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POLISH LOGISTICS MACRO-SYSTEM IN THE GLOBAL MARITIME LOGISTICS SPACE

Abstract

The main purpose of the paper is to identify and analyse the principal factors shaping the global logistics area as well as to point out key tendencies of its development within the global economy. The author also makes an attempt to assess the influence of the global logistics system on the Polish logistics system. The purpose of the analysis carried out on the basis of reports and accounts published by international organizations is to compare the main tendencies observed within both logistics systems, indicate the differences between them, and specify the reasons behind them. The author indicates the activities and measures necessary to boost the efficiency and effectiveness of the Polish logistics system, especially its maritime sector. This can only be achieved by facilitating the functioning of global logistics chains and ensuring that Polish SCM meets global standards.

Keywords: logistics macro-system, global logistics space, maritime transport infrastructure

Introduction

Attempting to characterize the global logistics space, one should first and foremost define its place and functions within the global economic space, which – in terms of its structure, actual scope, character, as well as forms and dynamics of global economic activity – is, in turn, determined by the current shape of the world-wide structure that we call the global economy. The global economy is comprised of diverse organisms and institutions that conduct direct or indirect economic activity on both national and international levels; these interconnected entities create a network of international economic relations – an economic mega-system.

The global economy is therefore a complex system of production, technological, commercial, financial, and institutional relations between national economies on different levels of social and economic development, which incorporates them into the global process of production and exchange.

From the viewpoint of logistics, the global economy can be perceived as a mega-system of commercial and logistical relations shaped on the basis of the existing infrastructure by the active and logistics supply chains and networks, which connects the main production and consumption centres dispersed in the global space. The global logistics network is the physical structure of the global logistics provider and customer service that interferes with this global space in all its dimensions and gradually adapts to new market conditions, integrating fragmentized commodity and service markets, but also financial and labour markets (Grzelakowski, 2016, p. 319). This system is schematically presented in Figure 1.

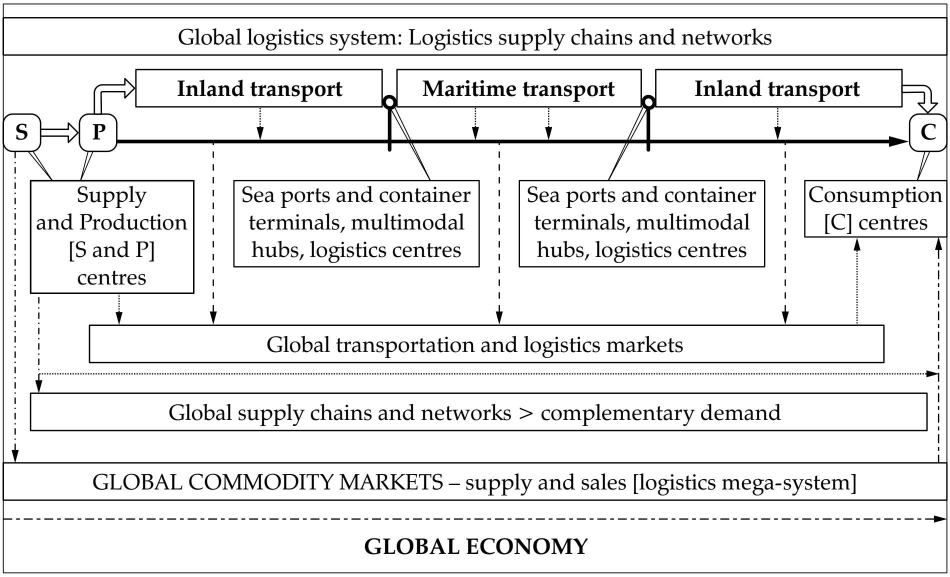

Figure 1. Global logistics system as a segment of the global economy: Its subjective, spatial, and functional structure
Source: (own elaboration)

Global supply chains and networks incorporate all types of global markets. They regulate all kinds of flows, optimizing them in terms of time, cost, intensity, and liquidity. The factor that physically connects these markets and, at the same time, integrates the flows, is transport – especially transport and logistics infrastructure.

1. Globally relevant marine transport infrastructure and its influence on the logistics mega-system

One of the crucial components of the global transport infrastructure and, at the same time, the logistics mega-system infrastructure, are marine canals – the most important element of the global maritime logistics space, which determines the layout of the main global commodity trade flows as well as the logistic effectiveness and efficiency of the global trade (Grzelakowski, Matczak, 2015, p. 37).

The importance of marine canals for the global logistics space stems from the dominant role of maritime transport in servicing global trade. In 2014, ca. 81% of world trade volume was shipped by sea – this amounted to over 10 billion t, which, with the average shipping distance of 5.000 NM, means that, in ton-mile terms, maritime transport accounted for ca. 92% of world trade in goods (UNCTAD, 2015, pp. 8–13).

Seaborne trade also dominates global trade in terms of value. It is estimated that in 2014 it accounted for ca. 60% of global trade value (11.4 of 18.95 billion US$) including intra-EU trade and ca. 76% of global trade value not including intra-EU trade, while the share of airborne trade is estimated at ca. 12% (WTO, 2015, p. 21).

The average value of 1 ton of cargo shipped by sea is currently about 1.135 US$ (based on exports). In 2014, it constituted ca. 82% of the value of 1 ton of cargo shipped globally by various means of transport. Its ratio to the value of 1 ton of cargo transported by air, however, is currently 1:55.

Main global maritime shipping routes along with the intensity of transport along those routes are presented in Figure 2. Maritime shipping routes reflect the spatial extent and intensity of economic relations between particular production, supply, and consumption centres located in different countries. Those global relations, in turn, are shaped under the strong influence of the processes of integration and globalization of the world economy, which mostly affect the highly-developed countries of North America, Europe, and the Far East. Those three main economic centres with the highest growth dynamics and shares in global trade, connected by a dense network of supply chains, account for nearly 70% of global seaborne commodity trade. Moreover, the shipping routes between them concentrate over 75% of high-value container shipments.

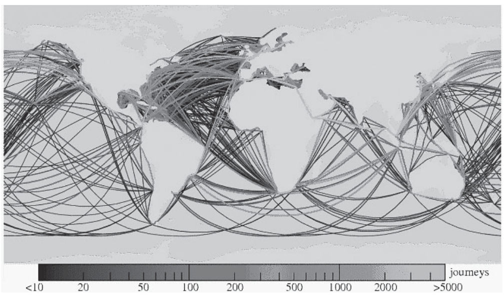

Figure 2. Main maritime shipping routes in the global logistics space
Source: (Kaluza et al., 2010)

Global maritime transport uses not only natural, but also artificial canals – elements of the maritime infrastructure of the global logistics space. These include mainly the Suez Canal and the Panama Canal. The former was built and commissioned in the second half of the 19th century, and the latter – at the beginning of the 20th century. They were created to facilitate the connection of the most important areas of the maritime transport space and shorten the freight distance between the main global supply, production, and consumption centres.

The Suez Canal (total length of 163 km), which currently transports ca. 8% of world trade, i.e., 800 million t, is of essential importance. In the years 2014–2015, it was thoroughly developed and modernized at a cost of 8.2 billion US$. A new section of the Canal was built, 35 km long, 24 m deep, and 320 m wide, allowing for the simultaneous passage of two ships; at the same time, all 37 km of bypasses were deepened to 24 m (CM Container Management, 2015, p. 5). As of August 6, 2015, the Canal can accommodate ships with a draft of up to 20 m (66 ft). This development of the Suez Canal changes not only maritime, but also global logistics space parameters.

Figure 3. North end of the Suez Canal with a container terminal in Port Said
Source: (Le Parisien, 2015)

As a result, transit time became considerably shorter – 11 instead of 18 hours (CM Container Management, 2015, p. 21). With an 80-day (on average) round journey on the Far East–Europe route through the Suez Canal, this is not a decisive factor, but in the current freight market (mainly container freight), highly competitive and sensitive to the ship exploitation costs, every hour that gives grounds for optimizing total travel time counts. Although this factor plays an important role for both maritime transporters and shippers (exporters and importers) as well as international forwarders and operators of global logistics supply chains, it is of special significance for shipping operators employing tonnage on the Far East/Australia/East Africa–Europe route, who, thanks to the upgraded linear infrastructure, gained the possibility to make better use of the annual transport capacity and improve service organization, which ultimately translates into reduced costs of ship operation. These savings allow, as is the case in container shipping, to increase the results obtained by commissioning large units, e.g. VLCC tankers (above 14 thousand TEU and with a draft of 16 m), which are able to freely use this route, fully utilizing their transport capacity. They are especially expected by ship owners under conditions of high or rising fuel prices.

The actual savings depend, however, not only on their level estimated by the ship owner, but also on the fees imposed by canal management. This is why sea carriers, who analyse these relations in depth, under conditions of high or significantly rising fees and fuel prices often decide to take an alternative route, usually free of charge. Being unable to absorb the increasing costs of tonnage with the savings resulting from the scale of production, they forgo a shorter, more pricy route in favour of a longer but cheaper one. Such situations are fairly common during freight market crises (tonnage oversupply), to which carriers respond by employing slow steaming strategy. Reducing the speed of the ship (large post-Panamax container ship) by 10% allows to reduce fuel consumption even by 35% (bunker costs by over 25%), which at the same time allows to employ more tonnage. In the years 2011–2013, these effects, perceived by sea carriers narrowly and in a short-term perspective, convinced them to frequently use the route around Africa (Cape of Good Hope) instead of the Suez Canal to reach North Sea ports. This indicates how much the costs of access to maritime infrastructure affect the carriers' decisions. Managers of such facilities thus have to very carefully calculate the level of access prices.

As a result of upgrading the Suez Canal, its capacity will double from 45–50 to 97 units per day by 2023; utilization of this capacity, however, depends on the state of the global economy, fuel prices, and dues levied by Suez Canal Authority. And these will not be low, given that the Egyptian government, "contributing" to the improvement of the functioning of the global maritime logistics space, has planned to increase revenues from 5.3 billion US$ in 2014 to 13.2 billion US$ in 2023.

Due to the development and modernization of the Suez Canal and the resulting reduction of the total transit time, sea carriers have also gained competitive advantage over railway carriers, who service the China–Europe route in 35–40 days. These new parameters of time and cost give grounds for optimizing the choice of a Far East–Europe route and rationalizing logistics costs in the supply chain system.

Two years ago, adapting to the main trends in global trade and maritime transport, the government of Panama, at the cost of 5 billion US$, also undertook to rebuild and upgrade the Panama Canal locks (81.6 km) to make it possible for post-Panamax ships to transit the Canal. The end of works, repeatedly rescheduled for technical reasons, is planned for 2016.

Deepening and widening the Canal and its locks (12 in total) as well as building an additional, third set of locks will make it possible for a unit 49 m wide, 366 m long, and with a draft of 15 m (i.e., a container ship of up to 14 thousand TEU) to use the Canal. As a result of the elimination of the queue of ships waiting to enter or exit (even as long as 11 days) and reduction of transit time to 12 hours, which is estimated to increase the number of transiting ships from 14 thousand in 2014 to ca. 28 thousand by 2025, the Canal will maintain the minimum standard of global logistics efficiency as a strategic sea route.

Figure 4. Panama Canal Gatún Locks
Source: (Wikimedia)

Due to this infrastructural investment, which will result in a significant reduction of individual maritime transport costs, and thus total logistics costs, the upcoming years will bring changes in the global "logistics map," especially in the distribution of global cargo flows on the Far East–North America (US) routes.

2. The influence of maritime linear infrastructure on the global logistics space

The development and modernization of the Panama Canal will strongly affect the shape of the global logistics space, especially its American segment. The costs of maritime transport, decidedly lower than the costs railway transport, additionally reduced by introducing larger units able to transit the Panama Canal already in 2016, will result in shifting the cargo flows from the West Coast to the ports of the East Coast. This will principally concern the ports of the Pacific Northwest (Seattle, Tacoma), which will lose a significant part of their revenue to the ports of New York and New Jersey.

Already 35% of container cargo shipped from East Asia to the US reaches the ports of the East Coast. Detailed studies of this market indicate that by 2020 this share will increase to 40% irrespectively of the expansion of the Panama Canal, and even to 50% after the expansion has been completed.

The development of the Suez Canal and the resulting increased size of ships servicing trans-Pacific routes able to freely reach East Coast ports gives shippers new opportunities in terms of transporting cargo to the central states. This gives grounds for logistics operators to relocate supply chains. The Panama Canal therefore builds a new dimension of this segment of the global logistics space. By creating new possibilities in terms of cargo flow, this facility, as a component of the global maritime infrastructure, actively shapes the logistics services markets distant by thousands of kilometres by stimulating and integrating them. The results of the development and modernization global maritime service markets (Suez Canal and Panama Canal) are already or will soon be visible not only in the freight market, but also other transport markets, mainly the markets of port and railway services.

They will be felt primarily by the port sector – global marine hubs. In these new conditions they will have not only to meet the requirements posed by global alliances of maritime carriers – who, optimizing the costs of operating ships, more and more frequently eliminate some of them from the established schedule – but also to face challenges resulting from the intensifying regional inter-port competition. These new logistical and transportation challenges and forms of ports' responses to them are visible especially in the US.

Thus, in a regional perspective, ports are rearranging the hitherto competitive relations into cooperative ones, creating port alliances modelled after the alliances of maritime carriers. The first such alliance came into being on July 4, 2015, from the initiative of the Seattle and Tacoma ports, which in this way together attempt to defend their market position from the competing ports of both the East Coast (Long Beach and Los Angeles) and the West Coast (New York and New Jersey). This is a new tendency and a new impulse for a further integration and concentration of the maritime sector of the global logistics space.

3. Factors for the development of the global logistics space and measures of its effectiveness and efficiency

One of the most important economic factors determining the development of the global logistics space is globalization, stimulated by the processes of deregulation and liberalization of all kinds of markets, the dynamic development of the main engines of world trade, and the development of international trade. A special role in this regard is played by the world trade, especially the merchandise sector, as well as its generic and directional structure. Figure 5 presents the pace of its development in the years 2005–2015.

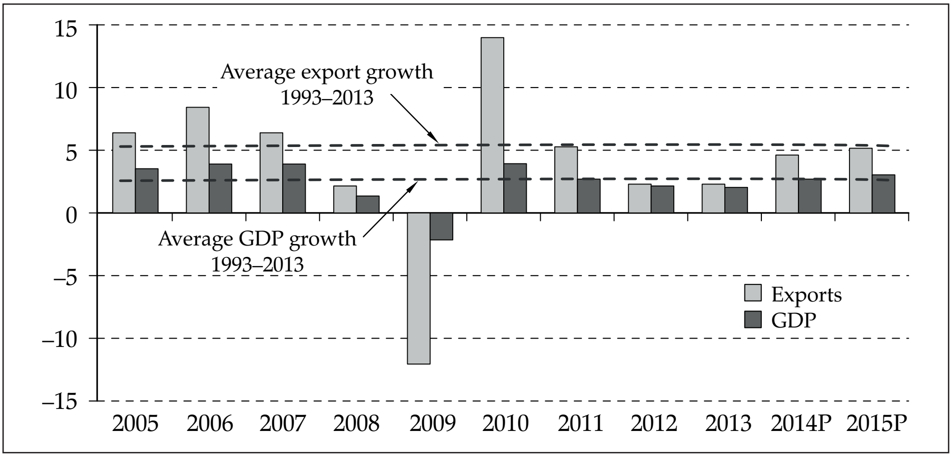

Figure 5. Growth in volume of world merchandise and GDP, 2005–2015 (annual % change)
Source: (WTO, 2015, p. 14)

The effectiveness and efficiency of the global cargo flows is determined by a number of factors. Among them, infrastructure – which is usually one of the main barriers in this area – is of special significance. For this reason, when assessing the effectiveness and efficiency of a logistics mega-system – which is essentially a set of logistics macro-systems of particular countries participating in the global division of labour – one should also take into account measures which directly or indirectly encompass the infrastructure factor, i.e., the level of infrastructure development of particular logistics macro-systems and the efficiency and quality of network transport markets.

The most important measures of this kind, which assess the effectiveness and efficiency of the world economy both as a collection of national economies at varying levels of participation in the international division of labour, and as a global logistics space, highly diversified in terms of quality (with regard to the level of development and in the operational and technical aspect), include:

– Global Competitiveness Index (GCI), developed by the World Economic Forum (WEF) as part of the annual *Global Competitiveness Report*, which covers 144 countries and includes the infrastructure factor in the first of the three sets of competitiveness indicators (second pillar) (WEF, 2014, p. 25),
– Enabling Trade Index (ETI), developed by the WEF's Supply Chain & Transport Industry as part of the annual *Global Enabling Trade Report* (138 countries in 2014), which includes in the group of four dominant sets of trade enabling factors also a set of transport and infrastructure factors (sub-indexes transport and telecommunication infrastructure) (WEF, 2015, p. 11),
– Logistics Performance Index (LPI), developed by the World Bank, which for each of the logistics macro-systems covered by the surveys (160 countries in 2014) is the weighted average of the results obtained from the six major areas that determine its efficiency and effectiveness; among them, transport infrastructure and quality of logistics services are of prime importance (WB, 2015, pp. 5–7).

Based on these parameters, an assessment can be made of the logistics performance and efficiency and the competitiveness of particular logistics macro-systems that together constitute a logistics mega-system integrated by the network of supply chains.

4. Polish logistics system as part of the global logistics space: Effectiveness and efficiency ranking

The place of Poland in the global economic and logistics space is reflected in the rankings prepared by international economic and financial organizations based on the above-mentioned parameters, i.e., GCI, ETI, and LPI. Each of these indicators, presented in Table 1, encompasses a basic set of transport and logistical factors that determine the level of effectiveness and efficiency of particular logistics macro-systems.

Table 1. Ranking of the main global engines of world trade in terms of competitiveness as well as transport and logistics performance in 2014 (including Poland)

Country	GT	GCI	GCI-Inf.	ETI	ETI-Inf.	ETI-JDI	LPI	LPI-Inf.
China	1	28	> 50	> 50	36	16	28	9
US	2	3	11	15	8	8	9	4
Germany	3	5	7	10	6	5	1	1
Japan	4	6	6	13	5	7	10	5
Netherlands	5	8	4	3	3	9	2	3
France	6	23	8	21	9	4	13	7
Korea, Rep.	7	26	17	30	8	7	21	8
UK	8	9	10	6	4	10	4	6
Singapore	14	1	2	1	1	2	5	2
Poland	27	43	> 50	45	49	76	31	> 50

Notes: GT – position in global trade; GCI – Global Competitiveness Index; ETI – Enabling Trade Index; LPI – Logistics Performance Index; GCI-Inf. – transport infrastructure as a factor affecting competitiveness; ETI-Inf. – transport infrastructure as a factor affecting the position in the ETI ranking; ETI-JDI – transport infrastructure service quality; LPI-Inf. – transport infrastructure as a factor affecting logistics performance.
Source: (own elaboration based on: WTO, WEF, and WB 2015 reports)

Table 1 indicates that the relatively high position of Poland in the global trade (27 based on export and 26 based on import, according to WTO) unfortunately is not reflected in other rankings that describe the place of our country in the global economy and logistics mega-system: Poland ranks 43 in terms of competitiveness, 45 in terms of trade-enabling solutions, and 31 in terms of logistics performance.

The differences between the position of Poland in the global trade and the other dimensions of its performance result, on the one hand, largely from the character and generic and directional structure of the Polish international trade, and on the other – from the actual low competitiveness of its economy.

Conclusions

In terms of high-value goods, Poland exports mainly finished products assembled from Western components and destined principally for other EU markets, i.e., shipped by land rather than by sea. It also does not generate high income, as most of these products are manufactured in special economic zones, where there is no corporate tax, and foreign-owned companies are exempt from property tax. In this situation, the only upside, not fully satisfactory from the macroeconomic point of view, is the creation of new jobs, which, however, due to the generally low wages, not always generate high consumer demand.

The real sphere of the Polish economy, in which the technical infrastructure (especially transport infrastructure) that creates the material base of the country’s network industries plays an important role in the process of economic growth and creating prosperity, also deviates significantly from the level of the world’s leading economies. In terms of the quality of transport infrastructure, network transport services, and other transport services, Poland occupies between 49 and 76 place in global rankings. This translates into all areas of its economic activity and its evaluation at the international level, co-determining the level of development and efficiency of Poland's transport and logistics system, which constitutes the TSL sector, important for its development.

The consequences of this state of affairs are also visible in the maritime transport sector, including maritime ports, which are commonly regarded as efficient links of both this sector and the country's logistics system. They are manifested, among others, in the low average value of 1 ton of cargo handled in Polish seaports, which is 2.3 times lower than the world average. The qualitatively new global maritime logistics space thus poses increasing challenges to the Polish logistics system.

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DEVELOPMENT OF LOGISTICS SERVICE PROVIDERS FROM THE PERSPECTIVE OF THE VALUE-BUILDING GROWTH MODEL

Abstract

The primary objective of any logistics service provider is to develop. Although it appears natural, the challenges that it poses are bigger than we think. The concept of development – generally seen as a process of changes – is ambiguous and can mean something else for each service provider. The aim of this article is to attempt to verify, based on the value-building growth model (VBG), whether the financial results achieved by logistics service providers translate into their success, which is equated with development.

Keywords: logistics service providers, development of logistics service providers, value-building growth model

Introduction

Times are changing, but for companies one thing remains constant – development. Attempts to define the concept of development made in literature point to its ambiguity. Development is generally perceived as a process of changes occurring in stages. As the main objective of any company, it constitutes a necessary condition of its activity and can refer to one or all areas of its functioning (goals, technology, etc.). Moreover, development can be seen as an attempt to reduce (eliminate) the development gap or as a process of improving the company's competitive position (Machaczka, 1998, p. 14). This means that development is a change which takes place according to the established principles and leads to certain consequences for the company. It therefore occurs as a result of gradual, purposeful, and long-term changes.

1. Development and growth of logistics service providers

The development of logistics service providers (LSPs) requires a successful integration of all areas of their activity: the whole value chain, the provider and customer market, strategy, and operational activities (Deans, Kroeger, 2006, p. 33). For each logistics service provider, development can mean something different – extending the scope of activities, achieving operational excellence by increasing the quality of services, improving structures, reducing costs, etc. That being said, most often development attests to the company's pursuit of profit.

In recent years a new way of thinking about development emerged. It was pointed out that productivity, cost-effectiveness, or operational excellence cannot be treated as the only development criteria. We should focus more on revenue increase, so as to exploit the potential to generate value in the long-run (especially for owners or shareholders). In this context, development means a constant, long-term organic growth of revenue and profit. We should also work toward creating a growth mechanism which will ensure that companies enjoy a lasting competitive advantage, have a higher market value, and are perceived as innovative entities that satisfy the requirements of corporate social responsibility.

Company growth is a positive, measurable change of its size. It is an internal process, which occurs naturally as the company continues its operations. In order to achieve growth, LSPs take numerous steps by extending the scope of their activities.

Although the concepts of development and growth are inextricably linked, there is an essential difference between them. Development is a combination of many factors that encompasses all changes (positive and negative, measurable and immeasurable) and thus gives shape to the hierarchy of the company's goals in terms of both internal and external relations. Growth, on the other hand, usually occurs as a result of changes introduced in the company's value system (Pierścionek, 2003, pp. 53–55).

2. Development possibilities of logistics service providers

The primary objective of any logistics service provider is to develop. It is not, however, that simple. The challenges that it poses are bigger than we think. Development, although it seems natural, is most often illusory or unprofitable.

On their way towards a steady growth, most LSPs (especially the smaller ones, e.g. 2PL) have to overcome numerous serious internal and external barriers. The most important external barriers include unstable geopolitical situation (armed conflicts, embargos, legislative changes) and the unstoppable market force: industry consolidation. Internal barriers refer mainly to:

– geographic expansion: increasing the number of geographic markets in which the company can sell its services,
– portfolio expansion: introducing new services, including value-added services,

– technology: offering higher-quality service based on new technologies and IT systems,
– improvement of competitiveness in terms of costs (as a result of more economies of scale) and possibility of offering more higher-quality services for a lower price.

It can be observed that most LSPs do not fully exploit their development potential. Success – understood as a stable and organic development – can be achieved by:
– organizing operational activities in the area of process management, service quality improvement, development and implementation of new services consistent with customer expectations, innovation, customer service improvement, sales effectiveness, price strategy, or customer management,
– building an effective organizational structure which promotes loyalty, creativity, and entrepreneurship of employees, with a clear communication and decision-making process (who is responsible for what), with higher and middle management located closer to the rest of the employees,
– embracing and realizing a holistic strategy based on a strategic *status quo*, which means focusing on those areas of activity that allow to secure a strong competitive position.

Looking at it from a perspective of a few years, it is much easier to notice the changes which took place in the logistics market. Despite the 2008–2009 global crisis and the growing conflicts (the EU embargo on Russia, minimum wage for drivers in the EU), which greatly hinder the development of LSPs, we observe a stable increase of revenue in the TSL industry.

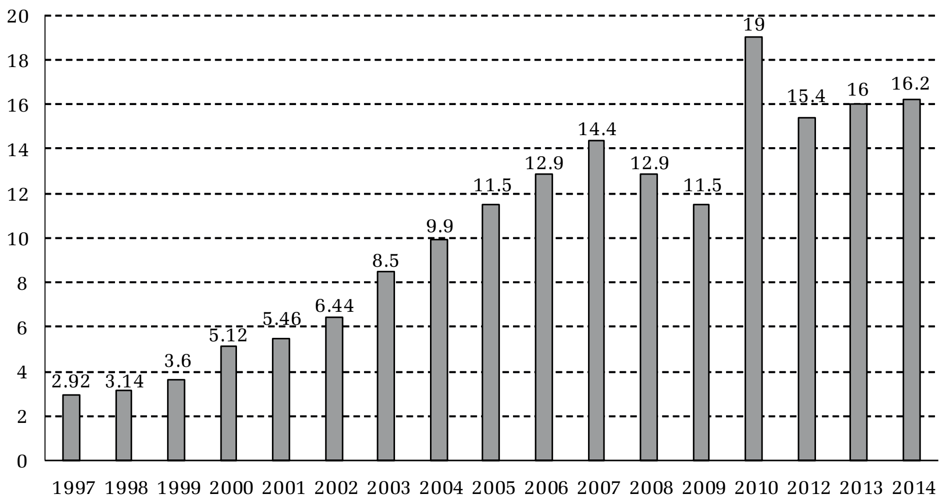

Figure 1. Sales revenue in the Polish TSL market (PLN bn)
Source: (own elaboration based on: Płaczek, 2012; Brdulak, 2014)

3. Value-building growth matrix of logistics service providers

Taking a closer look at the above data, an attempt was made to answer the question of whether the financial results achieved by LSPs translate into their success, which is equated with development. One of the many tools to evaluate the development of a logistics service provider is A.T. Kearney's development matrix, called the VBG (value-building growth) matrix. Two main attributes used to build the VBG matrix are revenue growth and value growth (Deans, Kroeger, 2006, p. 16). Four categories of LSPs can be distinguished depending on their average results: value growers (Q1), profit seekers (Q2), simple growers (Q3), and underperformers (Q4).

Referring to the results of the last study[1] and assuming that the structure of the sample reflects the current diversification of LSPs, an analysis of the present state of the VBG matrix has been conducted. In order to do so, the following questions have been asked: how are LSPs currently located in the VBG matrix? Did they follow in the footsteps of value growers in improving their activities? Did they change or retained their previous position in the VBG matrix?

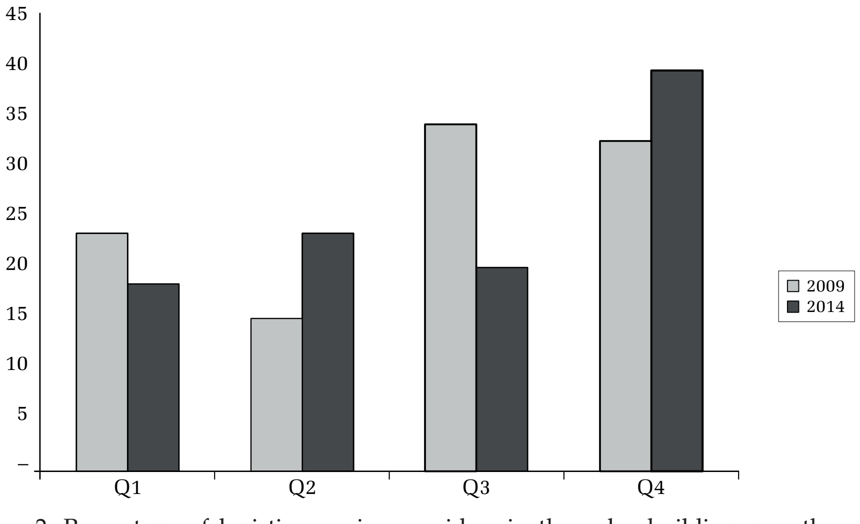

Figure 2. Percentage of logistics service providers in the value-building growth matrix (using average revenue and value index)
Source: (own elaboration)

A change of the position of LSPs in the VBG matrix can indeed be observed between 2009 and 2014: reduced share of value growers (by 7%) and simple growers (by 12%) and increased share of profit seekers (by 8%) and underperformers (by 11%).

As the assumption is that companies will move to Q1, theoretically this situation is unfavourable for LSPs, for, as we can see, most of them moved from their previous position to Q4. This means that either their revenue or value decreased. Practically

[1] The last study covered the years 2003–2007 and 2007–2009 and was presented in: (Płaczek, 2012). In the current study, the sample includes 57 logistics service providers.

speaking, however, it is difficult to unequivocally classify the changes as positive or negative. It should rather be assumed that the current situation is a passing one and constitutes a result of "temporary" difficulties (e.g. the EU embargo on Russia) which directly influence the demand for road transport logistics services.

In order to conduct a more in-depth analysis of the changes in the VBG matrix, a scatter plot was used showing the positions of LSPs relative to their competitors. The average revenue index was 0.155 (indicating average revenue growth by 15%, i.e., 29.55 million PLN), and the average value index was 0.84 (indicating average value growth by 84%, i.e., 83.9 million PLN).

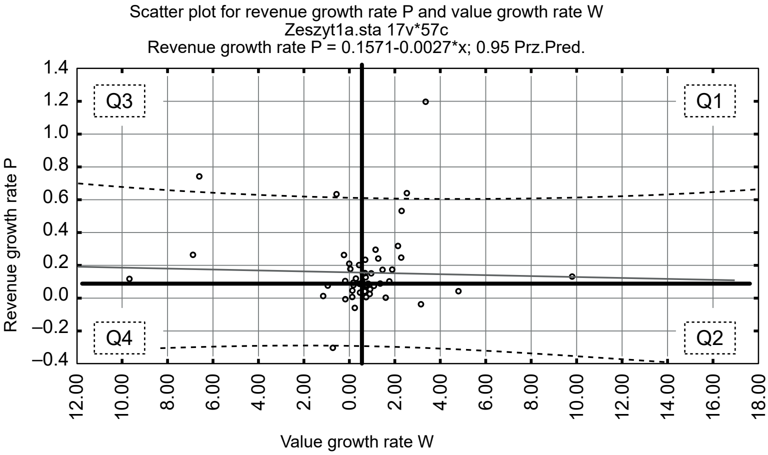

Figure 3. Scatter-plot value-building growth matrix, 2013–2014 (using average revenue and value index)
Source: (own elaboration)

Figure 3 shows a very high concentration of LSPs in Q2 and Q4 with respect to the average revenue and value index. This means that the range of the services offered became less diverse, which in turn led to a fierce product and price competition. In the case of Q1 and Q3 we can observe a larger dispersion.

From the point of view of LSPs, the changes of their positions in the VBG matrix are the consequence of the undertaken operational activities. For most companies this means not only the necessity to optimize their own costs, but also, most of all, to expand their product offer and to further adjust their activities to customer expectations and business needs. The products offered are expected to change along with the conditions in which the customers carry out their activities. Due to the availability of technology, it no longer serves as an indicator of competitive advantage, and those LSPs who pay more attention to the product and its excellence are able to achieve competitive advantage, profits, and value growth.

The VBG matrix built based on the average revenue and profitability index shows increased concentration in Q4, which indicates a situation unfavourable for most LSPs.

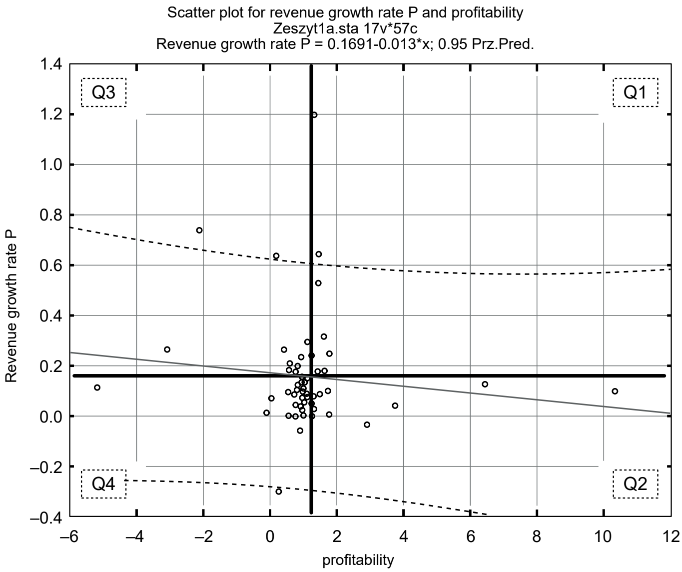

Figure 4. Scatter-plot value-building growth matrix, 2013–2014 (using average revenue and profitability index)
Source: Own elaboration.

A question arises whether this concentration is the result of changes in the profitability of LSPs. Studies indicate that, since 2009, average profitability remains constant at 3%. The concentration of LSPs therefore indicates that most of them achieve similar, relatively stable profitability levels. Profitability histograms from the years 2013 and 2014 exhibit a unimodal, right-skewed distribution. Half of the sample achieve average profitability of 2% (Me=0.02). At the same time, 25% of them achieve average profitability of 1%, and 75% – of 4% or above (top and bottom quadrant). The biggest changes are visible in the interquartile range (box-and-whisker plot). In 2014, the interquartile range decreased (the whiskers became shorter) and three outliers appeared which indicate deviations.

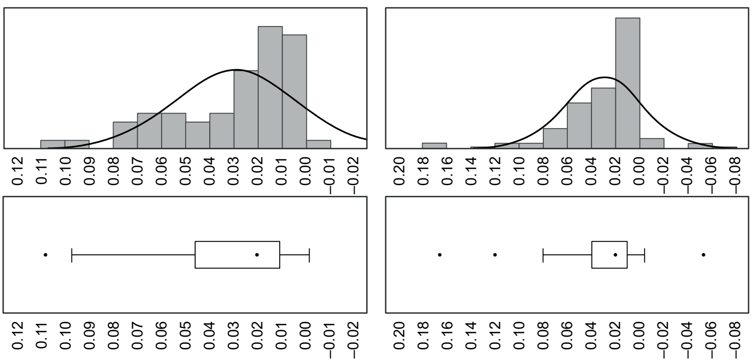

Figure 5. Profitability histogram, 2013–2014
Source: (own elaboration)

Based on the observation of the TSL market and the scatter plots we can definitely confirm that LSPs are still developing intensively, establishing lasting foundations for growth. There is no reason to expect turbulent changes in their positions in the VBG matrix. That being said, the position of a LSP in the given quadrant is not permanent, but depends on numerous internal and external factors. It may be assumed that further concentration of LSPs in the VBG matrix will be observed, and their position in the given quadrant (not necessarily favourable) will depend on the average results of the selected attributes. There is no guarantee of success; the occupied position and the level of development are not permanent, and to secure them LSPs have to constantly improve all areas of their activity – by raising customer satisfaction, reducing costs, increasing profitability, building teams of professional and effective employees – while achieving financial benefits.

Conclusions

The development need of logistics service providers stems from the present situation in the TSL market, which imposes constant change in the business activity. The operations undertaken in this regard are mainly meant to prevent elimination from the market, boost competitiveness, and, most of all, meet the needs of increasingly demanding customers. It is important for logistics service providers to realize their goals in the turbulent business environment. Fortunately, TSL service providers are aware that nowadays the ability to develop is the fundamental condition of success. Development should occur with accordance to established principles and achieve the intended results.

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ARCHITECTURES OF LOGISTICS PROCESSES AND SYSTEMS

Abstract

Logistics management requires a lot of ideas, methods, and tools to control the logistics processes and systems. Analysing, planning, implementing, and monitoring logistics activities without a map of the controlled processes is especially difficult, if not impossible; to do it, an idea of how to transfer the reality into the map is needed. It is therefore worth asking about the method of performing that task, and thus about the so-called architecture from the scientific point of view. In an attempt to answer these questions, based on modelling methodology, the paper discusses three frameworks: ARIS, IDEF, and Zachman. The research results are models of forecasting and simulating of logistics processes and the conclusion is that architectures are of great importance as they enable the creation of maps, models, schemes, procedures, instructions, etc., which are necessary for effective logistics management.

Keywords: architecture, model, logistics

Introduction

One of the phenomena observed in actual logistics processes and described in source literature is the complexity of logistics[2]. This means that along with the evolution, development, or changes of logistics processes and systems their complexity (understood as a growing number of logistic operations, loading units, providers, intermediaries, and consumers of logistics services, employees, and,

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2 One of the documented examples of the phenomenon of logistics complexity and a way of dealing with the problems it entails is the example of the Škoda car producer, which belongs to the Volkswagen group. The relevance of this phenomenon is confirmed by the fact that Škoda's project, which contained a proposition of solving the problems of logistics complexity, is regarded as innovative and earned it the award of the European Logistics Association in 2014 (Škoda, 2014, p. 5).

most of all, rapid logistic information accrual) increases, causing multidimensional management problems that also concern other areas, such as production, finance, IT, or staffing. In the context of logistics management, this phenomenon generates problems mostly with planning and controlling increasingly complex logistics systems. To solve these problems, works are undertaken to search for and evaluate different concepts, methods, and tools in order to test their application possibilities. So far, research on the construction and functioning of natural systems (Maciaszek, 2004a, pp. IS-9–IS-13) indicates that they have a hierarchical structure, which allows them to control their own increasing complexity, and thus supports the whole system in its development. This conclusion permits to propound a thesis that knowing the construction and functioning of a given logistic structure – or, more precisely, identifying its components and understanding the internal and external interconnections – is the starting point for tackling the problems of logistics complexity.

A consequence of logistics complexity – or the grounds for identifying the structure of logistics processes and systems independent of this phenomenon – are the problems of logistics management, especially with analysing, planning, implementing, an controlling logistic events, operations, resources, and relations, along with their parameters. Performing these tasks without mapping the whole logistics support system or its elements (e.g. in the form of a map, routine model, reference model, or flow sheet), in a desired perspective and required level of aggregation or concretization, is difficult, if not impossible. Apart from day-to-day management needs, this necessity arises especially if a decision has been made to engineer, reengineer, or certify logistics processes and systems. In these cases, it becomes indispensable to map the actual logistics support system, analyse it, and improve it by designing its planned (target, master, reference, etc.) image.

It is therefore suggested to perceive logistics systems and processes as hierarchical structures, and to use suitable methodology of measuring (mapping), analysing, and designing logistic structures to gather knowledge and use it in logistics management, especially in the areas of planning, analysis, organization, and control (Maciaszek, Liong, 2003, pp. 120–149). With this aim in mind, we can draw on research papers from the field of management studies, which discuss a number of architectures (Maciaszek, 2004b, p. 57) – concepts, methods, and tools used to examine economic structures – in order to test their usefulness and possibilities of their application in logistics. Thus, the aim of this paper is to identify the architectures of logistics processes and systems and evaluate their application possibilities. The former aim is achieved by reviewing literature and conducting case studies; the latter – by drawing on the author's own modelling experience and using specialized software (ARIS Toolset). The first section of the paper presents the results of the analysis of the ARIS, IDEF, and Zachman frameworks; the second section evaluates the application possibilities of the ARIS architecture, which, based on the author's own experience and the results of the research conducted by the Business Application Research Centre (BARC), an institution that assesses the usefulness of IT tools in business, is regarded as best fitted for logistics use.

1. ARIS, IDEF, and Zachman frameworks

The architecture of economic systems or their elements (enterprises, IT systems, organizational divisions and units, etc.) is their organizational and functional structure along with the internal and external interconnections (Maciaszek, 2004b, p. 57). Although there can be found examples of numerous architectures in economic theory and practice (Luisi, 2014, pp. 317–322; Milchman, 2017, pp. 15–17), for the purpose of this paper a closer look only at the ARIS, IDEF, and Zachman frameworks will be taken.

According to the ARIS architecture, as subjects of research, analysis, design, etc., economic processes and systems, including logistics processes and systems, should be considered from four perspectives (Rosing, Scheer, Scheel, 2015, p. 40):
- data perspective,
- functional perspective,
- organizational perspective,
- control perspective.

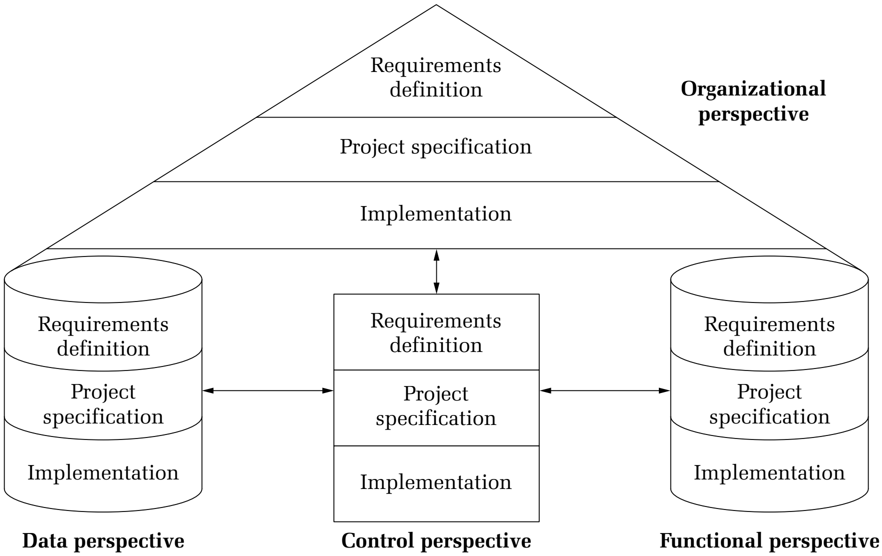

Figure 1. ARIS architecture
Source: (Rosing, Scheer, Scheel, 2015, p. 40)

The first three allow to analyse the components of a logistics system, i.e., data, functions, and organizational structure. The last perspective makes it possible to perceive these components as one system, and thus to coordinate and integrate them. Each of the above-listed perspectives is further divided into the following three levels of description that differ by the degree of concretization, and which can also be regarded as three subsequent stages of designing logistics support systems:

– defining the management requirements of the system users (information about logistics events and activities, who performs them, what resources are required, what are the logistics costs, etc.),
– design specification (hardware and software, storage equipment, automatic identification of goods, office equipment, etc.),
– implementation (training, purchasing, testing, etc.).

The highest level is the most general and conceptual, and thus remains relatively unchanged over a longer period of time. The second level, which requires specification of the equipment necessary to fulfil the management requirements identified on the first level, is characterized by a relatively shorter time horizon, mainly due to the lifetime of computer equipment and software. The third and lowest level is basically a description of a one-time implementation into the economic practice defined and specified on the previous levels of the logistics support system.

The ARIS architecture is used in a number of ARIS applications provided by Software AG (Software AG, 2017). They currently include eighteen applications; among them, ARIS Architect & ARIS Designer and ARIS Simulation are intended especially for mapping, simulating, analysing, and designing economic processes and systems. They are methodologically compatible with their previous versions: ARIS Toolset, ARIS Easy Design, and ARIS Express (simplified version). The achieved results, especially in the form of reference models of logistics processes, in addition to their incidental use (e.g. to detect the areas of logistical inefficiency – bottlenecks, waste, etc.), find constant application in IT systems or those of their modules that are responsible for the IT support of logistics processes. These models are part of a database of IT reference models; they serve as a basis to configure or redesign the functionalities of IT systems (and thus logistics management systems) according to the information needs of their users and to develop additional elements ("information cockpit," quality manuals, procedures for performing tasks, instructions, document flow charts, etc.). An IT system most compatible with the models of logistics processes and systems designed using the ARIS architecture is the integrated SAP ERP system, as it includes a set of automation tools to convert the ARIS models into executable programs and vice versa, to enable the modelling of already realized logistics processes monitored using PPM (Process Performance Manager) software.

IDEF (Integrated Definition Methods) is another architectural description of the economic, and thus logistical, reality (Lankhorst et al., 2017), which uses a set of fourteen methods, depending on the aim of design work.

Table 1. IDEF methods

Symbol	Name of the method
IDEF0	Function Modelling
IDEF1	Information Modelling
IDEF1X	Data Modelling
IDEF2	Simulation Model Design
IDEF3	Process Description Capture
IDEF4	Object-Oriented Design

Symbol	Name of the method
IDEF5	Ontology Description Capture
IDEF6	Design Rationale Capture
IDEF7	Information System Auditing
IDEF8	User Interface Modelling
IDEF9	Scenario-Driven IS Design
IDEF10	Implementation Architecture Modelling
IDEF11	Information Artefact Modelling
IDEF12	Organization Modelling
IDEF13	Three Schema Mapping Design
IDEF14	Network Design

Source: (Rouse, 2017)

The basic tool for mapping the structure of economic systems is the block diagram proposed by the first of the above methods, IDEF0, where the "block" represents the function of a given system (e.g. manufacturing function), the realization of which requires inputs (material, information, financial). A special kind of information input, which controls the function, is mapped separately. The function of the system is also supported by another type of input –mechanisms, e.g. hardware, software, machines, tools, organizational units, and employees. The result of performing functions obtained from inputs, controls, and mechanisms is presented below in the form of outputs (products, documents, etc.).

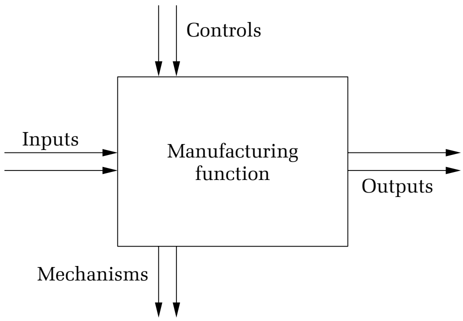

Figure 2. Block diagram of IDEF0
Source: (IDEF, 2017)

The IDEF0 architecture has multiple applications. Its idea is so basic that every application used to construct a graphic model of any system or process refers to it either directly or indirectly. It bears a strong resemblance to Sankey's material flow diagram (Skowronek, Sarjusz-Wolski, 2012). Although it uses thicker or thinner lines instead of arrows to graphically distinguish the material flow rates between the points of origin and destination, the essential goal remains the same – to map the particular elements of a system or a process using conventional graphic symbols. This means that if we have even a standard graphic program at our disposal, e.g. CorelDRAW[3], MS Visio[4], or a set of graphic symbols from any application, e.g. MS Office[5], we are able to construct a model of a logistics system or process according to the IDEF0 methodology. Specialized applications recommended for use within the IDEF0 architecture include AIØ WIN®, SMARTER®, PROSIM®, MODELMOSAIC®, and ConceptDraw PRO® (IDEF Software, 2017).

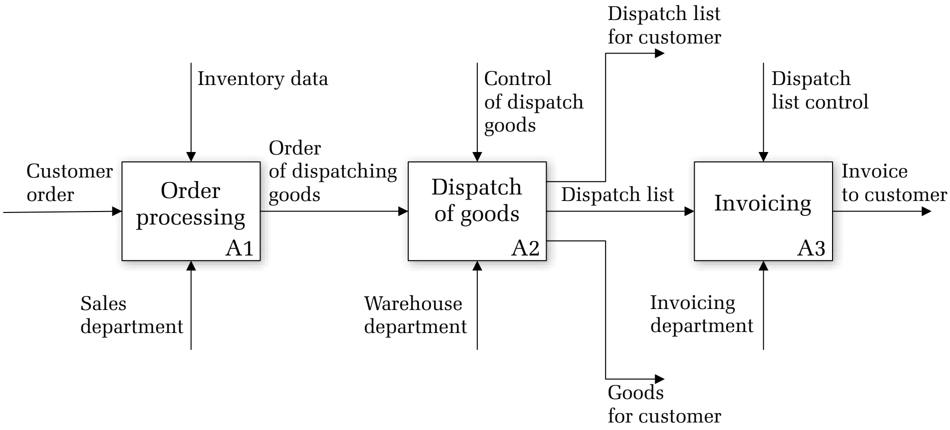

Figure 3. Partial model of a logistics process according to the IDEF0 standard
Source: (IDEF0, 2017)

An application example of IDEF0 containing a partial model of a logistics process is presented in Figure 3. The process includes three functions: order processing, dispatch of goods, and invoicing. Each of these functions requires resources, and its execution also results in obtaining a resource that powers another function. For example, the dispatch of goods is carried out by the warehouse department and depends on information resources in the form of an order of dispatching goods and a dispatch control. The results of executing this function are three products: two information products (in the form of a dispatch list for customer and a dispatch list that constitutes an information input to the function – invoicing), and a third product in the form of goods for customer. Other functions are described in an analogous manner. Similar block diagrams are also used to create models of logistics processes compatible with the SCOR (Supply Chain Operation Reference) model developed by the American Production and Inventory Control Society (APICS, 2017).

J.A. Zachman is the creator of another architecture of economic processes applicable for logistical purposes. Called Zachman Framework™ (Zachman, 2017) after its creator, it should be treated as an authorial concept of describing the structure of an economic entity. Analysing Zachman's proposition, whose current version 3.0

[3] CorelDRAW was developed by Corel Corporation.
[4] MS Visio was developed by Microsoft Corporation.
[5] MS Office was developed by Microsoft Corporation.

is presented in Figure 4, it can be noticed that it distinguishes four perspectives of viewing economic systems:
– audience,
– model names,
– enterprise names,
– classification names.

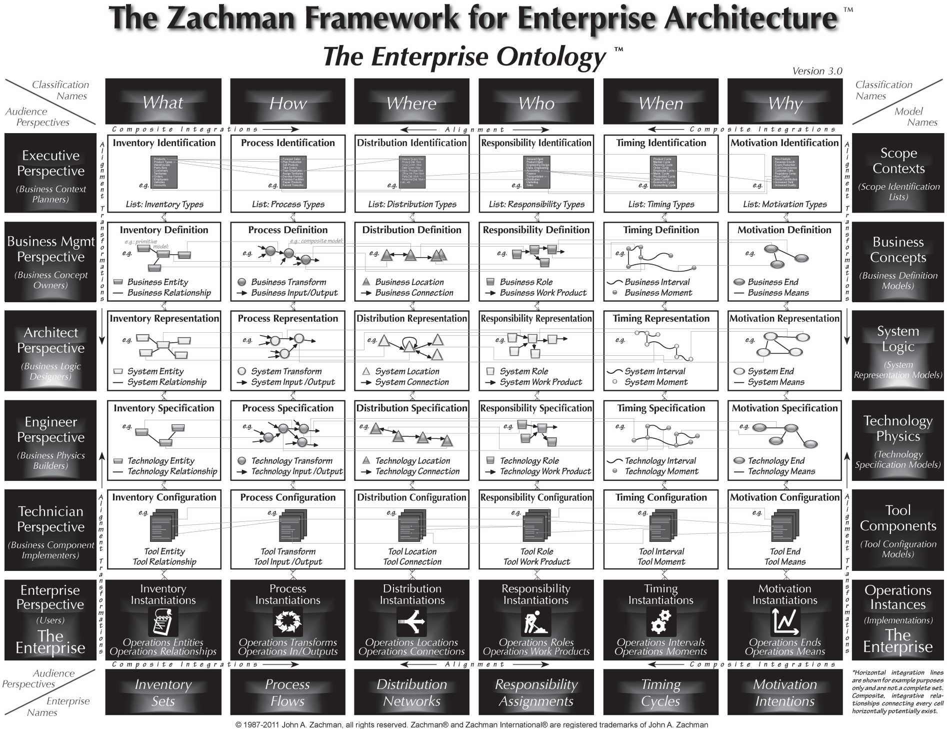

Figure 4. The Zachman framework
Source: (Lapalme et al., 2016)

All of these perspectives are subject to further divisions. The most basic and, at the same time, controversial seems to be the classification names' perspective, according to which elements of the researched economic system, including logistics, can be identified by answering six questions: what? how? where? who? when? and why? The answers to these questions should allow to classify the particular elements of the system into one of six classes: products (what?), e.g. stocks; processes (how?), e.g. delivering; location (where?), e.g. at the recipient's warehouse; human resources and the scope of their responsibilities (who?), e.g. warehouse employees; schedule (when?), e.g. in 24 hours; motivations (why?), e.g. logistic goals. What may be considered controversial are the subjectivity of the classification and interpretation problems (how should we understand motivation, or do products indeed include only material objects, such as stocks?).

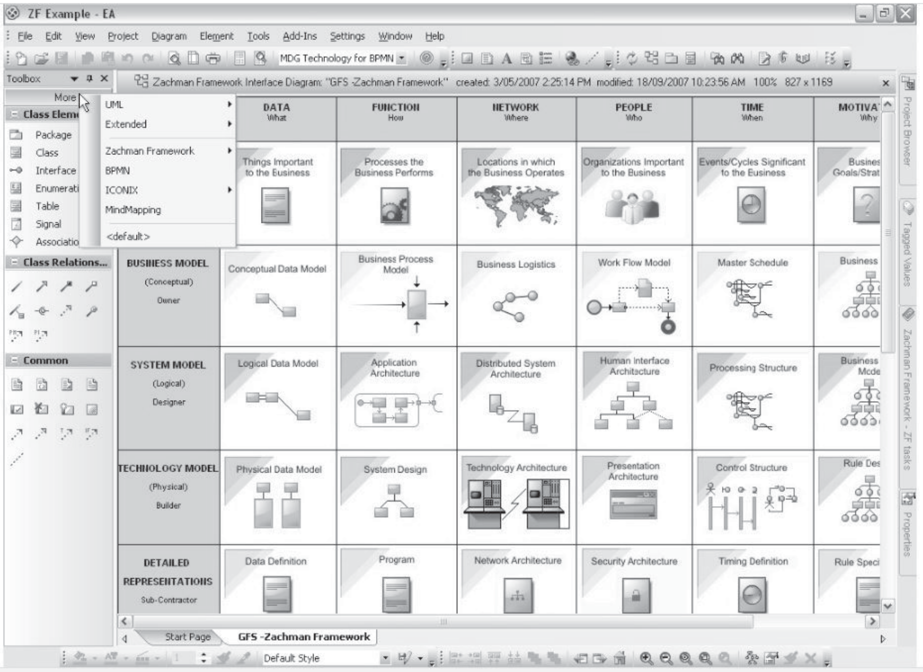

Figure 5. Application of the Zachman framework in Enterprise Architect®
Source: (Zachman framework, 2017)

There are several computer programs based on the Zachman framework used in modelling work. Applications that directly refer to this model include IBM® Rational® System Architect®, and Enterprise Architect® (Sparx, 2017). Figure 5 presents an application example of the Zachman framework in Enterprise Architect®; it should be noted that the particular models of logistics processes in the business and functional perspective are constructed using symbols similar to those used in the IDEF0 architecture. This means that unlike the two previously discussed architectures, Zachman did not develop his own symbols – or, to put it differently, his own standard, language, or notation of mapping the studied reality – but instead drew on the existing ones. This is not equivalent to a negative assessment of the Zachman framework, as it can still use different methods and tools for application purposes.

Making an attempt at comparative evaluation of the described architecture, it should be stated that each of them has undeniable advantages and disadvantages, listed in Table 2 based on the author's own experience in modelling logistics systems and processes. According to his subjective assessment, the ARIS architecture is the most recommended for logistics design. This conclusion is objectivized by the study conducted by BARC, which, assessing the usefulness of IT tools in business, in 2016 awarded it the first place (Kraus, 2016; Kraus, Böhn, 2016). For this reason, the remainder of the paper discusses ARIS logistics modelling capabilities.

Table 2. Advantages and disadvantages of the ARIS, IDEF0, and Zachman frameworks

Framework	Advantages	Disadvantages
ARIS	– a comprehensive control perspective – own EPC standard (method) of designing processes	unclear reason for categorizing human resources in a separate organizational perspective, and other resources (material, information, financial) in a data perspective
IDEF0	– systemic approach based on an input–output model – relatively simple and logical methodology and symbolism	no possibility of mapping logistics events, e.g. receiving deliveries
Zachman	the fullest possible set of detailed perspectives	no comprehensive perspective including all elements on one map

Source: (own elaboration)

2. Designing logistics systems and processes using the ARIS Toolset

The ARIS Toolset possibilities of designing logistics systems and processes are presented on the examples of logistic forecasting and simulation models (Figures 6 and 7). The design activities carried out in relation to the logistic forecasting system indicate that it consists of two components: the process and the resources (input, output). With respect to the former, the forecasting process is understood as a sequence of functions that is initiated by an event(s) and that also generates a subsequent event(s). This initial event, defined as "the need for forecasting arose," is a general description of potential concrete situations, such as:

- a forecast order has been received to determine material and distribution requirements and storage capacity, develop the main production plan, schedule transportation, etc.,
- the time has come to make a forecast (e.g. according to the previously adopted procedure material requirements have to be forecasted each week, month, or year),
- another event has occurred (e.g. a wish to verify a given forecasting method).

The event "the need for forecasting arose" initiates the first function[6] of the logistic forecasting process, namely "formulate a forecasting task." To execute this function it is necessary to have resources (the second element of the system); e.g. within the data perspective the necessary information resource is "the need." This is also a general term for the concretely expressed need for forecasting (e.g. material requirements) regarding the function "formulate a forecasting task." Thus, the relation (arrow) connecting both elements is the input. To put it differently, "the need" constitutes an (information) input to the function "formulate a forecasting task." To execute this function, an organizational resource is also needed, here defined as "R&D, J. Smith." Thus, the relation connecting these items is termed execution or

[6] In the ARIS architecture, function is identified with such elements of logistics processes as: activity, action, operation, work, sub-process, stage, phase, etc.

responsibility relation. If IT support is required to execute the function, an appropriate item should be included in the model. Such is the situation in the discussed case, as indicated by the information resource "IT system" (hardware and software), that supports the function "formulate a forecasting task." In addition to inputs, each function has to "produce" something – have an output or outputs. The result (product) of the execution of the function "formulate a forecasting task" is an information defined as, e.g., "what will be the demand?" This information constitutes, at the same time, an (information) input to the following function: "determinate forecasting premises." The execution of the function "formulate a forecasting task" creates a new situation described by an event termed "problem formulated." This event ends the first function and, at the same time, initiates another function, "determine forecasting premises." The above description is applicable to subsequent elements of the forecasting system and simulation system. An element of the ARIS architecture present in both models that has not been discussed is the logical operator "xor" (exclusive or). It means that the function "determinate forecasting premises" (Figure 6) can be initiated by one of the three mutually exclusive events:
- "problem formulated,"
- "forecast not accepted,"
- "forecast verified negatively."

The other operator not explained is "and," which connects the particular elements; e.g., the function "verify the forecast" and "logistics processes" are performed simultaneously, but not necessary at the same place. It should be added to the above explanations that the dashed lines indicate the run-sequence of the process, while the solid lines present the flow of resources.

Although Figures 6 and 7 do not show attributes – such as the frequency of events, time and cost of functions, or number of employees – as they are hidden in dialogue windows of the particular elements of the modelled process, the ARIS Toolset makes it possible to simulate the course of each logistics process according to the criteria of time, cost, and utility of the resources (Scheer, Nüttgens, 2000). The obtained results allow to analyse the designed logistics processes in the following aspects:
- types of functions (activities),
- items of the system (functions, events, organizational units, entities),
- cost and duration of functions,
- use of the working time of the people performing the process,
- lack of resources (so-called dynamic waiting time) or not making use of available resources (low value of utilization indicator).

The analysis of these aspects makes it possible to decide to implement the model to the practice of logistics (if the result is positive) or to improve the designed logistics process by redesigning (reconfiguring, reengineering) it until the intended results are obtained.

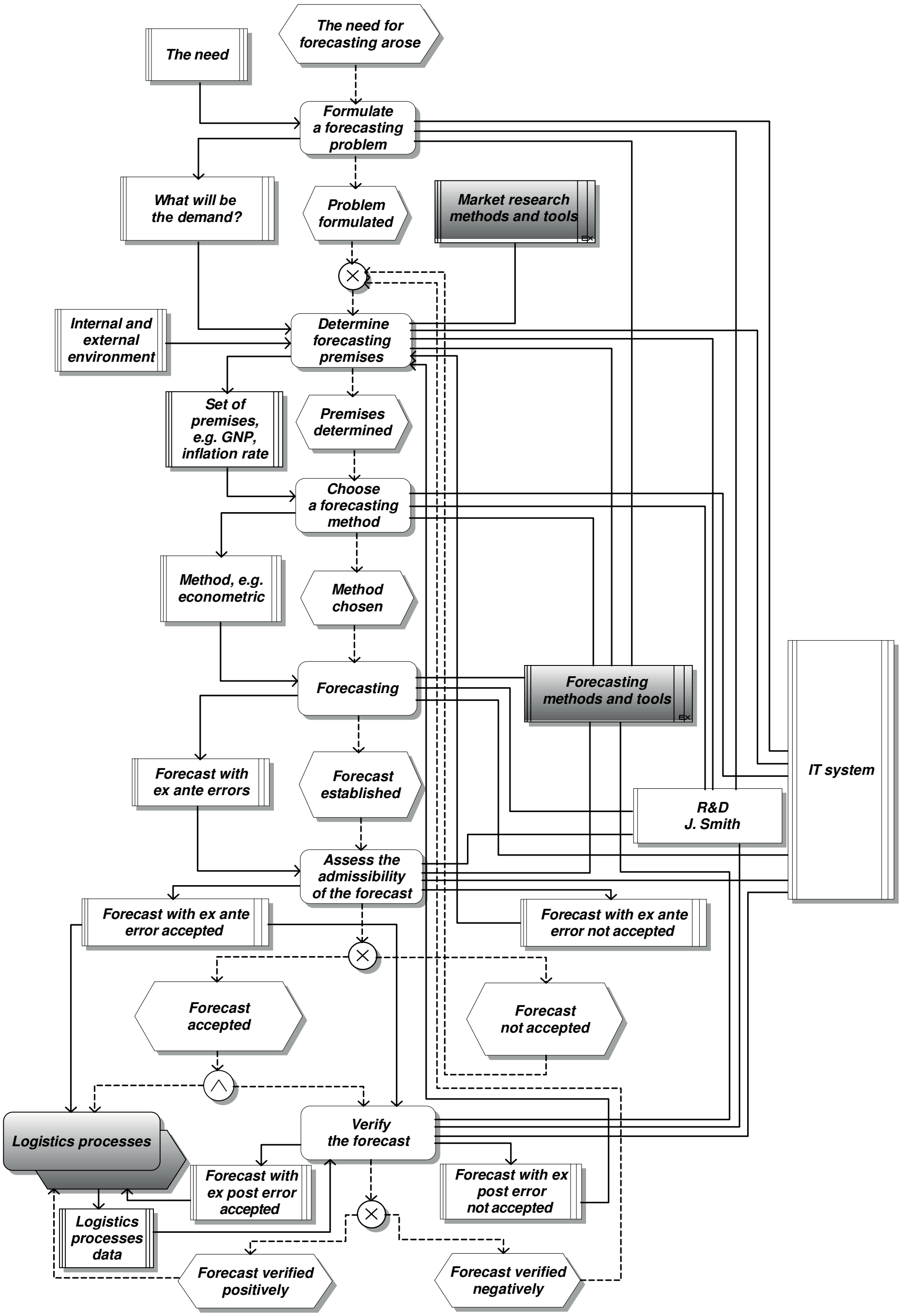

Figure 6. Model of a logistic forecasting system
Source: (own elaboration using the ARIS Toolset software)

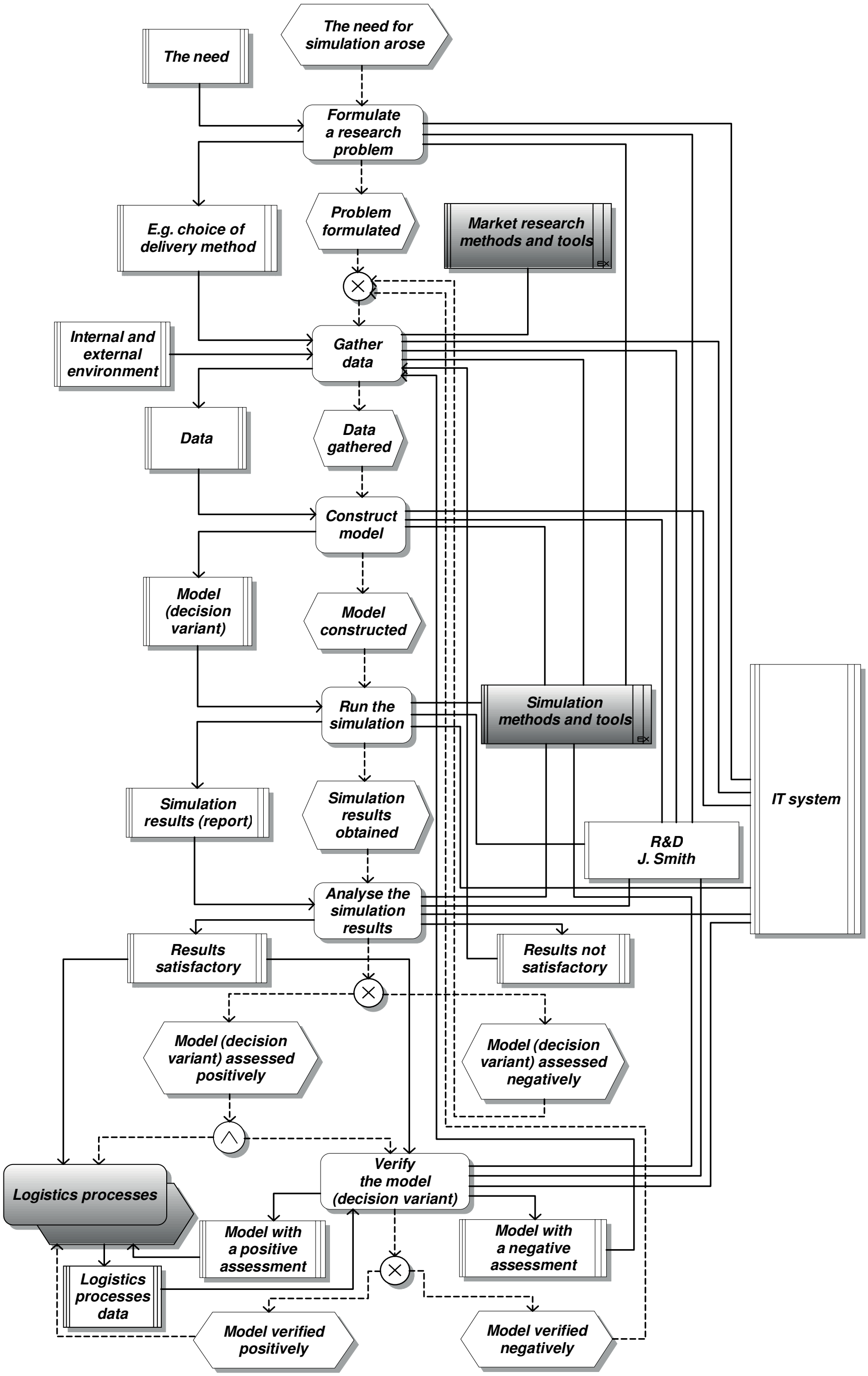

Figure 7. EPC model of a simulation system
Source: (own elaboration using the ARIS Toolset software)

Conclusions

Architectures used for mapping logistics processes and systems are indispensable for logistics management, where they serve an important purpose from both theoretical and practical point of view. Theoretically speaking, architectures determine the way of perceiving the subject of the design, offering its description according to the given set of perspectives (function, resources, events, etc.) and on many levels of concretization (conceptual, business, technological, etc.). In the practice of logistics, architectures constitute standards of formalization of processes in the form of charts, maps, or models (e.g. forecasting), procedures (e.g. procurement of goods), instructions (e.g. warehousing), quality manual of logistics support system, flow diagram of logistics documentation, etc. The ARIS, IDEF0, and Zachman frameworks described in the paper represent three concepts of describing logistics processes and systems which, although different in terms of the offered perspectives and levels of overview, essentially attempt to map the studied object both wholly and partially, depending on the researcher (user) needs. The above theses are confirmed by the presented capabilities of the ARIS Toolset, which demonstrate that the models of logistics processes constitute an important element of functional and economically effective logistics management.

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AN ATTEMPT TOWARDS A MODEL APPROACH TO CHOOSING A STOCK REPLENISHMENT SYSTEM UNDER CONDITIONS OF INDEPENDENT DEMAND

Abstract

The premise for approaching the subject is the need to support companies in selecting the best stock replenishment system, taking into account all external or internal limitations related to delivery terms and order volumes assuming that safety stock is the central factor ensuring the achievement of the intended availability level. In order to meet the objective, several stock replenishment systems are briefly described. Then, prerequisites for their proper selection are identified and classified. As a result, a selection table is developed along with an algorithm for selecting an optimal stock replenishment system based on an economic or qualitative criterion.

Keywords: inventory management, stock replenishment systems

Introduction

The approach presented in the paper was developed by the author in order to aid enterprises in choosing the right system of stock replenishment and determining the principles of estimating the parameters controlling those systems as part of the consultation work of the Institute of Logistics and Warehousing. It was also used in the doctoral dissertation of one of its faculty members (Kolińska, 2015).

The two basic questions that arise when designing stock replenishment systems are: when to place orders and what should be the size of the order. The answer is provided directly or indirectly by the parameters controlling stock replenishment systems. There exist numerous such systems and the implementation of the most of them is backed by IT systems supporting the management of the flow of goods available in the market (Pyrek, 2007).

A correct calculation of control parameters, which answer the above questions, is usually given crucial importance. These calculations have to take into account a number of conditions connected with demand and quantities that characterize the process of stock replenishment:

– random variability of demand – its scale and character (including the type of frequency distribution),
– random variability of replenishment lead time – its scale and character,
– quantitative and qualitative deficiencies in deliveries, damage made during acceptance of delivery, losses during storage – also in statistical terms,

as well as the criteria related to the availability of stock and its replenishment costs:

– service level – its value according to the assumed type of indicator – probabilistic or quantitative approach (Tempelmeier, 2000, pp. 361–380),
– the costs of replenishing, maintaining, and lack of stock.

Very often, however, the essential issue is the very choice of a system, determined by organizational and technical constraints on the part of both the provider and the recipient, as well as the above-listed criteria.

1. Review of stock replenishment systems

The necessity to react to the above-mentioned random variability of demand requires employing either a "fixed quantity, variable cycle" system or a "fixed cycle, variable quantity" system. In both cases the aim is to adjust the rhythm and size of orders to the observed random variability of demand.

		Order quantity	
		FIXED	VARIABLE
Period between orders	VARIABLE	• BQ – system based on re-order level (re-order point) • sQ – periodic review with decision level s and fixed order quantity Q	MIN-MAX systems • BS system – system based on re-order level with variable (depending on actual stock level) order quantity • sS system – periodic review with decision level s and variable (depending on actual stock level) order quantity
	FIXED	• QT system (fixed-quantity orders placed at fixed intervals) Contition – very low variability of demant during the replenishment cycle ($\sigma_D \approx 0$; $\sigma_{LT} \approx 0$)	• ST – system based on periodic review

Figure 1. Classification of stock replenishment systems based on safety stock
Source: (own elaboration)

This approach can be generally presented in the form of a simple matrix which shows the most important stock replenishment systems corresponding to the discussed cases. The symbols of the systems are based on the terminology developed by the European Logistics Association (ELA, 1994).

The paper examines five selected systems presented in Figure 1. Their implementation rules are discussed below.

1) BQ system – based on re-order level (re-order point). Order is placed in a fixed quantity Q when, after another operation (including reservations), the quantity of economic stock S_E becomes equal to or less than the re-order level B. Each time, economic stock is calculated as follows:

$$S_E = S_W + S_O - S_R \tag{1}$$

where:
S_W – warehoused stock,
S_O – stock on order, but not yet delivered,
S_R – stock requisitioned, but not yet issued.

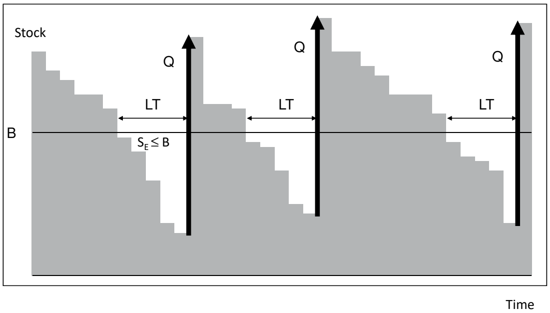

Figure 2. Stock replenishment in BQ system
Source: (own elaboration)

2) ST system – based on periodic review. Orders are placed at fixed intervals (T_o), in a quantity equal to the difference between maximum stock level S and current quantity of economic stock S_E.

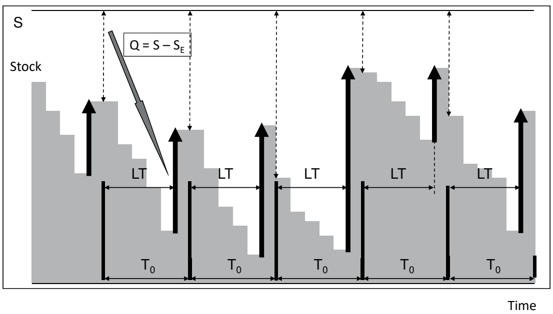

Figure 3. Stock replenishment in ST system
Source: (own elaboration)

3) BS system – MIN-MAX system based on re-order level. Order is placed when, after another operation, the quantity of economic stock S_E becomes equal to or less than re-order level B, in a quantity equal to the difference between maximum stock level S and current quantity of economic stock S_E.

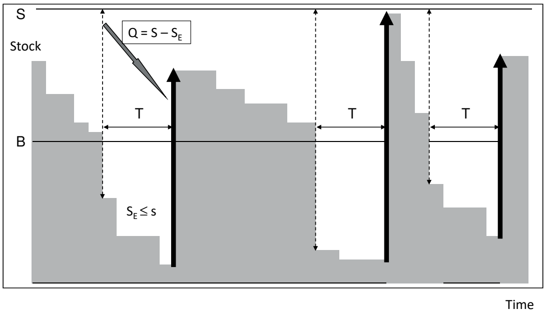

Figure 4. Stock replenishment in BS system
Source: (own elaboration)

4) sS system – MIN-MAX system based on periodic review. Stock review is conducted at fixed intervals (T_o), but orders are placed only if the quantity of economic stock S_E at the time of review is equal to or less than re-order level s, in a quantity equal to the difference between maximum stock level S and current quantity of economic stock S_E.

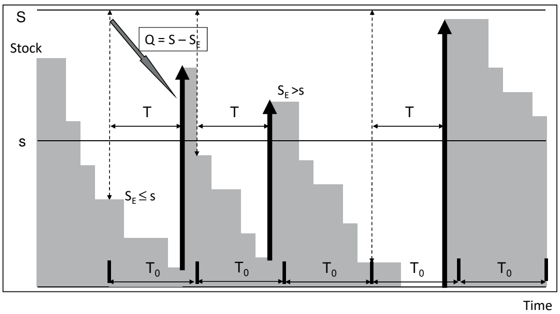

Figure 5. Stock replenishment in sS system
Source: (own elaboration)

5) sQ system – system based on interim review. Stock review is conducted at fixed intervals (T_o), but orders in a fixed quantity Q are placed only if the quantity of economic stock S_E at the time of review is equal to or less than re-order level s.

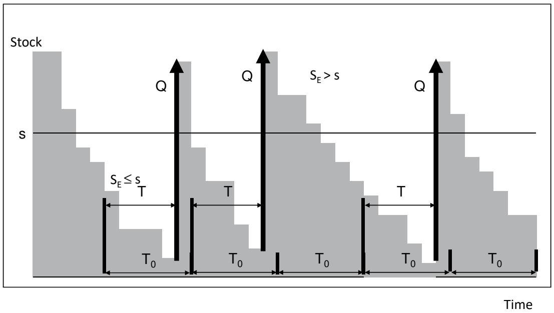

Figure 6. Stock replenishment in sQ system
Source: (own elaboration)

2. Limitations in selecting a stock replenishment system

The process of selecting a suitable stock replenishment system must be conducted in two stages. First, all organizational or technical limitations on the part of both the provider and the customer that could exclude some of the systems under consideration should be identified. Those limitations can be related to the two crucial issues of when and how much to order. To determine that, the following three questions must be answered:

– Do orders have to be placed at fixed intervals (e.g. once a month, once a quarter) T_o, or can they be placed at any given time?
– Can order quantity Q be variable?
– Is there a minimum order quantity (either imposed by the supplier or determined by internal arrangements) Q_{min}?

Assuming that the only possible answers to the above questions are "yes" and "no," Table 1 summarizes all possible variants[7] of answers, at the same time indicating those sequences of answers that rule out particular stock replenishment systems. It has also been assumed that, e.g., a positive answer to the question "Can order quantity Q be variable?" does not rule out solutions with fixed order quantities (it *can*, but does not *have to* be variable).

Based on the limitations to implementing the stock replenishment systems under consideration identified in Table 1, suitable systems for each variant of limitations (or lack thereof) are presented in Table 2.

Based on Table 2 as well as on the characteristics of all five stock replenishment systems under consideration Table 3 was constructed, which presents the connections between particular systems, their control parameters, and quantities resulting from qualitative (service level), economic (economic order quantity EOQ, economic review cycle T_{oec}), or imposed constraints (minimum order quantity Q_{min}, imposed review cycle T_{oI}).

[7] The number of variants considered corresponds to the number of variations with repetitions (three questions, two possible answers) $n = 2^3 = 8$.

Table 1. Possible variants of answers to the questions identifying the limitations to implementing the stock replenishment systems under consideration

Is there a fixed order interval T_O imposed?

Is there a fixed order interval T_O imposed?	Can order quantity Q be variable?	Is there a minimum order quantity (Q_{min}) set?	BQ	ST	BS	sS	sQ
NO	NO	NO				NO	
NO	NO	YES				NO	
YES	YES	NO	NO		NO		
NO	YES	YES					
NO	YES	NO					
YES	YES	YES	NO		NO		
YES	NO	YES	NO		NO	NO	
YES	NO	NO	NO		NO	NO	

Can order quantity Q be variable?

Is there a fixed order interval T_O imposed?	Can order quantity Q be variable?	Is there a minimum order quantity (Q_{min}) set?	BQ	ST	BS	sS	sQ
NO	NO	NO		NO	NO	NO	
NO	NO	YES		NO	NO	NO	
YES	YES	NO					
NO	YES	YES					
NO	YES	NO					
YES	YES	YES					
YES	NO	YES		NO	NO	NO	
YES	NO	NO		NO	NO	NO	

Is there a minimum order quantity (Q_{min}) set?

Is there a fixed order interval T_O imposed?	Can order quantity Q be variable?	Is there a minimum order quantity (Q_{min}) set?	BQ	ST	BS	sS	sQ
NO	NO	NO					
NO	NO	YES		NO			
YES	YES	NO					
NO	YES	YES		NO			
NO	YES	NO					
YES	YES	YES		NO			
YES	NO	YES		NO			
YES	NO	NO					

Source: (own elaboration)

Table 2. Suitable stock replenishment systems for each variant of limitations

Is there a fixed order interval T_O imposed?	Can order quantity Q be variable?	Is there a minimum order quantity (Q_{min}) set?	BQ	ST	BS	sS	sQ
NO	NO	NO	YES				YES
NO	NO	YES	YES				YES
YES	YES	NO		YES		YES	YES
NO	YES	YES	YES		YES	YES	YES
NO	YES	NO	YES	YES	YES	YES	YES
YES	YES	YES				YES	YES
YES	NO	YES					YES
YES	NO	NO					YES

Source: (own elaboration)

Table 3. Connections between particular systems, their control parameters, and quantities resulting from qualitative, economic, or imposed constraints

Parameters → / Circumstances ↓ / Systems	Q	B	To	S	s
Economic order quantity EOQ considering that $EOQ \geq Q_{min}$	BQ sQ			BS sS	
Service level SL		BQ BS		ST sS	sQ sS
Economic review cycle T_{oek} considering the limitation related with an imposed review cycle T_{oN}			ST sQ sS		sS

Source: (own elaboration)

Based on Tables 2 and 3, for each system usable under given constraints sets of control parameters and quantities that affect their optimal values were identified, taking into account the qualitative, economic, and imposed constraints.

Table 4. Sets of control parameters of the stock replenishment systems under consideration and quantities that affect their optimal value

Is there a fixed order interval T_o imposed?	Can order quantity Q be variable?	Is there a minimum order quantity (Q_{min}) set?	SYSTEM	Parameters				
				Q	B	To	S	s
NO	NO	NO	BQ	EOQ	[SL]			
			sQ	EOQ		T_{oec}		[SL]
NO	NO	YES	BQ	EOQ/Q_{min}	[SL]			
			sQ			T_o (Q)		[SL]
YES	YES	NO	ST			T_{oI}	[SL]	
			sS			T_{oI}	[SL, T_{oI}]	

Is there a fixed order interval T_o imposed?	Can order quantity Q be variable?	Is there a minimum order quantity (Q_{min}) set?	SYSTEM	Parameters				
				Q	B	To	S	s
NO	YES	YES	BQ	EOQ/Q_{min}	[SL]			
			BS		[SL] + [$Q_{>min}$]		B+Q	
			sS			Toec	s + Q_{min}	[SL, T_{oec}]
			sQ	EOQ/Q_{min}		T_o (Q)		[SL]
NO	YES	NO	BQ	EOQ	[SL]			
			ST			T_{oec}		[SL]
			BS		[SL] + [EOQ]		B+EOQ	
			sS			T_{oec}	s+EOQ	[SL, T_{oec}]
			sQ	EOQ		T_o (EOQ)		[SL]
YES	YES	YES	sS			ToI	s + Q_{min}	[SL, T_{oI}]
			sQ	EOQ/Q_{min}				[SL]
YES	NO	YES	sQ	EOQ/Q_{min}				[SL]
YES	NO	NO	sQ	EOQ		T_{oI}		[SL]

Source: (own elaboration)

3. General principles of selecting an optimal stock replenishment system

Having identified all limitations to selecting a suitable system as well as their control parameters and quantities affecting those parameters, an attempt can be made to select an optimal system. Figure 7 presents the subsequent steps that lead to this decision and the connections between them:

1) identifying input data that includes:
   - historic data about demand and replenishment lead time that allow to determine key parameters describing the variability of demand in replenishment lead time (σ_{DLT}): average demand D, its standard deviation σ_D, average replenishment lead time LT, and its standard deviation σ_{LT},
   - limitations and requirements imposed on the process;
2) determining the set of acceptable solutions (systems) along with optimal (acceptable) values of control parameters;
3) determining the criterion for choosing the particular system from this set;
4) choosing the optimal system according to the adopted selection criterion.

The adopted selection criterion can be of various nature. One of the basic criteria is undoubtedly the cost criterion, where the objective function is the total replenishment, holding, and stock-out cost:

$$TSC = FRC + VRC + FHC + VHCoSS + VHCoCS + SoC_1 + SoC_2 \qquad (2)$$

where:

FRC – fixed replenishment cost (independent from the frequency and number of deliveries),
VRC – variable replenishment cost (dependent on the frequency and number of deliveries),

FHC – fixed holding cost (independent from its quantity),
VHCoSS – variable holding cost of safety stock (dependent on its quantity),
VHCoCS – variable holding cost of cycle stock (dependent on its quantity),
SoC_1 – stock-out cost depending on the probability of shortages in replenishment lead time,
SoC_2 – stock-out cost depending on the number of shortages in the given period.

The particular cost components, especially those associated with stock replenishment – both fixed and variable – can, generally speaking, depend not only on the values of control parameters, but also on the stock replenishment system itself. For instance, review costs in BQ and BS systems can be higher than in ST, sQ, and sS systems. These costs also depend on the mutual dependence of control parameters (Krzyżaniak, 2016, pp. 59–72).

Another criterion can be related to quality measured by service level (stock availability) – not so much the value of this parameter (as it will usually constitute one of the limitations), as, for instance, the sensitivity of the actual service level to various factors – e.g. in sS (Krzyżaniak, Fechner, 2013, pp. 127–142) and BS (Krzyżaniak, 2015).

The choice can also be based on a multi-criteria approach (Reszka, 2014).

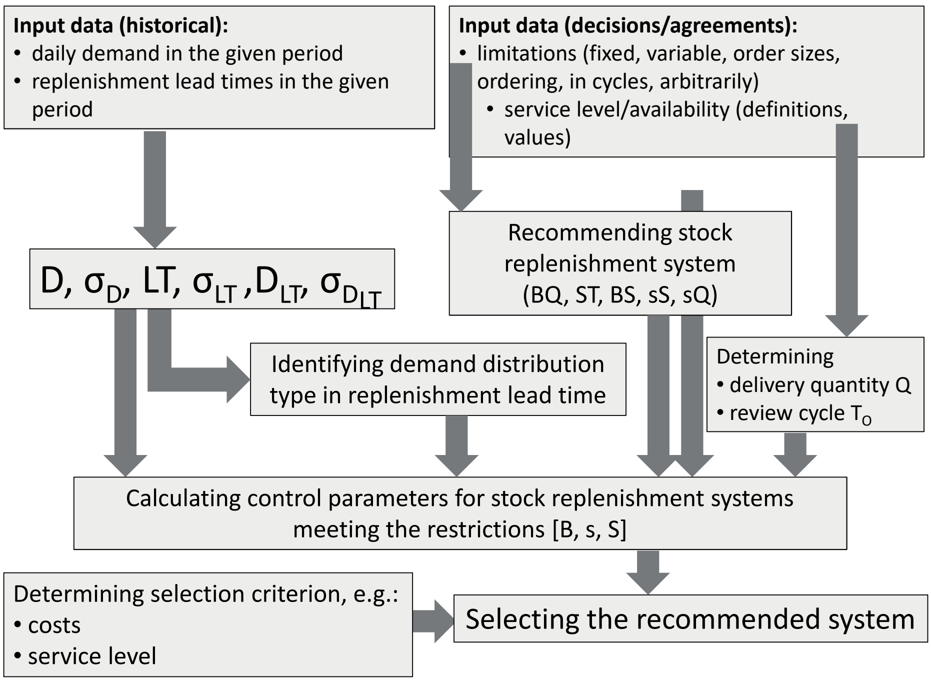

Figure 7. Graphic illustration of the steps leading to the selection of an optimal stock replenishment system
Source: (own elaboration)

Conclusions

The paper presents a model approach to choosing an optimal stock replenishment system. The said approach consists of several steps. The first step is to identify the limitations imposed on stock replenishment based on the answers to three questions regarding the quantity and frequency of orders. The answers narrow the set of applicable systems. The article discusses five basic systems: BQ, ST, BS, sQ, and sS.

Control parameters are determined for acceptable systems, taking into account qualitative (required service level) or economic criteria (e.g. based on economic order quantity).

Thus selected and parametrized systems should be then compared based on the chosen economic or qualitative criteria (or their chosen combination) and the best stock replenishment system under given circumstances should be recommended based on the results of this comparison.

The presented approach has been – to some extent – used in practice for selecting optimal spare parts replenishment system of a manufacturing company.

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AN ANALYSIS OF INTER-ORGANIZATIONAL NETWORK DYNAMICS ON THE EXAMPLE OF ELECTRONIC FREIGHT EXCHANGE

Abstract

Inter-organizational networks are the subject of numerous research projects, which explore not only the importance of companies within a network, its impact on the companies, and the ties between the actors, but also the structure of networks. Due to the rapidly changing environment of organizations, the need arises for an analysis of the dynamics of networks, which can be performed using Dynamic Network Analysis (DNA). The aim of the paper is to propose the use of this method for the analysis of network ties occurring in electronic freight exchange. For this purpose, a model was developed and implemented in a simulation environment. On the basis of selected scenarios, a simulation experiment was carried out. The authors present the most important conclusions from the statistical analysis of the experiments.

Keywords: Dynamic Network Analysis (DNA), network analysis, electronic freight exchange

Introduction

Along with the development of studies of networks in the economy, a growing interest in structural analysis, also called network analysis, became visible. It derives from social network analysis (SNA), whose original subject were the interdependencies and relationships between members of social groups. With regard to companies, the focus is on the relationships between particular persons within organizations, divisions in which they work, or specific teams of employees. Information and knowledge flow paths are analysed, bottlenecks are identified, and, as a result, communication is improved (Kawa, 2014a, p. 47). That being said, more and more often we hear about organization network analysis (ONA) and business network analysis (BNA). The latter, which explores the ties between separate and independent organizations, is especially interesting.

Using SNA to analyse inter-organizational networks requires, however, adopting certain assumptions regarding the subject matter. Companies function differently from members of a community. Information spreads differently in a social and in an economic network. Attempts to adapt SNA to the specifics of management studies have been made for some time now. This research, however, concerns mainly static analyses. They are a photograph of sorts of a network as it is in the given moment. Although stability of such a system is frequently assumed by default, networks are often dynamic and transform in time (Czakon, 2007). Both the ties (e.g. their content, strength, influence, scope) and their configuration as well as the number and type of actors (some join the network, others leave it) are subject to changes. The results of an analysis of a static network thus are of limited use in practice. Some of them can be simply outdated. More and more frequently managers wish to know how their network will look, what will be its structure, and what will be the role of their company in the network once the internal and external environment changes. What is more, they prefer to test different scenarios in a model that reflects particular economic systems rather than to experiment in practice.

In view of the above, network researchers developed a method called dynamic network analysis (DNA), which can be used to analyse network dynamics. It draws on the achievements of SNA and the knowledge from the area of link analysis and multi-agent systems (Carley, 2008, pp. 1324–1347).

The aim of the paper is to propose the use of DNA method for the analysis of network ties occurring in electronic freight exchange. For this purpose, a model was developed and implemented in a simulation environment. On the basis of selected scenarios, a simulation experiment was carried out. The authors present the most important conclusions from the statistical analysis of the experiments.

1. Dynamic network analysis

Dynamic network analysis differs from traditional network analysis in that it explores large networks comprised of many types of ties with varying degrees of uncertainty (Carley, 2002, pp. 206–220). A model of such a network is stochastic, and ties and actors have a probabilistic character. Some nodes and edges appear, others disappear (Rajaraman, 2006). A change in one part of a network can result in a change in other parts or even the whole network.

Dynamic network analysis often uses computer simulations, which make it possible to test different modifications. It is also assumed that particular network links have the ability to learn due to the application of agent technology (Kawa, 2009, pp. 382–389). In such a network, nodes and edges are represented by a program agent that acts and makes decisions autonomously.

DNA is not commonly used by researchers, which is why, unlike SNA, it is not quite as well-developed as a research method yet. It can be said that it is in the early stages of development, as evidenced by a relatively small number of studies and publications as well as the immaturity of the concepts of dynamic network analyses. This probably results from several factors. The most problematic, as in the case of SNA, is the gathering of data on the selected network. The data should be complete, i.e., cover all nodes and ties between them. Another problem is the development of a simulation model, which requires identifying dependent and independent variables as well as putting forward research hypotheses, which usually point to the relationships between the variables. On this basis, an algorithm is developed and then implemented in an appropriate simulation environment. These actions require not only knowledge and experience in modelling economic processes, but also programming skills, which can constitute a barrier for researchers who represent the field of management studies.

However, efforts should be made to make this relatively new research method more commonly used in management studies and economic studies in general. K.M. Carley (2003, p. 134) believes that dynamic network analysis is absolutely indispensable to understand the modern world. We can find numerous examples of dynamic networks. One of them is the Internet, where a multitude of new websites and ties between them are created each day. The network of telecommunication, transport, and organizational ties is also changing. In this latter case we speak of dynamic organizational structures. An example of such a structure is a dynamic supply chain, characterized by changing ties between particular companies that play the role of providers or customers. The Internet – and especially Internet-based IT systems – is increasingly often used as a tool for their configuration. An example of such a system is electronic freight exchange (Wieczerzycki, 2006, pp. 25–38.), which is the subject of this paper.

2. Electronic freight exchange

Electronic freight exchange (EFE) is, in most general terms, a virtual market for companies that offer or look for freight loads to be delivered or cargo spaces. The logic behind electronic freight exchange largely resembles other e-business enabling solutions, such as online shops and auction sites. Their characteristic feature is the automatization of processes and digitalization of documentation (Kawa, 2014b, p. 79).

From an operational perspective, the mechanism of EFE boils down to posting information about transportation and cargo requests, which allows other operators to find an attractive transport service offer and make better use of their cargo space. Electronic freight exchanges are primarily intended for forwarders and carriers, but are also increasingly frequently used by manufacturing and commercial companies (Kawa, 2014b, p. 81).

Initially, electronic freight exchanges were used mainly to conduct one-time transactions and were complementary to other, traditional forms of searching for a counterparty. The exchange was supposed to provide current information about potential providers and customers. However, previous research conducted by the authors indicates that the role of electronic freight exchange for logistics companies has changed during the last few years. Nowadays, thanks to EFE, companies more frequently form long-term ties based on trust and commitment. This is facilitated by the rather restrictive requirements imposed by EFE operators on its potential users (minimum period of operation, set of documents required to conduct activities, etc.). Information provided by credit reference agencies, debtors register, and Internet reviews are also checked (Kawa, 2015, p. 4).

There are numerous electronic freight exchanges in the world – more than a hundred in Europe alone (Majszyk, 2016). Each is used by several to several hundred thousand registered and verified companies. In Poland there are a dozen or so such exchanges, but only three of them – Teleroute, TimoCom, and Trans.eu – are commonly used. The biggest exchanges operate in most European countries. The subject of this paper is Trans.eu, which is briefly described in the next section.

3. Trans.eu

Trans.eu is a Polish electronic freight exchange, established in 2004 in Wrocław by the Logintrans company. Trans.eu is available in twenty languages and used by users from twenty-four European countries. The company has branches in eight European countries. In a year, Trans.eu (2016) publishes more than 35 million offers (82% cargo offers and 18% transportation offers). Since 2005, more than 480 thousand companies from all over Europe have registered. Trans.eu is currently the biggest exchange in Central and Easter Europe and third biggest freight exchange in Western Europe (Romanów, 2011, pp. 43–46).

The subject of this paper is the network of ties between the users of Trans.eu. The content of these ties is the purchase or sale of cargo transportation service or cargo space. The analysis covers 1.07 million transactions registered in 2013 in Poland between 24 thousand companies. The preliminary analysis indicated that 85% of them were one-time transactions. What is more, there are many single (consisting of repeated transactions) ties between transport service providers and their customers within the Trans.eu system. Only 46% of users cooperated with at least two other companies, 0.5% (97% of them were forwarders) cooperated with at least a hundred other companies, and 1.8% – with at least fifty. The average number of counterparties of the network users was 10.5. Forwarding companies had the most ties to other users. The biggest of them cooperated with four hundred and sixty-six other users. These data attest to the high diversification of exchange participants.

After conducting a preliminary network analysis of Trans.eu we can distinguish many so-called components – independent clusters of interrelated actors disconnected from other network clusters. The biggest component consisted of 23 thousand users and more than 840 thousand ties between them. Such a component, comprised of vertices and edges, is a networked structure, which makes it possible to determine the degree of its connectivity, i.e., the number of ties between the actors, their density, the distance between the actors, etc.

4. Issues and research procedure

As already mentioned, the results of the author's previous research among the participants of Trans.eu show that they increasingly often form long-term ties, of both a formal and informal character (Kawa, 2015, pp. 2–9). On the other hand, an in-depth social network analysis indicates that companies engage in manifold – direct and indirect, horizontal and vertical – relationships (Fuks, Kawa, Pierański, 2015, pp. 151–159). Within the Trans.eu environment thus emerged a specific network comprised of separate companies providing and using transport services. This network, however, is subject to changes. On the one hand, the exchange environment is stabilizing; on the other, it is constantly expanding. Each year it is joined by new users. This increases competition, as the customers have a wider choice of logistics service providers, and they increase the number of their potential customers. This also benefits the exchange operator, because every new user has to pay for using the system. There is, however, a growing risk that there will be dishonest or unreliable counterparties among the new users, whose activities will lead some of the important – from the perspective of the operator and the network itself – users to resign from the service. This can cause a chain reaction, making companies dependent on those users also leave the network. Those "important" users are the so-called centralized actors, which concentrate a relatively large number of other actors (network nodes).

A safer solution seems to be to develop the exchange by means of increasing its connectivity. This can be done by creating new ties to actors with which other users (customers, service providers, and competitors from a particular company) already cooperate. Thus, a question arises if, from the point of view of the operator, it is worth to increase the number of ties between the users. Dynamic network analysis served to provide an answer. Before conducting an analysis using the DNA method, however, a simulation network model has to be developed.

For the purposes of the research process, the authors proposed three strategies, which from an operational perspective constitute experimental factors, i.e., independent variables. Changes that occur under the influence of the introduced experimental factor constitute dependent variables (Apanowicz, 2002, p. 64.). The developed strategies concern the way of building a network depending on the tendency to increase the number of ties by exchange participants:
1) openness strategy: there is full freedom of creating new ties,
2) lockdown strategy: creation of new ties is put on hold,
3) regulation strategy: mix of the two.

With regard to the earlier presented research problem, a hypothesis can be formulated that openness to the creation of new ties between the users increases the connectivity of the EFE network. SNA measures, such as network density, diameter, clustering coefficient, small-world effect, will serve to determine the degree of connectivity.[8] These measures are the dependent variables.

The analysis considers long-term ties, which in strategic management constitute a prerequisite for establishing network ties (Klimas, 2014). However, it is difficult to unequivocally determine which ties are long-term. They definitely go beyond one-time, sporadic, and thus unrepeated transactions. The authors arbitrarily assume that for their relationships to be long-term, the same companies have to conduct at least ten transactions per year. This allowed to limit the number of actors to 978, out of which 761 constitute a big component, i.e., a tight-knit network. Further network analysis provided information about the density, diameter, clustering coefficient, and small-world effect.

The density of the network is the total number of ties divided by the number of possible ties. It is also often called network completeness. Density of 0.0042 means that the network is complete in 0.42%. The potential of the analysed network in terms of the number of ties remains largely unexploited. The relatively low density is, however, characteristic of economic networks. Additionally, the density of such networks decreases as the number of nodes grows – a given actor is unable to or not interested in cooperation with all other actors, especially that some of them are its competitors.

The diameter of the network is the maximum shortest path length between all the possible pairs of the network nodes. It is determined based on the path length between two most distant nodes (the path length between another randomly selected pair of nodes is smaller than the diameter of the network). Within the analysed network, the hop count between the two most distant nodes is 13 (there are twelve other nodes between them). This high value indicates the existence of peripheral nodes and impairs the connectivity of the studied object.

Clustering coefficient is the number of all closed triplets (so-called cliques) over the total number of connected triplets (both closed and open, i.e., consisting of three nodes and two edges). Clustering coefficient of 0.0112 means that 1.12% of all cliques (at least three nodes) are fully connected. There are relatively few such connections between any three nodes within the analysed network. A higher value would indicate a higher degree of connectivity.

Small-world effect is the average shortest path length between any two nodes. The large number of network participants means that in the vast majority of cases they are interconnected through indirect ties. The value of 5.126 means that any two nodes can reach one another in five steps (i.e., four additional ties). This is a relatively high value, even for an inter-organizational network. The higher the value, the lower the degree of connectivity (Fuks, Kawa., Pierański, 2014, pp. 47–53).

In the next step of the analysis, the ties between the nodes were mapped. Three clusters emerged as a result of network visualization using a heat map, in which a dominant role is played by forwarders (central nodes). These clusters are connected through so-called bridges created by forwarders and transportation companies with which they cooperate.

8 For a more in-depth description see: (Fuks, Kawa, Pierański, 2014, pp. 47–53).

The next step of the study required choosing the simulation environment in which the model was to be implemented and the experiment carried out. The authors decided to develop the simulation from scratch using the Python programming language (release 2.7.4). For a better analysis and network visualization, the NetworkX Python library was used. NetworkX allows to create, change, and study the structure, dynamics, and functions of highly complex networks. It is equipped with numerous business dictionaries and structural analysis measures. It also allows to generate pseudorandom numbers, import and export data, and visualize networks. Thanks to the implementation of his own algorithms, the programmer can perform simulation experiments within the studied network (NetworkX, 2016).

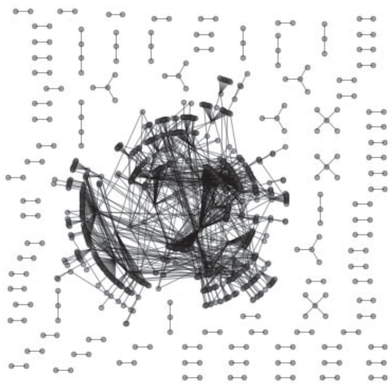

Figure 1. Ties between companies that conduct at least ten transactions per year with the same actors within Trans.eu
Source: (own elaboration)

Figure 2. Heat map of the ties between the users of Trans.eu
Source: (own elaboration)

5. Simulation experiment

In accordance with the procedure of carrying out scientific research in the form of a simulation experiment, after having identified the research problem, formulated the hypothesis, identified the variables, and chosen the programming environment, a simulation model has to be developed and implemented, and a simulation experiment performed (Stańczyk-Hugiet, 2013, pp. 64–77).

As already mentioned, the simulation model developed for the purpose of the study consists of an independent variable in the form of a strategy of action and dependent variables expressed by the SNA measures. The presented strategies translate into the scenarios of the performed simulation experiments implemented by the authors from scratch in the Python programming language using the NetworkX library. These are:

1) openness scenario: the ties between the nodes are established at random. The only criterion that has to be met is the transportation route serviced by the provider (country of origin – country of destination), i.e., for a service provider to be considered, it has to service the route indicated by the job parameters;
2) lockdown scenario: ties are created primarily from the base of service providers with which the given actor has already established long-term cooperation. The prerequisite is, of course, that the provider services the given route; otherwise an actor is selected from the total pool of service providers (scenario 1);
3) regulation scenario: the probability of randomness is determined, e.g. a probability of 20% means that 20% of transactions will be random (scenario 1), and 80% – preferential (scenario 2).

Based on the above scenarios, the following simulation algorithm has been developed:

1) for each service provider and service recipient, a transaction list is compiled which stores the following data:
   - date of the transaction (a key that identifies the particular lines on the list),
   - total number of transactions on the given day,
   - data regarding the country of origin and the country of destination (which determines routes for the service provider and job parameters for the service recipient);
2) for each service recipient, all offers are taken into account and processed, and a new network is created on this basis;
3) for each offer, a list of potential service providers is compiled based on the country of origin and the country of destination;
4) if the list is not empty, the system selects a service provider according with a given scenario;
5) a tie is established in the new network between the service recipient and the chosen service provider;
6) the procedure is repeated from point 3, unless the given service recipient presents no other offers, in which case the procedure is repeated from point 2, i.e., another service provider is chosen.

The described procedure was repeated many times. The subsequent iteration depended on the value of the random parameter (corresponding to the random scenario), increased by 1 in the range [0, 5) and by 5 in the range [5, 100].

As a result of the performed simulation experiment data was obtained which was then exported to external files. The data concerned the structure (the vertices of a given network tie) and parameters of the network (described in the previous paragraphs) defined in a programming language using the NetworkX library. The data were imported into a MS Excel spreadsheet and analysed statistically. The results are illustrated as graphs.

Figures 3–6 present the changes in the network parameters as a result of increasing the value of the random parameter. Figures 7–9 present network visualizations with the random parameter value of 1, 3, and 20, respectively.

The random parameter value of 0 indicates a complete implementation of the lockdown strategy (no random ties). As already noted, such a network is characterized by the following values: density (0.0042), diameter (13), clustering coefficient (0.0112), and small-world effect (5.126). An increase of the value of the random parameter (transition from the lockdown strategy towards the openness strategy) to ca. 3% results in lower values of connectivity measures. The diameter of the network and the small-world effect measure increase, while the density and the clustering coefficient decrease. The value of ca. 3% is a border point – for this value of the random parameter, the values of connectivity are similar to those for the original network. This means that at the initial stage of implementing the openness strategy the studied object becomes "disnetworked," i.e., the actors strengthen their ties to their current, most reliable partners.

As a result of implementing the regulation strategy, subsequent iterations improve the values of connectivity measures. The changes, however, are the most pronounced when there are between ca. 3% and ca. 20% of random ties. This means that along with the transition from the lockdown strategy towards the openness strategy the degree of connectivity of the studied object increases significantly. With ca. 20% to 100% of random ties these measures continue to increase and still have a positive influence on connectivity, but to a lesser degree (with accordance to the principle of diminishing marginal benefit).

The next step was to measure the statistical dependence between the independent variable (random parameter) and the dependent variables (network measures). There is a strong correlation between the random parameter, the density measure, and the clustering coefficient (0.99 and 0.97, respectively). Correlation coefficients are also high for network density and small-world effect (–0.82 and –0.99, respectively). All correlations are statistically significant at the $p < 0.001$ level (two-tailed).[9]

The above dependencies and conclusions confirm the research hypothesis, which posited that openness in terms of establishing ties between the users of electronic freight exchange increases its connectivity. The openness strategy, which consists in increasing the number of new, but reliable companies, has a positive effect on the network, increasing its stability and resilience to structural changes. It also increases the competitiveness of both service providers and service recipients.

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9 Spearman's Rho tests were used to check the statistical significance of the investigated features.

The lockdown strategy, on the other hand, by prohibiting the establishment of new ties, results in the actors' growing dependence on other companies and increases the risk of failure; for instance, resignation or bankruptcy of one of the service providers and service recipients can seriously disrupt the current operations of a company.

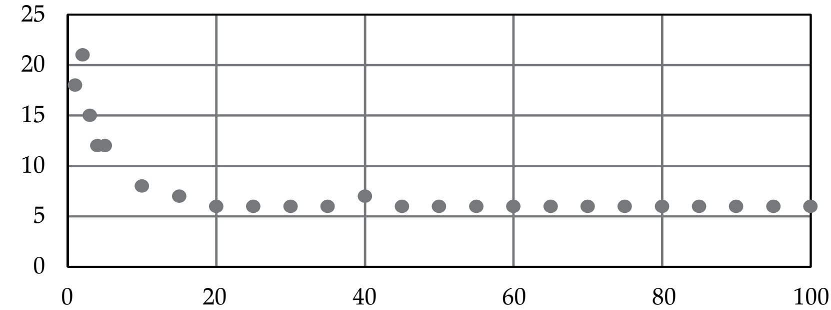

Figure 3. Dynamics of changes in network diameter with an increasing value of the random parameter
Source: (own elaboration)

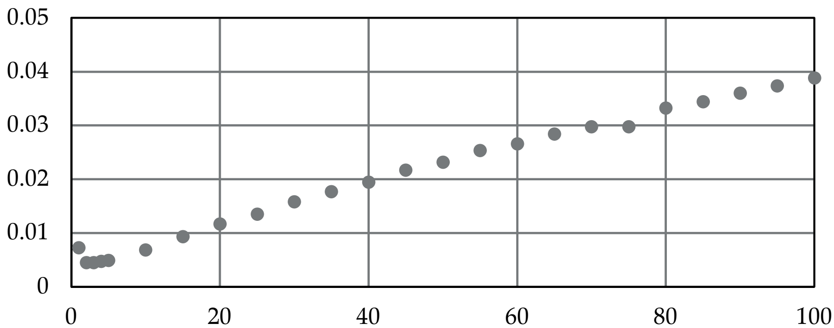

Figure 4. Dynamics of changes in network density with an increasing value of the random parameter
Source: (own elaboration)

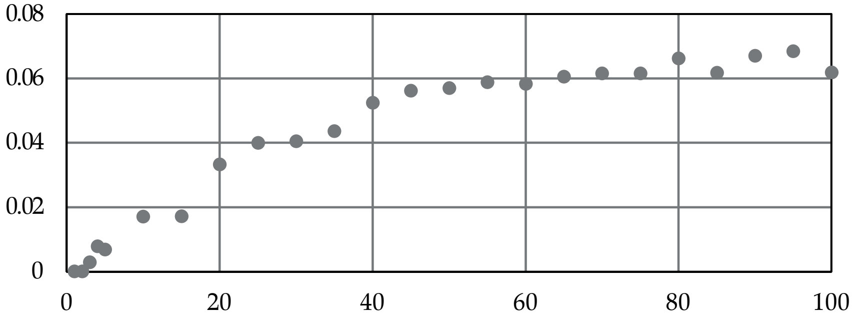

Figure 5. Dynamics of changes in clustering coefficient with an increasing value of the random parameter
Source: (own elaboration)

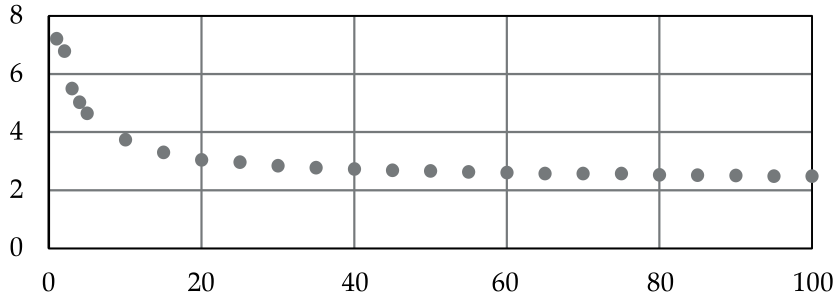

Figure 6. Dynamics of changes in small-world effect with an increasing value of the random parameter
Source: (own elaboration)

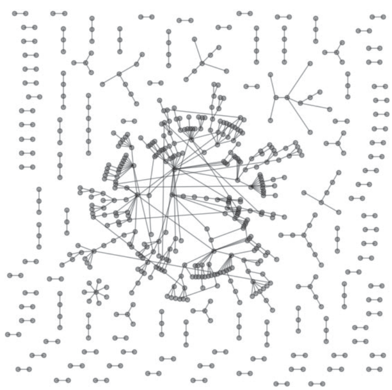

Figure 7. Network visualization with the random parameter value of 1
Source: (own elaboration)

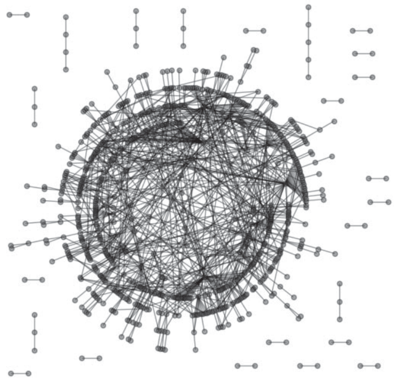

Figure 8. Network visualization with the random parameter value of 3
Source: (own elaboration)

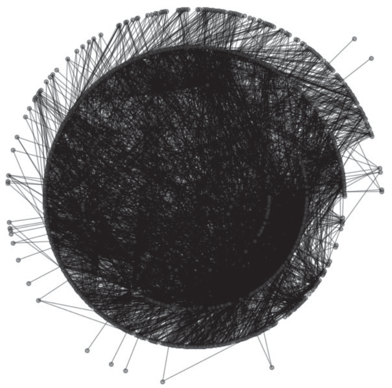

Figure 9. Network visualization with the random parameter value of 20
Source: (own elaboration)

Conclusions

In the modern economy, not only companies, but also the relationships between them are subject to rapid changes. If an organization directly or indirectly establishes both formal and informal ties to different types of actors, those ties can form a network and become the subject of numerous studies.

Static network analysis is well-covered in literature, although it is the opinion of the authors that there is a shortage of empirical research, especially with regard to inter-organizational networks (the perspective of economic systems). Due to the dynamic character of the networks, the SNA method is insufficient. The concept of dynamic network analysis comes to the aid, which allows to analyse networks taking into account the changing internal and external environment by using computer simulations. It also allows to register the interactions and behaviours that are difficult to observe in reality (Balcerak, Kwaśnicki, 2005, pp. 5–15). Moreover, simulation experiments are a safer solution than testing scenarios on a "living" organization.

The authors of the paper used the DNA method to study the network of the electronic freight exchange Trans.eu. For the purpose of the study, three scenarios have been distinguished and used to analyse the dynamics of the network. The performed simulation experiment confirmed the hypothesis that posited a correlation between the implementation of the openness strategy and the connectivity of the network.

The model presented in the paper allows to carry out simulation experiments in a specific inter-organizational network. The model is fairly universal and can be of use for studies of similar objects. Its adaptation requires, however, certain modifications and additional assumptions characteristic for the given network. Each time the validity of their application needs to be considered due to the complexity of the algorithmization and codification process in the simulation environment. Nevertheless, it is still a much faster and cheaper method than the verification of scenarios under real conditions.

Although the paper confirms the validity of using the DNA method to analyse inter-organizational networks, it needs to be remembered that it has certain limitations. First of all, it requires the researcher to be acquainted with the SNA method and possess to ability to model and perform simulation experiments. This barrier can be eliminated by creating interdisciplinary research teams, in which the cooperation of researchers from two or more scientific disciplines results in a synergy of economic and IT competencies.

A disadvantage of simulation experiments is that they do not provide precise information about how the system will act in reality, but only indicates its typical, i.e., most probable, behaviour (Mielczarek, 2005, pp. 133–141). What is more, it requires adopting many assumptions that can grossly simplify and even distort the studied object, which is why simulation experiments are regarded as an abstraction of reality.

The main element taken into account when analysing socio-economic phenomena is man, whose behaviour is not always predictable and rational. Attention should be paid to the scope and strength of man's influence on the simulation model and the course of the simulation experiment (Kawa, Fuks, Januszewski, 2016, pp. 109–126). When analysing a phenomenon from the level of a community, a group, or a network (and not an individual), the results of simulation experiments are more predictable.

It is therefore the authors' opinion that the use of simulation experiments to analyse the dynamics of socio-economic networks is the most suitable research method, which can be successfully used to test hypotheses formulated in scientific studies.

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THE CONCEPT OF A SMART CITY IN THE CONTEXT OF AN AGEING POPULATION

Abstract

The aim of this paper is to highlight the issues of smart cities in the context of a dynamic increase in the number of the elderly. From the point of view of urban development, the discussion about shaping cities in a way that would guarantee a high standard of living of their inhabitants becomes particularly topical. The process of urban planning should take into account the expectations of both citizens and investors. Developing a coherent strategy, based on cooperation between various groups of interest, will allow to create a city tailored to the needs of its "users" as well as to involve citizens in city management. From this perspective, it seems that the primary task of a smart city is to emphasize the significance of building social capital. The study focuses on a detailed analysis of the problems faced by the elderly in urban areas, including the issue of transportation.

Keywords: ageing society, smart city, sustainable development, social capital

Introduction

Urbanization is a process of urban development that involves a growth in urban population, expansion of existing cities, and establishment of new ones. These changes also influence cultural, social, demographic, economic, and spatial transformations. Thus, in order to achieve sustainable development, it becomes necessary to take into consideration all aspects of urbanization processes.

The level of global urbanization, measured as the share of urban population in total population, is constantly increasing. Cities play an increasingly important role in the life of the majority of people and are crucial for global social and economic development. According to UN data, over half of the world's population live in cities, and by 2050 this percentage will exceed 70% (EYGM Limited, 2013), which will be most visible in developing economies.

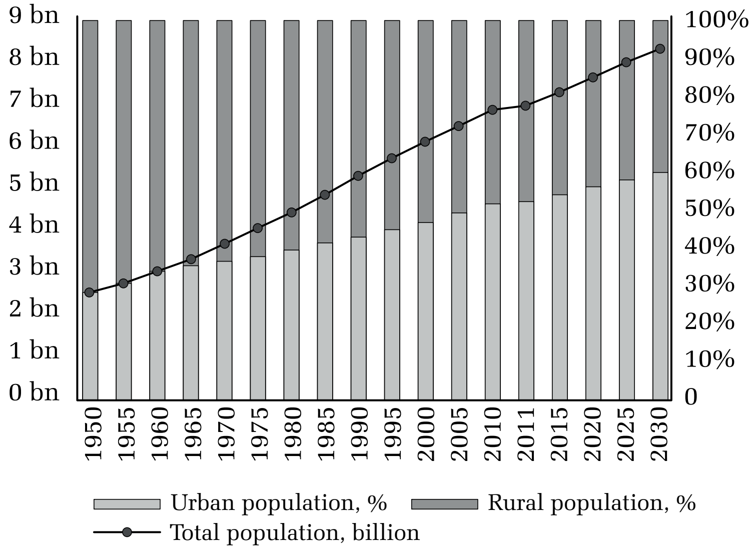

Figure 1. Urban and rural population in the years 1950–2030
Source: (EYGM Limited, 2013)

The urban population ratio is the highest (above 80%) in both of the Americas; in Europe it amounts to 73% (60.5% in Poland in 2015), in Asia – 47%, and in Africa – 40%. The most dynamic urbanization, however, was recorded in South American, Asian, and African countries (Wojtowicz, 2014).

Increased urbanization reshapes urban structures. We see the emergence of monocentric (based on suburban centres) and polycentric cities (where cities of tantamount importance are connected by a network of roads). Conurbations and megalopolises constitute varieties of polycentric agglomerations where strong municipal centres blend seamlessly, making it impossible to indicate where one city ends and another begins. It is expected that one of the consequences of the dynamic increase of urbanization will be that in the next decade ca. 65% of GDP will be generated by 600 biggest cities in the world (McKinsey Global Institute, 2013).

Along with increased urbanization, the problem of an aging society becomes more and more visible, especially in Europe. According to the 2011 report entitled *Starzenie się społeczeństwa polskiego i jego skutki* [The aging of Polish society and its consequences] (KSBAiD, 2011), in the early 1950s average global life expectancy was 47 years. Currently, it is 65 years, and by 2050 it is expected to be 75 years.

The number of people aged 60 and older is growing. In 1950, there were ca. 200 million people aged 60+ in the world. Currently there are 617 million people aged 65+, which means that seniors constitute 8.5% of the global population. By 2050 the number of the elderly will increase to 1.6 billion, which will constitute 17% of the global population. The current life expectancy is 68.6 years; by mid-century it will be almost 8 years longer, amounting to 76.2 years.

The number of people aged 80 and older will also increase dramatically. Currently amounting to 126.5 million, by 2050 it will triple, reaching 446.6 million. In some Asian and Central-American countries it will even quadruple (He, Goodkind, Kowal, 2016).

In Poland, the number of people aged 60 and older constituted 22.7% of the population in 2015 and is on an upward trend. According to AgeWatch Report, by 2030 this share will reach 28.6%, and by 2050 – 39.3%.

The significance of the problem of an aging population has been noticed by the European Union, which designed diversity management programs aimed, i.a., at professional activation of people aged 50 and over. According to 2014 Eurostat data, in Poland the employment ratio of people between the ages of 55 and 64 to overall population was over 42.5% (Eurostat, 2014). This result was below the average for UE-28 (51.8%), and incomparably lower than in Switzerland (71.6%).

If national policy will not take into account the above-described phenomena, in the longer run the quality of life of city dwellers can decrease dramatically. Thus, we currently search for solutions that would allow to better manage urban public transport or improve urban architecture. One answer to the above challenges is the concept of smart cities (Brdulak, Brdulak, 2015, pp. 50–60).

1. The concept of a smart city

There is no unequivocal definition of a smart city (Anthopoulos, 2015, p. 9). It is a combination of an intelligent use of IT systems allowing to actively manage different areas of urban activity with the potential of institutions and active engagement and creativity of the citizens (RWE, 2013).

According to A. Caragliu from the Polytechnic University of Milan, a smart city could be defined as one in which investments in human and social capital and traditional (transport) and modern (based on ICT technologies) infrastructure translate into sustainable economic growth and high quality of life with smart management of natural resources by means of participatory governance (Caragliu, Del Bo, Nijkamp, 2009). One of the main conditions of the development of the cities of the future is therefore the cooperation between local authorities with a wide range of entities in their surroundings which influence the functioning of the city, such as all kinds of social organizations, social initiatives, or groups of activists.

According to the analysts from Frost & Sullivan, the development of the cities of the future means the application of new technologies to urban logistics and improvement of the mobility of different social groups, including the elderly. The cities differ from one another in terms of spatial planning, infrastructure solutions, and location.

Because today's administrative borders constitute a limitation for further development of the cities, in the future their relevance will decrease. Functional areas (communes on the outskirts), bound by a broadly understood shared social infrastructure, will gain in importance. Polish cities begin to take interest in intelligent solutions, but remain unwilling to experiment. This is confirmed by a preliminary study conducted by the author in the Silesian agglomeration (Brdulak, 2015, pp. 211ff.).

In the Leipzig Charter on Sustainable European Cities from May 2007 we find a description of the role of cities. It indicates their "unique cultural and architectural qualities" as well as "strong forces of social inclusion and exceptional possibilities for economic development." Cities are "centres of knowledge and sources of growth and innovation." They face, however, demographic problems, such as "social inequality, social exclusion of specific population groups," e.g., the elderly, "a lack of affordable and suitable housing and environmental problems."

Increasing income disparities – the growing gap between the rich and the poor – are responsible for the concentration of inequality in some societies, which takes the form of a low level of education, high unemployment rate, bad housing conditions, and limited access – or lack thereof – to certain services, e.g., ICT, health care, or transportation. This problem is also present in the richest cities, where the phenomenon of social and spatial segregation is especially pronounced. Because of low incomes or marginalization, certain social groups, such as the elderly or the disabled, have difficulty finding affordable apartments. The increasing number of "social outcasts" in many cities and on their outskirts can result in an emergence of closed subcultures hostile towards the rest of the society (UE, 2011, pp. vi–vii). Thus, particular attention should be paid to initiatives preventing the further growth of these disparities.

At this point in time, particular municipal centres attempt to implement certain solutions, but they lack a shared vision of long-term development. This can result from the low level of social capital – especially visible in Poland – which causes unwillingness to cooperate in creating a vision of development and consistently implementing solutions specified in the strategy.

The concept of social capital was popularized in literature by R.D. Putnam (1995, pp. 65–78), and further developed by F. Fukuyama (1997), among others. They emphasised that the process of building social capital should be considered in the long term. It then acquires the character of a pubic good, promoting social integration and solidarity, preventing discrimination and exclusion, etc. The indicator of social capital is the level of trust, voluntary support of the local community, and openness to others (Czapiński, Panek, 2014, p. 27).

In terms of overall trust, Poland occupies one of the last positions among the countries covered by the European Social Survey (ESS) in 2006 and 2012. According to the ESS, in 2012 18% of the respondents agreed with the statement that "most people cannot be trusted," and according to a 2013 survey conducted by Czapiński – 12.2%. Since 2003, Poland has recorded a very slight increase in the number of people who trust others (0.7pp). In countries such as Norway, Denmark, or Finland this percentage exceeds 60% (UN, 2013).

In light of the above data it should be mentioned that the concept of smart cities is based mainly on a high level of social capital, involvement of local communities, and willingness of all entities located in a given area to engage in cooperation

(Benevolo, Dameri, D'Auria, 2016, p. 14). These factors contribute to the sustainable development of cities. The key element of this concept is the issue of eliminating barriers to "using" the cities by ensuring access to government offices and socio-cultural institutions as well as the mobility of the elderly. For the purpose of the paper, the author has limited her further considerations to the area of urban mobility of the elderly.

2. Smart cities and the elderly

It has to be noted that smart cities should take into account the needs of all groups of their "users." The possibility to move freely across the city, which depends on suitable urban planning and the availability of public transport, is the key factor influencing the activity of the elderly.

This issue is present in numerous discussions devoted to the topic of smart cities. Senior mobility increases their access to social and health services as well as their level of civic engagement and, therefore, of aware participation in city life.

Focusing on the issue of transportation, we should first take a look at the availability of the means of public transport. According to the result of the research conducted by the World Health Organization (WHO) (2007, pp. 20ff.), the availability of public transport services is satisfactory in almost all cities, but not in all areas.

The elderly citizens of developed and transition economies (e.g. Russian Federation) are more likely to consider the domestic public transportation system as well developed and satisfactory. Despite this declaration and the wide range of transport services in many cities covered in the research (e.g. public and private buses and minibuses, metro, trains, trams, trolleybuses, public and private rickshaws), however, many gaps can be observed which require being filled and adjusted to the needs of the elderly.

The mentioned deficiencies include, i.a., long waiting periods on public transport stops or lack of elevators facilitating getting into or out of the platform.

The above problem is well illustrated by the public transport system in Wrocław, based mainly on tram and bus connections. The main barriers to their use by the elderly include small number of low-floor vehicles, long distances between the vehicle and the platform (passengers often get into the vehicle from the street), and uncooperative drivers, who, upon seeing an elderly person, do lower the vehicle (which is possible only in buses), but do not extend a special platform which creates a footbridge between the floor of the vehicle and the platform. What is more, only selected lines of low-floor public transport vehicles in Wrocław accommodate the needs of the elderly, which means that if they wish to change lines, it can indeed become impossible for them to get to their destination.

An interesting example is the city of Budapest, which has a highly developed network of connections. It is known for the fact that most of its districts are extremely well connected by different means of transport, such as buses, trolleybuses, trams, metro, or suburban trains.

Although the city makes it possible to easily and quickly reach the chosen destination, the elderly who wish to commute by metro encounter a barrier in the form of a lack of elevators between the platforms. Another difficulty, even for younger persons, is posed by fast-moving escalators. Moreover, Line 1 (the oldest metro in Europe) does not accommodate the needs of the elderly or people with limited mobility; lack of elevators and large gaps between the platforms and the vehicles make it impossible for them to use it (authors' research, 2016).

Another barrier to using public transport by the elderly can be the relatively high prices of tickets. Some cities offer subsidies or introduce public transport completely free of charge. For example, in Geneva, Switzerland, the carer of an elderly person can use public transport free of charge. The situation is similar in Dundalk, Ireland, where people aged 66 and over permanently resident in the country can also travel free of charge, as can the carers of holders of the Companion Pass card (Citizens Information).

In some cities, however, public transport is considered too pricy. The elderly in Nairobi complain about price increases charged because of bad weather, public holidays, and peak travel periods (WHO, 2007, pp. 20ff.). In Rio de Janeiro, Brazil, free transport is not provided to the older people who live in the favela, because public transport simply does not service this area. And in the already mentioned city of Geneva, discounted travel can only be obtained if older people purchase a railway season ticket. In most cities, subsidized fares cannot be used for private transport services. An interesting exception from this rule is Dundalk, where free travel passes are accepted on some private bus services.

Another already mentioned barrier is the frequency of public transport services. It is one of the key factors determining the age-friendliness of a city. There are, however, a number of reports from cities at different stages of development that public transport services are not frequent or reliable enough. In Istanbul, for example, the elderly indicate that travelling by public transport takes a very long time. In certain areas of Melbourne, Australia, there is no bus service from Saturday afternoon until Monday morning. The elderly living in the Ruhr metropolitan area, Germany, face a similar difficulty, claiming that public transport to the outer areas of the city and at night is not frequent enough. In Wrocław the connections are also less frequent during the weekends and public holidays, as well as summer and winter breaks; the city clearly adjusts frequencies mainly to the needs of children and students, forgetting about the elderly.

The convenience of using public transport depends largely on whether one is able to reach the chosen destination, which, in turn, is contingent upon appropriately adjusted rolling stock, frequency and punctuality of services, density of connections, and optimal coverage of the urban space. An equally important role is played by the urban infrastructure, i.e., stops and platforms adjusted to the needs of the elderly, which maximizes their safety as they wait for, get in, and get out of the vehicle.

In this context, the main ways of minimizing the barriers to the use of public transport include:

- appropriate construction of public transport vehicles, accommodating the needs of the elderly with limited mobility (wheelchair ramps, lowered and functional steps, appropriate design of handrails and chairs),
- stops located in the vicinity of public buildings,
- information charts inside the vehicles and at the stops – easy to understand, legible, suited to the needs of poorly sighted and blind (Braille, large text, audio recordings) with particular focus on public spaces.

Among private transport solutions we should list:

- signposts pointing the way to public offices – visible, coherent, and well located,
- parking spaces – their location (vis-à-vis entrances to public buildings), signage, and size (Wolniak, Zasadzień, Skotnicka-Zasadzień, 2016, p. 524).

When implementing the above solutions, particular attention should be paid to consulting them with associations of the elderly, organizations cooperating with them, and the target group itself. It is also worth to draw on the experiences of highly-developed countries with high percentage of the elderly, such as the countries of Scandinavia or Germany. It will make it possible to adjust cities to the actual needs of the elderly instead of those who design such solutions.

3. Global organizations' support for the concept of smart cities

Analysing the issue of sustainable development of cities, it should be pointed out that in the European context there exists a well-described Smart City Model and the raking of cities (www.smart-cities.eu). Significant support in this area is provided by the programs of institutions not only from Europe – such as the European Commission's Horizon 2020 program "Smart Cities and Communities solutions integrating energy, transport, ICT sectors through lighthouse (large scale demonstration – first of the kind) projects" – but also from all around the world.

One example is the WHO which, in the 2007 document *Global age-friendly cities: A guide*, indicated areas that require particular attention in the context of the increasing ratio of the elderly to the overall urban population.

An interesting initiative is the program inaugurated in September 2015 aimed at meeting the recommendations of the United Nations General Assembly (UNGA). It specified seventeen sustainable development goals, including good health and well-being of people, affordable and clean energy, industry, innovation, infrastructure, or climate action.

In light of the discussed problem it is especially worth taking a closer look at the eleventh goal, i.e., sustainable cities and communities. A specially designed program will serve to evaluate Polish cities in terms of the realization of sustainable development criteria. The undertaken activities will be aimed at:

- reducing negative influence of citizens on the environment, with particular attention to air quality,
- ensuring easy access to affordable, safe, and sustainable transport systems and improving road safety,
- ensuring access to safe and inclusive green public spaces for all.

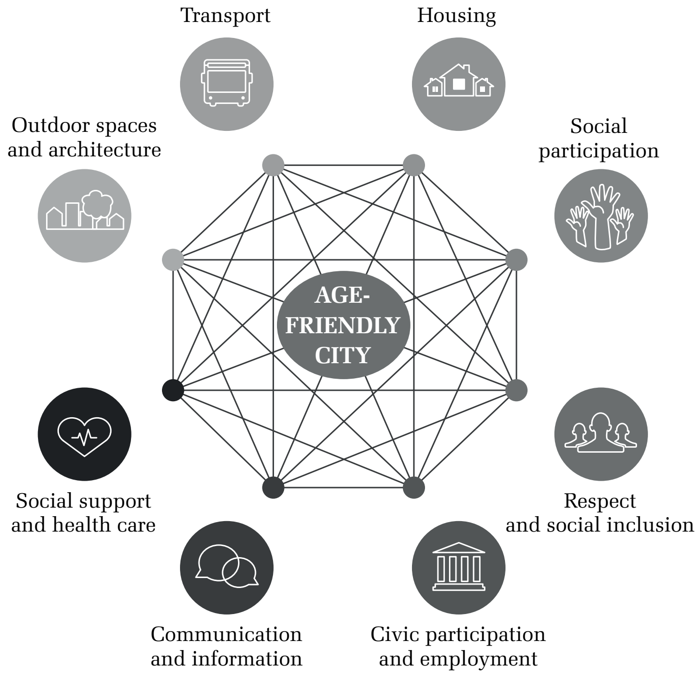

Figure 2. Dimensions of an age-friendly city
Source: (WHO, 2007)

The effect of the evaluation will be a ranking of Polish cities and resorts prepared based on problem areas crucial from the point of view of sustainable development. The program envisages achieving the set goals by 2030 (GCNP, 2016).

The issues related to urban transport are also discussed in the 2011 White paper on transport. The document points to the need to change the existing model of transport usage. In particular, it highlights the necessity of developing passenger transport, introducing ICT solutions to the traffic management system, designing vehicles to accommodate people with limited mobility, and using technological solutions that will allow to reduce fuel consumption or use alternative energy sources. It also emphasizes the significance of the quality, accessibility, and reliability of transport services.

In the context of the progressive aging of the European population, the possibility to acquire reliable information about travel time, alternative routes, or different means of public transport becomes especially important. It should also be highlighted that the main features of high-quality services are: attractive frequencies, comfort, accessibility, reliability of services, and intermodal integration.

Conclusions

The dynamic urbanization all across the world presents authorities with new challenges. They are particularly important in the context of an increase in the number of the elderly. Maladjusted infrastructure, which has to ensure water, energy, and mobility of the citizens, becomes a problem. Cities should "grow" as the needs of their citizens increase. On the one hand, they should guarantee safety; on the other hand, they should allow them to lead comfortable lives, accommodating each and every one of them.

Smart cities are developing dynamically. All around the world, metropolises are being established based on new technologies, which serve to achieve the goals of sustainable development. In this context, it would be interesting to determine to what extent modern solutions decrease the degree of exclusion of particular social groups, such as the discussed elderly, disabled, or parents with small children. It would also be worth to investigate the degree of mutual compatibility of the implemented systems, so that the elimination of one problem would not imply the need to face another one.

Development cannot be prevented. We should consider, however, in what direction should we steer it for it to be beneficial for the three areas of sustainable development: environment, economy, and society. The analysis of the solutions implemented by the cities can cause concern that the costs will, at some point, exceed their budgetary capabilities. It seems that to solve this issue city authorities make more and more use of new technologies to adjust city architecture to the needs of people with limited mobility.

Examples of such technologies include intelligent transportation systems (ITS) that allow to adjust traffic lights to the current traffic density, city monitoring system that increases the safety of citizens and facilitates locating current failures, energy-harvesting pavement tiles, systems created for selected social groups, such as carers of children or the elderly, which allow them to monitor their wards in the defined safety zone, as well as a number of other currently designed and implemented solutions which fit into the idea of smart cities. Cities aim to be smart and are more and more successful in doing so.

It is worth asking ourselves if Polish cities can be smart as well. If so, this would undoubtedly be a chance not only to manage metropolises more effectively, but also to build social capital by engaging all citizens, irrespectively of their age, in discussions about the issues that concern them. A social dialogue would allow for more aware changes in the urban space and an improvement in the living comfort of all social groups, including the elderly and disabled.

The improvement of the living conditions of the elderly citizens can be ensured by the funds from the budget of the European Union available for that purpose. Presently, however, the factor hindering the development of smart cities in Poland is the fragmentary implementation of projects, which results in weak coordination of particular sectors and limited cooperation between entities (Frost & Sullivan, 2014). As long as there is no one compatible platform to manage information, the authorities will not be able to effectively manage the city, and its citizens will encounter different obstacles in the form of, e.g., lack of information about tram or bus failures and diversions, lack of single ticket for all means of transportation, lack of adequate transport infrastructure, solutions for the users of bicycle lanes, or unavoidable traffic jams.

These are pressing issues – not to mention the elements of urban infrastructure, such as semaphores and quality and height of pavements, which make it impossible to easily cross the street not only for the elderly and disabled, but also for parents with bogies or small children. The potential for implementing modern solutions in this area is enormous. First, however, the actual needs of the users should be considered in detail and in depth, by involving them in a dialogue with the authorities.

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THE ESSENCE OF THE ACTIVITY OF DEVELOPERS IN THE POLISH INDUSTRIAL AND WAREHOUSE MARKET

Abstract

The industrial and warehouse market is a significant part of a free market economy. Its functioning involves a number of challenges and risks, as it is dependent on a number of global and local factors. In these conditions developers have an important role to play. The aim of the paper is to highlight the activities undertaken by developers in the Polish modern warehouse market and the selected solutions that allow them to meet customer needs. An additional objective is to identify the most important trends that are going to influence the future actions of developers. In order to fulfil the main goal of the paper a review of the literature as well as an analysis of reports and information published by agencies and consultants operating in the real estate market and by developers have been carried out. Among developers operating in the Polish commercial warehouse market, there are both entities of global importance and local, smaller companies. Many of them perform a wide range of functions and they are still taking up new challenges (in technical and organizational terms). This undoubtedly affects the investment attractiveness of the Polish industrial and warehouse market and is a factor influencing its development. Research findings indicate also other warehouse market trends which constitute challenges for warehouse developers.

Keywords: Polish industrial and warehouse market, modern commercial warehouse facilities, developers of modern warehouse spaces

Introduction

Among the logistics processes carried out by companies, those connected with warehousing occupy an important place. The significance of such activities for the whole supply chain reveals itself frequently. For this reason, nowadays it becomes imperative to use modern commercial warehouse facilities. In Polish conditions this is made possible by the dynamic development of the modern industrial and warehouse market over recent years. While in 2004 there was only 1 million m^2 of warehouse space in the country, in the first quarter of 2016 this amount exceeded 10.4 million m^2 (Colliers International, 2016, p. 6). Despite such dynamic development, Polish property market, unlike Western European ones, is not what we call a mature market. During a time period of only a dozen or so years it was necessary to "catch up" and establish a number of institutions indispensable for its functioning. It is worth noting that the warehouse market is subject to the influence of numerous factors – global trends (fluctuations in the related markets) on the one hand and certain local and national conditions (i.a. formal and legal) on the other. Its specificity results from the necessity to adapt properties to the needs of different types of customers. Thus, an important role in the creation of solutions consistent with user expectations is played by developers of modern warehouse spaces. It goes beyond the usual tasks performed by developers in different property markets (e.g. residential) and, in recent years, it has clearly been evolving.

Therefore the main purpose of the paper is to highlight the activities undertaken by developers in the Polish modern warehouse market and the selected solutions that allow them to meet customer needs. In addition, the objective is to identify the most important trends that are going to influence the future actions of developers. In order to fulfil the main aim of the paper a review of the literature as well as an analysis of reports and information published by agencies and consultants operating in the real estate market and by developers have been carried out.

The paper is divided into five parts. The introductory parts 1 and 2 present an analysis of the main theoretical issues and literature review. Parts 3 and 4 discuss practical aspects and specificity of the functioning of warehouse developers in the Polish market. Part 5 presents market changes which influence developers' today's and future actions.

1. The specificity of the modern industrial and warehouse market

The property market[10] occupies an important place in every modern free market economy. Generally speaking, it consists of the deposit market (this is where property rights and similar rights – e.g. the right of perpetual usufruct in the Polish legal system – are transferred) and the rental market (where contracts are concluded by which the title to the property is obtained) (Kucharska-Stasiak, 2006, p. 41). For the purpose of this paper, a presentation of the classification of the real estate market from the point of view of the function of the property is in order; thus, we can

[10] Understood in the literature as "all the exchange relations and parallel relations between market participants that create the demand and supply of real estate. The exchange relations include the disclosure of plans for the purchase, sale, leasing, or renting by various entities (a subject approach), the leasing or renting of various types of property (an object approach), the confrontation of intentions, and the tendering mechanism that encompasses the negotiation processes. The essence of parallel relations is the confrontation of intentions between both those who generate the demand and those who generate the supply" (Kucharska-Stasiak, 2006, pp. 40–41).

distinguish the following: *residential*, *commercial* (office, retail warehouse, etc.), *industrial* (warehouse, factory), *land* (pasture, agricultural, etc.), and *special-purpose* real estate (cemeteries, churches, etc.) (Kucharska-Stasiak, 2006, p. 43). In Poland there is a dynamically developing market of modern[11] commercial industrial and warehouse spaces (real estate). It entails higher risk (Gostkowska-Drzewicka, 2007, p. 112) than, for instance, the residential real estate market, due to its dependence on the fluctuations in other connected markets. There are several types of entities that operate in this market, including: investors, creditors, developers; brokers and consultancies; lessees and tenants; and technical service. Due to the functions they perform and their characteristic evolution, the boundaries between some of them are nowadays becoming blurred (Kucharska-Stasiak, 2006, pp. 54–57). A wide range of tasks is carried out by developers of modern warehouse spaces.

2. The essence of property development

A developer is "an entity that, in order to achieve future income, organizes and coordinates the real estate investment process, from planning the project, through its realization, to delivering the final product into operation or for further development" (Trojanowski, 2004, p. 220). Due to the range of functions they perform in the real estate market, the literature assigns them the roles of builders, investors, organizers, and coordinators of the investment process (Trojanowski, 2004, pp. 212–220). For E. Kucharska-Stasiak (2006, p. 229), a developer is a visionary able to anticipate the potential of a given location and deemed trustworthy by other entities in the market, which makes it possible for him to realize his investments. As a result of their work, developers receive income from selling or renting the property (Gostkowska-Drzewicka, 2007, pp. 112ff.). Depending on the adopted solution, the role of a developer can change over time and encompass all phases of the investment process. He can undertake tasks within the following basic phases (Gostkowska-Drzewicka, 2007, pp. 116, 120)[12]: *pre-realization* (asserting title to the property, securing design documentation, obtaining building permit, etc.) and *realization* (technical design, construction, technical commissioning, negotiation and signing of contracts with tenants or buyers, etc.). When the developer is also the investor, he also carries out important tasks in the third phase – *exploitation* – which include real estate management, operational activities, negotiating and signing of further tenant agreements, possible modernizations and expansions, etc. (Gostkowska-Drzewicka, 2007, pp. 120–121). It is suggested in the literature that due to the form of the development process, the developer can be perceived as a *developer-contractor* (when his actions are basically a response to a market demand report) or a *developer-promoter* (whose business activity is associated with higher risk and who generates supply based on market analysis)[13]. It is important to take a closer look

[11] According to a consultancy report, modern warehouse stock is "a total stock of warehouse space delivered to the market after 2000" (Cushman & Wakefield, 2016a, p. 6).

[12] Along with the literature referenced there.

[13] More on this subject in (Kucharska-Stasiak, 2006, p. 230)

at the developers in the Polish industrial and warehouse market and see which of these formulas characterize their activities.

3. Developers in the Polish industrial and warehouse market

The total commercial warehouse space stock in the Polish market is currently over 10 million m^2. Due to the realization of a number of new construction projects caused by the recent boom in this segment of the real estate market, several hundred thousand square meters of modern industrial and warehouse space are being commissioned each year (in 2015, for instance, it was 925.000 m^2). The main Polish warehouse markets are still responsible for the largest share of the newly built space (60%) (Cushman & Wakefield, 2016a, p. 1). In terms of the growth of developers' activity, however, we should also point to other, heretofore less significant locations, such as Rzeszów, Lublin, and Szczecin (Cushman & Wakefield, 2016a, p. 1), referred to as "emerging markets" (Cushman & Wakefield, 2016b, p. 5). The growing interest in these locations is dictated by the investments in the nearby special economic zones and the improved transport infrastructure (Libiszewska, 2016, p. 21) a factor of great importance to various sectors of the economy. It should also be added that demand for modern warehouse spaces is reported by, i.a., the logistics, automotive, light manufacturing, and trade sectors, including the e-commerce sector (Cushman & Wakefield, 2016a, p. 1). In 2015, the largest share in demand came from the logistics and distribution sector (40% of total volume of transactions), 12% from light manufacturing, ca. 10% from automotive and commercial chains sectors each, 5% from the food industry, 4% from e-commerce, and 3% from electronics (Cushman & Wakefield, 2016a, p. 4).

There are currently dozens of developers in the Polish warehouse market, including about ten large global corporations (such as Prologis, Segro, Panattoni), whose real estate properties are located all around the world, and more than fifty Polish, local, medium-sized entities (JARTOM Real Estate, 2016, p. 3). Commercial warehouse space in Poland is, to a large extent, owned by warehouse developers. Other owners include investment funds and private investors (Fechner, 2016, p. 115). The ownership structure of the Polish warehouse market is presented in Figure 1.

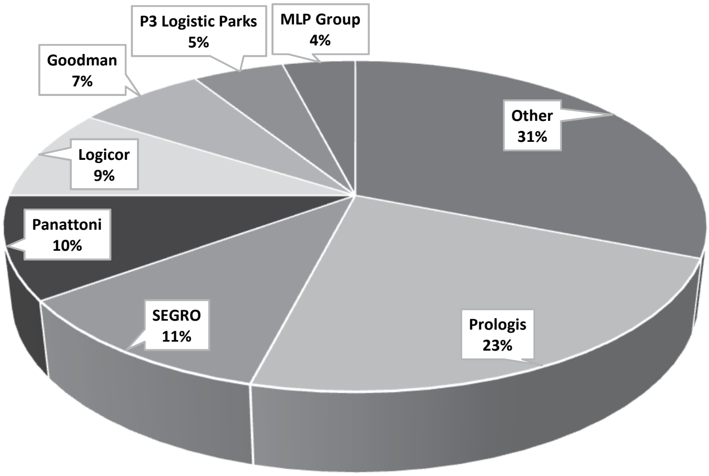

Figure 1. The ownership structure of the Polish commercial industrial and warehouse market (as of the end of 2015)
Source: (own elaboration based on: Cushman & Wakefield, 2016a, p. 3)

Regarding the activity of developers in the main regional markets, it should be noted that foreign capital developers and investors own a dominant share of the available warehouse space in Warsaw (area I, II, and III) and Łódź; in Upper Silesia, Poznań, and Wrocław, on the other hand, both Polish and foreign developers are present (Colliers International, 2015c, pp. 3–32). The same is true for Tricity, which is not one of the main warehouse markets, but is gaining in significance. Warehouses located in the immediate vicinity of seaports are built based on a variety of legal and organizational solutions, by both local entities (i.a., Zarząd Morskiego Portu Gdynia S.A.) and global companies (Goodman's facilities in the Port of Gdańsk). Directing our attention to the remaining regions, we should mention those that have been experiencing intensive property development: Szczecin, Bydgoszcz–Toruń, Rzeszów, and Lublin. Here, due to the relatively low warehouse stock, we can still encounter single investments by large foreign developers (such as Panattoni, Goodman, and Prologis) (Colliers International, 2015c, pp. 33–52) and other operators.

Table 1. Total stock in the main warehouse markets in Poland and Tricity and the shares of particular developers (as of the fourth quarter of 2015)

Warehouse market	Total stock (m^2)	Developers and investors, their shares in the market
Warsaw (area I)	559 thousand	Prologis (17.9%); CBRE Global Investors (16.2%); Hines (13.1%); SEGRO (8.9%); Platan Group (5.8%); ECI (5.3%); Norblin (4.9%); other (27.9%)
Warsaw (areas II and III)	1.84 million; 464.1 thousand	Prologis (29.9%); P3 Logistic Parks (13.7%); MLP Group (10.2%); SEGRO (8.6%); Logicor (7.8%); other (29.8%)
Upper Silesia	1.75 million	Prologis (28%); SEGRO (14%); Logicor (12%); Panattoni (8%); Deka Immobilien (7%); Hines (6%); Menard Doswell&Co (5%); other (20%)

Warehouse market	Total stock (m^2)	Developers and investors, their shares in the market
Central Poland (Łódź region)	1.16 million	SEGRO (23%); Logicor (21%); Prologis (15%); Emerson (12%); PZU Fundusz Inwestycyjny (11%); P3 Logistic Parks (6%); Panattoni (4%); other (8%)
Poznań	1.38 million	Panattoni (21%); SEGRO (18%); Prologis (12%); CLIP (11%); Goodman (10%); Logicor (10%); P3 Logistic Parks (7%); other (11%)
Wrocław	1.29 million	Prologis (40%); Goodman (18%); Panattoni (15%); Hillwood (10%); PZU Fundusz Inwestycyjny (5%); other (12%)
Tricity	314.3 thousand	Prologis (29%); 7r Logistic (17%); Goodman (17%); SEGRO (10%); PZU Fundusz Inwestycyjny (9%); Panattoni (6%); Zarząd Morskiego Port Gdynia (5%); other (7%)

Source: (own elaboration based on: Colliers International, 2015c, pp. 3–37)

Despite the dynamic development, the Polish commercial warehouse space market is still significantly smaller than, e.g., the German market (ca. 80 million m^2 of warehouse space) (Libiszewska, 2016a, p. 71), but analysts predict that it will double over the next decade. There is currently (first quarter of 2016) about 780 thousand m^2 of warehouse space under construction in leading and emerging locations, where investments are realized and planned by both the biggest developers and those with smaller shares in the market, such as 7R Logistic, BIK, DL Invest, Goodman, Ideal Idea Formad, Jakon, MLP, Panattoni, Prologis, Rex-Bud Properties, SEGRO, and Waimea Holding (Ryńska, 2016, pp. 81–82).

An important aspect of property development is not only an efficient execution of current and planning of new investments, but also anticipating the future, even remote, needs of customers. In order to ensure their ability to carry out further investments, developers constantly expand their real estate portfolio by purchasing land in locations which, according to their predictions, will gain in attractiveness in the future. They emphasize that having at their disposal a stock of land provided with adequate formal and legal status and sound in terms of design and technical condition means that when the needs arises they are able to quickly carry out an investment (even in half a year) (Libiszewska, 2016a, p. 70; 2016d, p. 28). Apart from the so-called greenfield investments – constructing new facilities – developers also make an effort to undertake brownfield redevelopment, that is, to "restore" abandoned or contaminated facilities "to a serviceable condition for future users." This is a difficult task from both legal and technical point of view. One of the pioneers in this field in the Polish market is Panattoni (Libiszewska, 2016c, p. 90). In the longer term, such solutions can gain in importance due to the aging of facilities; this tendency is already visible in the more mature real estate markets.

In order to gain a full view of the Polish market and property development we should also address the issue of selling industrial and warehouse facilities. In Poland, there is a high demand for and a low supply of warehouse facilities (Cushman & Wakefield, 2015, p. 7). Portfolio transactions become increasingly frequent, by which investors (often foreign) "acquire whole platforms or companies of great value and development potential" (real estate yielding a steady income and, additionally, a stock of attractive land) (Kwaśniewski, 2016, p. 68). Foreign institutional investors (nowadays also insurance companies etc.) and REITs (Real Estate Investment Trusts) come not only from nearby markets, but also, more and more frequently, from Asia, Australia, or Canada. Investors active in the Polish market include: Hillwood Europe, Deka Immobilien, Logicor, P3 with TPG Real Estate, Ivanhoé Cambrige, and W.P. Carey (Kwaśniewski, 2016, p. 69).

4. Basic types of property development ventures in the Polish market

Modern warehouses are usually built in the form of industrial and warehouse (or warehouse and office) parks, also called logistic parks – big-box facilities (from several dozen to over 100 thousand m^2) with multiple users who carry out their activities side by side. In Poland, there are 275 such facilities; in 2016 their number is expected to exceed 285 (5% increase) (JARTOM Real Estate, 2016, p. 2). They are usually located on the outskirts of urban agglomerations or in some distance from them, but close to road (or rail) infrastructure. When discussing the types of properties in the Polish market we should also mention small business units (SBUs) – smaller industrial, warehouse, and office spaces (usually from several to over 10 thousand m^2) in attractive locations (the element of prestige), i.a. closer to customers in urban agglomerations. Following the example of the Western European markets, such solutions become increasingly frequent in Poland as well, i.a. due to the dynamic development of the e-commerce sector (Colliers International, 2015b, p. 3), and the wish to create here a so-called fresh centre (Libiszewska, 2016a, p. 71).

With regard to the degree of adaptation of warehouse space to the requirements of tenants, the investments in question are, to a large extent, carried out as *build-to-suit* (BTS) projects, tailored to the needs of specific users.[14] Variants of the BTS formula are presented in Table 2. Another type are "speculative" investments, not secured by lease agreements in the execution phase and "waiting" for future tenants, and thus constructed in a standard finish with the possibility of adaptation at a later time.

Table 2. Solutions for build-to-suit facilities

Aspect	Possible solutions
location	1) on the customer's plot of land; 2) on the plot of land owned by the developer; 3) on the plot of land purchased to fit the specific needs of the customer
formal and legal aspects	1) lease agreement; 2) ownership title (of the customer), so-called build-to-own (BTO); 3) construction with the view to sell in the future
size, technical equipment	size and equipment adjusted to the needs of a specific customer; office space for one employee no less than 2 m^2

Source: (own elaboration based on: Panattoni Europe, 2016)

[14] For instance, 56 thousand m^2 of warehouse and office space for Leroy Merlin in the Panattoni Park Stryków II (in a warehouse park) or other projects carried out by Panattoni, i.a. BTS H&M in Poznań (Panattoni Europe, 2016).

The share of BTS and speculative facilities in the total stock of space commissioned in a given year depends on, i.a., market fluctuations and the presence of future tenants with special requirements. It should be noted that the years 2000–2008, when the Polish market experienced a dynamic development, was also a period characterized by a significant share of "speculative" projects. One consequence of the intensive development of the logistics market and commercial chains was that warehouses built in attractive locations quickly found their tenants. The situation was changed dramatically by the economic crisis, as a result of which many developers had to struggle with vacancies. Nowadays the situation in the real estate market is stable and developers once again turn to "speculative" facilities (Colliers International, 2015b, p. 3), which are usually located in the same warehouse parks as built-to-suit facilities (Cushman & Wakefield, 2016a, p. 4).

Because developers are increasingly perceived as highly-experienced specialists operating in a difficult market, they are more and more frequently entrusted with the task of constructing "tailored" industrial and warehouse facilities that will become the property of the customer. The build-to-own (BTO) formula concerns entities from the production sector or those that have specific technological requirements and employ advanced technologies (Ryńska, 2015, pp. 88–91).

Due to the growing demands of tenants, who use the rented space not only for storage, but also for a number of complementary activities, and even manufacturing (also, i.a., pharmaceutical), the role of developers in this market in clearly evolving. It is worth noting the recently increasing complexity of development projects in terms of their technical (adapting the facilities to the needs of tenants, providing special equipment, etc.) as well as organizational and legal aspects. An increased cooperation between developers and customers, i.a. logistics operators, is observed (Krawiecki, 2015, p. 89).

In the case of commercial spaces, the relations between the owner of the facility and its tenant are regulated by an agreement (usually a lease). An important element of such agreements are the provisions relating to rent. The standard rate is the base rate (Duda, 2016, p. 94), which depends on, i.a., the duration of the lease, the size of the rented space, its location, and the costs of necessary adaptations (JARTOM Real Estate, 2016, p. 5). There are also other types of rental rates in this market, i.a. effective rates (after discounts) and maximum rates (e.g. for the best locations). They currently range from ca. 2 to over 5 euro per m^2 per month (Cushman & Wakefield, 2016b, p. 3). Any reduction of rent constitutes an incentive for potential tenants and thus increases the chances of signing an agreement. Maintenance costs incurred by the tenant also encompass exploitation costs (security, heating, etc.). The tenant usually pays back the owner of the warehouse (also as part of the rent) the costs of adapting it to the needs of a specific user. Due to the tendency to adapt warehouses to the needs of tenants these costs are increasing and can exceed 1 million euro for ca. 10 thousand m^2 (JARTOM Real Estate, 2016, p. 5).

In addition to reducing rents, developers employ other incentives, offering tenants above-standard finishing, covering relocation expenses, or providing environmentally certified real estate (and thus lower exploitation costs) (Duda, 2016, p. 94). Another distinguishing feature of the developer is his manner of managing the warehouses (e.g. the range of services offered to tenants) or optimizing costs by negotiating conditions with the suppliers (of utilities etc.) (Libiszewska, 2016d, p. 28). It is important that the characteristics of the warehouse itself and the way it is managed by the developer constitute an incentive to renew or even extend the lease. To express this fact, developers use the so-called customer loyalty index. For instance, in 2015 for Prologis it amounted to 81%, with a share in the Polish warehouse market of 23% (Libiszewska, 2016d, p. 28).

5. Warehouse market trends as a challenge for developers

The role of storage facilities in modern economic processes is clearly changing, as they acquire additional logistical or even commercial functions (JARTOM Real Estate, 2016, p. 4). This process is accompanied by varied requirements of tenants from different sectors. These changes grow into market trends and constitute challenges for warehouse developers; some of them are presented in Table 3.

Table 3. Selected trends and changes in the industrial and warehouse market

Trend	Description
e-commerce warehouses	warehouses as showrooms and centres for handling orders and returns; more storage docks, mezzanines; more employee-friendly conditions; more dispersed facilities closer to final consumers
automation	lifts and carousels; conveyor belts etc.; robotics; Internet of Things, machine-to-machine communication; increased number of silos
pro-ecological solutions	application of environmentally-friendly solutions to building construction (materials, daylight, etc.) and equipment; growing importance of ecological certification (LEED, BREEAM, etc.)
aging of facilities	the aging of warehouses, especially in attractive locations, necessitates the transformation of some of them into, e.g., return centres, server rooms, special entertainment venues; so-called brownfield projects
warehouses for manufacturers	installation of skylights; reinforcement of floors; additional ventilation; permits for conducting the chosen type of activity; usually a longer lease term

Source: (own elaboration based on: JARTOM Real Estate, 2016, pp. 4–10; Colliers International, 2015a, p. 8)

Conclusions

Dozens of industrial developers operate in the Polish commercial warehouse market. Among them are both entities of global importance and local, smaller companies. Its ownership structure is dominated by the biggest shareholders (i.a. Prologis, Segro, Panattoni, and Goodman), who have significant warehouse stocks at the most attractive locations in the country, as well as facilities in the emerging markets. Responding to the needs of customers, developers realize (playing an active part in the whole investment process) diversified construction undertakings, mainly logistic parks (over 275 big-box developments in the country) and small business units (more prestigious facilities, in growing demand due to, for instance, the dynamic development of e-commerce). In response to the specific needs of tenants, developers deliver on-demand, "build-to-suit" or even "build-to-own" facilities. In addition, more and more warehouse space is being built without a specific order (so-called "speculative" property), which is associated with a higher risk. Numerous developers, in anticipation of the future needs, also expand their real estate portfolio.

The limited volume of the paper makes it difficult to accurately describe the activity model of the largest developers, or those performing the widest range of functions, and those who carry out a limited number of tasks. Generally speaking, it should be noted that many developers active in the Polish market perform a very wide range of functions. They are still taking up new challenges, in both technical and organizational terms (e.g. dealing with clients). Considering the creativity of the developers in the Polish market and their ability to anticipate the future needs of customers, they can hardly be treated solely as developers-contractors – rather, they evolve into developers-promoters. This undoubtedly affects the investment attractiveness of the Polish market and real estate, which is confirmed by the interest on the part of foreign institutional investors and increasingly frequent portfolio transactions.

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LOGISTICS PROJECT PLANNING UNDER CONDITIONS OF RISK AND UNCERTAINTY

Abstract

The paper discusses highly important issues related to the practice of logistics project planning under conditions of certainty, risk, and uncertainty. This process requires the use of a variety of planning information (complete or incomplete, express or implied) as well as the generation of new knowledge. The decision-making process takes place in a deterministic or an nondeterministic situation; the former involves complete information (i.e., certainty) and the latter incomplete information (i.e., risk and uncertainty). Becoming acquainted with the discussed issues provides valuable practical knowledge that may be helpful in making important decisions when formulating concepts and models of logistics projects planning undertaken by a single enterprise or a supply chain.

Keywords: project, logistics project, planning, uncertainty, project success

Introduction

The growing complexity and uncertainty of the environment forces enterprises to perform non-standard logistics activities with the aim to solve unusual problems of various nature with non-standard procedures and processes (Pisz, Łapuńka, 2016b). This also includes accepting custom orders and providing logistics services to particular groups of customers (Pisz, Łapuńka 2016a). This results in a growing demand for concepts, models, methods, and techniques of project management, including logistics project management (Kisperska-Moroń, Krzyżaniak, 2009). The significance of projects, including logistics projects, in the contemporary economy is constantly increasing (Kasperek, 2006; Nowosielski, 2008; Witkowski, Rodawski, 2008). This is due to many circumstances, mainly the growing complexity and diversity of management problems and undertakings necessary to solve them (Artto, Jaakko, 2008). This situation elicits expectations of new, original products, services, and systems, including logistics systems, and their constant improvement. This takes place in conditions of increasingly unpredictable changes in enterprise environment and growing competition between enterprises and supply chains, which imposes high requirements of effectiveness and efficiency. The future conditions of the implementation of a given project are difficult to predict and unambiguously define; we are dealing here with a very particular, "fuzzy" project environment (Shanmugasundari, Ganesan, 2014; Khan et al. 2012; Haque, Hasin, 2012; Wei, Liang, Wang, 2007). The number and type of factors influencing the project can vary and depend on its type and scope, the type of resources it utilizes, the place and time of its implementation, etc. It should be emphasized that, at the beginning of implementation, logistics projects are characterized by a particularly high risk and uncertainty due to the multitude of parameters that need to be taken into account when assessing the influence of the environment on their implementation and estimating their characteristic variables, which are, for the most part, fuzzy and uncertain.

The paper presents selected problems of logistics project planning in various planning conditions, including conditions of risk and uncertainty, most frequently encountered in the practice of project planning. It can be argued that becoming acquainted with the discussed issues provides valuable practical knowledge helpful in making important decisions when formulating concepts and models of logistics project planning undertaken by a single enterprise or a supply chain.

1. The essence and significance of logistics projects for logistics management

Various kinds of projects that represent a practical dimension of solutions that need to be implemented in order to increase the effectiveness and efficiency of material flows in enterprises and supply chains can serve as examples of how they realize the assumptions and guidelines of logistics. Both enterprises and supply chains take upon themselves the implementation of particular logistics projects to avoid or mitigate problems related to the flow of cargo (products, goods) and people (Pisz, Łapuńka, 2015).

Logistics projects can be defined as one-time undertakings of limited duration and funding, whose implementation serves to improve the effectiveness and efficiency of the product flows and the accompanying information flows in enterprises, supply chains, or spatial systems (Witkowski, Rodawski, 2008). Among them we can list those that concern the deployment of production and warehouse facilities, transport, storage, development or modernization of linear elements of logistics infrastructure, stock management, or customer service. Logistics projects are therefore aimed at improving the effectiveness and efficiency of activities undertaken in order to solve a particular economic, social, environmental, or legal problem (Żuryński, 2015).

The research results published by the Polish Logistics Managers Panel show that in the course of a year Polish logistics managers implement diverse logistics projects that concern, i.a., constructing warehouses or reloading terminals, reorganizing processes, changing the product range, as well as purchasing and distribution of finished goods within enterprises or supply chains (PPML, 2011).

The following basic characteristics of logistics projects are what makes them stand out from the general classification (Kasperek, 2006):

- the need to take into account logistical conflicts (cost trade-offs),
- using the total cost of logistics as a decision-making criterion during analyses,
- the need for adaptive management,
- the need to develop methodology dedicated to the implementation of a given project,
- the need to determine the level of customer service offered as a result of implementing the project and within the project itself,
- determining the role and place of a logistics project in the organizational structure of an enterprise.

Cost trade-offs are one of the most important factors to be analysed when planning a logistics project. They show the relations between the particular spheres of logistics and are to a large extent responsible for shaping the logistical costs incurred by an enterprise. When planning and implementing a logistics project, the risk of the occurrence of logistical conflicts should be analysed and appropriate remedies should be employed in order to optimize the above-mentioned costs. Optimizing cost trade-offs is inextricably linked with using total cost as the main decision-making criterion. As the total cost is nothing else than the sum of particular partial costs, its use as a decision-making criterion requires defining logistics cost accounting in an enterprise, and thus also in a project, and making appropriate calculations on this basis. The next two distinguishing features of a logistics project are strictly connected. Due to the fact that in the practice of implementing logistics projects, at the stage of planning, an unspecified goal is often formulated (a so-called design intent), which is then gradually refined and specified, they need to be adaptively managed.

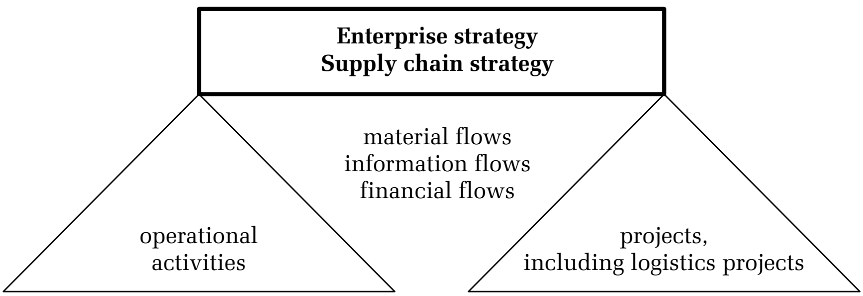

Figure 1. The activity of an enterprise or a supply chain based on a design approach
Source: (own elaboration)

A project, including a logistics project, is a specific set of interconnected activities aimed at achieving an intended goal. The basic characteristic of any project is its finite nature. Practically speaking, this means that a project should have a clearly defined beginning and end. The concept, implementation, and result of a project determine its unique character, and this uniqueness is precisely what introduces the element of risk and uncertainty. The project is subject to time and resource constraints (team, techniques, methods, and tools). It is usually defined by its end product (scope), execution time (deadlines), and execution costs (budget). A clearly defined scope of the project can reduce potential overruns. It needs to be remembered that inadequate planning and inaccurate definition of the scope of the project can lead to costly changes, delays, alterations, overestimation of costs, and thus to the failure of the whole project (Assaf, Al-Hejji, 2006). An accurate definition of the project at the preliminary stage of planning is the key condition for its successful implementation and obtaining satisfactory results (Fageha, Aibinu, 2013). Each project has a certain economic, organizational, technical, and social value determined by its complexity and uniqueness.

2. Logistics project planning conditions

The process of logistics project planning requires the use of a variety of planning information (certain and uncertain, complete and incomplete, express and implied) regarding the given project, as well as the generation of new knowledge about the project and its environment. Three types of planning situations can be distinguished: planning under conditions of certainty (i.e., complete information; a deterministic situation), risk, and uncertainty (i.e., incomplete information; nondeterministic situations).

Under conditions of certainty, the decision-maker has enough information to predict the effects of each possible variant. These effects are fully (or nearly fully) determined, i.e., each action invariably leads to the same result. Thus, the decision-maker can be completely (or nearly completely) sure as to the result of selecting a given variant. Under conditions of risk, the decision-maker has information to predict various effects of the possible variants. These effects are uncertain, but their (more or less probable) occurrence is estimable. Under conditions of uncertainty, the decision-maker has incomplete and uncertain information about different effects of different possible variants. The probability of these effects cannot be objectively or subjectively estimated. Figure 2 presents the possible conditions of logistics project planning, i.e., certainty, risk, and uncertainty.

In order to answer the questions facing him, the decision-maker needs to be acquainted with the given project environment and have the ability to properly estimate the duration of each activity based on the available information, knowledge, and experience.

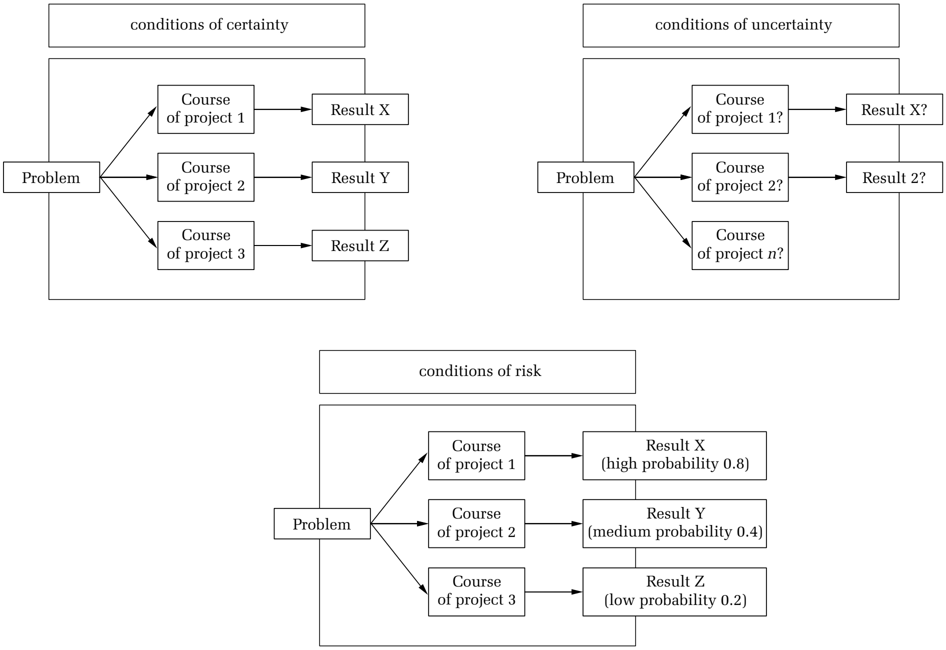

Figure 2. Conditions of project planning, including logistics project planning
Source: (own elaboration based on: Schermerhorn 2008; Trocki, Wyrozębski, 2015)

3. The role of logistics project planning in achieving project success

The implementation of a project, including a logistics project, requires answering the question of how to achieve project success. Practically speaking, this means defining activities that need to be undertaken in order to achieve the project's primary objective in the given time, with the given budget, and while maintaining the required quality. In the source literature we can find discussions devoted to the so-called critical success factors in project management. Most of the published research results indicate professional project planning as one of the key factors of the successful implementation of a project. A study of Polish enterprises conducted by S. Spałek (2006) confirms the significant influence of planning on project success. Drawing on the results of the research conducted by GPA Deutsche Gesellschaft für Projektmanagement we can list the following factors of project success (Engel et al. 2008):
- project planning,
- qualified project participants,
- good communication,
- clearly defined project objectives,
- experienced and committed top management.

The success of the project depends on numerous elements that together constitute the overall project plan (Baccarini, 1999; Belout, 1998; Spałek, 2004), for example:

– schedule of project activities,
– list of activities and tasks and their detailed characteristics,
– resource analysis,
– project budget,
– information transfer system plan and communication plan,
– plan of a system of monitoring and controlling the process of carrying out particular activities, achieving intended goals, etc.,
– quality management plan,
– risk management plan,
– coordination plan, troubleshooting procedures.

The authors' previous paper (Pisz, Łapuńka, 2016a) discusses the key factors of logistics project success and presents an approach to measuring it with a practical example.

Taking into account the above elements at the stage of project planning can contribute to reducing the uncertainty and risk entailed in project management, which is of significance for both functional and institutional problems of project management (Stabryła, 2008), allows to reduce the execution time and costs, minimizes the risk of failure and the risk of having to introduce changes during the course of the project, and reduces the uncertainty of project activities.

The data published in 2011 by the Polish Logistics Managers Panel and the research conducted by the authors of the paper indicate that most of enterprises do not plan the course of their logistics projects correctly. The vast majority of respondents declare that they do not make the necessary calculations, which results in not meeting deadlines and exceeding the budget and confirms the low effectiveness and efficiency of logistics projects. More than 30% of the analysed logistics projects end on time. Those that do not, exceed the deadline by ca. 20%. Nearly 60% exceed the planned budget. It should be noted that 19% of managers are unable to indicate the actual cost of the logistics project in comparison with its planned cost. Among the most frequently indicated barriers to project success were: insufficient understanding of the premises of logistics projects by other divisions of the enterprise and changes of conditions or requirements during their implementation.

Project planning is an important element of a comprehensive project management system. Its place in project management is presented in Figure 3.

Figure 4 presents the various project planning processes, i.e., the processes of planning the structure, schedule, and resources under conditions of certainty, risk, and uncertainty. Basic factors which require planning have been identified along with the hierarchical and cooperative structure of the project and its components (structure planning), the plan of the course of the project in time (schedule planning), and the plan of resources and budget (resource planning). It should be noted that because these processes are interactive and interconnected, a comprehensive, integrated approach to project planning is necessary. The results of planning the intended outcome are used when planning the course of the project.

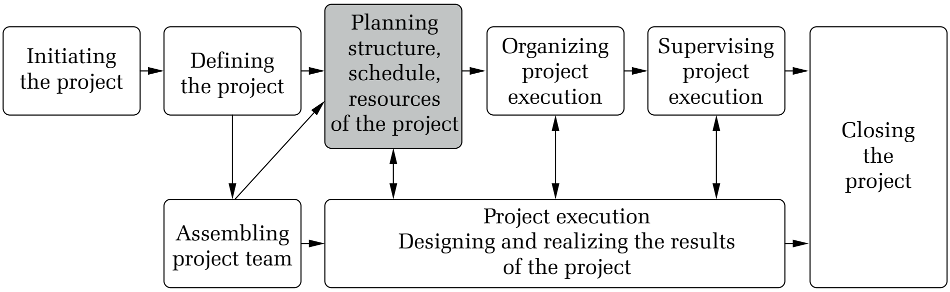

Figure 3. The place of project planning in project management
Source: (Trocki, Wyrozębski 2015)

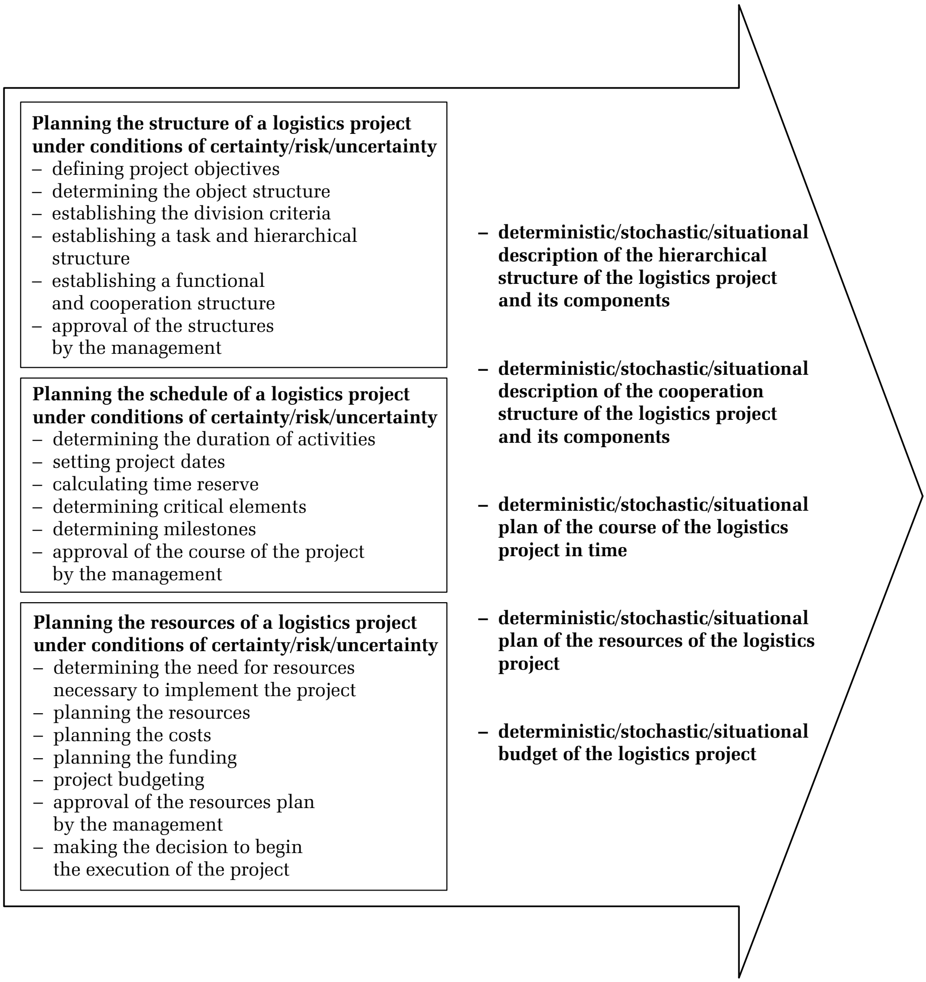

Figure 4. The essence of logistics project planning
Source: (own elaboration)

Different concepts and models of logistics project planning have been developed depending on the availability of planning information, which should be adapted to the possibilities and limitations of the given planning situation by logistics project managers. Depending on whether the available information is complete or incomplete, the decision-maker will be dealing with deterministic or nondeterministic (stochastic) project structures. The third group are the so-called situational concepts and models of project planning.

In the case of logistics project planning under conditions of certainty, it is possible to unequivocally and with certainty determine both the hierarchical and cooperation structure of the project. The duration of project activities, their beginnings and ends, as well as their time reserves can be deterministically estimated. It is possible to clearly set out a critical path. The resources necessary to implement the project can be precisely defined and key resources and their limits can be deterministically estimated. Moreover, it is possible to unequivocally determine the need for particular groups of resources in relation to the manner and time of their use. The availability of complete information makes it possible to precisely estimate project costs and determine the need for financial resources (including the manner and time of their use). Under conditions of certainty, the project manager can make use of classical project planning models, mainly Gantt charts and network planning methods, such as critical path method (CPM) and metra potential method (MPM). Additionally, the available concepts and models of project planning include the critical chain path method (CCPM) and the line-of-balance (LOB) method. The development of network programming techniques made it possible to conduct a time analysis of projects taking into account their costs (PERT-COST, CPM-COST), which provides the project manager with answers to the following questions: by how much will the cost of the project increase if its implementation is shortened by a given time unit? How much can we shorten the execution time by incurring a given cost?

Logistics project planning under conditions of risk requires using different, stochastic concepts and models, such as program evaluation and review technique (PERT), graphical evaluation and review technique (GERT), and its variant, graphical evaluation and review technique simulation (GERTS). For instance, the GERT method utilizes probability theory for calculating the most probable duration of particular activities and for variant modelling of the project's logical structure, which makes it possible to take into account alternative courses that the implementation of the project can take depending on the expected random disruptions which might occur at the execution stage. At the same time, a variable type of sequence relationships is assumed, which are either strong (hard logic) or weak (soft logic), using three types of relations: "or," "exclusive-or," and "soft" (Wang, 2005; Pisz, Banaszak, 2010). Figure 5 presents the ambiguous weak sequence relationships that correspond to alternative sequence relationships in real situations. Figures 6 and 7 present variants of executing a logistics project under conditions of risk. In this case, possible scenarios are taken under consideration, and the likelihood of the actual occurrence of a given scenario is determined with a certain degree of probability.

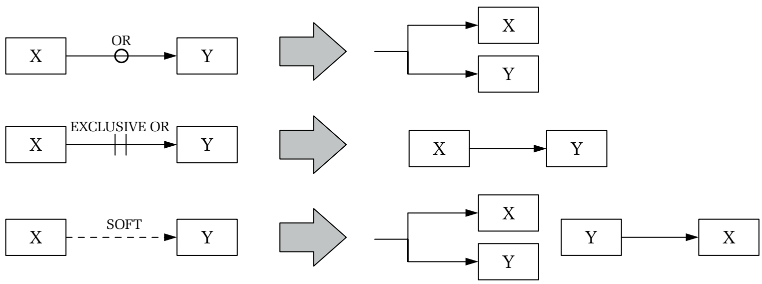

Figure 5. Interpretation of weak sequence relationships
Source: (Wang 2005)

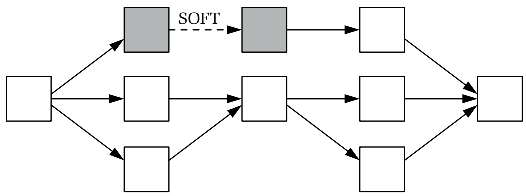

Figure 6. Example of a logistics project implementation variant with weak sequence relationships
Source: (own elaboration)

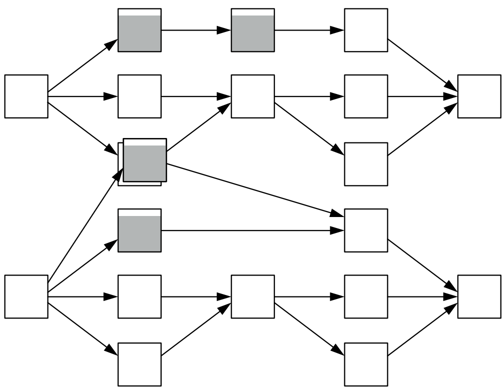

Figure 7. Example of alternative logistics project implementation variants after taking into account weak sequence relationships
Source: (own elaboration)

GERTS uses a random number generator to simulate disruptions and their possible influence on the duration of alternative activities. When planning a logistics project under conditions of risk, it is not possible to unequivocally determine its structure. In this case, it is necessary to ascertain alternative structures and the likelihood of their execution. Incomplete data make it impossible to fully estimate the duration and costs of executing a given logistics project. The duration of activities, schedule, time reserves, critical path, necessary resources, key resources and their limits, as well as the need for resources (including financial resources) in terms of their type and time of their use are all determined stochastically.

When planning a logistics project under conditions of uncertainty – having only incomplete, unclear, and nondeterministic information at one's disposal – it is impossible to determine the future structure of the project (or it is possible only to determine its hierarchical structure). It is also not possible to estimate the duration of particular activities, the cost of the project, and the need for financial resources, to determine the schedule and time reserves, or to set out a critical path. Such conditions call for the application of situational concepts and models of project planning. In this case, it is recommended to use heuristic approaches, such as relevance trees, adaptive approaches, agile project management (APM), Scrum, and extreme programming (EP). The lack of complete, certain information does not preclude planning but gives it new meaning. The published research results indicate that agile project management requires up-front planning (Coram, Bohner, 2005). Irrespectively of the chosen planning variant, at the beginning of each iteration it is necessary to develop a plan, which is the basis of all activities. Practically speaking, this means that planning is distributed throughout the life cycle of the project (Serrador, Pinto, 2015). An adaptive approach prescribes planning only those actions that are to be performed in the nearest future, in accordance with the "just in time" philosophy (Wysocki, McGary, 2005). It should be emphasized that changes, which result from both their external environment and their internal structure, constitute an important element of each enterprise or supply chain that implements a logistics project. Change can be defined as a modification of the current state of an object (in this case, an enterprise or a supply chain) or its environment that results in an increase or a decrease of the effectiveness of its operations, processes, and projects. This means that an enterprise or a supply chain that undertakes a logistics project should be able to eliminate or mitigate the consequences of changes and to quickly respond to those changes in order to achieve the project objectives. Logistics project managers are forced to undertake specific activities to adapt to the changes in the (closer and more distant) environment. It is important that the decision-makers understand the need to undertake adaptive actions to ensure an appropriate adaptive ability of an enterprise or a supply chain. This requires a constant observation of events occurring both within them and in their environment.

An iterative approach to project planning allows for better adaptation to project conditions. The activities that are to be undertaken in the next project cycle are planned in detail. A characteristic feature of agile project management is the elimination of wastefulness (*muda* in Japanese) in the form of unnecessary thinking. The main role of a project manager is to develop a vision of the project's outcome and to lead the project team on the path to realizing this vision. Planning and control constitute integral elements of agile project management, but not its central points, as is the case with the traditional approach to project management. Adaptive structures require minimal documentation and a mechanism of transferring information about the successes and failures of the project to other people in the enterprise or supply chain. The solution is not to eliminate documentation or processes, but to approach them with the aim to facilitate them, *lean* them, restrict them to the necessary minimum (Highsmith, 2007).

Agile project management requires giving up long-term in favour of short-term prediction based on the knowledge of particular facts emerging in subsequent iterations of the project. Figure 6 presents an adaptive project structure. Unlike planning under conditions of certainty, a preliminary plan of the whole project is created, which is then decomposed into mid-level labour division structures. It such a structure, names of activities come from the project's partial objectives. A detailed plan is created every time only for the next project cycle, in which the project is decomposed into tasks. A traditional approach, on the other hand, suggests creating a detailed plan of the project right away and decomposing all activities into tasks. Agile project management adopts an incremental approach. The product is developed in a series of releases and release plans within subsequent cycles. Releases are determined by a directive term and a high-level set of functionalities. Each subsequent version should constitute a working subset of the whole functionality provided to the customer. When planning the releases, the scope described in the backlog is divided into particular releases, taking into account their priorities and relevance, using the MoSCoW technique, which allows to prioritize functionalities in order to achieve a mutual understanding between stakeholders regarding the importance they place on delivering each of the requirements. According to *A guide to the business analysis body of knowledge*, version 2.0, section 6.1.5.2, the following categories of the MoSCoW technique can be distinguished:

- M – must have: requirement that has to be met in the final solution,
- S – should have: high-priority item that should, if possible, be included in the solution,
- C – could have: requirement perceived as desirable, but not necessary; its inclusion depends on time and resources,
- W – won't have: requirement that, with the consent of stakeholders, will not be implemented in the given release, but can be considered in the future.

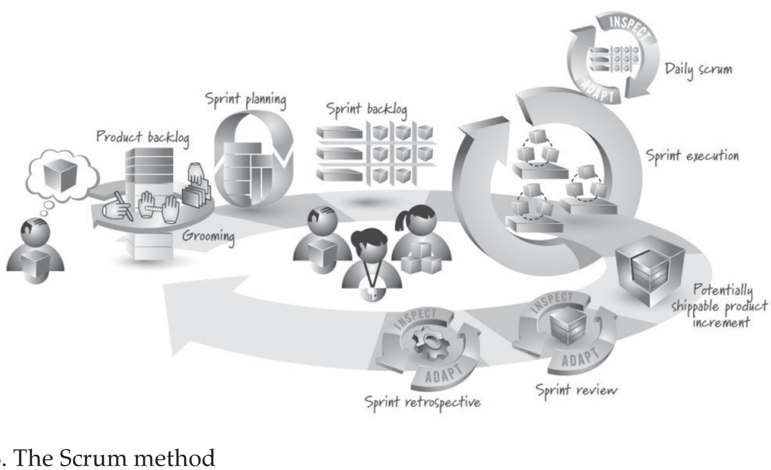

Figure 8. The Scrum method
Source: (Scrum Talks, 2015)

The decisions find reflection in the so-called release backlogs. In this case, a backlog is a list of requirements with specific priorities to be implemented in the project. Sprint backlogs contain information about the requirements along with the priorities to be implemented in the given cycle.

One of the APM methods is Scrum. A project is divided into iterations called sprints. Particular sprints last from one to four weeks and should, if possible, have the same duration within one project. A release comprises from one to even several dozen sprints (usually, however, between three and twelve). The lack of a plan significantly increases the risk of failure. At the beginning of working on a product, a list of user requirements is compiled, usually illustrated with user stories. Each story describes one feature of the given system. The product owner is obligated to prioritize the requirements and present the main objective of the first sprint. Next, a product backlog is formulated. The goal of the sprint is written down in a visible place in the project team room. When planning the sprint, the highest-priority tasks are selected, which also contribute to the achievement of the sprint's objective. At this stage, the duration, labour intensity, complexity, and risk of each task are estimated and sprint backlog is created. Planning the sprint allows to move on to its next stage, in which the product owner should work with the team to reach the best possible understanding of the requirements, but refrain from interfering with the manner of their implementation. Generally speaking, the scope of a given sprint should not be changed.

It should be emphasized that a project team is, by assumption, a self-organizing body. This means that team members are not assigned particular tasks "top-down," as is the case with traditional project management, but they choose their own tasks according to their mutual agreements, abilities, knowledge, and expertise. An important characteristic of the Scrum method is the daily scrum – daily meetings, less than 15 minutes long, during which the team discusses the tasks from the day before, the current problems, and the tasks for the next day. Each sprint closes with a sprint review, during which the results of the work on the product are presented. Each team member, in particular the end users, are required to attend it, and each of them can express his opinion on the product. Next, the date of the planning meeting for the next sprint is set. Generally speaking, the Scrum method focuses on delivering increasingly refined products as a result of a series of sprints, involving the future users in the process, and the self-organization of the project team (Rubin, 2013).

Conclusions

The need to introduce constant and regular changes in enterprises and supply chains in order to adapt to the market requirements makes it necessary to apply project management practices to logistics systems. Properly planning the course of logistics projects improves the effectiveness and efficiency of the product flows and the accompanying information flows in enterprises, supply chains, or spatial systems. The discussed problems concern highly important issues related to the practice of logistics project planning in conditions of certainty, risk, and uncertainty. It can be argued that becoming acquainted with the discussed issues provides valuable practical knowledge helpful in making important decisions when formulating concepts and models of logistics project planning undertaken by a single enterprise or a supply chain.

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THE ROLE OF INFORMATION IN E-COMMERCE

Abstract

The article presents different definitions of e-commerce and discusses the impact of technology development, the Internet, globalization, and changes in public awareness on its current form. It also indicates the functions of information and its pathologies most frequently encountered in e-commerce and presents the role of logistics information in building its competitive advantage.

Keywords: Big Data, information logistics, e-commerce

Introduction

Information is currently the main asset of companies, independently of the market in which they operate, their profile, or their size. The success of an enterprise in the competition game depends largely on its ability to acquire, store, and use information. The main factors that contributed to the increased importance of information for enterprises include rapid globalization, information technology development, and changes in customer behaviour. The same is true for enterprises operating in the e-commerce market. Regardless of their size or scope of operations, they process large quantities of information – even larger than in the case of traditional commerce, as they operate in virtual markets. This translates into a growing interest in information and its possible uses for building competitive advantage in e-commerce. E-commerce companies are currently exploring functions of information other than their role in supporting the decision-making process. The quantity and quality of information, however, make it a considerable challenge. Modern enterprises operate in an environment in which the number of information sources increases at a fast pace due to the rapid development of information technology. They use more and more high-tech support systems, larger-capacity data servers, and faster Internet connection, which increases the speed of information acquisition. Facilitated access to sources of information means that the available information is more diverse in terms of both quantity and quality. These changes result in increased complexity of relations between particular e-commerce companies, which, in turn, generates problems that might be termed pathologies of information. Thus, it becomes necessary to perceive information as an asset, and information logistics begins to play an increasingly important role in e-commerce enterprises.

The main aim of this paper is to present the relations occurring between e-commerce and information logistics. It also discusses the pathologies of information most common in e-commerce as well as the essence of treating information as an asset that could contribute to building competitive advantage of e-commerce companies.

1. Electronic commerce

Analysing source literature, it is difficult to unequivocally pinpoint the beginning of electronic commerce. Many authors point to the dawn of commercial use of the Internet in the 1990s (Tian, Stewart, 2006, pp. 559–560). Along with it, the notion of electronic commerce was born, ceaselessly evolving and adjusting to ever-changing conditions. E-commerce itself, however, existed long before the term was coined. Analysing this issue, we might notice that many entrepreneurs and authors treat the terms “e-commerce” and “e-business” as synonymous, which, unfortunately, is incorrect. Just like traditional commerce is an element of business, so is e-commerce an element of e-business (Szpringer, 2000, pp. 22–26). This interrelation is presented in Figure 1. The broadest term is e-economy, defined as a virtual arena in which companies operate, commercial transactions are being conducted, values are being generated and exchanged, and participants engage in direct contact (Gregor, Stawiszyński, 2002, p. 77).

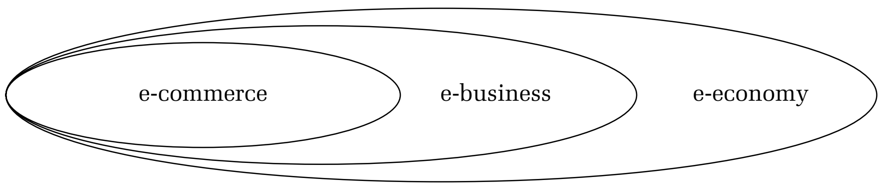

Figure 1. Interrelations between e-commerce, e-business, and e-economy
Source: (own elaboration based on: Gregor, Stawiszyński, 2002, p. 77)

The most popular and, at the same time, the simplest definition of electronic commerce views it as a commercial transaction conducted via the Internet (Oxford Dictionaries). It must be noted, however, that e-commerce is not limited to the Internet, but extends to EDI, cable and satellite TV, electronic cards, as well as Intranet and Extranet. Keeping in mind the multitude of communication channels, it can be argued that e-commerce existed before the beginning of commercial use of the Internet. An example from Poland from before the “era of the Internet” could be the buying of goods and services by calling the 0700 numbers; in this case, TV advertisements, telephone sales, and the very transaction, which constituted a connection fee, all took place by means of electronic communication, making it an example of e-commerce (Jasiński, 2013, p. 17). Nevertheless, the Internet dominated other sales channels, which is why very often e-commerce transaction are considered to be conducted via the Internet – just like in the above-cited definition.

A broader definition, in terms of sales channels, is proposed by Ph. Kotler, who believes "e-commerce" to be a more general term referring to purchase and sale processes conducted with the use of electronic channels in general (Kotler et al., 2002, p. 1055).

From the point of view of the present paper it is worth taking a closer look at the two definitions proposed by the World Trade Organization (WTO) and the Organisation for Economic Co-operation and Development (OECD). According to the WTO, e-commerce means production, advertisement, sale, and distribution of products using ICT networks. The OECD, on the other hand, believe that the term should encompass clearly distinguished electronic transactions and Internet transactions (GoST). The former should be understood as sale or purchase of goods or services over computer networks, and the latter as using the Internet as the channel of communication between the parties. The Central Statistical Office of Poland defines e-commerce as ordering goods and services using only the Internet or EDI, but notes that payment and delivery of the ordered goods or services do not have to take place online. Transactions can be concluded between companies, individuals, government institutions, or other private or public agencies. Orders placed by phone, fax, or e-mail are not considered part of e-commerce (GUS).

The above discussed definitions are more or less overlapping. Their main common features include:

– purchase and sale transactions are conducted over electronic channels,
– the Internet is the main channel for conducting transactions (including payment) and communication,
– delivery of goods or services can but does not have to take place online.

There are other more or less similar definitions of e-commerce to be found in source literature, which results from the need to adjust the concepts to the present trends in globalization and customer wants – the main reason, however, is the ceaseless and rapid development of new technologies. The indicated similarities do not rule out differences and inaccuracies in the definitions of e-commerce, and the many discrepancies result from confusing or combining the concepts of e-commerce and e-business and other terms close in meaning.

In connection with the profile of their operations, channels of communication, sales, and finalisation of transactions, e-commerce companies generate, take in, and use enormous quantities of information. A comparison of information and data flows with the physical flows of products is presented in Figure 2.

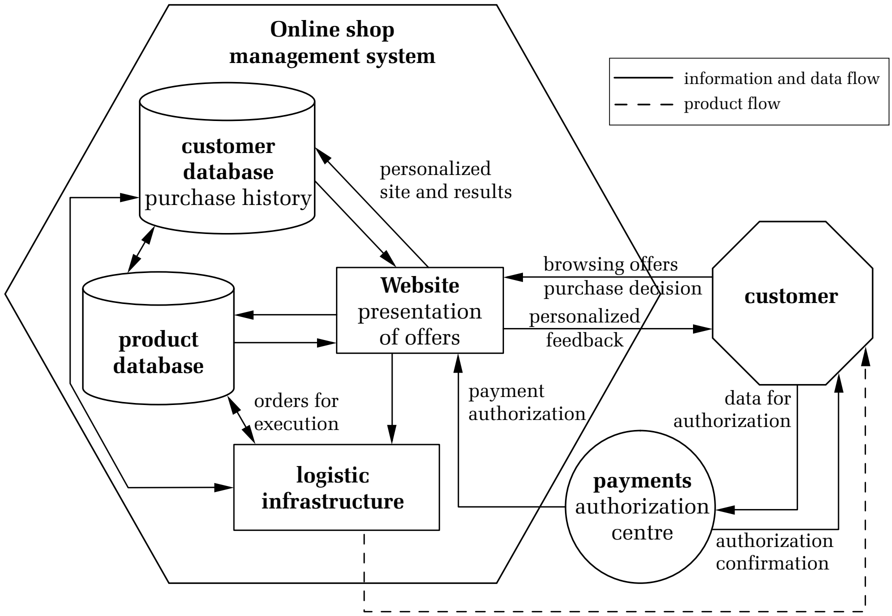

Figure 2. Model of information and product flow in an e-commerce company
Source: (own elaboration)

The above example refers to one of the most popular models of e-commerce, B2C (business to customer). Other models distinguished from the point of view of the mutual relations between transaction parties include (Nemat, 2011, pp. 100–104):
– B2B (business to business),
– B2A (business to administration),
– C2C (customer to customer),
– C2B (customer to business).

Irrespectively of the adopted model or classification of business models, however, they are characterized by a similar proportion of information flow to the physical flow of goods or services.

2. Information society

IT development and globalization significantly influenced and still influence not only the development of e-commerce, but also, first and foremost, the emergence of information society (Kotler et al., 2002, p. 59), whose characteristic feature is how highly it values information. According to B. Gregor and M. Stawiszyński (2002, p. 15), the issues of information are at the centre of society's attention, setting aside consumption, and IT infrastructure is regarded as the factor of the growth of national wealth.

Information society is largely based on knowledge, which, along with land, capital, and labour, is regarded as one of the most important resources, at the same time becoming one of the fundamental factors of production. It has to be remembered, however, that information is the tool that generates knowledge – and, conversely, knowledge is what enables us to generate high-quality information. Information, thus, becomes a carrier and should be considered as a resource and one of the most important factors of production. Undoubtedly, what substantially influenced the development of information society was the access to new technologies, which created unlimited possibilities of communication.

Information society is difficult to define. Source literature provides a large number of definitions. One of the most popular ones views it as a "society that not only possesses developed means of processing and communicating information, but those means constitute the basis for generating national income and the source of livelihood for most members of the society" (Goban-Klas, Sienkiewicz, 1999). For the purpose of this paper, the fundamental principles of information society compiled by Z.E. Zieliński (2008) are of importance, which include the following:

– generating information (mass production of, mass demand for, and mass use of information),
– storing information (technological development provides unlimited possibilities of gathering and storing information),
– processing information (new technologies and unified standards of information description and exchange),
– transmitting information (not restricted by time and space),
– retrieving information (availability of information to everyone interested),
– using information (open and unlimited access to the Internet as the source of information).

The above-listed features not only shape e-commerce, or e-business, but also the whole economy. For many companies, information used by information society can be an element of building strong competitive advantage, not only in e-commerce, but also in traditional sales channels. This testifies to the significance of information for the 21st-century society, and shows how important it is for companies to generate and use high-quality information.

3. Information: Its characteristics and functions

The etymology of the word "information" derives it from the Latin *informatio*, which should be understood as an illustration, explanation, or notification (PWN). Many authors state that it is difficult to provide an unequivocal definition of the word "information," others do not even attempt to do it – they content themselves with its intuitive understanding (Skrzypek, Grela, 2005, p. 16). N. Weiner (1971, p. 152), who is regarded as the father of cybernetics, believes that information is "a name for the content of what is exchanged with the outer world as we adjust to it." Another definition is provided by J. Gościński (1968, p. 19), who argues that "information should be understood as the content – a link, a recommendation, an order, an instruction – transmitted by the sender, which can be any thing or any person, to the receiver, which can also be any thing or any person." W. Falkiewicz (1971, p. 37) perceived information as the factor that increases our knowledge of the surrounding reality. His definition is regarded as the simplest and the most pragmatic one.

Apart from the multitude of definitions, substituting the word "information" with other words close in meaning, such as knowledge or data, is also a source of difficulties and results in blurring the boundaries between these concepts. The interrelations between them are presented in Figure 3.

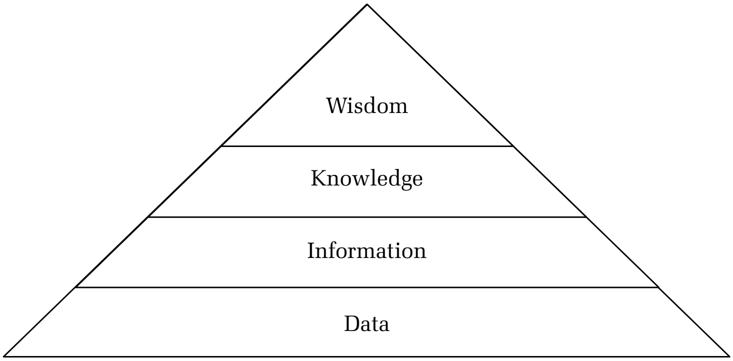

Figure 3. Hierarchy of data, information, knowledge, and wisdom
Source: (own elaboration based on: Heracleous, 1998, p. 155)

Data should be understood as all unstructured single facts about an event or an object. They may be the result of observation, research, raw statistical data, or transcripts of commercial transactions. They can constitute the material for the process of information generation, which, unlike data, is characterized by both sense and purpose. Data can be transformed into information, for instance by being properly processed with regard to their assumed purpose and classification, subjected to mathematical, statistical, or econometric analysis, as well as presented in a graphic form (figures, graphs). During this process a certain value added is generated, which gives information higher priority and underlines its superiority over data. Information, therefore, is processed, interpreted, and contextualized data. It has a subjective character and has to be considered in the context of its receiver, because the same data can be interpreted differently by different people depending on their knowledge.

Knowledge, on the other hand, is processed information. According to the pyramid in Figure 3 and logically speaking it is impossible to derive knowledge directly from data. Data can be transformed into information, and from that, making use of our experience and intuition, we are able to gather knowledge. Unlike data and information, which can be compiled by computer programs, possessing knowledge and wisdom is only characteristic of humans. The development of artificial intelligence and neural networks is more and more advanced, but they are still unable to substitute man in his innovativeness, awareness, and perception.

Wisdom, placed at the top of the pyramid, should be understood mainly as a skilful use of resources (knowledge, information, data) in practice – the ability to make good decisions on the basis of the gathered knowledge.

There is a reason for presenting the interrelations between data, information, knowledge, and wisdom in the form of a pyramid, which is confirmed by P. Drucker (2000), who believes that organizations are rich in data but poor in information. These words attest to the quantity of data in the environment and the company itself. The same goes for knowledge and wisdom. Many people are knowledgeable, but not wise – this feature is ascribed only to a handful of individuals.

However, irrespectively of the chosen definition, several features of information as well as its functions in modern-day economy can be distinguished. The most important features of information include:

– inexhaustibility (including the possibility of being processed without being used up),
– substitutability,
– complementarity,
– objectivism,
– virtuality,
– synergy,
– diversity,
– possibility of endless multiplication and relocation in time and space,
– subjectivity of assessment.

One of the most important features distinguishing information from other goods is the fact it is not being used up in consumption. This means that the same information can be used by multiple agents at the same time without the need to restock. It should be noted, however, that information is subject to the process of aging, as a result of which it becomes outdated.

Another important feature of information – its substitutability – is manifested when different pieces of information allow us to obtain the same benefits. A related characteristic is its complementarity, which means that one piece of information is often useless without another one. Synergy of information, on the other hand, can be observed when the use of multiple pieces of information by one agent is more beneficial than the use of a single piece of information by multiple agents.

Objectivism of information means that it is independent, in terms of quality and quantity, from the observer. It can, however, be assessed differently by different receivers. Virtuality of information means that it is not assigned to only one type of medium. It can be recorded in different ways and on different carriers without changing its characteristics. A closely related feature is the possibility of endless multiplication and relocation of information in time and space, which makes it possible to be sent even between very remote carriers and receivers.

On the basis of the described features and the definition of information we can now list its fundamental functions (Falkowicz, 2002, pp. 18–19):

– informative function,
– decision-making function,
– steering function,

– consumptive function.

The first function should be understood mainly as providing knowledge by processing information. Information is also the fundamental resource supporting the decision-making process, as decision-making units insufficiently supplied with information are unable to make the right choices. It also performs a steering function, as it requires an appropriate response from the receiver. Its consumptive function should be understood as the ability to satisfy the needs of its receiver and user.

Some authors touching upon the issues related with information in their works also indicate other functions of information, such as cognitive, motivational, coordination, or control function (Bolesta-Kukułka, 2003, p. 75).

4. Pathology of information

Rapid development of technology contributes to the ever-increasing speed of information accrual. E-commerce companies generate, process, store, and use information, but the enormous quantity of information in company environment causes problems. Information can be laden with pathologies related to its inadequate quality and quantity. The most common pathologies of information faced by e-commerce companies include:

– information overload,
– information ambiguity,
– information anaemia,
– information distortion,
– information retention,
– blockage of information flow channels.

In e-commerce, information overload occurs when the customer, either internal or, most of all, external, receives much more information than he needs, which can result in, i.a., increasing the costs of information processing, incoherence of information, and the time necessary to find relevant information, or lowering his motivation. It is most frequently observed in product descriptions provided by online shops and auction sites, whose customers often have to spend a lot of time to find information they are looking for. The underlying reason is that many online shops do not have a professional approach to creating product descriptions, which they most often copy from the producer's site and which contain mostly technical details, not relevant from the point of view of the customer.

Information ambiguity occurs when information can be interpreted in various ways by the same person who has no means of establishing which interpretation is correct. There can be various causes of information ambiguity. It has to be remembered that what is clear and understandable to e-sellers may be unclear to their customers, as the former, unlike the latter, have direct contact with the merchandise. The use of abbreviations, numbers without the unit of measurement, or jargon can serve as an example. Ambiguity can be prevented by, i.a., standardizing product descriptions, using a system understandable for the potential customers, and properly describing the used measuring systems.

Another important information pathology encountered in e-commerce is information anaemia – in other words, shortage of information, a situation opposite to information overload. Information anaemia can develop in phases. Its first and mildest form is manifested when relatively ample and high-quality information becomes partially outdated as the time passes. A slight change introduced into the technical specification of the product by the producer that was not accompanied by updating product description can serve as an example. The next stage is characterized by high diversification of information in terms of both quantity and quality – information is dispersed, incomplete, or very outdated. The last and most serious stage is extreme information poverty.

Information distortion is yet another information pathology; it results principally from all the previous aberrances, but can also be caused by the customers of online shops, who provide incorrect data in contact forms, order information, or address information.

Information retention is another very important and quite peculiar kind of information inefficiency faced by e-commerce companies, influenced by both their external and internal environment. It can be the result of, e.g., software or external server malfunction. The main cause of information retention is the fact that online shops allow for 24/7 purchases, but their staff works the same hours as in traditional stores; what is more, even large online shops, which are able to hire 24-hour service, experience information retention that causes many slowdowns and interruptions.

Just like information retention, blockage of information flow channels is characterized by a longer time of information transmission and processing; in this case, however, there is no slowdown of the processes – the problem is that information is not being provided simultaneously with their realization, but later. Such a situation is most often caused by the lack of full integration of human, technical, and organizational factors.

In practice, any combination of the above-described dysfunctions is possible and sometimes treated as a completely new kind of information pathology.

5. Information as a logistical asset

Information can be produced, stored, or sold, just like any other asset – and it should be treated as such. It is, however, a particular kind of asset, which, as mentioned, is not used up during the production process. The production process can be understood as a decision-making process that produces a decision, and information is a direct asset required to carry out this process. Another feature distinguishing information from typical assets is its immateriality. Admittedly, we can give form to information, for instance by storing it in data banks, servers, or data carriers; by default, however, it is immaterial, and what is actually stored are just “zeros” and “ones” – that is, information in binary code.

Treating information as an asset also requires proper logistics. Logistics encompasses all purposeful human activities, both related and unrelated to business. The essence of logistics is steering the processes of asset flow within and between organizations connected by logistic channels and chains (Chaberek, 2002, p. 15). One of such assets is information. Information should be used in a way that is effective and beneficial for the company. It is particularly difficult in today's turbulent economy, which is why logistics, as an area of activities that rationalize fundamental processes, plays an important role in building the competitive advantage of companies (Szmelter, 2013, p. 129). Logistic handling of information translates mainly into creating systems of information flow, storing and processing information, and ensuring the correct implementation of main and support processes. This boils down not only to providing the necessary equipment, but also suitable technical and organizational solutions. The essence of these activities is to achieve the goals of information logistics, that is, to ensure that required information is available in the right time, place, quantity, and quality, and for acceptable price. Another task of information logistics is to prevent the occurrence of pathologies of information.

As already indicated, in the recent years the asset that is information has been gaining in importance for companies. Along with such assets as labour, land, and capital it is becoming one of their strategic resources. This requires them to pay more attention to logistics (including information logistics). The aim of information logistics should be to maximize the use of the available equipment, tools, and technologies in implementing information supply processes. E-commerce companies face an enormous challenge, which is to create an information logistics system comprised of numerous elements, having multiple recipients (not only internal, but also external), and functioning in a dynamically developing economy. A properly designed information logistics system will allow to process data into information with attention to the above-listed goals of logistics, which should give companies advantage in the competition game in the e-commerce market.

6. Role of information logistics in building competitive advantage in e-commerce

Knowing the goals and assumptions of information logistics, we must now understand the need for systematic absorption and processing of new technologies and IT concepts, because this path of information development and flow will allow e-commerce companies to generate increasingly attractive values for their customers, which for many of them in the course of the last few years became the measure of success and a gateway to new business opportunities. New information technologies play an increasingly decisive role in shaping the conditions of storage, shipping, transport, and presentation of merchandise to Internet customers. Analysing the e-commerce market from its very beginning, we might notice the significant influence of IT development on the functioning of e-commerce companies and draw a conclusion that in the 21st century – the information age – there will be only two types of companies in the e-commerce market: those that are going to be prepared for and follow the occurring changes, and those that are going to fail. Rapid development of both IT and IT tools enables to create new possibilities of optimising the IT supply, but just like new technologies in other areas, e.g. transportation, storage, or supply services, they can be effectively used only after a comprehensive design of their implementation. IT development also allowed for the creation of IT systems (including online shopping platforms), whose aim is to facilitate and support the processes connected with conducting e-commerce. Such systems, however, need to be adjusted to the needs of the company, its character, conditions, and, above all, demands of its customers, in order to clarify the IT system as much as possible – which, of course, is related to the above-described principles of treating information as an asset. According to M. Chaberek (1999), it is the very operation of clarifying the IT system from irrational information links and overflow of unnecessary information as well as properly designing the content of information packages and time required to supply all structural elements of an organizational unit with information that should be the subject of information logistics. The systems supporting the functioning of many of today's e-commerce companies could be compared to a sponge that absorbs information irrespectively of its quality and indispensability from the point of view of the company's operations. Thus, they become suffused with unnecessary information, which hinders the communication not only between company units, but also, above all, with the potential customer. A proper way of processing, storing, and distributing information will increase the possibility of a purchase. Chaberek (2001) notes that this means that the role of information logistics is to fully integrate the processes of information flow so as to ensure the best possible adjustment of the quality of information to the requirements of the recipient and to avoid the unnecessary system oversaturation. System oversaturation is most frequently observed in data regarding particular products. Very often online shopping sites quote descriptions copied directly from the producer, without paying attention to whether the information contained there is understandable or relevant from the point of view of the customer. Such an approach results in an overflow of unnecessary information, which can contribute to the emergence of one of the above-described pathologies. Getting to know the customers and adjusting product descriptions to their needs with attention to the aims of information logistics will increase the competitiveness of the company.

Information logistics also becomes a fundamental tool in building competitive advantage in multichannel sales. Many such companies do not see the need to integrate information between the channels. Often particular sales channels within one company compete for customers instead of cooperating. Information stored in particular channels is independent, which frequently causes problems resulting from contradictory and incomplete information. Such a situation does not favour building competitive advantage, which is the goal of the process of making decisions regarding multichannel sales. These problems can be prevented by creating an information logistics system whose main feature would be a shared database for all channels as well as a proper adjustment of information for the customers. Multichannel sales companies, regardless of their assumed strategy, should strive to provide their customers with the same purchasing experience in each of the channels.

Conclusions

Although information plays an important role in e-commerce companies, they frequently underestimate it or are unable to fully grasp its meaning. This paper has demonstrated the significance of information as an asset and, consequently, the need for a properly organised information logistics system in e-commerce companies. Information is the carrier of knowledge, which a seller very often wishes to pass on to the potential customer, but it also facilitates communication between the units of an enterprise. Properly designed and functional information logistics should translate into a lasting competitive advantage. In every company, pathologies of information occur at particular stages of the processes; implementing adequate logistics processes will help to prevent them and, by the same token, to strengthen the company's competitive advantage. The e-commerce market requires companies to find themselves in the labyrinth of information and to be able to extract from it only what is indispensable for the implementation of their processes, including decision-making processes. Meeting these requirements will not be possible without an understanding of information logistics.

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E-LOGISTICS AS A SOURCE OF MODERN TOOLS AFFECTING THE COMPETITIVENESS OF ENTERPRISES

Abstract

Nowadays, the competitive position of enterprises depends not only on prices, but also on factors such as quality, customer service, and execution time, which can be improved by implementing modern solutions into the logistics processes. This paper presents the influence of e-logistics on competitiveness. It also describes several e-logistics technologies and points out the benefits of using such technologies as wearables, 3D vision, or Pick-by-Voice and Pick-by-Light systems.

Keywords: logistics, e-logistics, competitiveness

Introduction

Logistics operations constitute an inseparable part of the effective functioning of enterprises. The main task of logistics is to ensure the availability of all resources necessary to carry out the primary process of production (the main activity of an enterprise). The evolution of logistics processes observed in recent years indicates a growing demand for the creation of integration and strategic processes. In order to maintain a stable position in the market, enterprises have to make a constant effort to gain competitive advantage over others in the market. A proper understanding of logistics operations allows to secure such a position. Conducting rational economic activity and using up-to-date logistics tools facilitate gaining competitive advantage (Godzisz, Ścibisz, 2013). The complex relations occurring within supply chains render the functions of logistics relevant enough for it to become a source of innovative solutions used in enterprises (Chaberek, 2014). The aim of this review paper is to present e-logistics solutions which can improve the competitive position of enterprises based on such sources as books, journals, and Internet sites dedicated to this topic.

1. E-logistics and competitiveness

Logistics operations have an undeniable influence on the functioning of the economy and the entities that comprise it. Logistics is defined as a field of knowledge that studies the product and information flows within the economy and its sectors (Skowronek, Sarjusz-Wolski, 2011). Its attention is focused on resources and on delivering them to the right place at the right time in the right quantity, etc., in accordance with the 6R principle (Chaberek, 2011). A list of a number of areas of logistics operations could be devised, but the most important thing is to perceive them as a coordinated whole. The systemic understanding of logistics offers a division into logistic subsystems (Wieczerzycki, 2012):

– distribution logistics,
– production logistics,
– supply logistics.

Such a wide range of logistics operations comes with numerous difficulties related to the coordination of primary and support processes. Enterprise management is practically impossible without using modern information technologies. The bigger the company, the more difficult it is to implement new technologies. Small and medium-sized enterprises often do not go beyond automating primary logistics processes. The implementation of transaction systems aimed at supporting shipping and warehousing operations can be an example. It is, however, only the first step in using information technologies. Primary processes can be properly and comprehensively supported by integrating support systems with particular production activities (Wieczerzycki, Wieliński, 2003). The implementation of integrated logistics systems, such as Enterprise Resource Planning (ERP), can be an example. Moreover, the dynamic development of IT brought about new solutions, e.g. augmented reality, wearable technologies, or Pick-by-Voice and Pick-by-Light systems.

E-logistics is strictly related to e-business, which can be defined as the use of ICT in business processes management (Wieczerzycki, 2012). The implementation of information technologies is mainly limited to digital products, which can be divided into (Cellary, 2008):

– documents,
– copyrighted works,
– money,
– digital "gadgets,"
– software.

In this context, documents can be described as digitally available (sometimes for a fee) information about various events, such as journals published in a digital form; copyrighted works – as digital products protected by copyright laws, such as art or literary pieces, scientific works, patented ideas and solutions; money – as a digital variety of information about financial resources stored on computers, such as exclusively digital bonds, investment fund units, or shares; digital "gadgets" – as an authorial product offered by a number of companies in the market (from the possibility of sending text messages or using an unusual payment method to modern devices or services offered by specialized providers); and software – as a combination of zeroes and ones (bits) that supports the functionality of a particular device, thus serving as a foundation for e-logistics solutions (Wieczerzycki, 2008). Most of the products aimed at supporting logistics processes are special software programs and "gadgets." The essence of e-logistics consists in using ICT solutions for supporting logistics processes. We can easily list the areas of logistics that can be thus improved (Wieczerzycki, 2008):

– control over order placement and execution,
– transport of resources,
– control over supply,
– storage and tipping,
– distribution of goods.

Better functioning of even one of these areas will contribute to the improved competitiveness of the company, but the more modern solutions are implemented, the more benefits can be achieved.

Logistics is responsible for the effectiveness of primary processes. Each customer expects that the product he generates demand for will be delivered in the right place at the right time in the right quality. To meet the growing needs of customers, enterprises have to make use of all possible technological solutions. In order to determine the influence of e-logistics on the competitive position of an enterprise, we should specify measurable objectives that they endeavour to achieve. In an attempt to do so, we can first distinguish the possible methods of gaining competitive advantage (Harrison, Hoek, 2010):

– "hard" methods,
– "soft" methods,
– auxiliary abilities.

Soft methods concern the product service system, which contributes to building customer trust. Hard methods are applicable to specific cost, time, and quality objectives. Auxiliary abilities relate to dealing with uncertainty (Harrison, Hoek, 2010).

Hard methods owe their name to their clearly determined benefits. Although cost advantages have less and less bearing on competitiveness, their influence is still noticeable. In the case of a specific group of products, their price can be precisely the factor that will encourage the customer to make a purchase. Another aspect related to hard methods is time. It is strictly connected with logistics customer service and, in this case, defined as the period between the placement of an order and the delivery of the finished product. The faster a company is able to deliver the product; the more customers will use its services. The last aspect relevant for hard methods is quality, which has the most significance for the customer. A product that does not break down (proper logistics handling of the primary process) or get excessively worn out will be the obvious choice.

The effects of soft methods, on the other hand, are not measurable. The customer will feel safe if the company respects the confidentiality of the information he provided in order to make a purchase and if the communication procedure is carried out in an effective and honest manner. Customer trust also depends on the quality of the delivered product.

Auxiliary abilities mainly help to deal with unexpected situations. The set time, price, and quality standards refer to standardized orders. Problems with reliability can arise when non-standard orders are being placed. For this reason, it is important to establish certain levels of reliability, as is the case in Vision Express. This company offers to assemble prescription glasses within an hour, at the same time stating that 95% of their customers will receive their orders in time. Although individualized products require a different approach, production companies should be able to guarantee a definite execution time as the measure of their reliability, keeping in mind the possibility of unexpected situations. A company has to be reliable, but also flexible in its reliability (Harrison, Hoek, 2010).

In many cases, e-logistics operations can affect not only the measurable factors, such as time and costs, but also the less measurable ones, such as quality, as well as auxiliary abilities and soft methods. A company can use less or more e-logistic solutions. Because the final result is the cumulative effect of the improved functioning of particular areas, e-logistics solutions give a chance to gain significant competitive advantage.

2. Examples of using e-logistics in practice

Today's market is brimming with modern devices and solutions. Wearable devices become one of the most popular of them. Smartwatches and smartbands, endowed with the same functions as modern mobile phones, are the simplest example. However, their use can be much broader, if they are applied to improve logistics operations. Their main task is to facilitate communication between company units, and thus their productivity. Companies use devices such as smartglasses, smartwatches, smartrings, and smart armbands (Oracle, 2015). Their most important feature is that they are always turned on and the employees always have them on them. Using such technologies allows to increase productivity and security. They are most often used for warehousing operations. They enable direct transfer of information between warehouse employees and office employees, facilitate the location of goods and resources and the identification of dispatched and received products, and optimize the use of storage space. It is also worth noting that they make it easier for the workers to perform their tasks, as they leave their hands free. Appropriate devices also find application in production processes, e.g. to develop production plans and service activities. They provide more information in a shorter time, thus reducing the risk of human error (Oracle, 2015). In this form, the use of such devices allows to reduce production time and production costs and maintain a desired quality of the final product. For this reason, they can be classified as e-logistics solutions – hard methods affecting company competitiveness.

Another example of a technologically advanced solution is the so-called augmented reality (AR). It is, in a way, connected with wearable devices, especially smartgasses. Augmented reality allows to observe the world and, at the same time, obtain additional information about it. It is defined as a real-time view of the real world augmented by additional information generated by special computer devices, e.g. smartglasses (Carmigniani, Furht, 2011). AR can be achieved in four steps. The first step is to capture the live image which is to be augmented by information using appropriate devices. The second step is to identify the captured location by using landmarks or GPS coordinates. The third step is to process these data and find matching "augmented" information using the Internet or any database. The fourth step is to visualize the location using the information gathered in the third step (Glockner et al., 2014). Although AR is only at the first stages of implementation into logistics, it guarantees significant benefits. Most of all, it ensures that required information will be delivered in the right place at the right time and in the right quality, which is necessary for the effective planning of particular processes and supporting operations related to the optimization of loadings, and thus translates into high-quality customer service. AR can also be used to train new employees and plan the placement of goods in a warehouse (Glockner et al., 2014). It also finds application in transport optimization (improving completeness verification procedures, international commerce, driver navigation systems, loading of goods) and storage operations (improving order picking processes). Accuracy in order picking saves time and reduces the risk of damage in transport. Supporting international commerce facilitates information exchange between global service providers, real-time language interpretation, and automatic identification of goods. Navigation systems allow drivers to move faster and more efficiently, make punctual deliveries, and reduce the number of accidents (and thus company losses). AR would also make it possible for the person responsible for the loading of goods to be provided with information about the right placement of palettes on an ongoing basis, which would make loading and unloading processes faster (Glockner et al., 2014). There is more than one method of using augmented reality to gain competitive advantage. Implementing the AR technology in even one of the described areas results in shortened production time and reduced production costs. It therefore contributes to the image of a company as an effective entity in the market and can prevent non-standard situations from occurring.

Another example of a modern technology used in logistics is 3D technology, often used in tandem with and complementary to AR devices, especially smartglasses. It undoubtedly makes it easier to view the particular elements or a given product and its assembly method. Just like AR, 3D technology also facilitates storage processes by generating a three-dimensional plan of the storage facility; the possibility of viewing the object in 3D will make each paper blueprint more legible and understandable. It will also make it possible to reorganize and thus speed up the processes of producing complex goods (Thamer et al., 2014). The use of 3D technology is not, however, limited to 3D visualizations of storage facilities and products or device diagrams – it is also used in printing, allowing to reduce the costs of producing all the necessary components and to produce certain products in much shorter time than using today's technologies (Logistyka.net.pl, 2015). 3D technology is one of the most innovative solutions and thus it is still, in many aspects, underdeveloped. However, the described examples suggest that it is only a question of time before it becomes widely used. The first companies to exploit its possibilities will have the chance to gain advantage over their competitors by reducing production time and production costs, and even increasing the final quality of the product.

The next solution is less futuristic. It is constantly being improved, and yet is still underrated, which is why it can be a major tool in gaining competitive advantage. It is the Pick-by-Light system and its variation, Pick-by-Voice. These systems are used mainly in warehouses. Using light or audio signals, they provide information about the location from which a product needs to be picked up and where it needs to be delivered, serving as guides for warehouse employees (Dematic). An appropriate database, such as is used by the Pick-by-Light system, allows to transfer information between employees. An additional advantage of the Pick-by-Voice system is the possibility of voice communication with employees ensured by special headphones usually connected with a microphone (Sobczak, 2014). Using such systems in practice brings numerous benefits, among which we can list: reduction of the number of employee errors, additional savings, increased quality of customer service, faster realization of the order picking process, improved storage system, and increased productivity. Pick-by-Voice and Pick-by-Light are another systems that guarantee better functioning of logistics operations. Improvements can be made upon all factors subject to the influence of both hard and soft methods (reduction of execution time or improved customer service), thus strengthening the competitive position of an enterprise.

Conclusions

The solutions described in the paper are selected examples of modern technologies whose use in logistics support allows to optimize primary processes. They are innovative both in terms of their use and implementation and have a specific purpose based on the described "hard" and "soft" methods. The listed technologies are advanced enough that they improve more than one factor. Using any one of them results in reduction of execution time and production costs, higher quality of human and machine labour, increased security, and, most of all, higher quality of customer service – which are the factors most relevant for the competitive position of enterprises. It should be noted, however, that the discussed solutions are subject to constant improvements and thus their use is very costly. Using such technologies requires following certain rules – otherwise it may lead to results directly opposite to those intended. They are mainly implemented and used by large companies and their availability to others, especially small ones, is limited.

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