be translated into a primary process. The Authors of this paper have taken advantage of this property while developing their tool for process evaluation.

PROCESS EVALUATION

The first step in the evaluation procedure is identifying the process. In the top-down approach consists in identifying strategic, main, core processes in the first place, and building auxiliary processes around them later on. In the bottom-up approach basic activities realized within an organization are identified in the first place, and then pieced together into a whole based on the criterion of functional similarity [Nowosielski 2007].

Process modelling may be a further stage of the process evaluation. Process modelling allows for grasping complex dependencies between individual processes taking place at various organization levels and for arranging processes in a hierarchy. A map is a tool supporting processes modelling. A process map enables the visualisation of activities, evaluating the structuring of the process and its sub-processes and, in consequence, assigning resources to their actual realizations [Lisiecka 2000]. Models can be classified into diagnostic and predictive - based on the nature of the work. Diagnostic models represent the actual situation in an organization. They show "what is". Predictive models describe the desired state of affairs and show what will be or should be [Nowosielski 2007].

According to D. Estampe, S. Lamouri, J.L. Paris, S. Brahim-Djelloul [Estampe et al. 2013] a process performance efficiency may be evaluated from the point of view of the customer and from the point of view of the costs of logistics processes. On top of that the authors of the publication referred to above introduce a set of models measuring the performance of logistics processes.

The Authors of this paper believe that it is of key importance for the process performance evaluation to indicate process attributes that will be evaluated along with the evaluation tools. Cost, time and quality are the process attributes which can be subject to evaluation [Nowosielski 2007]. The first attribute is related to the cost perspective, whereas the remaining two - to the customer perspective. Table 2 presents a list of process attributes along with their evaluation tools.

Table 2. Attributes of the process and tools for their evaluation
Tabela 2. Atrybuty procesu i narzędzia ich oceny

Process attribute	Attribute description	Tool for evaluation
Cost	assigning process implementation cost as the total of the costs of individual resource consumption activities, required to perform these processes	activity-based costing
Time	one of basic performance indicators of business activity	value stream mapping
Quality	referring to process input	statistical process control

Source: own study

The Authors hold that as regards the tools for process evaluation (in reference to process attributes presented above) prime importance is attached to activity-based costing, which identifies process implementation costs. Activity-based costing means assigning resources to activities and activities to cost objects with the use of resource cost drivers and activity cost drivers. It allows for a precise identification of the implementation costs of a process, sub-process or an activity not only by identifying indirect costs of consumed resources, but first of all by assigning direct costs to processes [Zieliński 2007]. P. Fenies, M. Gourgand, S. Rodier [Fenies et al. 2006] also used activity-based costing in their publication discussing efficiency models of logistics processes, pointing to the advantages of the above mentioned tool.

Value Stream Mapping is a tool used to define and evaluate process lead times. Value stream mapping is a graphic representation of all processes indispensable for delivering a finished product or service to the customer (external or internal). The key metric used for mapping and the key element measured by means of value stream mapping is process lead time. On top of that value stream mapping allows for eliminating muda in the form of processes which add no value from the point of view of the customer [Rother & Shook 1999]. From the process perspective, the value stream mapping tool is used to define process lead times and analyse lead time values from the customer point of view. The map method allows for the correction of processes, intended to enhance value-adding time as viewed from the customer perspective.

The last process subject to evaluation is process quality, which is the extent to which the process output is matched to the expectations held by customers or to the values that have been assumed. The tool used for evaluating this process is Statistical Process Control (SPC). It is a method of monitoring and improving processes over time. There are two types of variations in statistical process control [Woodall 2000]:

- common cause variations - resulting from statistic fluctuations, falling within the specific tolerance range.
- special cause variations - caused by unforeseeable situations occurring in the course of process implementation, falling outside of the prescribed tolerance range.

Statistical process control uses control charts, which capture the values of measured attributes. The nature of the deviation presented in the statistic control chart - common cause or special cause - is of prime importance for the process evaluation. The identification of the causes underlying those variations allows for implementing measures intended to streamline the process implementation and to enhance the quality of its output.

Process simulation and modelling may be the elements linking the value of attributes assigned to particular activities with process performance evaluation. With modern IT tools, processes and phenomena can be modelled and experimented with to an ever-greater extent. Simulation analysis fosters a better understanding of the interdependencies between implementation stages of individual processes. The study of M. and P. Waszczur [Dobrzyński, Waszczur 2012] presents the opportunities for analysing the process in combination with its performance evaluation. The Authors of simulation experiments compared their outcomes with basic process performance indicators and quality assessment as based on SIX Sigma approach. The next chapter discusses the use of simulation in respect of the three process attributes described above.

RESEARCH MODEL - PROCESS EVALUATION WITH THE USE OF SIMULATION TOOLS

This research is intended to identify process attribute values based on the attributes of individual activities with the use of modelling and simulation methods. The evaluation of each of the process attributes is an initial stage of the assessment procedure. To illustrate the capabilities offered by the global process evaluation (the evaluation of all of the process attributes) the discussion of tools has been supplemented with process simulation.

A sample model comprising three activities has been created for cognitive purposes. Three types of material go through a process, referred to as white, green and blue. All of the operations are performed on each material. One employee (resource) is assigned to an operation, which means that only one material can be assigned to one activity at a time. Input data for the process performance evaluation has been captured using the tools discussed in the previous chapter. Their values are presented in table 3.

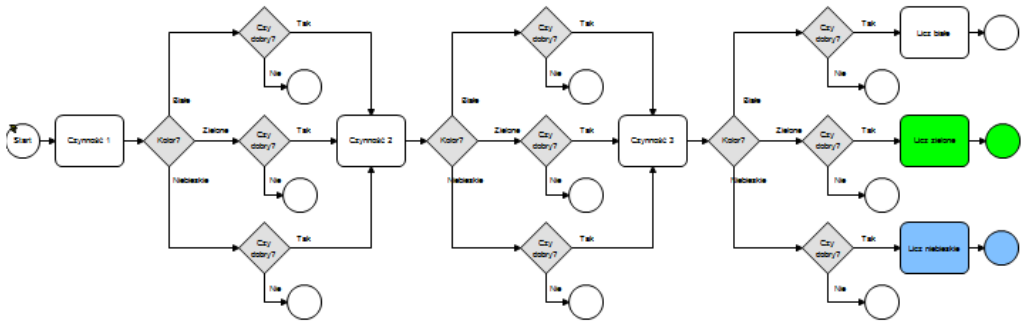
Table 3. The input data for the simulation of process
Tabela 3. Dane wejściowe do symulacji przykładowego procesu

	Cost			Time			Quality		
	Act. 1	**Act. 2**	**Act. 3**	**Act. 1**	**Act. 2**	**Act. 3**	**Act. 1**	**Act. 2**	**Act. 3**
Green	PLN 200.00	PLN 100.00	PLN 300.00	2h	1h	4h	98%	96%	97%
White	PLN 500.00	PLN 200.00	PLN 300.00	4h	2h	2h	99%	98%	97%
Blue	PLN 300.00	PLN 400.00	PLN 500.00	3h	3h	3h	99%	99%	99%

Source: Own study

The cost shown in table 3 is the cost of performing a given operation on a defined type of material. The total implementation cost has been increased by the resource (employee) cost, which is PLN 20/h. This cost has not been included in the table, because it has been incurred in the case of both employees working time and waiting time. Process quality (of each of the actions) is understood as reliability, which is the likelihood of obtaining a result (process/operation output) in compliance with the requirements.

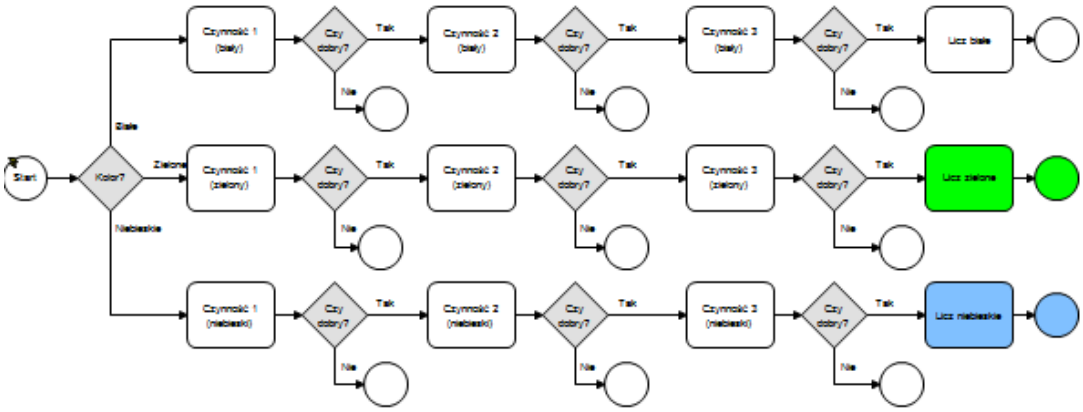
Three process variants have been evaluated: serial (fig. 1), parallel (fig. 2) and mixed (fig. 3). Input consists of a sequence of materials in three colours with a defined order. Input to a process is provided every hour.



Source: Own study

Fig. 2. A simulation model of process in serial variant
Rys. 2. Model symulacyjny przykładowego procesu w wariancie szeregowym

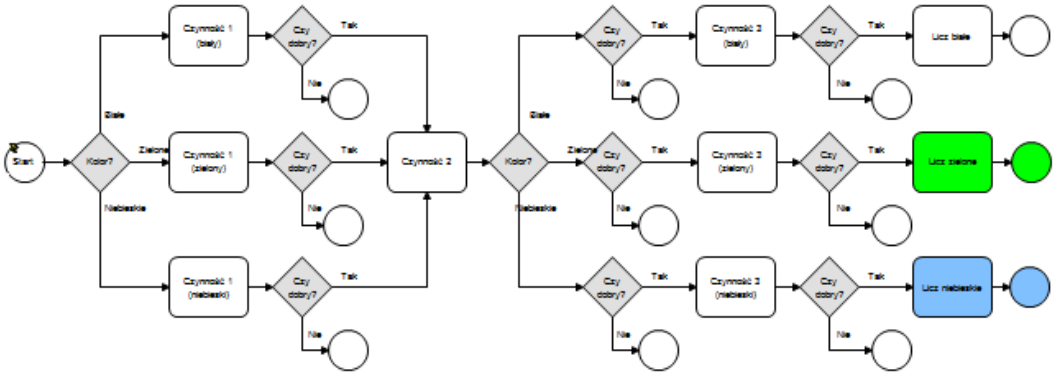
A serial variant of the process implementation consists in performing specific operations on materials appearing in the process. A defective operation eliminates the material from further processing (in all variants). This variant requires 3 resources (employees).



Source: Own study

Fig. 3. A simulation model of process in parallel variant
Rys. 3. Model symulacyjny przykładowego procesu w wariancie równoległym

Parallel variant consists in allocating a separate set of resources and activities for each of the material colours. This variant requires 9 resources (employees).



Source: Own study

Fig. 4. A simulation model of process in mix variant
Rys. 4. Model symulacyjny przykładowego procesu w wariancie mieszanym

A mixed variant is a combination of the two variants presented above. Operation 2 is performed using one resource for all of the colours of materials. This variant requires 7 resources.

Upon the completion of simulations their outcomes have listed based on its attributes (cost, time, quality) and process implementation variants. The outcomes are shown in Table 4.

According to the forecasts, the process lead time and average cycle time (material going through the process) for the parallel variant was the shortest (the shortest waiting time for a free resource). The implementation cost incurred on performing the operations and employing the resources (employees) was the lowest in the case of the serial variant. Importantly, the cost incurred on implementing the mixed variant was the highest, which points to the role of bottlenecks in the process. Resources unmatched to one activity lead to significant downtimes regarding other operations, which generates costs. The process quality was the same for each of the variants. This is because reliability was assigned to activities (technological dimension) and colour (material dimension). The quantity of resources does not affect the number of correct items at the output.

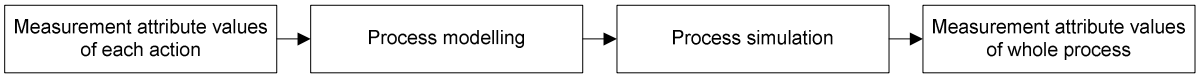
Table 4. A simulation model of process in mix variant
Tabela 4. Model symulacyjny przykładowego procesu w wariancie mieszanym

	Serial variant	Parallel variant	Mixed variant
Total cost [PLN]	110 960	115 220	121 120
Time [days]	53,21	22,04	36
Average cycle [days]	25,53	8,41	19,02
Good products White [%]	90,32	90,32	90,32
Good products Blue [%]	92,11	92,11	92,11
Good products Green [%]	87,10	87,10	87,10

Source: Own study

CONCLUSIONS

The article presents the tools for evaluating processes. They have been proposed for assessing child elements such as activities. With the application of this method of simulation, the attributes of particular activities have been transformed into the attributes of the entire process. The diagram of the functioning of the tool is presented in fig. 5.



Source: own study

Fig. 5. Diagram of the functioning of tools for logistics processes evaluation
Rys. 5. Schemat funkcjonowania narzędzia oceny procesów logistycznych

The course of procedure presented in the paper has more advantages than the evaluation of the entire process with the use of three tools. The key advantage is the opportunity for configuring the process from smaller components. It suffices to perform a one-off evaluation of the attributes pertaining to the constituent elements of the process (e.g. particular activities), and then to verify the evaluation of any configuration of this process - through modelling and simulation. Such an activity has profound implications in practice, for it makes business processes much less time- and cost-consuming. Nowadays we can observe a strong tendency to enhance the effectiveness of logistics processes. In view of the above the tool that has been presented allows for evaluating variant forecasts at the design stage, which reduces the need for reconfiguration processes.

A universal metric will be developed in the course of working on the tool for evaluating logistics processes. This metric will comprise the values of particular attributes, including their weights. Such a solution in the field of evaluating performance efficiency of logistics processes was applied by J. Zhangab and W. Tana [Zhangab, Tana 2012] - with the use of the AHP (Analytic Hierarchy Process). The implementation of a universal metric would ensure an objective (according to the selected weights) evaluation of particular configuration variants.

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and customer service strategy", pursued at the Faculty of Logistics Systems at the Poznan School of Logistics.

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NARZĘDZIA OCENY PROCESÓW LOGISTYCZNYCH

STRESZCZENIE. **Wstęp:** Wzrost znaczenia koncepcji podejścia procesowego i zarządzania dynamicznego wynika z oczekiwań rynku związanych ze skracaniem czasu realizacji zamówień oraz presją na obniżenie kosztów. Efektywne zarządzanie procesami wymaga umiejętności ich opomiarowania i oceny Celem artykułu jest przedstawienie narzędzi wykorzystywanych w ocenie procesów oraz ich współdziałania w warunkach symulacyjnych.
Metody: Autorzy prezentują pogląd, że ocena procesu może zachodzić poprzez ocenę jego atrybutów: kosztu, czasu oraz jakości. Dla każdego z tych atrybutów zidentyfikowano narzędzie oceny. Dla kosztu takim rozwiązaniem może być rachunek kosztów działań, dla czasu - mapowanie strumienia wartości, a dla jakości - statystyczna kontrola procesu. Każde z narzędzi pozwala na ocenę jednego z atrybutów, dowolnego elementu w hierarchii procesu. Uzupełnieniem zaprezentowanych metod jest modelowanie i symulacja procesów.

Wyniki: Autorzy w celu przedstawienia połączenia narzędzi oceny atrybutów procesu z symulacją procesu prezentują przykładowy proces w trzech wariantach (szeregowym, równoległym oraz mieszanym). Symulacja każdego wariantu (przeprowadzona w środowisku informatycznym iGrafx) pozwala na określenie wartości atrybutów całego procesu na podstawie danych określonych dla jego elementów (czynności). W zaprezentowanym przykładzie wariant procesu nie wpływa na jego jakość. Zmianie podlegają koszt realizacji procesu oraz czas.
Wnioski: Zastosowanie zaprezentowanych narzędzi służących do identyfikacji wartości atrybutów procesów oraz powiązanie ich z modelowaniem i symulacją procesów niesie ze sobą wiele korzyści w rzeczywistości biznesowej. Daje przede wszystkim możliwość dokonania oceny procesu na podstawie wartości atrybutów poszczególnych jego czynności co z kolei pozwala na dowolne konfigurowanie procesu na etapie jego projektowania. Opisane rozwiązanie ma może być dalej rozwijane w kierunku standaryzacji oceny procesu i rekomendacji najlepszego jego wariantu.

Słowa kluczowe: ocena procesów, modelowanie procesów, symulacja procesów, zarządzanie procesami.

WERKZEUGE ZUR BEURTEILUNG LOGISTISCHER PROZESSE

ZUSAMMENFASSUNG. Einleitung: Der Prozessansatz und das Konzept des dynamischen Managements gewinnen zunehmend an Bedeutung. Dies ergibt sich aus den Erwartungen des Marktes, die Zeit der Auftragsausführung zu reduzieren und aus dem Druck des Marktes, Kosten zu senken. Ein effizientes Prozessmanagement bedarf der Fähigkeit, Prozesse zu messen und zu beurteilen. Dieser Beitrag hat zum Ziel, Werkzeuge, die bei der Beurteilung der Prozesse eingesetzt werden, und deren Zusammenwirken in Simulationsbedingungen zu präsentieren.
Methoden: Die Autoren vertreten die Ansicht, dass die Beurteilung des Prozesses durch Beurteilung seiner Attribute, wie etwa Kosten, Zeit und Qualität, erfolgen kann. Für jedes Attribut wurde ein Werkzeug zur Beurteilung identifiziert. Bei Kosten kann das die Kostenrechnung für einzelne Aktivitäten, bei Zeit - die Abbildung des Wertstroms, und bei Qualität - die statistische Kontrolle des Prozesses, sein. Jedes Werkzeug ermöglicht es, ein Attribut, ein beliebiges Element in der Hierarchie des Prozesses, zu beurteilen. Eine Ergänzung zu den präsentierten Methoden stellen die Modellierung und die Simulation der Prozesse dar.
Ergebnisse: Um die Verbindung der Werkzeuge zur Beurteilung der Prozessattribute mit der Simulation des Prozesses zu beschreiben, präsentieren die Autoren einen Beispielprozess in drei Varianten (Reihen-, Parallel- und Mischvariante). Die Simulation jeder Variante (im iGrafx durchgeführt) ermöglicht es, den Wert der Attribute des ganzen Prozesses anhand der Daten festzulegen, die für seine Elemente (Aktivitäten) bestimmt wurden. Im angeführten Beispiel hat die Variante des Prozesses keinen Einfluss auf seine Qualität. Es verändern sich jedoch die Kosten der Prozessausführung und die Zeit.
Fazit: Die Anwendung der präsentierten Werkzeuge zur Identifizierung der Attributwerte und ihre Verbindung mit der Modellierung und Simulation der Prozesse bringt Nutzen für die Geschäftstätigkeit. Sie bietet insbesondere die Möglichkeit, den Prozess anhand der Attributwerte der jeweiligen Aktivitäten zu beurteilen, was wiederum ermöglicht, den Prozess auf jeder Stufe seiner Gestaltung beliebig zu konfigurieren. Die beschriebene Lösung kann in Richtung der Standarisierung der Prozessbeurteilung und Empfehlung der besten Variante weiter entwickelt werden.

Codewörter: Prozessbeurteilung, Prozessmodellierung, Prozesssimulation, Prozessverwaltung.

Michał Adamczak, Roman Domański, Piotr Cyplik, Żaneta Pruska
Poznan School of Logistics
ul. Estkowskiego 6, 61-755 Poznan, POLAND
e-mail: michal.adamczak@wsl.com.pl, phone +48 605 584 362
e-mail: roman.domanski@wsl.com.pl, phone +48 603 205 275
e-mail: piotr.cyplik@wsl.com.pl, phone +48 608 652 832
e-mail: zaneta.pruska@wsl.com.pl, phone +48 534 502 275

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LOGISTICS POTENTIALS IN BUSINESS COMPETITIVE ADVANTAGE CREATION

Rafał Matwiejczuk

Opole University, Opole, Poland

ABSTRACT. Background: Companies constantly search for ways to achieve and sustain long-term competitive advantage. Among the factors influencing the competitive advantage creation there are so called logistics potentials, which constitute a component part of a business strategic potentials. Logistics resources, logistics capabilities and logistics competences are the main components of the logistics potentials structure and hierarchy.
Methods: In order to recognize the logistics potentials which determine the competitive advantage creation one may use the assumptions and elements of contemporary management concepts, including strategic management. In particular the article deals with Resource-Based View (RBV), Dynamic Capabilities Concept (DCC) and - first of all - Competence-Based Management (CBM).
Results and conclusions: Several significant research projects have presented a wide scope and a large number of possibilities of logistics potentials (and logistics competences in particular) influence on business competitive advantage creation. The article briefly presents the research results conducted by: (1) Michigan State University (USA), (2) European Logistics Association (ELA) in cooperation with A.T. Kearney, (3) Computer Sciences Corporation and (4) Capgemini. The research results have pointed out to differentiated but at the same distinctive symptoms of logistics competences influence on competitive advantage creation. The article also refers to the results of the research carried out by the Chair of Logistics & Marketing at Opole University (Poland) in companies operating in Poland. The research has been mainly dealing with the significance of logistics competences in competitive advantage creation.

Key words: logistics, competitive advantage, potentials, resources, capabilities, competences.

INTRODUCTION

Firms constantly aim at gaining and maintaining competitive advantage. Such advantage seems to be the central "point of interest" within contemporary strategic management. In competitive advantage creation the key role is assigned to so called "business success potentials", also referred to as "strategic potentials of business success". In general, the potentials may be understood as factors influencing business success [Blaik, Matwiejczuk 2011]. The most important symptom of the success is when the firm reaches the expected market outcomes (for example: market share, customer satisfaction, customer loyalty) and economic outcomes (for example: profit, profitability, ROA, ROE, ROI, EVA). The outcomes are related to competitive advantage.

Many business success potentials are related to logistics area. Among these potentials there are logistics resources, logistics capabilities and logistics competences. Logistics potentials should be embedded on strategic management concepts, which allows their exploration and exploitation. It is strategic management which creates a basis of defining so called "strategic profile of business success potentials", including logistics competences which rely on logistics resources and logistics capabilities.

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STRATEGIC MANAGEMENT AS A BASIS OF BUSINESS SUCCESS POTENTIALS DEVELOPMENT

Among different fields and disciplines of management sciences, a key role is assigned to strategic management due to its practical aspects and matters [Kaleta 2008]. Many practical aspects of strategic management are related to managers' expectations formulation, connected with proposals and solutions leading to a firm's expected market and economic outcomes achievement and business competitive advantage creation.

The majority of authors distinguish two basic approaches to a firm strategy - resource oriented approach, based on business success potentials (resources, capabilities, and competences) and positioning approach, based on competitive position of a firm within the market. P. Huovinen [2008] enumerates a more detailed proposition of contemporary approaches within strategic management field:

- Porterian value chain concept,
- Resource-based approach,
- Competence-based management,
- Knowledge-based management,
- Organization-based management,
- Process-based management,
- Dynamism-based management,
- Evolutionary approach.

Business success potentials which influence competitive advantage creation are widely presented especially within three superior strategic management concepts: Resource Based View (RBV), Dynamic Capabilities Concept (DCC) and Competence Based Management (CBM).

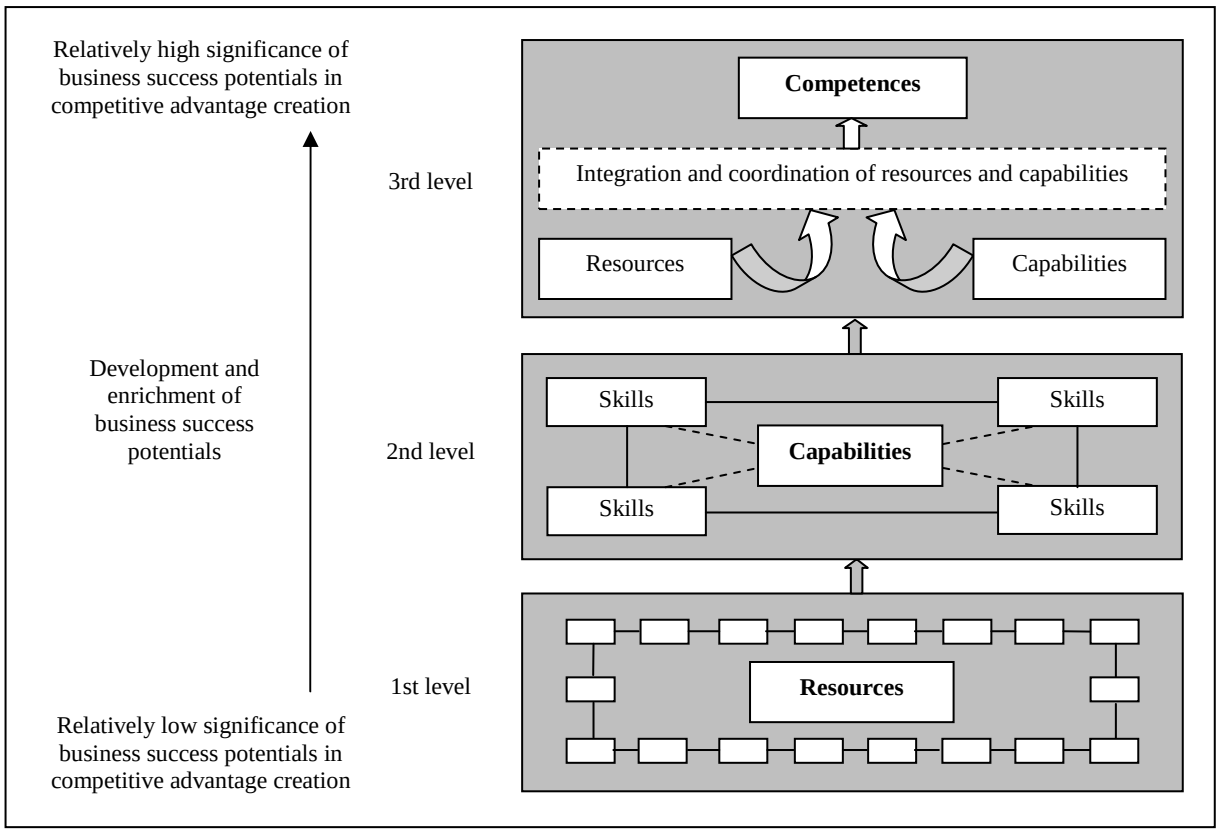
HIERARCHY OF BUSINESS SUCCESS POTENTIALS AS FACTORS INFLUENCING COMPETITIVE ADVANTAGE CREATION (BASED ON RBV, DCC AND CBM CONCEPTS)

According to RBV concept, sustained competitive advantage achievement depends particularly on resources and capabilities of their exploitation in relation to assumed goals [Barney, Clark 2007]. Resources, generally understood as tangible and intangible assets, occupy the lowest (first) level in the hierarchy of business success potentials. Such assets ensure business tasks performance and result in assumed goals achievement related to competitive advantage creation [Sanchez, Heene 2004]. Resources which are particularly important in achieving competitive advantage are referred to as key resources. J. Barney [1991] suggests that key resources have to be valuable, rare, difficult to imitate and non-substitutable.

DCC concept emphasises the key importance of dynamic business capabilities in competitive advantage creation. The capabilities, which occupy the medium (second) level in the hierarchy of business success potentials, make it possible to acquire, integrate and reconfigure the resources and to adjust a firm to market changes. Dynamic capabilities involve strategically important processes, activities and mechanisms, which enable a firm to create new resources configurations within new markets emergence, their differentiation, development and decline [Eisenhardt, Martin 2000]. Dynamic capabilities determine the creation, integration and reconfiguration of operational capabilities connected with securing current tasks performance [Teece, Pisano, Shuen 1997] and create premises and possibilities of business success. It may be said that within DCC concept, the most important sources of competitive advantage are assigned not just to business (firm) resources, but to firm capabilities of their use and effective exploitation (business dynamic capabilities).

Within the CBM concept, competences are the main "component" of business success potentials related to competitive advantage creation. R. Sanchez and A. Heene [2004] define organizational competence as the ability of an organization to sustain coordinated deployments of resources in ways that help the organization to achieve its goals. Competences result from interfunctional integration and coordination of capabilities relating to processes, activities and resources performed and exploited within the firm as well as the whole value chain [Javidan 1998].

Competences integrate firm resources with capabilities of their exploitation, accounting for the highest (third) level in the hierarchy of business success potentials which influence competitive advantage creation (figure 1) [Matwiejczuk 2011d].



Source: Own concept based on: Day, Wensley 1988; Javidan 1998; Prockl 2007.

Fig. 1. Hierarchy levels of business success potentials in the context of competitive advantage creation
Rys. 1. Poziomy hierarchii potencjałów sukcesu przedsiębiorstwa w kontekście tworzenia przewagi konkurencyjnej

As presented at figure 1, the hierarchy of business success potentials comprises the following components situated at three levels: resources (level 1), capabilities (level 2), and competences (level 3). Such components may be referred to as "strategic profile of business success potentials". The profile involves many detailed factors (types of resources, capabilities, and competences) influencing competitive advantage creation. Apart from "normative" factors concerning general business management, one may distinguish several "functional" types of factors determining competitive advantage. One of such areas is contemporary logistics.

LOGISTICS POTENTIALS AS COMPONENTS OF STRATEGIC PROFILE OF BUSINESS SUCCESS POTENTIALS

A. Sennheiser and M. Schnetzler [2008], who use the term "logistics potentials of outcomes", define the potentials as specific resources and capabilities in the logistics or even supply chain management area. A firm can exploit and / or develop these potentials in the long run in order to achieve sustained and significant outcomes within logistics / supply chain management area.

According to P. J. Daugherty et al. [2009], logistics resources may be perceived as

business strengths, exploited in competitive strategy development leading to sustained competitive advantage. Key logistics resources are important parts of logistics system. They are of higher value compared to other resources. This value depends on the level of inputs which are necessary to acquire and develop the resources. Such value is also related to the level of logistics service. In this sense logistics resources may be a significant source of sustained, long-term competitive advantage.

As to logistics capabilities, likewise "general" business capabilities, one may say about dynamic capabilities within logistics area [Matwiejczuk 2011c]. Dynamic logistics capabilities tend to exploit not only the existing business potentials, but also their long-term formation and development. Such capabilities may be then perceived as "drivers" of changes related to both business management system as well as market system. Dynamic logistics capabilities make it possible to efficiently and effectively exploit firm resources and firm operational capabilities, by means of "creating" their new and innovative configurations, ensuring better changes adjustment. Integration and coordination of logistics resources and logistics capabilities enable, finally, formation and development of logistics competences which may have significant influence on competitive advantage creation.

LOGISTICS COMPETENCES AS BUSINESS SUCCESS POTENTIALS INFLUENCING COMPETITIVE ADVANTAGE CREATION IN THE LIGHT OF RESEARCH STUDIES

Logistics competences and their influence on competitive advantage creation have been the subject of several interesting research studies. Among them there is the research carried out by: (1) Michigan State University (MSU) /in two editions: 1995 and 1999/, (2) European Logistics Association in cooperation with A.T. Kearney (ELA/A.T. Kearney), (3) Computer Sciences Corporation (CSC) and (4) Capgemini (table 1).

Table 1. Logistics competences in world-wide research studies
Tabela 1. Kompetencje logistyki w badaniach światowych

Logistics competences	MSU 1995	MSU 1999	ELA / A.T. Kearney	CSC	Capgemini
1. Logistics positioning and integration within business management	■	■	□	□	□
2. Integration with suppliers	□	■	□	□	□
3. Integration with distribution companies	■	■	□	□	□
4. Integration with customers	■	■	■	■	■
5. Internal integration	□	■	□	■	■
6. Agility (adaptability and flexibility)	■	■	■	■	■
7. Flow leaness and transparency	□	□	■	■	■
8. Logistics processes	□	□	□	■	■
9. Order management	■	■	■	■	■
10. Information systems and technologies	□	□	■	■	■

■ Logistics competences presented in relatively wide scope within world-wide research studies
□ Logistics competences presented in relatively narrow scope within world-wide research studies

Source: Own concept based on: Blaik et al. 2013; Matwiejczuk 2011a; Matwiejczuk 2011b; Matwiejczuk 2012a; Matwiejczuk 2012b

The above research studies have confirmed relatively differentiated, but - in general - positive impact of complex logistics competences on business success and competitive advantage creation [Matwiejczuk 2011a, Matwiejczuk 2011b]. The world-wide research results have been a basis of research on logistics competences as factors influencing business competitive advantage carried out at Chair of Logistics and Marketing at Opole University, Poland. (The research has been carried out by author during 2012 using CAWI (Computer Assisted Web Interview), CATI (Computer Assisted Telephone Interview), and CAPI (Computer Assisted Personal Interview) methods. The sample comprised 62 firms representing the following lines of business (sectors): mining and extraction mining (1 firm), industrial processing (19), media production and delivery - energy, gas, etc. (2), building engineering (3), commerce (21), transport and warehousing (7), accommodation and catering (2), information and communication (7)). The most significant result of the research has been the original model of business success potentials and symptoms with highlighted role of logistics competences influencing competitive advantage creation (figure 2).

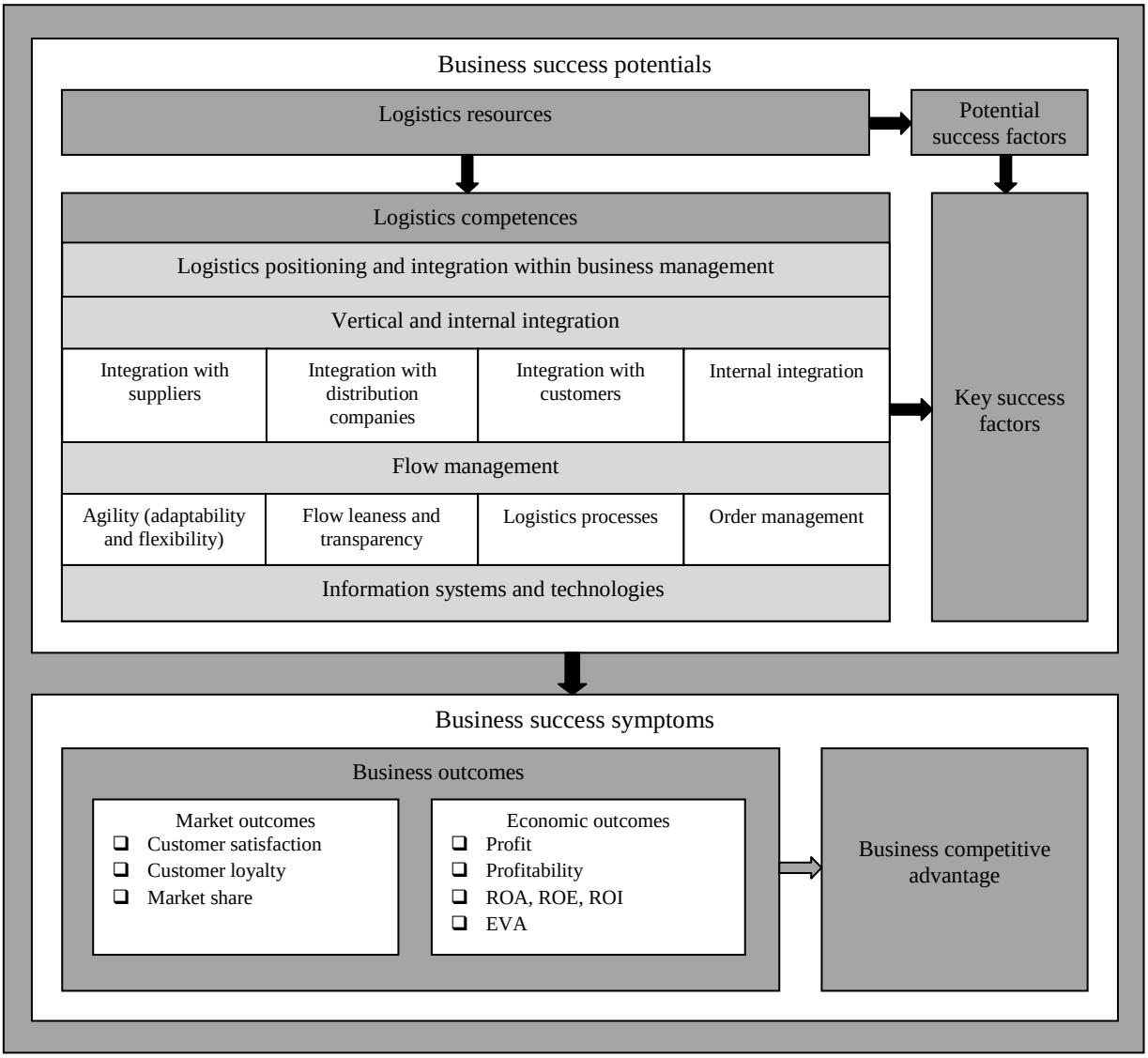


Fig. 2. Logistics competences within the model of business success potentials and symptoms
Rys. 2. Kompetencje logistyki w modelu potencjałów i wyznaczników sukcesu przedsiębiorstwa

Firstly, four key (superior) logistics competences have been distinguished. They may vary significantly contribute to business competitive advantage creation. These competences are as follows:

1. Logistics positioning and integration within business management,
2. Vertical and internal integration,
3. Flow management,
4. Information systems and technologies.

Within logistics competences concerning vertical and internal integration there are:

1. Integration with suppliers,
2. Integration with distribution companies,
3. Integration with customers,
4. Internal integration (integration within the firm).

As to logistics competences within flow management, the following competences have been specified:

1. Agility, comprising adaptability and flexibility,
2. Flow leanness and transparency,
3. Logistics processes,
4. Order management.

In the next step, the mentioned (ten) groups of logistics competences have been detailed into itemized logistics capabilities influencing business competitive advantage creation (table 2).

Table 2. Structure of logistics competences (detailed logistics capabilities) influencing business competitive advantage creation

Tabela 2. Strukturyzacja kompetencji logistyki (szczegółowe zdolności logistyczne) wpływających na tworzenie przewagi konkurencyjnej przedsiębiorstwa

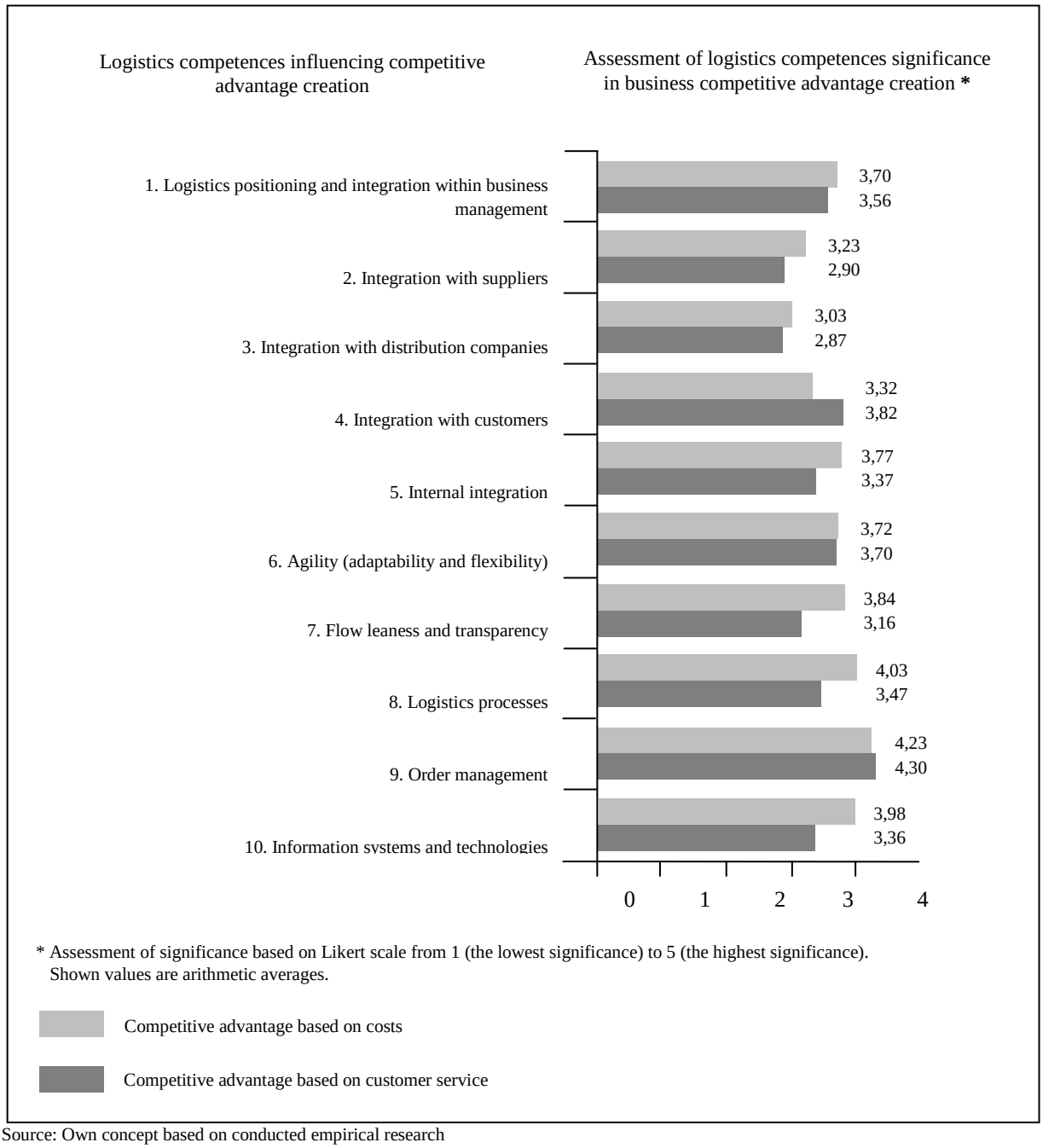
Logistics competences influencing competitive advantage	Detailed logistics capabilities ("bricks" of logistics competences) influencing competitive advantage
1. Logistics positioning and integration within business management	1.1. Logistics integration within corporate mission and strategic trends of business development 1.2. Integration of logistics goals with general corporate goals 1.3. Integration of logistics strategies with general corporate strategy 1.4. Integration of logistics operational tasks with corporate tasks 1.5. Integration of logistics planning with corporate planning 1.6. Logistics as functional area within corporate organizational structure
2. Integration with suppliers	2.1. Suppliers segmentation 2.2. Key suppliers identification 2.3. Business information sharing with suppliers 2.4. Suppliers engagement within product development process 2.5. Revenues, costs and profits sharing with suppliers
3. Integration with distribution companies	3.1. Distribution companies segmentation 3.2. Key distribution companies identification 3.3. Business information sharing with distribution companies 3.4. Distribution companies engagement within product development process 3.5. Revenues, costs and profits sharing with distribution companies
4. Integration with customers	4.1. Customers segmentation 4.2. Key customers identification 4.3. Business information sharing with customers 4.4. Customers engagement within product development process 4.5. Revenues, costs and profits sharing with customers
5. Internal integration	5.1. Logistics and operations management (production) integration 5.2. Logistics and marketing / promotion integration 5.3. Logistics and technology development integration 5.4. Logistics and trade / sales integration 5.5. Logistics and procurement integration

Logistics competences influencing competitive advantage	Detailed logistics capabilities ("bricks" of logistics competences) influencing competitive advantage
6. Agility (adaptability and flexibility)	6.1. Monitoring / identification of suppliers' needs and expectations 6.2. Monitoring / identification of distribution companies needs and expectations 6.3. Monitoring / identification of customers' needs and expectations 6.4. Suppliers service care 6.5. Distribution companies service care 6.6. Customers service care 6.7. Suppliers' unique order execution 6.8. Distribution companies unique order execution 6.9. Customers' unique order execution
7. Flow leaness and transparency	7.1. Value creation streams flowgistics 7.2. Value creation processes / tasks focusing 7.3. Non-value creation processes / tasks outsourcing 7.4. Raw materials and materials stock monitoring 7.5. Products (finished goods) stock monitoring
8. Logistics processes	8.1. Transportation management (TMS) 8.2. Warehousing management (WMS) 8.3. Handling, packaging and labeling management 8.4. Inventory management 8.5. Raw materials and materials supply management 8.6. Distribution management 8.7. Reverse flow management
9. Order management	9.1. Reliability of supply (delivery) 9.2. On-time supply (delivery) 9.3. Completeness of supply (delivery) 9.4. Accuracy of supply (delivery) 9.5. Flowgistics of supply (delivery) 9.6. Speed of supply (delivery) 9.7. Flexibility of supply (delivery)
10. Information systems and technologies	10.1. Material Requirements Planning (MRP) 10.2. Manufacturing Resource Planning (MRP II) 10.3. Distribution Resource Planning (DRP) 10.4. Enterprise Resource Planning (ERP) 10.5. Electronic Data Interchange (EDI) 10.6. Radio-Frequency Identification (RFID) technology and systems

The aim of the research conducted by the author within the Chair of Logistics and Marketing research studies has been an attempt to evaluate logistics competences significance in business competitive advantage creation. Every time the evaluation has been related to two basic dimensions of competitive advantage: (1) competitive advantage achieved through focusing on costs (cost leadership) and (2) competitive advantage achieved through focusing on customer service (creation and delivering of unique value for customers) (figure 3).

The research results have mostly confirmed the significant importance of logistics competences as potentials of a business competitive advantage creation. According to firms (managers) which (who) took part in the research, logistics competences concerning customers' orders management are the most important factors influencing competitive advantage creation. These competences contribute to both: competitive advantage based on cost leadership, as well as competitive advantage based on customer service.

Relatively high importance has also been assigned to competences related to logistics processes and competences related to information systems and technologies. These two groups of competences contribute mainly to competitive advantage based on costs.



Source: Own concept based on conducted empirical research

Fig. 3. The significance of logistics competences in business competitive advantage creation in the light of research conducted in firms operating in Poland

Rys. 3. Znaczenie kompetencji logistyki w tworzeniu przewagi konkurencyjnej przedsiębiorstwa w świetle badań w przedsiębiorstwach w Polsce

FURTHER RESEARCH

The purpose of further research will be a more detailed identification of premises and possibilities concerning logistics potentials influence on competitive advantage creation. Logistics resources as potential business success factors and logistics capabilities as well as logistics competences as key (superior) business success factors require deeper and more comprehensive assessment. Such assessment could lead to better embedding of logistics potentials (i.e. resources, capabilities and competences) within strategic management area, and especially within competitive advantage creation problems.

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POTENCJAŁY LOGISTYKI W TWORZENIU PRZEWAGI KONKURENCYJNEJ PRZEDSIĘBIORSTWA

STRESZCZENIE. **Wstęp:** Przedsiębiorstwa stale poszukują sposobów osiągania i utrzymywania przewagi konkurencyjnej na rynku. Wśród czynników determinujących tworzenie tej przewagi można wy-mienić m.in. tzw. potencjały logistyki, stanowiące część składową potencjału strategicznego przedsiębiorstwa. Strukturę i - jednocześnie - hierarchię potencjałów logistyki tworzą w kolejności: (1) zasoby logistyczne, (2) zdolności logistyczne oraz (3) kompetencje logistyki.
Metody: W celu rozpoznania potencjałów logistyki determinujących tworzenie przewagi konkurencyjnej warto wykorzystać założenia i elementy współczesnych koncepcji zarządzania, w tym zwłaszcza zarządzania strategicznego. Szczególną rolę w świetle problematyki niniejszego artykułu można przypisać koncepcji zasobowej, koncepcji dynamicznych zdolności oraz - przede wszystkim - koncepcji zarządzania opierającego się na kompetencjach.
Wyniki i wnioski: Zakres oraz możliwości oddziaływania potencjałów - w tym zwłaszcza kompetencji - logistyki na tworzenie przewagi konkurencyjnej przedsiębiorstwa przedstawiono jak dotąd m.in. w kilku znaczących projektach badawczych. Zaprezentowane syntetycznie w niniejszym artykule wyniki badań przeprowadzonych przez Michigan State University, European Logistics Association we współpracy z A.T. Kearney, Computer Sciences Corporation oraz Capgemini, wskazały na zróżnicowane, ale jednocześnie wyraźne przejawy oddziaływania kompetencji logistyki na tworzenie przewagi konkurencyjnej przedsiębiorstwa. W artykule odniesiono się również do rezultatów badań Katedry Logistyki i Marketingu Uniwersytetu Opolskiego przeprowadzonych w przedsiębiorstwach w Polsce, dotyczących znaczenia kompetencji logistyki w tworzeniu przewagi konkurencyjnej..

Słowa kluczowe: logistyka, przewaga konkurencyjna, potencjały, zasoby, zdolności, kompetencje.

LOGISTIKPOTENTIALE IN DER BILDUNG DES KONKURRENZVORSPRUNGS DES UNTERNEHMENS

ZUSAMMENFASSUNG. Einleitung: Die Unternehmen suchen ständig nach Art und Weise, den Konkurrenzvorsprung auf dem Markt zu erreichen und zu erhalten. Unter den diesen Vorsprung determinierenden Faktoren kann man u.a. die s.g. Logistikpotentiale nennen, die den Bestandteil des strategischen Unternehmenspotentials bilden. Die Struktur und - gleichzeitig - die Hierarchie von Logistikpotentialen bilden in folgender Reihe: (1) Logistikbestände, (2) Logistikfähigkeiten sowie (3) Logistikkompetenzen.
Methoden: Um die die Bildung des Konkurrenzvorsprungs determinierenden Logistikpotentiale zu erkennen, lohnt es sich, die Voraussetzungen und Elemente der Gegenwartsmanagementskonzepte anzuwenden, darin besonders die des strategischen Managements. Im Lichte der Problematik des vorliegenden Artikels kann man der Bestandskonzeption, der Konzeption der dynamischen Fähigkeiten und - vor allem - der Konzeption des sich auf die Kompetenzen stützenden Managements eine besondere Rolle zuschreiben.
Ergebnisse und Schlussfolgerungen: Der Umfang sowie die Möglichkeiten der Einwirkung von Potentialen - darin besonders von der Logistikkompetenz auf die Bildung des Konkurrenzvorsprungs des Unternehmens - sind bisher u.a. in einigen bedeutenden Forschungsprojekten dargestellt worden. Die im vorliegenden Artikel zusammenfassend präsentierten Forschungsergebnisse, die von (1) Michigan State University (USA), (2) European Logistics Association in Zusammenarbeit mit A. T. Kearney, (3) Computer Sciences Corporation sowie (4) Capgemini durchgeführt wurden,

haben auf differenzierte, aber zugleich deutliche Einwirkungszeichen der Logistikkompetenz auf die Bildung des Konkurrenzvorsprungs des Unternehmens hingewiesen. Im Artikel hat man sich auch auf die Ergebnisse der Forschungen des Lehrstuhls für Logistik und Marketing der Universität Opole bezogen, die in den Unternehmen in Polen durchgeführt worden sind und die Bedeutung der Logistikkompetenz in der Bildung des Konkurrenzvorsprungs betroffen haben.

Codewörter: Logistik, Konkurrenzvorsprung, Potentiale, Bestände, Fähigkeiten, Kompetenzen

dr inż. Rafał Matwiejczuk
Opole University
Faculty of Economics
Chair of Logistics & Marketing
46a Ozimska St.
45-058 Opole, Poland
e-mail: rmatwiejczuk@uni.opole.pl

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A MEASURE OF INTERNAL SYNERGY OF THE COLLECTIVE SYSTEM

Novikov V.A.[1], Sapun O.L.[1], Shipulina L.G.[2]

[1] Belarusian State Agrarian Technical University, [2] International University "MITSO"

ABSTRACT. Background: The authors examine the methodology of HRM personnel management based on ratings. Proposed to represent a collective system that uses a matrix of pair relations as a system of linear differential equations. The condition of auto generation of an autonomous system can be determined by the application of the Laplace transformation to the system. This condition mainly depends on the main eigenvalue of dating relationships matrix. Assuming the oscillation frequency is straightly proportional to the system's synergy rating, a special algorithm of comparative evaluation of several collective systems was suggested.
Methods: The calculation of the rating of internal synergies is based on the representation of the collective system as a system of linear differential equations, the coefficients of which are obtained by questionnaire survey of all members of the team. Internal representation of the system's synergism as a stimulation of an autonomous system allows using the eigenvector of the system as a measure of internal synergies.
Results: The result of this method is the rating of members of interacting collective systems in terms of their contribution to the self-organization sharing behavior.
Conclusions: Using a matrix of pair relations allows without direct programming and only using MathCad determines the measure of internal synergy of a collective system.

Key words: synergy, rating, matrix of pair relations, autonomous system, differential equation, Laplace transform, frequency of auto generation, eigenvalue, eigenvector.

INTRODUCTION

According the concept of HRM, the most important task of any collective system is to establish the collective ratings of system activities. Nowadays the concept of ratings adopted as the basis of incentives for a team activities. Obviously, the mechanisms of ratings should be based on tangible results of each team's member. The purpose of the ratings is to provide greatest synergy [Lodon 2005] of the team as a collective system. In this regard, the rating of the members defined not by the system of an administrative control, but by the team itself is really important. Obviously such a rating takes into account the underlying mechanisms of synergy and can be used by the administration to identify the reserves for increasing the effectiveness of the system, not only from the point of view of the actual results, but also in terms of ensuring a favorable atmosphere inside the team. Moreover a mission of any organization is impossible without a clear, structured approach for its activities [Fedotova, Semenov, Siskin 2003], with identification of the active mediums of the mission [Shpak 2002].

The matrix criteria-oriented testing based on the game theory matrix of the states can play a special role in detection of the ratings.

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RESULTS AND DISCUSSION

Let us suppose a collective system as the dynamic system with absence of any non-linear mechanisms of interaction between the elements of the system. In this case, for a system of N elements, dynamic behavior of the system in time is described by a system of differential equations

$$\frac{dX}{dt} = AX + B,$$

where:

$X \equiv X(t)$, $X=(x_1,\ldots,x_N)^T$, $x_i(t)$ - dynamic behavior in time of i-element of the system,
B - administrative and other external influence on the system,
A - matrix of pairwise interactions of system's elements.

In our case the stationary behavior of the system is under interest, B = const and A = const. Our task is finding out the ratings of a collective system from the point of view of its internal synergy thus B=0 because we should consider the autonomous system.

The meaning of the matrix of pairwise interactions a_{ij} is to evaluate the usefulness for j-th member of business communication to i-th member of the team, for example in terms of scores from 0 to 10. The value $a_{12}=6$ means that second member evaluates the usefulness of a business communication with first member as 6 points. Thus, the matrix a_{ij} is asymmetric. From the standpoint of internal synergies $a_{ii}=0$, because this is not pair interaction.

So the task is to evaluate the dynamic behavior of an autonomous system of differential equations

$$\frac{dX}{dt} = AX(t)$$

with constant coefficient matrix a_{ij}. To solve the problem we pass from the time domain to the frequency domain by Laplace transform [5]:

$$X(p) = \int_0^{\infty} x(t) e^{-pt} dt = L(x(t))$$

In accordance with the property of the Laplace transform

$$L\left(\frac{dX}{dt}\right) = pX(p)$$

and the original autonomous system of partial differential equations comes to a system of linear algebraic equations:

$$pX = AX$$

Obviously, there will be a non-trivial solution X if the determinant

$$|A - p| = 0$$

i.e.

$$\begin{vmatrix} a_{11}-p & a_{12} & \Lambda & a_{1N} \\ a_{21} & a_{22}-p & \Lambda & a_{2N} \\ \Lambda & \Lambda & \Lambda & \Lambda \\ a_{N1} & a_{N2} & \Lambda & a_{NN}-p \end{vmatrix} = 0$$

This equation determines the condition of finding the eigenvalues p of A. For matrix A of size N the number of eigenvalues is equal to N, since this problem is equivalent to the calculation of roots of N-degree polynomial. Indeed, if we expand the determinant of A by the rules of its calculation, we obtain a polynomial equation of N-degree relatively to *p*. Among the eigenvalues may be real and complex roots. Complex roots do not have any meaningful interpretation. The real roots within the meaning of the variable *p* in Laplace transform represent the frequencies of the excitation of the system. If we identify a collective system with the cybernetic system, the system will always be excited at the largest positive frequency. From the point of view of the collective system, this means that the system tends to its most dynamic state in order to ensure the greatest internal synergies. The largest positive value of eigenvalue is known as the principal eigenvalue. If we compare some collective systems by the principal eigenvalue then the rating of internal synergies will match the ranking of principal eigenvalues in descending order. If we know the principal eigenvalue λ of the matrix A then we can determine the contribution of each x_i element of the system in formation of the excited state of the system at a frequency of λ:

$$A\overset{o}{X} = \lambda \overset{o}{X}$$

The solution of this system of equations for A is called an eigenvector of the system, which obviously will not be zero, as | A-λ | = 0. The resulting eigenvector can have positive or negative values, which in terms of their contribution to the internal synergies does no matter. That is why it is necessary to recalculate

$$\overset{o}{X} = \left|\overrightarrow{\overset{o}{X}}\right|$$

in accordance with the rules of vectorization in Mathcad. The measure of internal synergies in the form of λ and $\overset{o}{X}$`completely characterizes the system as a dynamic linear system. The contribution of each element of the system $x_i$ to the internal synergy is defined by ranking of the vector $\overset{o}{X}$` in descending order. The largest contribution to the internal synergies provides the resulting $\overset{o}{X}_1$.

The problem above is solved in full volume using Mathcad only. Suppose that we have a matrix A:

$$A = \begin{bmatrix} 0 & 1 & 5 & 8 \\ 3 & 0 & 9 & 4 \\ 9 & 1 & 0 & 7 \\ 2 & 6 & 3 & 0 \end{bmatrix}$$

in which each column *j* determines a value of the business relationship a_{ij} with i-th member of the team. Calculate with Mathcad the eigenvalues of A

$$p := \text{eigenvals}(A)$$

$$p = \begin{pmatrix} 14.177 \\ -7.638 \\ -3.269 + 4.727i \\ -3.269 - 4.727i \end{pmatrix}$$

among which we choose the principal eigenvalue λ = 14.177. For this eigenvalue compute eigenvector X1:

$$\lambda := p_1$$

$$X1 := \text{eigenvec}(A, \lambda)$$

$$X1 := \left|\overrightarrow{X1}\right|$$

$$X1 = \begin{pmatrix} 0.466 \\ 0.561 \\ 0.542 \\ 0.418 \end{pmatrix}$$

As follows from X1 greatest contribution to the internal synergy makes the 2nd team member, and the smallest - the 4th member.

Consider the second collective system with the matrix A:

$$A := \begin{bmatrix} 0 & 1 & 2 & 5 & 6 \\ 5 & 0 & 7 & 4 & 8 \\ 6 & 8 & 0 & 3 & 9 \\ 7 & 10 & 1 & 0 & 1 \\ 3 & 4 & 5 & 6 & 0 \end{bmatrix}$$

Similarly to the first system we calculate the principal eigenvalue λ2 = 19.972, which implies that the internal synergy of the second system is higher than of first system. Calculate the eigenvector of the system

$$X1 = \begin{pmatrix} 0.308 \\ 0.516 \\ 0.547 \\ 0.414 \\ 0.411 \end{pmatrix}$$

Comparative analysis of the rating systems must consider their principal eigenvalue as a measure of self-organizing systems. One can assume that the measure of self-organization of a system is proportional to the principal eigenvalue, i.e. oscillation frequency of the system. For a comparative analysis of rating indicators of the two systems together let us recount rating $X1_2$ as follows:

$$X1_2 = X1_2 \frac{\lambda_2}{\lambda_1},$$

$$X1 = \begin{pmatrix} 0.433 \\ 0.727 \\ 0.77 \\ 0.583 \\ 0.579 \end{pmatrix}$$

where λ_1 - the principal eigenvalue of the first system.

Comparing vector $X1_1$ and $X1_2$ we can define a total contribution of each member of the collective on their own internal synergies. As we can see, the third element of the first system has the largest rating in this regard, and the lowest rating is in the fourth element of the first system.

CONCLUSION

The proposed method of calculating measures of internal synergies could be on a par with other rating indicators useful in identifying formal and informal leaders and outsiders in the collective system.

The method is attractive because the initial data is one unified question and its solution does not require direct programming, since the problem can be easily solved by means of Mathcad [Chernyak 2003].

HRM concept of openness of the collective system from the standpoint of human resource management is one of the most important conditions for the moral climate in the collective. The identification of the internal rating of synergy may be an additional motivation for the team's unity in the conditions of the transition to the business-process structuring. Obviously, during reengineering [Oyhman, Popov 1997] of this transition, taking into account internal synergy eliminates the negative aspects of the reorganization of the team from the point of synergy [Novikov, Kharitonov 2011].

The proposed method of application of the criteria evaluation matrix is of particular interest in the implementation of mechanisms for management decisions [Ulyashina 2007] at stages of training of government specialists.

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POMIAR SYNERGII WEWNĘTRZNEJ SYTEMU

STRESZCZENIE. **Wstęp:** Autorzy przeprowadzili badanie metodologii zarządzania pracownikami HR w oparciu o metodę rankingową. Omawiana metoda pozwala na zastosowanie matrycy zależności jako systemu równań liniowych.
Metody: Przygotowanie ranking wewnętrznych zależności zostało oparte na przedstawieniu badanego systemu jako systemu równań liniowych, których współczynniki zostały dobrane na podstawie przeprowadzonych ankiet. Wewnętrzne przedstawienie synergizmu systemu jako czynnika stymulującego autonomiczny system pozwala na zastosowanie wektorów własnych systemu jako mierników wewnętrznych synergii.
Wyniki: Zaprezentowano ranking członków złożonego systemu w odniesieniu do ich udziału w współtworzenie organizacyjne tego systemu.
Wnioski: Zastosowanie macierzy wzajemnych zależności pozwala bez konieczności bezpośredniego programowania, a tylko za pomocą MathCad, na wyznaczenie mierników synergii wewnętrznej system złożonego..

Słowa kluczowe: synergia, ranking, macierz wzajemnych zależności, system autonomiczny, równanie, transformacja Laplace'a, częstotliwość autogeneracji, wartość własna, wektor własny.

BEMESSUNG DER INNEREN SYNERGIE EINES SYSTEMS

ZUSAMMENFASSUNG. Einleitung: Die Autoren haben eine Untersuchung in Bezug auf die Methodologie des Managements von HR-Mitarbeitern in Anlehnung an die Ranking-Methode durchgeführt.
Methoden: Die Ermittlung des Rankings von inneren Abhängigkeiten wurde auf die Projizierung eines Systems als System von Linien-Gleichheiten, deren Koeffizienten auf Grund von gewonnenen Fragebögen erfasst wurden, gestützt. Die innere Projizierung des System-Synergiesmus als des das autonomische System stimulierenden Faktors erlaubt, die eigenen Vektoren des Systems als Messer der inneren Synergien anzuwenden.
Ergebnisse: Es wurde das Ranking der Mitglieder eines komplexen Systems in Bezug auf deren Beteiligung am organisatorischen Aufbau des betreffenden Systems präsentiert.
Fazit: Die Anwendung der Matrix für gegenseitige Abhängigkeiten erlaubt ohne die Notwendigkeit eines direkten Programmierens, sondern lediglich mithilfe von MathCad, die Messwerte der Synergie innerhalb eines komplexen Systems zu ermitteln.

Codewörter: Synergie, Ranking, Matrix für gegenseitige Abhängigkeiten, autonomisches System, Gleichung, Laplace-Transformation, Frequenz der Autogeneration, eigener Wert, eigener Vektor

Novikov Vasiliy
International University „MITSO”
220099, Belarus, Minsk, Kazintsa St. 21/2
e-mail: vanovikov@tut.by

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CYCLIC DELIVERY SCHEDULING TO CUSTOMERS WITH DIFFERENT PRIORITIES

Katarzyna Zofia Gdowska, Roger Książek

AGH University of Science and Technology, Krakow, Poland

ABSTRACT. Background: In this paper a cyclic delivery scheduling problem for customers with different priorities is presented. Shops, which are provided with deliveries, are occasionally located in places which are crucial for the proper flow of traffic. In such places coordination of deliveries is crucial; therefore it allows to completely eliminate the phenomenon of the simultaneous arrivals of suppliers.
Methods: In this paper the cyclic delivery scheduling problem for customers with different priorities was presented. To this theoretical problem a mix integer programming model was developed. Specific approach to the cyclic delivery scheduling problem is inspired by timetabling problem for urban public transport.
Results: Mixed integer programming model was employed for solving four cases of cyclic delivery scheduling problem for customers with different priorities. When the value of the synchronization priority assigned to a single customer raised then the total number of synchronizations in the whole network decreased. In order to compare solutions a synchronization rate was utilized. A simple factor was utilized - the proportion of number of synchronizations of deliveries to a given customer to the total number of synchronizations obtained for the whole network. When the value of synchronization priority raised then the value of synchronization rate of this customer improved significantly.
Conclusions: The mixed integer programming model for the cyclic delivery scheduling problem for customers with different priorities presented in this paper can be utilized for generating schedules of serving customers located in places where only one delivery can be received and unloaded at one go and where there is no space for other suppliers to wait in a queue. Such a schedule can be very useful for organizing deliveries to small shops united in a franchising network, since they operate in a way that is very similar to the network presented in this paper. Moreover, in a franchising network it is possible to implement and control coordination between deliveries.

Key words: cyclic delivery scheduling problem, mixed-integer programming, optimization, time windows.

INTRODUCTION

In this paper a cyclic delivery scheduling problem for customers with different priorities is presented. This issue seems to be a very significant problem in the field of city logistics, especially when cyclic deliveries to small shops in the city center are considered. Small restaurants and small shops, where people do food and grocery shopping, are located one next to another in narrow, crowded and sometimes one-way streets of residential areas and city centers. Such shops and restaurants need to be cyclically supplied: firstly, they offer fresh products which need to be replaced no later than their best before date and, secondly, they usually are short of storage facilities. Nevertheless, more and more often such shops are united in a franchising network, so that deliveries to all of them are organized and coordinated by a regional center; it is very

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useful as far as deliveries of such good as pastry or dairy product are concerned. Suppliers-wholesalers cyclically provide their customers-shops with subsequent lot of fresh goods. Due to the fact that the frequency and number of deliveries is significantly high, uncoordinated arrivals of the suppliers' vehicles may interfere in a negative way the flow of the traffic in the given area. Therefore there is a need to introduce coordination of cyclic deliveries by setting a schedule for all the suppliers and customers. If there is no coordination of suppliers' arrival, we can observe a situation which we know very well by experience of our everyday lives - two or three suppliers' cars arrive at the same time to a given customer and they have to wait until the previous ones in the queue are unloaded. These cars frequently block a street in which the shop is located and, as a result, they hamper the flow of traffic. Furthermore, it should be emphasized, that shops to which this paper is referred are occasionally located in places which are crucial for the proper flow of traffic. In such places coordination of deliveries is crucial, since it allows to eliminate completely simultaneous arrivals of suppliers. The customers know the demand for goods they offer, therefore, they are able to determine time between consecutive deliveries, so that their shops never run out of products. Similarly, the suppliers know locations of all the customers they serve, as well as travel times between a wholesaler's warehouse and the location of a shop-customer, hence, suppliers also are able to determine a route for their cars; such a route is defined by the order of customer to be visited one after another. Certainly, specific conditions connected to both suppliers and customers should be taken into account in the structure of the delivery schedule.

In this paper the cyclic delivery scheduling problem for customers with different priorities was presented as a theoretical problem for which a mix integer programming model was developed. The model was employed for solving a small possible situation – computational experiment is presented and results are reported.

The paper is organized as follow: the first paragraph is devoted to general description of the cyclic delivery scheduling problem for customers with different priorities. In the second paragraph a mixed integer programming model for the cyclic delivery scheduling problem for customers with different priorities is presented. In two subsequent paragraphs utilization of the MIP model is presented and results obtained in computational experiments are reported. The final paragraph provides recapitulation of the presented problem and suggests directions for further research.

CYCLIC DELIVERY SCHEDULING PROBLEM FOR CUSTOMERS WITH DIFFERENT PRIORITIES

The problem of planning and realizing deliveries from suppliers to customers include the whole spectrum of issues referred to transportation, scheduling and synchronization. Particular problems were defined in different ways, depending on the aspects of the problem that were selected to be included and represented in the model. Transportation problems include numerous different problems, amongst others, vehicle routing problem [Toth and Vigo 1992, Ambroziak and Jachimowski 2011], travelling salesman problem [Laporte 1992, Takei et al. 2010], scheduling problem [Castelli et al. 2004] and timetabling problem [Ceder et al. 2001, Ibarra-Rojas and Rios-Solis 2012, Eranki 2004, Gdowska and Książek 2012a, 2012b]. Furthermore, the area of cyclic deliveries is also well explored. Amongst main problems may be listed: periodic service scheduling [Kazan et al. 2012], minimizing the number of vehicles [Campbell et al. 2005], seasonal deliveries [Ching-Ter and Hsiao-Ching 2013], manufacturing and distribution scheduling with fixed delivery departure dates [Leunga and Chen 2013] or with time windows [Ullrich 2013], cost optimization [Nidhi and Anil 2011] and issues referring to quality, safety and sustainability of distribution [Akkerman et al. 2010]. The reasons for the great number of formulations of transportation problems are, on one hand, criteria and goals to be fulfilled by the obtained solution and, on the other hand, specific organizational conditions of realizing deliveries.

In this paper utilization of a mixed integer programming model for the cyclic delivery scheduling problem with time windows for customers with different priorities is presented. The scope of the model is to obtain a schedule of synchronized deliveries, so that all the customers' receiving points are evenly loaded. Such an approach to the cyclic delivery scheduling problem is inspired by timetabling problem for urban public transport. The definition of synchronization and variables utilized in the model presented in this paper were taken from The Bus Synchronisation Timetabling Problem (BTP) [Ibarra-Rojas and Rios-Solis 2012]. As a result a model for the cyclic delivery scheduling problem was developed.

As it was mentioned before, every customer is characterized by specific conditions of delivery unloading; therefore, the priority of synchronization of deliveries' arrivals was assigned to every customer. According to the approach presented in this paper synchronization between deliveries is understood as a situation when deliveries from two suppliers arrive at a given customer's one after another and the required interval between their arrivals is kept. The customers achieve different values of synchronization priority, according to the following rule: the more important synchronization of deliveries at a given customer's is, the higher value of the synchronization priority is assigned to him. In result, deliveries to the crucial customers are synchronized, since they are awarded high value of the synchronization priority.

MIXED INTEGER PROGRAMMING MODEL FOR THE CYCLIC DELIVERY SCHEDULING PROBLEM FOR CUSTOMERS WITH DIFFERENT PRIORITIES

A mixed integer programming model was developed for the cyclic delivery scheduling problem for customers with different priorities. In the model following sets, variables and parameters were utilized: I - set of suppliers, B - set of customers, for each supplier there is a defined set of deliveries to be realized from the i-th supplier's warehouse (F_i), T – parameter, planning horizon, that is the period during which all the deliveries must departure from suppliers' warehouses, but it is not necessary for them to be delivered and unloaded at customers', f_{ri} - parameter, number of the last delivery to be realized from the i-th supplier's warehouse (i-th supplier provides all his customers with the same number of deliveries), h_i - parameter, minimal interval between departures of consecutive deliveries from the i-th supplier's warehouse (minimal headway time), H_i - parameter, maximal interval between departures of consecutive deliveries from the i-th supplier's warehouse (maximal headway time), t_{ib} - parameter, travel time between the i-th supplier's warehouse and the b-th customer's warehouse, w_b - parameter, desirable minimal interval between arrivals of consecutive deliveries in the b-th customer's. Parameter J_{ij} yields the value 1, if i-th and j-th suppliers have at least one common customer, and the parameter S_{ijb} yields the value 1, if i-th and j-th suppliers serve the b-th customer, which means that their deliveries may be synchronized according to the b-th customer's requirements.

In this model two types of variables were utilized: X_{ip} - departure time of the p-th delivery from the i-th supplier's warehouse, Y_{ijbpq} - presence or absence of synchronization between every pair of deliveries that arrive in the b-th customer's. Complete notation utilized in the model is presented in the table 1.

The original BTP model was modified in order to adjust it to the cyclic delivery scheduling problem. First of all, the objectivity function was changed: we maximize the total number of synchronizations augmented by the total sum of payments (priorities) earned thanks to obtained synchronizations. As it was already said, synchronization between deliveries is understood here as a situation when deliveries from two suppliers arrive at a given customer's one after another and the required interval (parameter w_b) between their arrivals is kept.

Table 1. Notation
Tabela 1. Oznaczenia przyjęte w modelu

Sets:	
I	set of suppliers
B	set of customers
F_i	set of deliveries to be realized from the *i*-th supplier's warehouse
Variables:	
X_{ip}	(integer veriable) departure time of the *p*-th delivery from the *i*-th supplier's warehouse
Y_{ijbpq}	Y_{ijbpq} = 1, if the *p*-th delivery from the *i*-th supplier arrives in (and is unloaded) the *b*-th customer's warehouse before the *q*-th delivery from the *j*-th supplier, otherwise Y_{ijbpq} = 0.
Parameters:	
T	planning horizon
H_i	maximal interval between departures of consecutive deliveries from the *i*-th supplier's warehouse (maximal headway time)
h_i	minimal interval between departures of consecutive deliveries from the *i*-th supplier's warehouse (minimal headway time)
w_b	upper limit of the time window during which only one supplier should be unloaded at the *b*-th customer's
t_{jb}	travel time between the *i*-th supplier's warehouse and the *b*-th customer's warehouse (time of unloading at every the customer's preceding the *b*-th customer on the *i*-th supplier's trip is included)
M	big number
J_{ij}	J_{ij} = 1, if a delivery from *i*-th supplier is allowed to be synchronised with a delivery from *j*-th supplier; otherwise J_{ij} = 0
S_{ijb}	S_{ijb} = 1, j if a delivery from *i*-th supplier is allowed to be synchronised with a delivery from *j*-th supplier in the *b*-th customer's warehouse; otherwise S_{ijb} = 0
fr_i	number of deliveries to be realized from the *i*-th supplier's warehouse
k_b	synchronization priority of the *b*-th customer

Source: own work based on the BTP model [Ibarra-Rojas and Rios-Solis 2012].

Table 2. Mixed integer programming model for the cyclic delivery scheduling problem for customers with different priorities
Tabela 2. Model programowania całkowitoliczbowego mieszanego dla problemu harmonogramowania cyklicznych dostaw do odbiorców o różnych priorytetach

Objectivity function:		
$\max \rightarrow \sum_{i\in I}\sum_{j\in I}\sum_{b\in B}\sum_{p\in F}\sum_{q\in F}(Y_{ijbpq} + Y_{ijbpq} * k_b) * J_{ij} * S_{ijb}$	$i, j \in I; b \in B; p \in F_i; q \in F_j$	
Subject to:		
$X_{i,1} \le H_i$	$i \in I$	(1)
$X_{i,fr_i} \le T$	$i \in I$	(2)
$T - H_i \le X_{i,fr_i}$	$i \in I$	(2a)
$h_i \le X_{i,p+1} - X_{ip}$	$i \in I; p \le F_i - 1$	(3)
$X_{i,p+1} - X_{ip} \le H_i$	$i \in I; p \le F_i - 1$	(3a)
$(X_{jq} + t_{jb}) - (X_{ip} + t_{ib}) \ge w_b - M(1 - Y_{ijpqb} J_{ij} S_{ijb})$		(4)
	$i, j \in I; b \in B; p \in F_i; q \in F_j$	
$Y_{ijbpq} J_{ij} S_{ijb} \le 1 - Y_{jibqp} J_{ji} S_{jib}$	$i, j \in I; b \in B; p \in F_i; q \in F_j$	(5)
$X_{ip} \in \{0,1,...T\}$	$i \in I; p \le F_i$	(6)
$Y_{ijbpq} \in \{0,1\}$	$i, j \in I; b \in B; p \in F_i; q \in F_j$	(7)

Source: own work based on the BTP model [Ibarra-Rojas and Rios-Solis 2012].

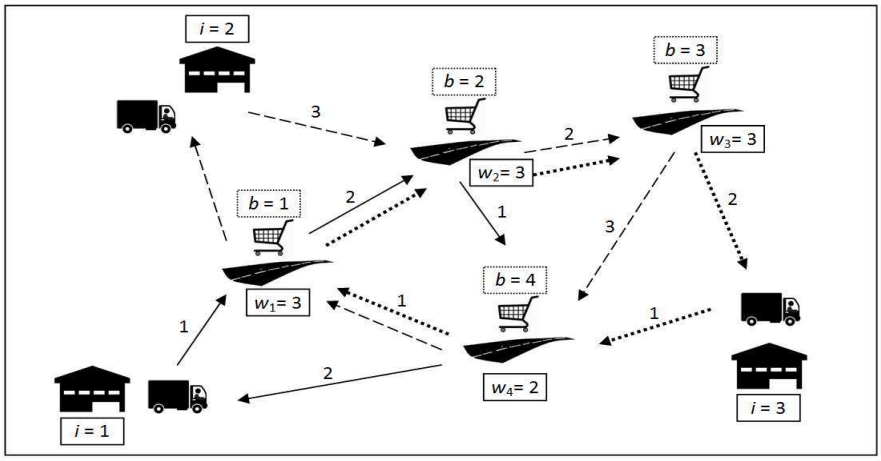
The constraint (1) of the model defines the latest possible departure time of the first delivery from the *i*-th supplier's warehouse; departure time equals to the maximal time between consecutive deliveries from the *i*-th supplier's warehouse (H_i). The constraints (2) and (2a) guarantee that all the deliveries will departure from suppliers' warehouses until the planning horizon T is over. The constraints (3) and (3a) assure that the required intervals between departures of consecutive deliveries from the i-th supplier's warehouse (parameters H_i and h_i) are kept. Synchronization of a pair of deliveries at the *b*-th customer's occurs only when the inequality in the constraint (4) is fulfilled, which means that the interval

between arrivals of two deliveries at the same customers' is no lesser than the value of the parameter w_b. The constraint (5) represents valid inequalities introduced to the model which forces the proper value of the variable Y_{ijbpq} depending on the value of the value of the opposite one, Y_{jibqp}. When the *i*-th supplier comes to the *b*-th customer before the *j*-th supplier no matter if they are or are not synchronized, then it is impossible to synchronize at the same time the situation when the *i*-th supplier comes before the *j*-th one.

COMPUTATIONAL EXPERIMENTS - A CYCLIC DELIVERY SCHEDULING PROBLEM FOR CUSTOMERS WITH DIFFERENT PRIORITIES SOLVED WITH THE MIP MODEL

Three suppliers provide cyclic deliveries to four customers. Every supplier visits the customers in the same order, planned in advanced. The route of the supplier remains the same for every trip he performs, since it was recognized to be the most suitable (the most frequently the cheapest) for the supplier. Therefore, in this situation, it is hardly possible to change the order of customers to visit.

During the week time every supplier (*i*) has to provide every customer *b* with a certain number of deliveries, f_{ri}. For every supplier (*i*) minimal (h_i) and maximal (H_i) intervals between departures of consecutive deliveries from his warehouse are defined. To every customer (*b*) is assigned a certain priority of synchronization (k_b). In result, the higher is the value of the priority of synchronization (k_b) assigned to the *b*-th customer, the more important is to synchronize deliveries arriving in the *b*-th customer's. It is because when the *p*-th delivery from *i*-th supplier arrives in the *b*-th customer's before the *q*-th delivery from *j*-th supplier and the interval between their arrivals is no lesser than the value of the parameter w_b, then the variable Y_{ijbpq} yields the value 1 and the objectivity function is augmented of the value k_{b+1}.



Source: own work

Fig. 1. Scheme of a problem of the cyclic delivery scheduling problem for customers with different priorities
Rys. 1. Schemat przykładowego problemu harmonogramowania cyklicznych dostaw do odbiorców o różnych priorytetach

In order to make it easier to schedule deliveries the following assumption was adopted: every customer works six days a week, ten hours a day. During working time a customer is ready to receive and unload one delivery at the same time. Therefore a 60-hour planning horizon *T* can be utilized in computations. What is more, it was assumed that time of delivery receiving and unloading is so short that it may be neglected.

In order to eliminate queues of vehicles waiting for unloading the model presented in the previous paragraph of this paper was utilized for the problem, since as a solution the model we obtain an optimal weekly delivery

schedule. Directly from the model we achieve departure time of every delivery from the supplier's warehouse. On that basis we can compute the arrival time of each delivery at customer's. The scheme of this problem is presented in the Fig. 1.

In the table 3 data utilized in computational experiments are presented. First of all, the order of deliveries is known and unchangeable. The number of deliveries to departure from every supplier's warehouse during the planning horizon (60 hours) is defined. In the table maximal and minimal intervals between departures of consecutive deliveries from the i-th supplier's warehouse are also given. This table also provides information of travel times t_{jb} between every supplier's warehouse and every customer is also provided; travel time between a supplier's warehouse and a customer was estimated as average travel time of driving along the route approved by the *i*-th supplier.

In table 4 routes of deliveries are presented as travel times between the *i*-th supplier's warehouse and the first customer on the route, and then travel times between every pair of customers visited consecutively by the *i*-th supplier. In this table information of desirable minimal interval between arrivals of consecutive deliveries in the *b*-th customer's (w_b) is provided.

Table 3. Data utilized in the computational experiment
Tabela 3. Dane wykorzystane w przykładowym zadaniu

	Order of deliveries / travel time t_{jb} [h]				Maximal time between consecutive deliveries from the *i*-th supplier's warehouse h_i [h]	Minimal time between consecutive deliveries from the *i*-th supplier's warehouse H_i [h]	Number of deliveries to be realised
	Customer						
	1	2	3	4			
Supplier 1	1/1	2/3	–/–	3/4	18	20	3
Supplier 2	4/9	1/3	2/5	3/8	12	15	4
Supplier 3	2/2	3/4	4/6	1/1	10	12	5

Source: own work

Table 4. Data - travel times between customers [h]
Tabela 4. Dane - czas przejazdu pomiędzy odbiorcami [h]

	Customer 1	Customer 2	Customer 3	Customer 4	Upper limit of the time window w_b
Supplier 1	1	-	-	-	-
Supplier 2	-	3	-	-	-
Supplier 3	-	-	-	1	-
Supplier 1	-	2	-	1	5
Supplier 2	2	-	2	1	5
Supplier 3	-	2	-	3	5
Supplier 4	1	1	3	-	7

Source: own work

The goal of the conducted computational experiment was to utilise a mixed integer programming model for solving four cases of cyclic delivery scheduling problem for customers with different priorities and to compare obtained results. Each of these four problems was formulated for data presented in tables 3 and 4. The only difference between them was different value of the synchronization priority assigned to the Customer 4. All the three suppliers provide customers with deliveries according to assumptions presented in the beginning of this paragraph (see Fig. 1.). In every case following values of the synchronisation parameter k_b were assigned (values of all the other parameters remain the same in every case - see tables 3 and 4):

- Case 1: k_1=0, k_2=0, k_3=0, k_4=0; (equal synchronization priorities),
- Case 2: k_1=0, k_2=0, k_3=0, k_4=1; (low synchronization priority assigned to the Customer 4),
- Case 3: k_1=0, k_2=0, k_3=0, k_4=10; (medium synchronization priority assigned to the Customer 4),

– Case 4: k_1=0, k_2=0, k_3=0, k_4=100; (high synchronization priority assigned to the Customer 4).

The goal of the conducted computational experiment was to solve these problems formulated as mixed integer programming models for the same set of data with the GLPK Solver (GNU Linear Programming Kit ver. 4.3). Computations were conducted with a computer equipped with a processor Intel® Core™2 Duo 2.00 GHz and 4 GB RAM. Searching for a solution was limited in advance by time limit that was equal 600 seconds. This amount of time was enough to obtain optimal solution for every problem.

RESULTS OBTAINED IN COMPUTATIONAL EXPERIMENTS

After solving four cases of cyclic delivery scheduling problem for customers with different priorities we obtained results which are to be found in the table 5. All the solutions are optimal from the perspective of the value of the objectivity function introduced in the utilised model. The value of the objectivity function equals the total number of synchronizations augmented by the total sum total number of synchronizations at the Customer 4 multiplied by priority of synchronization k_4. Priorities of synchronization have different values in every case, therefore there is no need to compare the quality of obtained solutions by comparing values of the objective function. Nevertheless, it is to be observed that solution obtained in Case 3 (medium synchronization priority assigned to the Customer 4) and in Case 4 (high synchronization priority assigned to the Customer 4) have the same the total number of synchronizations as well as the total number of synchronizations at the Customer's 4. Hence, attention should be paid to the total number of synchronizations obtained in every case. When the value of the synchronization priority assigned to the Customer 4 raised the total number of synchronizations in the whole network decreased. There was a following reason: by giving higher value of synchronization priority to the Customer 4 we forced the solver to search for the higher possible number of synchronizations for this customer and it made it more difficult to find synchronizations for other customers, so the total number of synchronizations was reduced but the value of the objectivity function rose.

Table 5. Results of computational experiments
Tabela 5. Wyniki eksperymentu obliczeniowego

		Priority assigned to the Customer 4			
		0	**1**	**10**	**100**
Value of the objective function		146	185	552	4242
Total number of synchronisations		146	145	142	142
Number of synchronisations	Customer 1	43	42	43	42
	Customer 2	45	45	42	42
	Customer 3	19	18	16	17
	Customer 4	39	40	41	41
Synchronisation rate	Customer 1	29,5 %	29,0%	30,3%	29,6%
	Customer 2	30,8 %	31,0%	29,6%	29,6%
	Customer 3	13,0 %	12,4%	11,3%	12,0%
	Customer 4	26,7 %	27,6%	28,9%	28,9%

Source: own work

According to assumptions adopted, quality of solutions can be evaluated by comparing obtained delivery schedules. In order to compare obtained optimal solutions the synchronization rate was developed. Synchronization rate is a proportion of number of synchronizations at a given customer's to the total number of synchronizations obtained for the whole network. As it was to be expected, when the value of synchronization priority assigned to the Customer 4 raised then the value of synchronization rate of this customer improved by ca. 2%. At the same time synchronization rate of other customers their

synchronization rates worsened. The size of improvement of the delivery schedule may not seem significant; however, obtaining one or two synchronizations extra in such a small network is not easy.

CONCLUSIVE REMARKS

The mixed integer programming model for the cyclic delivery scheduling problem for customers with different priorities presented in this paper can be utilized for generating schedules of serving customers located in places where only one delivery can be received and unloaded at one go and where there is no space for other suppliers to wait in a queue. Such a schedule can be very useful for organizing deliveries to small shops united in a franchising network, since they operate in a way that is very similar to the network prsented in this paper. Moreover, in a franchising network it is possible to implement and control coordination between deliveries.

Basing on results obtained in the computational experiments it may be stated that utilization of synchronization priority makes the problem more flexible and adjusted to the real conditions. In real conditions can be found shops or warehouses where simultaneous unloading of several suppliers is either impossible or unwelcome.

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 in this problem. Amongst them are to be listed: deliveries to warehouses or logistics center where many deliveries can be received in the same time, costs of travel and waiting time or vehicle assignment problem.

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HARMONOGRAMOWANIE CYKLICZNYCH DOSTAW TOWARÓW DO ODBIORCÓW O RÓŻNYCH PRIORYTETACH SYNCHRONIZACJI DOSTAW

STRESZCZENIE. **Wstęp:** W pracy przedstawiono problem harmonogramowania cyklicznych dostaw towarów do odbiorców o różnych priorytetach synchronizacji dostaw. Punkty handlowe, o których mowa w tym artykule, nierzadko są ulokowane przy ulicach, newralgicznych dla prawidłowego ruchu kołowego w mieście. W takich miejscach koordynacja dostaw do sklepów ma kluczowa znaczenie, gdyż zapobiega równoczesnym przyjazdom dostawców, a co za tym idzie tworzeniu utrudnień w ruchu.
Metody: Problem harmonogramowania cyklicznych dostaw towarów do odbiorców o różnych priorytetach synchronizacji dostaw został sformułowany jako zadanie teoretyczne, dla którego zbudowano model programowania całkowitoliczbowego mieszanego. Specyficzne ujęcie problemu harmonogramowania dostaw cyklicznych było inspirowane problemem układania rozkładów jazdy miejskiej komunikacji publicznej.
Wyniki: Eksperyment obliczeniowy polegał na rozwiązaniu i porównaniu uzyskanych wyników dla czterech zbudowanych zadań programowania całkowitoliczbowego mieszanego dla problemu cyklicznych dostaw do odbiorców o różnych priorytetach. Wraz ze wzrostem priorytetu dla jednego odbiorcy ogólna liczba synchronizacji dla całej sieci cyklicznych dostaw zmniejszyła się. W celu porównania jakości rozwiązań wyznaczono wskaźnik synchronizacji, rozumiany jako stosunek liczby synchronizacji dla danego odbiorcy do całkowitej ich liczby w rozwiązaniu dla danego zadania. Zastosowanie priorytetu synchronizacji dla odbiorcy spowodowało poprawę jego wskaźnika synchronizacji dostaw.
Wnioski: Przedstawiony model programowania liniowego mieszanego dla zadania harmonogramowania cyklicznych dostaw z priorytetami dla odbiorców może być wykorzystywany do tworzenia harmonogramów dla dostawców produktów do odbiorców, u których występują ograniczenia związane z jednoczesnym obsługiwaniem kilku dostawców równocześnie.

Słowa kluczowe: harmonogramowanie dostaw cyklicznych, programowanie całkowitoliczbowe mieszane, optymalizacja, okna czasowe.

Gdowska K.Z., Książek R., 2013, Cyclic delivery scheduling problem for customers with different priorities. LogForum LogForum 9 (4), 283-292.
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DER ZEITPLAN DER REGELMÄSSIG WIEDERKEHRENDEN PRODUKTLIEFERUNG MIT RÜCKSICHT AUF SYNCHRONISATIONSPRIORITÄTEN DER LIEFERUNG VERSCHIEDENER EMPFÄNGER

ZUSAMMENFASSUNG. Einleitung: In der Arbeit wurde das Modell der linearen vollnumerischen gemischten Programmierung für die Aufgabe des Zeitplans der regelmäßig wiederkehrenden Lieferung mit Fensterfunktionen für die Empfänger verschiedener Synchronisationsprioritäten dargestellt. Die Handelspunkte, von denen in diesem Artikel gehandelt wurde, sind nicht selten bei den Straßen untergebracht, die für den Fahrzeugverkehr neuralgisch sind. In diesen Plätzen hat die Koordination der Lieferung die Schlüsselbedeutung, weil sie den gleichzeitigen Ankünften der Lieferanten und demzufolge der Entstehung von Verkehrsbehinderungen vorbeugt.
Methode: Das Problem des Zeitplans von regelmäßig wiederkehrender Produktlieferung für die Empfänger verschiedener Synchronisationsprioritäten wurde als theoretische Aufgabe formuliert, für den das Modell der vollnumerischen gemischten Programmierung gebildet wurde. Die spezifische Darstellung des Problems wurde von dem Problem der Fahrplanzusammenstellung für den öffentlichen Verkehr inspiriert.
Ergebnisse: Das Rechenexperiment bestand darin, die erreichten (für vier gebaute Aufgaben der vollnumerischen gemischten Programmierung für das Problem der zyklischen Produktlieferung für die Empfänger verschiedener Synchronisationsprioritäten) Ergebnisse zu lösen und zu vergleichen. Mit der Prioritätssteigerung für einen Lieferanten hat sich die allgemeine Zahl der Synchronisierung für die ganze Netz der regelmäßig wiederkehrenden Lieferungen verringert. Zwecks des Qualitätsvergleiches von Lösungen wurde Synchronisierungsanzeiger festgelegt, der als Verhältnis der Synchronisationszahl für den gegebenen Lieferanten zu allen ihren Zahlen in der Aufgabelösung verstanden wird. Die Verwendung von der Synchronisierungspriorität für den Empfänger hat die Verbesserung seines Anzeigers der Lieferung-Synchronisierung verursacht.
Fazit: Das dargestellte Modell der gemischten Linienprogrammierung für die Aufgabe des Zeitplans von zyklischen Lieferungen mit Prioritäten für die Empfänger kann zur Zeitplanbildung für Produktlieferanten zu Empfänger verwendet werden, bei denen die Beeinträchtigung der gleichzeitigen Bedienung von einigen Lieferanten vorkommt.

Codewörter: Zeitplan der regelmäßig wiederkehrenden Lieferung, vollnumerische gemischte Programmierung, Optimierung, Fensterfunktion

Katarzyna Zofia Gdowska, Roger Książek
AGH University of Science and Technology
Faculty of Management
30 Mickiewicza Av., 30-059 Krakow, Poland
e-mail: kgdowska@zarz.agh.edu.pl
e-mail: rksiazek@zarz.agh.edu.pl

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TRENDS IN LOGISTICS IN THE GERMAN E-COMMERCE AND THE PARTICULAR RELEVANCE OF MANAGING PRODUCT RETURNS

Michael Brusch[1], Eva Stüber[2]

[1)] Anhalt University of Applied Sciences, Köthen, Germany, [2)] E-Commerce-Center Köln, Cologne, Germany

ABSTRACT. Background: There are several trends in logistics Internet retailers have to face nowadays, e.g. addressing and reaching customers through different sales channels (multi- or cross-channel management), integration of new payment alternatives (combined online and/or mobile payment methods), ordering and delivery of products from an Internet retailer at the same day (same-day delivery), and allowing product returns (management of product returns). Here the question is, whether relevant factors influencing the buying behaviour of online shoppers as well as groups of these can be found.
Methods: Our contribution is analysing this area in two ways. On the hand, an overview about these major trends and the German e-commerce market will be given. On the other hand, the particular relevance of managing product returns will be discussed and through findings from an empirical investigation of German online shoppers expanded.
Results: Four relevant factors influencing the behavior of online shoppers could be identified. Applying these four factors four different groups of online shoppers can be differentiated.

Key words: E-Commerce, Empirical Investigation, Product Returns, Trends in Logistics.

INTRODUCTION

In recent years, the importance of e-commerce has been increased. In combination with an increase of competition, Internet retailers have to face several challenges nowadays. One of these challenges is strongly related to their logistics and consists of general trends, e.g. using of as well as addressing and reaching customers through different sales channels (multi- or cross-channel management) and special trends in online shopping, e.g. integration of new payment alternatives (combined online and/or mobile payment methods), ordering and delivery of products from an retailer at the same day (same-day delivery), and allowing product returns (management of product returns, see, e.g., [Anderson et al. 2009, Bonifield et al. 2010, Mollenkopf et al. 2007, Petersen and Kumar 2009]).

Our contribution is related to this area. On the hand, an overview about these major trends and some best practice examples will be given and is followed by a description of the German e-commerce market. On the other hand, the particular relevance of managing product returns will be highlighted and through results from current research for the German market analysed in detail. The aim is to identify relevant factors influencing the buying behaviour of online shoppers as well as groups of these. Our findings will assist decision makers of Internet retailers regarding the recognition and evaluation of current trends in logistics.

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MAJOR TRENDS AND BEST PRACTICE EXAMPLES

As opposed to stationary trade the customer receives the product not directly at online shopping, but must wait for the delivery which lasts according to supplier between two and five days. Studies have already shown that late deliveries lead to dissatisfaction (e.g., [Holloway and Beatty 2003]). Thus many Internet retailers would like to raise the speed of delivery. Therefore, many Internet retailers (especially in the USA and Great Britain) experiment with same-day delivery (SDD) - the order and delivery of goods of an online shop at the same day. For example, since August 2012 eBay in San Francisco works on a related pilot project: As a new service and with the help of the application "eBay Now" buyers should be enabled to order products from retail stores and to have them delivered within less hours home. Up to now, however, such services are offered always restricted to certain regions. In Germany with Tiramizoo a logistics service provider operates limited to metropolitan areas and allows above all in the Munich region online shops the delivery of products within three hours (e.g., Lodenfrey, Cyberport).

Beside the speed of delivery also the time frame of delivery is focused. Amazon offers a delivery between 17 and 21 o'clock of the same day to customers from metropolitan areas with the "Evening Express" if the goods are ordered till 11 o'clock in the morning.

Positively for Internet traders and suppliers is in this context that according to US investigations, e.g., of the Boston Consulting Group, a high willingness to pay exists for a same-day delivery. Also an investigation of eBay regarding the future of trade showed that 60 percent would buy more online or mobile if the goods would be delivered at the same day (see, e.g., [Barr 2013, Utter 2013]).

Another big trend which online trade moves at the moment is the management of product returns. Consumers in online trade have only the possibility to examine products personally or to try on if it concerns goods of the fashion sector as soon as the order was delivered. Therefore, it should be expected that the whole delivery or parts must be sent back of it after the investigation. A technical innovation in the area Augmented Reality offers above all the possibility to fashion retailers to give assistance with regard to the correct fit to the customers in advance: Thus the enterprise UPcload from Berlin offers a virtual fitting for online shops which is offered meanwhile by about ten online shops in Germany (e.g., Otto, The North Face). Using a software application the clothes size is determined for the user free of charge, while with the help of a Webcam the body of the respective user is "scanned", afterwards his individual body measurements are calculated and suitable body dimensions recommendations provided. Here, a customary compact disk serves as reference object.

GERMAN E-COMMERCE MARKET

The number of online users and sales are still increasing in Germany (Figure 1). Because there are about 70.2 million citizens in Germany older as 14 years in 2012 and the percentage of online users amounts to 74% about 52.2 million people are online. About 74% of these uses the Internet for purchases, i.e. there are about 38.6 million online buyers. Their share and the share of so-called intensive online shoppers, i.e. persons who had at least 10 transactions during the last 12 months over the Internet, are continuously increasing within the last few years [Institut für Demoskopie Allensbach 2012].

Internet retail, i.e. the type of e-commerce used for business-to-consumer transactions, is growth driver number one in the German retail. Alone in 2012 the e-commerce with consumer goods increased up to about 33.0 billion Euros and had therefore a share of about 8% of the total retail sales (without FMCG (fast moving consumer goods) even more than 14%). Nearly three quarters of this market volume are gained by suppliers who do not have their origin in classical mail order selling: pure Internet seller, web shops of bricks-and-mortar retailer and of manufacturer are very prominent in Internet retailing. However, also the growth of the online sales of classical catalogue sellers is substantial furthermore [IFH Köln 2013].

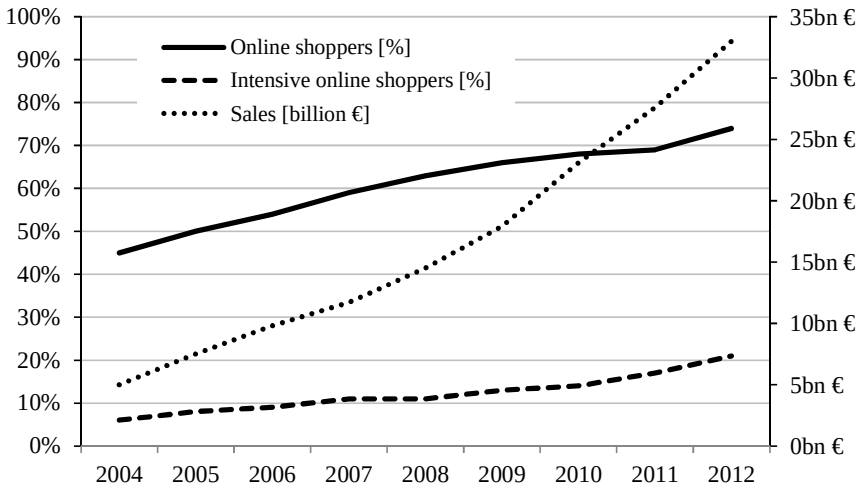

Fig. 1. Share of online shoppers and intensive online shoppers (at least ten transactions within the last 12 months) and sales volume of Internet retail in Germany
Rys. 1. Udział kupujących on-line oraz nasilenie ich aktywności (minimum 10 transakcji w przeciągu ostatnich 12 miesięcy) oraz wielkość sprzedaży detalicznej internetowej w Niemczech

The most important online bought category is fashion and accessories. With a share of about 27% of the sales in Internet retail this is meanwhile the biggest market on the Internet. Here the impulses are coming from stationary fashion chains and increasingly from pure Internet players like Zalando, and the big fashion brands. However, in other areas, like consumer electronics, do it yourself and garden as well as living and arrangement, a backlog has arisen. Especially the stationary retail chains stimulate the markets only to a limited extent. This could affect in the long term disadvantageously, because also in these assortment areas pure Internet players stand already in the starting blocks [Groß et al. 2013, IFH Köln 2013].

However, there are several trends which will affect the retail market in Germany. An already existing trend is multi-channel management which is still enormously important for stationary retail. Here, current analyses show that there are information-related interactions between web shops and local stores. These interactions resulted in 2012 in an amount of about 32% of purchases in stationary retail, i.e. local stores, which are prepared in online shops [IFH Köln 2013]. The existence of the other introduced trends (same-day delivery and management of product returns) in Germany will be analyzed using the data from an empirical investigation.

INVESTIGATION OF GERMAN ONLINE SHOPPERS

In January, 2013 a questioning of Internet buyers was carried out by the E-Commerce Center in Cologne, Germany. Here, the buying behavior and related information was collected using a representative online survey by means of a panel. The survey occurred in Germany (n=1,000), Austria (n=500) and Switzerland (n=500). The interviews lasted between seven and ten minutes. For the following analyses only the German participants will be used. This means that a sample of 1,000 participants is used which corresponds concerning the distribution of age and gender of the German population.

The total sample consists of 52% men and 48% women and has a mean age of 39.7 years. From the total sample 2.5% buy at least once a week, 8.6 % once in two weeks and 25.4% once a month although the majority (34.4%) buys once in the quarter. The household net income is mostly (with 28.0%) in the range 2,000-2,999 EUR and followed by a group

(with 25.6%) in the range 1,000-1,999 EUR. Regarding the purchase category most often (26.9%) "consumer electronics and home appliances" is bought, followed by "books and media" (22.8%) and "fashion and accessories" (21.9%).

In a next step of data analysis, an exploratory factor analysis (using principal component analysis and quartimax rotation; see e.g. [Hair et al. 2006]) was used to identify the underlying dimensions of delivery related factors. Here, four factors (with simple structure) were found: "time and speed of delivery", "cost of product returns", "cost of delivery", "alternatives of delivery". The factors consist of three or four items which were all measured on a five-point Likert scale (with "1…strongly disagree" and "5…strongly agree"). Table 1 shows the factors and their alignment ("+" indicates that higher values represent a higher importance, "-" indicates that lower values represent a higher importance). From the table it can be identified that all factors fulfill the necessary reliability requirements. Total variance explained by all factors is about 63.5%.

Table 1. Results of the exploratory factor analysis ("+"…higher values represent higher importance, "-"…lower values represent higher importance)
Tabela 1. Wyniki analizy czynnikowej ("+"…wyższe wartości prezentują większe znaczenie, "-"…niższe wartości prezentują większe znaczenie)

Factor (alignment)	Sample item	No. of items	Factor loadings	Cronbach's α	Variance explained
Time and speed of delivery (+)	It has a great importance for me that I can choose the delivery date myself.	4	0.650-0.823	0.799	62.487 %
Cost of product returns (+)	At first I check which return costs in an online shop accrue before I have a look at the product range.	4	0.697-0.860	0.792	61.686 %
Cost of delivery (-)	I am willing to pay for a higher speed of delivery higher shipping costs.	3	0.666-0.820	0.726	65.335 %
Alternatives of delivery (+)	It is important for me to be able to select from different alternative delivery solutions.	3	0.709-0.777	0.645	58.516 %

These factors will be used to classify different groups of buyers based on a cluster analysis as a multivariate classification method to divide a total sample into subsamples. Cluster analysis is a prominent method for classifying objects into groups - so called "segments" or "clusters" - with respect to their similarity [Punj and Stewart 1983]. Here, the found factors (i.e. the factor scores) are used within such a cluster analysis (using Ward's method, no standardization due to the usage of factor scores). As optimal solution four clusters (i.e. four groups of buyers) could be identified. The results differentiated for the clusters are shown with significance information in Table 2 and 3.

For example, one group of buyers (cluster 1) consists of the largest proportion of women (66.7%) and buys most often fashion and accessories. For this group the factor "cost of product returns" are very important as well as the factor "cost of delivery" (consider the opposite alignment of the factor, Table 1). In contrast to this, another group (cluster 4) which buys very frequent online (6.3% buy at least once a week) sees also a high impact of the factor "cost of product returns" but most important is the factor "alternatives of delivery" followed by the factor "time and speed of delivery".

The results of other simple items are shown in Table 3. Here, for the speed of delivery (measured directly using given scales) the respondents had to specify how fast they generally wish the delivery of their order. The expectations regarding same-day delivery were measured through the importance of the respondents that the delivery of their order

arrives on the same day (using a five-point Likert scale with "1…strongly disagree" and "5…strongly agree"). For the rate of returns the respondents had to indicate, how often they send back parts of the order or everything if they buy goods from the branch named before (using given scales). The question with respect to a too long delivery time was among the reasons why an already ordered product from the named branch was sent back (percentage of selections).

Table 2. General results of the four clusters (χ^2…χ^2 test (based on Pearson), F…F test)
Tabela 2. Wyniki ogólne czterech klastrów (χ^2…χ^2 test (oparty na Pearsonie), F…F test)

Characteristic	**Type**	**Cluster 1** (n=222)	**Cluster 2** (n=190)	**Cluster 3** (n=301)	**Cluster 4** (n=287)	**Significance** **Type**	**Value**	**p**
Factor scores								
Time and speed of delivery	M	-0.425	-0.472	0.260	0.368	F	54.785	.000
Cost of product returns	M	0.986	-0.688	-0.496	0.213	F	215.291	.000
Cost of delivery	M	-0.558	-0.469	-0.110	0.858	F	160.680	.000
Alternatives of delivery	M	-0.128	0.889	-0.911	0.466	F	290.220	.000
Factor averages								
Time and speed of delivery	M	2.492	2.383	2.904	3.415	F	84.313	.000
Cost of product returns	M	3.884	2.343	2.442	3.314	F	203.047	.000
Cost of delivery	M	1.800	1.949	2.208	3.154	F	200.855	.000
Alternatives of delivery	M	2.986	3.665	2.268	3.619	F	262.776	.000
Purchase frequency								
At least once a week	%	1.4	1.1	.7	6.3			
Once in two weeks	%	9.9	6.3	8.3	9.4			
Once a month	%	27.0	25.3	23.6	26.1	χ^2	31.811	.007
Once in the quarter	%	31.1	35.8	35.5	34.8			
Once half a year	%	20.3	22.6	21.9	15.7			
Once a year and less	%	10.4	8.9	10.0	7.7			
Age	M	37.2	41.8	41.5	38.3	F	6.343	.000
16-19 years	%	14.9	6.8	8.6	9.8			
20-29 years	%	20.3	16.8	17.9	24.0			
30-39 years	%	21.2	18.4	15.6	21.3	χ^2	33.315	.004
40-49 years	%	23.4	27.9	24.9	20.9			
50-59 years	%	13.1	16.8	18.9	18.1			
60+ years	%	7.2	13.2	14.0	5.9			
Gender								
Male	%	33.3	56.8	55.1	59.9	χ^2	41.204	.000
Female	%	66.7	43.2	44.9	40.1			
Household net income								
< 500 EUR		9.0	6.8	5.0	4.5			
500–999 EUR		8.1	13.2	10.0	11.1			
1,000–1,999 EUR		26.6	23.2	27.2	24.7			
2,000–2,999 EUR		27.5	25.8	29.2	28.6	χ^2	10.701	.907
3,000–3,999 EUR		14.9	15.8	14.3	16.7			
4,000–4,999 EUR		8.1	7.9	8.6	8.7			
≥5,000 EUR		5.9	7.4	5.6	5.6			
Purchase category								
Fashion and accessories	%	36.0	10.0	19.9	20.9			
Consumer Electronics and home appliances	%	20.3	27.4	27.9	30.7			
Sports and leisure time	%	5.9	9.5	8.6	4.9			
Books and media	%	16.7	31.6	22.3	22.3			
Furniture and fixtures	%	5.4	4.2	7.6	6.3	χ^2	85.044	.000
DIY and garden	%	0.5	0.5	1.0	0.7			
Cars and car accessories	%	0.9	2.6	2.7	2.8			
Office and writing materials	%	0.5	2.1	0.3	3.8			
Health and wellness	%	6.3	5.8	5.0	2.1			
Groceries	%	1.8	3.7	1.3	2.1			
Drugstore and perfumery	%	5.9	2.6	3.3	3.5			

Table 3. Delivery and product returns related results of the four clusters (χ^2…χ^2 test (based on Pearson), F…F test)
Tabela 3. Wyniki dotyczące dostaw i zwrotów towarów czterech klastrów (χ^2…χ^2 test (oparty na Pearsonie), F…F test)

Characteristic	**Type**	**Cluster 1** (n=222)	**Cluster 2** (n=190)	**Cluster 3** (n=301)	**Cluster 4** (n=287)	**Significance**		
						Type	**Value**	**p**
Speed of delivery								
Within one to two hours	%	0.5	0.0	1.0	0.7			
Within 24 hours	%	14.4	13.2	14.0	28.9			
Within two to three days	%	67.1	67.9	70.4	61.3	χ^2	41.575	.000
Within a week	%	17.1	18.4	13.6	9.1			
Within more than a week	%	0.9	0.5	1.0	0.0			
Same-day delivery	M	2.005	1.779	2.389	3.066	F	77.359	.000
Rate of returns								
At every order	%	5.0	0.0	1.7	2.1			
At every second order	%	11.7	2.1	2.7	4.9			
At every third order	%	12.6	2.6	5.0	8.7			
At every fourth order	%	9.0	0.0	3.3	8.4	χ^2	135.994	.000
At every fifth order	%	4.5	2.6	2.7	4.2			
Less frequent	%	46.8	60.0	59.8	63.1			
Never	%	10.4	32.6	24.9	8.7			
Too long delivery time	%	9.9	5.3	4.3	9.8	F	3.323	.019

Regarding delivery and product returns related results (Table 3) it can be identified that the majority of all clusters would like to have a delivery within two to three days. Also the rate of returns is in general and at all cluster mostly less frequent than at every fifth order. However, there are significant differences between the clusters. So, e.g., within cluster 4 more than a fourth (28.9%) would prefer to receive the ordered products within 24 hours. A too long delivery time is especially relevant for cluster 1 and cluster 4 (stated by 9.9% and 9.8% of respondents). The same-day delivery is mostly preferred by the frequent buyers of cluster 4.

CONCLUSIONS

From the existing trends in logistics Internet retailers have to face nowadays especially the same-day delivery and the management of product returns are analysed against the background of different buyer segments (four clusters found in a cluster analysis). It can be identified that a same-day delivery has not this high importance up to now. The same is valid for product returns. But there is a positive relationship between the number of purchases and the number of returns. This means that more intensive online shoppers prefer respectively expect these options. Furthermore, the majority of online buyers wishes to receive their ordered goods within two to three days. The presently achieved standard is therefore for most buyers satisfyingly. However, it exist customer groups whose satisfaction can be increased by a faster delivery. These groups are not the largest ones up to now but these are the frequent buyers (whose number will increase within the next years). Decision makers in logistics should consider these expectations and preferences of this increasing portion of buyers.

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TRENDY W LOGISTYCE W NIEMIECKIM E-HANDLU ORAZ ZNACZENIE ZARZĄDZANIA ZWROTAMI TOWARÓW

STRESZCZENIE. **Wstęp:** Aktualnie można wyróżnić kilka trendów w logistyce handle internetowego, tj. poszukiwanie i osiąganie klientów poprzez różne kanały sprzedaży (zarządzanie multi- oraz cross-kanałami), integracja nowych metod płatności (połączenie metod płatności on-line oraz mobilnych), zamówienie i dostawa w przeciągu tego samego dnia oraz możliwość dokonywania zwrotów (zarządzanie zwrotami towarów). Tutaj rodzi się pytanie czy można zdefiniować czynnik wpływającej na zachowanie się konsumenta dokonującego zakupu poprzez Internet.
Metody: Badania przeprowadzono na dwa sposoby. Przedstawiono przegląd najważniejszych trendów występujących w niemieckim e-handlu. Następnie poddano szczegółowej dyskusji zagadnienie zarządzania zwrotami towarów na podstawie przeprowadzonych badań empirycznych.
Wyniki: Zidentyfikowano cztery czynniki wpływające na zachowanie się konsumenta dokonującego zakupu poprzez Internet. Wpływ tych czynników na cztery różne grupy klientów internetowych jest zróżnicowany.
Wnioski: Uzyskane wyniki wspomagają proces decyzyjny w e-handlu w obszarze określenia i oceny aktualnych trendów logistycznych.

Słowa kluczowe: e-handel, badania empiryczne, zwroty towarów, trendy w logistyce.

LOGISTIK-TRENDS IM DEUTSCHEN E-COMMERCE UND DIE BESONDERE BEDEUTUNG DES RETOURENMANAGEMENTS

ZUSAMMENFASSUNG. Einleitung: Im Bereich der Logistik haben sich Online-Händler heutzutage einer Reihe verschiedener Trends zu stellen, z.B. der Ansprache und Bedienung der Kunden über verschiedene Verkaufskanäle (Multi- und Cross-Channel-Managemen), der Bereitstellung neuer Zahlungsmöglichkeiten (Zahlung mittels online- bzw. mobile-basierter Methoden), der Bestellung und Lieferung von Produkten eines Online-Händlers am gleichen Tag (Same-day-Delivery) und dem Erlauben von Warenrücksendungen (Retourenmanagement). Hierbei stellt sich die Frage, ob relevante, das Einkaufsverhalten von Online-Käufern beeinflussende Faktoren und, darauf basierend, Gruppen von Online-Käufern identifiziert werden können.

Methode: Unser Beitrag analysiert dieses Thema in zweierlei Hinsicht. Einerseits wird ein Überblick über aktuelle und zentrale Trends für den deutschen Online-Handel gegeben. Andererseits wird insbesondere das Retourenmanagement diskutiert und anhand der Daten einer empirischen Untersuchung von deutschen Online-Käufern ausgewertet.
Ergebnisse: Es zeigt sich, dass vier Einflussfaktoren für das Kaufverhalten von Online-Käufern relevant sind. Werden diese vier Faktoren zugrunde gelegt, können vier verschiedene Käufergruppen identifiziert und analysiert werden.
Fazit: Unsere Ergebnisse unterstützen Entscheidungspersonen in Unternehmen des E-Commerce hinsichtlich der kundenseitigen Wahrnehmung sowie der adäquaten unternehmensseitigen Berücksichtigung von aktuellen Trends im Bereich der Logistik.

Codewörter: E-Commerce, Empirische Untersuchung, Logistik-Trends, Retourenmanagement

Michael Brusch
Anhalt University of Applied Sciences
Köthen, Germany
e-mail: m.brusch@emw.hs-anhalt.de
Eva Stüber
E-Commerce-Center Köln
Cologne, Germany
e-mail: e.stueber@ifhkoeln.de