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Artur Świerczek

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USING TRIPLE-LOOP LEARNING TO IDENTIFY ADAPTIVE BEHAVIOUR OF RESILIENT SUPPLY CHAIN

Abstract

The contemporary environment of supply chains is characterized by discontinuity, being the source of unpredictable changes producing effects that are difficult to determine. Underestimating and not including the discontinuity in the managerial concept makes the supply chain homomorphic with respect to reality, thus, it is reflected only approximately (Jędralska, 1992). In other words, the situation of discontinuity is caused by the unreliability of the current management model. The answer to the discontinuity may be the formation of resilient supply chains that are aimed at developing specific patterns of adaptive behaviour. The aim of the article is to recognize the adaptive behaviours of a resilient supply chain in light of the assumptions of triple-loop learning in an organization. In the first part of the paper, the issue of a resilient supply chain is discussed, highlighting its adaptive capability. Next, the mechanism of preadaptation – adaptation of the supply chain based on triple-loop learning is explained. The final part of the paper presents the basic components of a resilient supply chain determining the adaptive behaviour consistent with triple-loop learning.

Keywords: learning, supply chain, preadaptation, resilience

Introduction

The concept of a resilient supply chain had covered a long path of development before it was possible to consider its essence in a theoretical approach and implement the assumptions in the practice of business. Many different definitions of the category of a resilient supply chain can be found in the literature, most of which

emphasizes the dynamic nature of the organization's functioning[1]. A key issue indeed is maintenance and development of the adaptive capabilities of a resilient supply chain that enable functioning when faced by a discontinuity (Juttner, Maklan, 2011). In the opinion of Sutcliffe and Vogus (2003), the resilient supply chain has the capability of 'rebounding' when disturbances or other problems have occurred. According to Wildavski (1988), a resilient supply chain has a dynamic capability of organizational adaptation that enables growth and development over time. In the opinion of Christopher and Peck (2004) resilience in the context of a supply chain defines the ability to return to the original state or to move into another that is more desirable after the occurrence of a specific disruption. This is in line with the etymological understanding of the resilience category, which dates back to the Latin language and means 'bounce', 'rebound' (Ponis, 2012). Hence, it means the ability to absorb disturbances and maintain the basic functions and structures of the system (Walker, Salt, 2006). Therefore, resilience can mean the system's ability to return to the state from before the disturbance (Petchey, Gaston, 2009). Pettit et al. (2010) emphasize nonetheless that from the point of view of a resilient supply chain, it is not the return to the original state that is important, but the ability to learn and to move the system to a new state. In light of the foregoing, Peterson et al. (1998) note that resilience combines two opposing aspects – one focused on maintaining the efficiency of the function performed, the other relating to the existence of a specific function. The former approach is consistent with the engineering resilience and means ensuring the equilibrium and flexibility. The latter perspective, on the other hand, refers to ecological resilience and emphasizes the importance of a state far from equilibrium, which provides the system with the ability to absorb disturbances and maintains its basic functionality (Holling, 1996). The concept of resilience in relation to the social system refers to adaptation, organizational learning and self-organization that enable the overall ability of the system to face disruptions (Folke, 2006). A resilient supply chain is of a dynamic nature, namely, it has great capabilities of adaptability to the environment (Ponomarov, Holcom, 2009). Specific links in the supply chain change under the influence of relations with other participants of the system (Brodbeck, 2002).

1. Preadaptation – adaptation of a supply chain based on triple-loop learning

The adaptive behaviour consistent with the triple-loop learning principles can be called preadaptation (Ameli, Kayes, 2011). Preadaptation is considered as the most advanced learning process that can be referred to as process learning (Buechel, Probst, n.d.). It reaches out to the deepest layers of the organization's diversity potential (Flood, Romm, 1996) that can be the source of its creativity. In other words, preadaptation can occur when managers are able to identify and use the organization's diversity potential (Hamel, Breen, 2008). Supply chains include diverse

[1] An extensive review of the literature on the concept of the resilient supply chain is presented in: Ponomarov and Holcom (2009); Hohenstein et al. (2015); Mandal (2014); Pereira, Christopher and Lago Da Silva (2014).

entities, specialists focused on their key competences (suppliers, manufacturers, distributors, logistics operators, providers of nonlogistic services) and functionally diverse areas of interrelation (logistics, marketing, production, research and development, finance, administration, etc.), which are the source of organizational creativity and enable the chain preadaptation. Hence, the mentioned differentiation means simplification and selection, namely, perceiving and responding only to specific aspects of the environment that may have a potential impact on the organization's survival and development. Focusing the effort on a selective activity, the organization preserves freedom and autonomy, but at the same time creates uncertainty resulting from omission of important elements in the process of selection and the lack of response to these elements (Steinmann, Schreyogg, 2001). In other words, the triple-loop learning is manifested in the form of collective awareness (Stacey, 2011). This means that the assimilated or acquired learning enables the creation of new structures and strategies. In the opinion of Batesson (Rokita, 2015) triple-loop learning means learning to learn. Previous learning is reflected in triple-loop learning, hence, the organization learns to improve its learning. In this way values as well as strategies and expectations can be modified (Argyris, Schön, 2006). In the process of learning, the supply chain is able to transform as its internal relationships are visible and obvious. Patterns of the organization's links with the environment are also recognizable. A deeper understanding of these patterns and possible consequences of the actions taken leads to changes in the structure. Learning according to the third loop is of a direct nature that allows identifying the role and importance of the organization (Morgan, 1996). From the point of view of the triple loop, the development of the organization's capability of learning is a prerequisite for survival and development in the face of the increasing complexity and dynamics of the environment (Georges, Romme, Witteloostuijn, 1999). Figure 1 shows the ideogram of preadaptation, the adaptive behaviour of a supply chain according to the assumptions of triple-loop learning.

Preadaptation includes corrective actions with a different degree of advancement from the point of view of the organization's mental model. On the one hand, they can be relatively shallow and involve a simple or relatively advanced modification of the existing activities and reach goals/values, and even structures and processes. Modification of the existing activities does not require using unique mental models to solve a specific decision problem. Its essence is the routine, cyclical nature of changes to which the supply chain can successfully respond in a manner analogous to the past. Therefore, recognizing a deviation and its simple correction enables the organization to continue the current policy or achieve previously planned goals. A more advanced pattern of corrective actions concerns the needs, motives, interests and values rooted in the organization. In this case, the necessary changes in the organization may require revision of the existing goals and tasks (Rokita, 2015). This is most of all the case when specific consequences of the action taken lead to questioning the current mental model of the organization, i.e. the standards and assumptions underlying the model. This means that complex learning forces not only a correction of activities, but above all a modification of the model on the basis of which these activities are conducted.

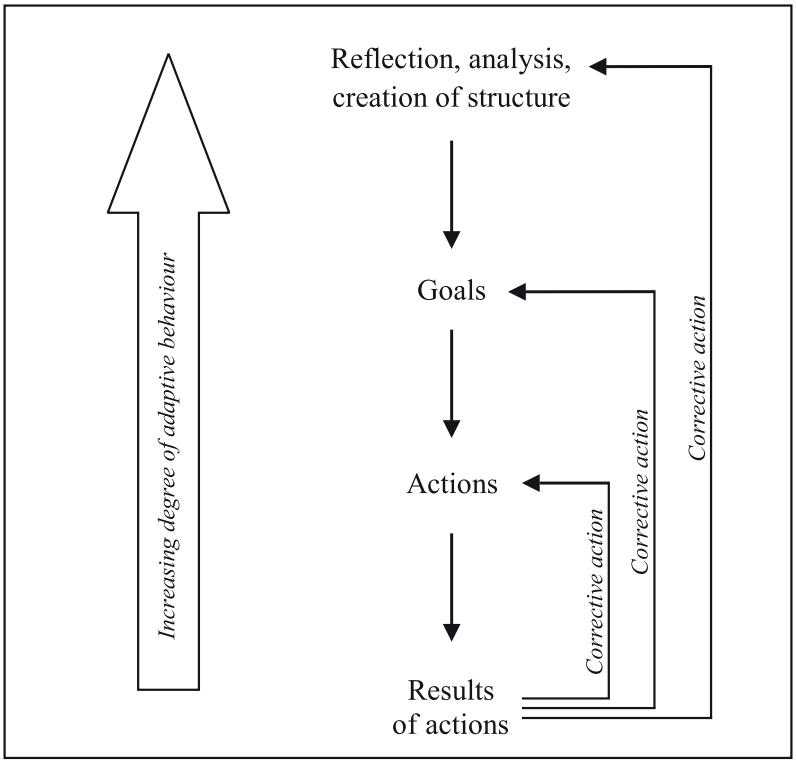

Figure 1. Adaptation of the supply chain according to triple-loop learning
Source: (own elaboration based on: Rokita, 2005)

The most advanced adaptation, constituting the quintessence of preadaptation goes much deeper into the mental model of the organization[2]. It modifies structures and processes, leading to a complete change of the existing pattern of behaviour. However, to achieve the expected state, at first the system should fall into chaos, to be reborn to a new state, more adequate to the environment. The ability of the supply chain to move from one state to the next one requires identification of change impulses, their analysis, selection and reactive response. Preadaptation emphasizes the necessity of the system to move from the state of equilibrium to the state of disequilibrium – Figure 2.

According to Figure 2, the system remains in the state of equilibrium 1 until moment t_1, then it moves to the state of disequilibrium. In this way, the system is heading in the direction of disequilibrium, attracted by infinity to an unstable or completely random pattern of behaviour. Heading towards disequilibrium is realized by a reinforcing (amplifying) – feedback. This type exponentially amplifies initially small disturbances without any internal limitations of the system, pushing the system towards the edge-of-chaos. It offers a diversity whereby the system is moving towards a creative, innovative and sometimes surprising state (Stacey,

[2] According to the idea of encapsulation, less advanced adaptive behaviours of the supply chain are included in more advanced patterns. More on this topic in: Świerczek (2017, pp. 46–71).

1996). As a result, the system is able to achieve a new, completely different state (at moment t_2) which will allow a much better adaptation of the supply chain to the ambient conditions. Using the opinion of Thietart and Forgues (1995), it can be said that it is chaos (the edge-of-chaos) that is a distinctive state for the supply chain preadaptation.

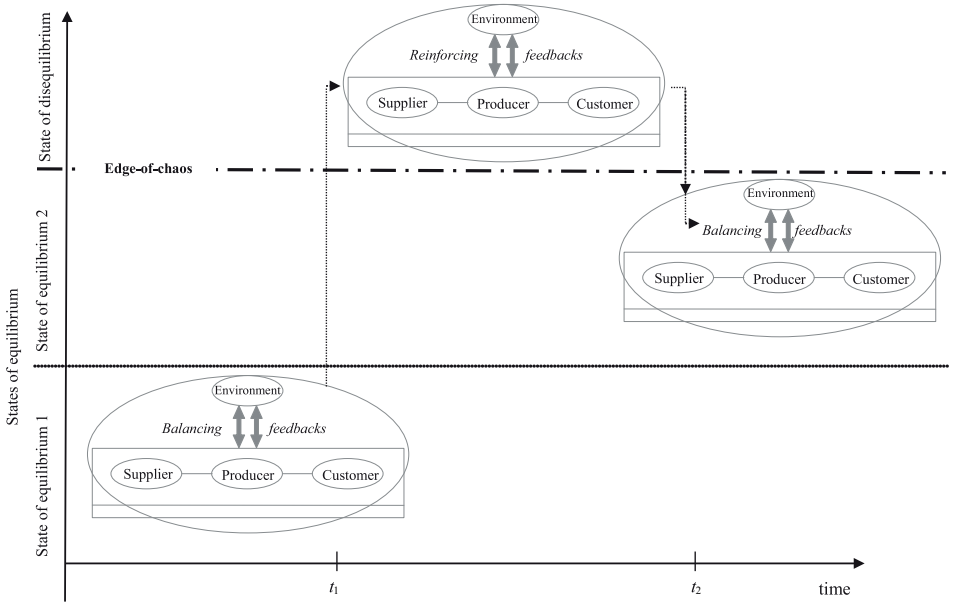

Figure 2. Adaptive behaviour of the supply chain according to triple-loop learning – conceptual scheme
Source: (own elaboration)

2. Resilient supply chain components determining adaptive behaviour consistent with triple-loop learning

The functioning mechanism of a resilient supply chain based on the third loop of learning enables the continuity of operation in an uncertain environment, and thus the ability to adapt and perform specific functions in an environment full of challenges and tensions (Ponomarov, Holcom, 2009). The main components determining the mechanism of functioning of a resilient supply chain include agents forming a specific supply chain, the edge-of-chaos and the ability to identify dissipative structures as a result of emergence. The conceptualization of a resilient supply chain by the basic components determining preadaptation is shown in Figure 3. The interrelationships between the resilient supply chain and its functioning environment are manifested by the occurrence of feedback loops (both balancing and reinforcing) and the reciprocity of influence referred to as coevolution.

A resilient supply chain comprises many enterprises that can be described as agents. Agents influence the course of events in the supply chain as they decide on the inclusion of a specific link in the implementation of specific tasks, strive for expansion into new markets, implement integrated processes of product development with suppliers and customers (Choi, Dooley, 2001). Following inter-organizational negotiations and creation of integrated decision centres in the supply chain, enterprises share common patterns that allow reducing transaction costs and increasing the communication efficiency. Agents in the supply chain have their own specific objective, which may be striving to secure a privileged position in the supply chain, increase the bargaining power of certain enterprises, identify reliable sources of material supply, develop a niche market, a stable market, etc. In addition to particular objectives in the resilient supply chain, a common goal is also formulated, achieved by matching the operating parameters to other participants in the supply chain. Owing to this, the supply chain operation can be regulated using the so-called 'invisible hand' that generates order and spontaneity at a given time. Therefore, enterprises should constantly observe structures selected within the supply chain and adjust their specific goals to the group of companies constituting a specific supply chain.

The key to the efficient functioning of agents in the resilient supply chain is adjustment and flexibility as well as the will to make deeper corrections and redefine the existing patterns of functioning facing the changes revealed in the environment (Choi, Dooley, 2001). Therefore, agents interact with each other in dynamic interactions, and their behavioural patterns take into account changes occurring in the environment, hence, mutual interactions allow generating behavioural patterns at the level of the whole supply chain (Stacey, 1994). Lewin and Regine (Stacey, 1994) include agents in one of the two groups: supporting and participating agents who contribute to the development of the system, and selfish and calculating agents who show reluctance to participate in the smooth functioning of the system. It should be noted that agents are specific entities of the resilient supply chain that are different from other links. They are characterized by autonomy (their actions are initiated within the system, without any external influence), flexibility (enabling proactive behaviour) and their own control mechanisms (Nilsson, Darley, 2006). In addition, agents in a resilient supply chain are heterogeneous, they have their own goals which they strive to attain under specific constraints and with different patterns of behaviour. The heterogeneous nature of agents contributes to the establishment of relations between them, if the agents had the same knowledge and characteristics (and thus they were homogenous), then they would not have the motivation to cooperate (Wycisk, McKelvey, Hulsmann, 2008). The behaviour of a particular agent changes dynamically as it remains in close interdependence with other agents. The behaviour of agents is determined by specific internal policies, and the behaviour of other agents which affects the non-linear nature of these interdependencies (Nilsson, Darley, 2006).

The result of collective behaviour of agents is a specific pattern of behaviour that agents would not achieve by acting individually. This is the reason why the behaviour of the resilient supply chain remains unpredictable and different than expected. As a result, the system can take advantage of emerging new opportunities

(Bonabeau, 2002). Although the final shape of the supply chain may be unknown, individual enterprises participate in its creation by means of decisions taken locally. In the case of a resilient supply chain, the leading link generally selects enterprises with which it initiates and implements multi-entity activities. While this affects direct partners (suppliers and/or customers) and sometimes second-order indirect partners, it is generally not possible to select companies located further down the flow of products in the supply chain (e.g. third- and fourth-order links). As a result, these links remain outside the regulatory influence of the company leading in the supply chain, ensuring autonomy, which in turn enables self-organization of the system.

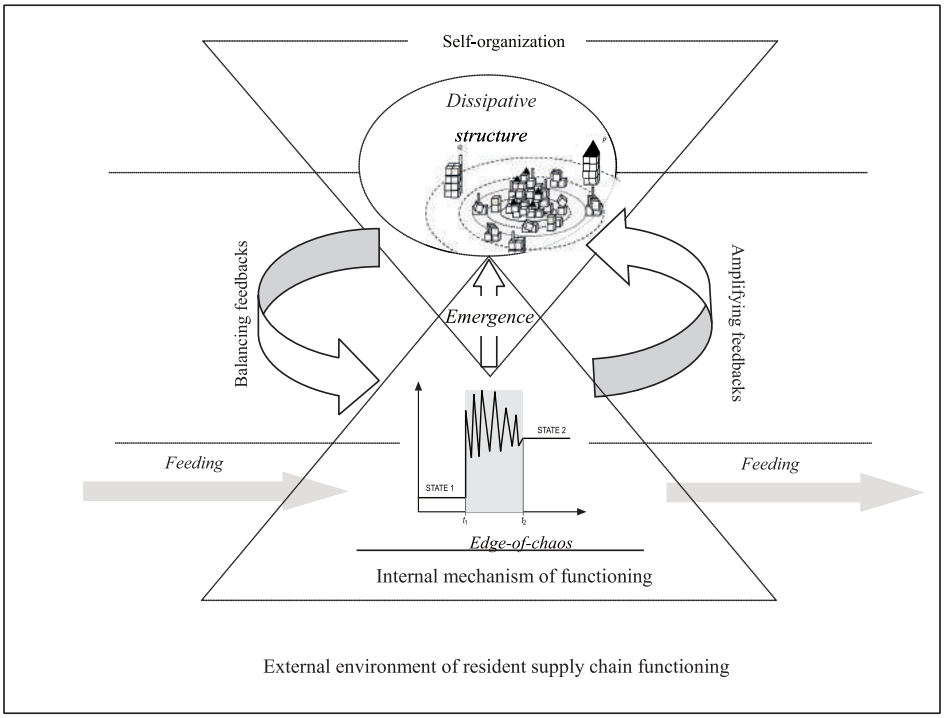

Figure 3. Basic components of resilient supply chain
Source: (own elaboration)

Self-organization occurs when the system remains in a state far from equilibrium, in other words, in which it reaches a critical point. This point enables generating a new different quality structure or behaviour pattern that cannot be predicted based on the previous state of the system. The newly created structure is referred to as a dissipative structure, since it derives material and information supplies to maintain the new state in which the system is located (Stacey, 1994). Imported resources from the environment are dispersed in the system, so that they push it towards disintegration. Nevertheless, the structure of the resilient supply chain has the ability to renew, as it is fed by resources from the environment (Stacey, 1994). In practice, there should be a minimum degree of coherence (links) between

actors in the supply chain, otherwise the system would be doomed to failure (Choi, Dooley, Rungtusanatham, 2001). The new pattern of the system's behaviour, created as a result of self-organization cannot be explained through the prism of the characteristics of the links forming a specific system and the relationship between these links. This means that the newly created structure is emergent (Stacey, 1994), probabilistic, and not deterministic. In other words, the resilient supply chain structure depends on local decisions of its links and on the way in which the choices made are combined to identify an organization of a probabilistic nature (Choi, Dooley, Rungtusanatham, 2001). Therefore, emergency means a process by which patterns or global structures emerge under the impact of local interactions (Bergmann, Lichtenstein, 2000). This refers to the tension between the striving for control and the emergence in the resilient supply chain. Insofar a specific link (e.g. manufacturer) can control the actions of direct partners (suppliers and customers), then it can extend its control over them. Nonetheless, directly related enterprises also have their partners, with whom they can shape inter-organizational relations on a voluntary basis. In this way, emergence appears, which means the decreasing impact of the leading link in the supply chain on other enterprises, in particular those that are not directly related to it (Choi, Wu, 2009). Paraphrasing Letiche's observations (2000), it can be concluded that emergent properties appear when the system surpasses the components of which it is built as a result of self-organization. Notwithstanding the fact that an accurate prediction of future behaviour of the system is difficult, nonetheless certain archetypes of such behaviour can be often found. The unpredictability of future behaviour patterns of the system corresponds to its incredible sensitivity. The smallest level of uncertainty can escalate. For example, a distortion caused by a small change in the functioning of the consumer market can be amplified and oscillate in the form of 'wild' totally uncontrolled fluctuations transferred onto other actors in the supply chain.

A major change in the existing functional pattern of the resilient supply chain may occur when the system influences its organizational boundaries by including or excluding specific agents from the supply chain structure, as well as by establishing or eliminating specific inter-organizational relations (Choi, Dooley, Rungtusanatham, 2001). Nevertheless, self-organization in the resilient supply chain does not appear in a linear and sequential manner. It occurs rather parallel, hence, it cannot be described by way of linear cause and effect relationships, which give similar effects in the short and long term. On the contrary, according to the systematics of analytical models proposed by Rokita (2011), a resilient supply chain can be presented by means of a non-linear model in which the cause and effect are separated from each other in time and space (Senge, 1990). A similar opinion is formulated by Wieck et al. (2008) who believe that resilience enables creation of a theoretical basis explaining the irregular behaviour of an organization in the conditions of increasing complexity and dynamics. Hence, the resilient supply chain includes network-related links, whereby causal relationships manifest a non-linear nature (Choi, Dooley, Rungtusanatham, 2001). Non-linear dependencies can be observed not only inside the supply chain, but also when analyzing the interaction between the supply chain and its surroundings. They manifest themselves in the form of balancing (stabilizing) and reinforcing feedback loops. Hence, the behaviour pattern

of the resilient supply chain is subject to change as a result of the reciprocal impact of feedbacks, pushing the system to the edge of chaos or towards the equilibrium.

Conclusions

The presented considerations are aimed at recognizing the adaptive behaviours of a resilient supply chain in light of the assumptions of triple-loop learning in an organization. The triple learning loop explains the preadaptive capability of a resilient supply chain owing to which the organization acquires the ability to cope with the discontinuity of the environment. The basic components of a resilient supply chain determining the adaptive behaviour based on triple-loop learning that should be mentioned include: agents forming a specific supply chain, the edge-of-chaos and the ability to identify dissipative structures. They create the dynamics of changes in the supply chain being a basic determinant of resilience. The economic practice provides examples of resilient supply chains which have been able to survive and develop due to specific components determining the adaptive behaviour based on triple-loop learning. The supply chain of Toyota which restored its operational capacity within a period of a few days after a fire at one of their major suppliers (Aisin Seiki), thus avoiding several months of paralysis of operation of more than a hundred of dependent links may serve as an example (Nishiguchi, Baaudet, 1998). In the case of Toyota's supply chain, enterprises operating similarly to agents had the capability of balancing on the edge of chaos and unveiling dissipative structures, which made the supply chain capable of surviving and developing in the face of a discontinuity in the environment.

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THE CONCEPT OF KEY SUCCESS FACTORS IN LOGISTICS AND SUPPLY CHAIN MANAGEMENT IN THE CONTEXT OF CREATING BUSINESS COMPETITIVE ADVANTAGE

Abstract

Firms are constantly looking for ways to create a competitive advantage. An important place among the factors affecting the way in which this advantage is gained is taken by success factors including, but not limited to, the so-called key success factors that may be related to the domains of logistics and supply chain management. The aim of the article is to identify the basic characteristics of the concept of key success factors in logistics and supply chain management. The article presents the essence and importance of success factors in the context of creating the business competitive advantage, the basic concepts of key success factors related to resource-based and market-based strategic management as well as the most significant characteristics of the concept of key success factors in logistics and supply chain management.

Keywords: logistics, supply chain management, key success factors, competitive advantage

Introduction

Firms are constantly looking for ways to create, maintain and strengthen their competitive advantage. In general terms, the competitive advantage means that the firm achieves market and economic outcomes more favourable than competitors, or that the firm takes a more competitive position on the market compared to its competitors (Matwiejczuk, 2014). One of the concepts often used in creating the business competitive advantage is logistics, perceived as the management

of materials, goods and information flow within the firm and the entire supply chain[1].

The business competitive advantage is related to the broadly understood business success which can be influenced by various factors, referred to as success factors. A set of various success factors creates the so-called business success potentials that can be associated with various functional areas of the firm, including, but not limited to logistics. Such potentials are then referred to as logistics potentials of success (Matwiejczuk, 2015).

The aim of the article is to identify the basic characteristics of the concept of key success factors in logistics and supply chain management. The key business success factors, enabling the firm to achieve the expected market and economic outcomes and, consequently, create a lasting long-term competitive advantage can be indicated both in the domain of logistics and in the supply chain management.

1. The nature and significance of business success factors

There are several factors affecting business success in the broad sense of the word. The basic problem associated with the concept of success consists in the fact that it is a quite commonly used concept, but at the same time difficult to be precisely defined. For this reason, the success factors play a special role in the description of business success, i.e. factors contributing to its achievement by the firm. The integrated composition (bunch) of success factors creates the so-called success potentials, sometimes referred to as the business potentials or strategic potentials.

A leading role in the efforts to identify business success potentials (factors) is played by the so-called resource-based strategic management (Barney, 1991; Grant 1991). According to Krupski (2006), the business potential is created by resources and competences that are the main components of the business competitive advantage. On the other hand, in the opinion of Gierszewska and Romanowska (2002) according to the resource-based concept, the business success is determined by the business strategic potential in the form of appropriately selected and competitive resources and the firm's capability of using these resources in an innovative and effective manner.

The strategic potential understood in this way is the basis for achieving the expected market and economic outcomes being the manifestations (symptoms) of business success.

2. Scope and directions of the impact of success factors on creating business competitive advantage

Various proposals of relations expressing the scope and directions of the impact of specific success factors on creating the business competitive advantage are

[1] For more on logistics as a concept of management of materials, goods and informationflow, see Blaik (2017).

presented in the literature on the subject. Examples of such relations are presented in Table 1.

Table 1. Relations between success factors and business competitive advantage

Author/Authors (year)	Concepts of relations concerning the impact of success factors on creating the competitive advantage
Grant (1991)	Resources ⇨ Capabilities ⇨ Competitive advantage ⇨ Strategy ⇨ Resources
Barney (1991)	Diversity and limited mobility of business resources ⇨ Value, rareness, imperfect imitability and substitutability of resources ⇨ Sustainable competitive advantage
Bharadwaj, Varadarajan, Fahy (1993)	Potential sources of competitive advantage (resources and skills) ⇨ Competitive advantage related to the competitive position on the market ⇨ Sustainability of the competitive advantage related to the competitive position on the market ⇨ Long-term outcomes ⇨ Reinvestments in resources and skills
Zahra, Das (1993)	Resources, production strategy, outstanding competences ⇨ Competitive advantage ⇨ Outcomes
Petts (1997)	Skills ⇨ Key competences ⇨ Competences related to benefits for the customer ⇨ Sustainable competitive advantage ⇨ Profit ⇨ Decisions on investment, training and recruitment
Olavarrieta, Ellinger (1997)	Firm resources ⇨ Strategic resources (superior assets, distinctive capabilities, key capabilities) ⇨ Sustainable competitive advantage ⇨ Relative, superior outcomes ⇨ Organizational learning
Veliyath, Fitzgerald (2000)	Firm (resources, capabilities, competences, 'new 7S') ⇨ Business strategies (differentiation, cost leadership, concentration) ⇨ Convergence with hypercompetition arenas ⇨ Competitive advantage ⇨ Firm competitiveness
Srivastava, Fahey, Christensen (2001)	Market-based assets (intellectual, relational) ⇨ Generating value for customers through processes related to market orientation and marketing concept (product innovations management, supply chain management, customer relationship management) ⇨ Sustainability of the customer value and competitive advantage ⇨ Performed values and financial returns ⇨ Investments in market resources

Source: (Matwiejczuk, 2014)

The striving of firms to achieve success and, consequently, gain a competitive advantage involve achieving the expected market and economic outcomes. These outcomes are the result of aimed and planned processes and activities oriented towards the performance of designated tasks carried out on both the strategic and operational levels (Matwiejczuk, 2014). Day and Wensley (1988) mention the following most important market outcomes that the firm is striving to achieve: (1) customer satisfaction, (2) customer loyalty, and (3) market share, while among the most important economic outcomes achieved by the firm they distinguish: (1) profit, (2) profitability, and (3) return on invested capital.

The expected outcomes achieved by the firm in the process of creating the competitive advantage are the 'traces' of success that can be understood as symptoms of business success. The relations between factors and symptoms of success have been presented by Day and Wensley in their concept of creating the business competitive advantage. This concept presents a mechanism of 'transformation' of success sources, which are the business success factors into symptoms of this success related to gaining a competitive advantage and obtaining – in relation to this

advantage – the so called benefits from the competitive advantage held, referred to in short as competitive benefits (Day, Wensley, 1988).

According to Day and Wensley, firms undertake long-term investment activities consisting in prioritising the treatment of resources and capabilities, specific for individual firms, constituting the basis for achieving success and creating a competitive advantage. The most important, potential sources of business success listed by the authors include resources and capabilities, distinguishing the firm against the background of competitors that form the basis for the development of distinctive competences. The distinctive firm resources, capabilities and competences are transformed from potential into real sources of success when they gain the status of the so-called key success factors (Day, Wensley, 1988).

3. Basic concepts of key business success factors in the context of creating competitive advantage

As it has been mentioned above, a competitive advantage means that the firm achieves market and economic outcomes more favourable than competitors, or that the firm takes a more competitive position on the market. Correct identification of key success factors is crucial for identifying the business strategic potentials, including resources, capabilities and competences that may be the determinants of creating the business competitive advantage.

According to Gołębiowski (2001) key success factors are all the important resources, competences, activities and results of the current activity which are necessary to achieve success in a given field of activity (industry). Taking into consideration the aforementioned concept of Day and Wensley, it seems that the achieved business results are rather symptoms of the business success than factors influencing such success.

Key success factors can be key resources, key capabilities and key competences, including in particular their integrated compositions, which – in addition to contributing to the business success – are distinctive with respect to the potential of competitors and thus enable a competitive advantage to be created. Key success factors which include an integrated composition of resources, capabilities and competences, perceived as unique compared to competitors, are the key potentials of business success.

As highlighted by Gierszewska and Romanowska (2002), key success factors should not be equated with market success factors. According to the authors, the market success factors determine the firm's and its products features, that are appreciated by customers and on the basis of which customers make their decisions about purchasing a product of a given brand or a given manufacturer.

The differences between key success and market success factors are related to two concepts of success factors – slightly differing from each other – the first of which is located in the area of strategic management, and more precisely, within the resource-based strategic management area, while the second concept concerns product development issues and is largely associated with the concept of marketing

and the positional stream of strategic management. Based on these two proposals, the concept of key success factors can be applied in other areas of broadly understood management sciences, including, but not limited to the area of logistics and supply chain management.

3.1. The Concept of Key Success Factors in the resource-based of strategic management

The Concept of Key Success Factors (Foss, Harmsen, 1996) placed within the framework of the resource-based strategic management is based on the criteria that form the basis for identification of key resources. These criteria include: (1) value, (2) rareness, (3) imperfect imitability and (4) non-substitutability (Barney, 1991). In addition to resources, these criteria can also be applied to capabilities and competences, contributing to the recognition of key capabilities and key competences, respectively. The 'key importance' of resources, capabilities and competences should be assessed in the first place from the perspective of the market and economic outcomes achieved by their utilization, which are more distinctive and more advantageous compared to competitors (Eden, Ackermann, 2010). In such event resources, capabilities and competences can be referred to as key business success factors.

A resource-based approach in the process of identification of business success potentials (factors) is presented by Gälweiler (1987) who believes that the strategic potential of the expected outcomes and success is a general structure of all specific product and market conditions that are relevant from the point of view of business success. Such success is related to achieving long-term profits and the desired level of benefits for customers as well as the implementation of other strategic business goals. According to Gälweiler (1987) the most important premises for achieving the expected business outcomes and success are related to specific functions and management systems, while the potentials of expected outcomes (including the number of detailed success factors) formulated at the strategic level are sources of business success in the long-term perspective.

3.2. Concept of Key Factors of Success in marketing and positional stream of strategic management

The Concept of Key Factors of Success (Foss, Harmsen, 1996) placed within the marketing and positional stream of strategic management is related most of all to the product development process. Identification of factors determining business success applies then in reality to the firm's market success, evaluated from the perspective of customers, including in particular their needs, preferences, requirements, expectations, etc. Therefore, this concept does not have to refer directly to the firm resources, capabilities and competences which often are not 'noticed' at all by customers assessing the market offer from the perspective of meeting their own needs. As has been mentioned above, resources, capabilities and competences are the business success factors, while market success – in addition to the competitive

position – can be perceived most of all as one of the most important symptoms of the business competitive advantage.

The positional approach to business success factors is presented by Pümpin (1986). He treats success factors not so much as capabilities and premises in the areas important for achieving business success, but as the symptoms of the so-called strategic position of success and the benefits related thereto that were successfully achieved in the process of competition. As a part of the positional approach to business success potentials (factors), special emphasis is put on the conscious endeavours of firms to achieve conditions for creating a competitive advantage to allow above-average market and economic outcomes to be achieved on a long-term basis. It is therefore why Pümpin (1986) aims primarily to identify the firm's position on the market in relation to competitors, referred to as the competitive position, which – similarly to the market success – is a symptom of the business competitive advantage.

3.3. Basic characteristics of the concept of key success factors in logistics and supply chain management

The concept of key success factors in the area of logistics and supply chain management mainly refers to the resource-based stream of strategic management which is associated with identification of the so-called logistics potentials of success, including:

1) Logistics resources, understood as the firm's tangible and intangible assets being components of its logistics system.
2) Logistics capabilities, perceived as business success factors related to the shaping and utilization of diversified compositions of logistics resources, taking into consideration activities, organizational routines, processes, systems and employee skills to develop products and services creating value for the customer and for the business,
3) Logistics competences constituting long-term capabilities (compositions of capabilities) of using resources (compositions of resources), in particular logistics resources, actively involved in the implementation of the set business goals and tasks, leading to the achievement of the expected market and economic outcomes, including primarily outcomes related to the generation of value that forms the basis for creating a competitive advantage (see Figure 1).

Similarly to the 'general' business success potentials, the logistics success potentials are sets of specific factors affecting the achievement of expected market and economic outcomes by the firm, which are the basis for creating a competitive advantage.

The increasing significance of logistics, more and more often perceived and implemented as a concept of management of the goods and information flow, affecting, *inter alia*, the creation of a competitive advantage, is substantiated by the results of many research studies conducted on a global scale (Blaik, 2017). A special type of logistics potentials considered from the perspective of the possibility of their impact on creating business competitive advantage are logistics competences (Blaik, 2017).

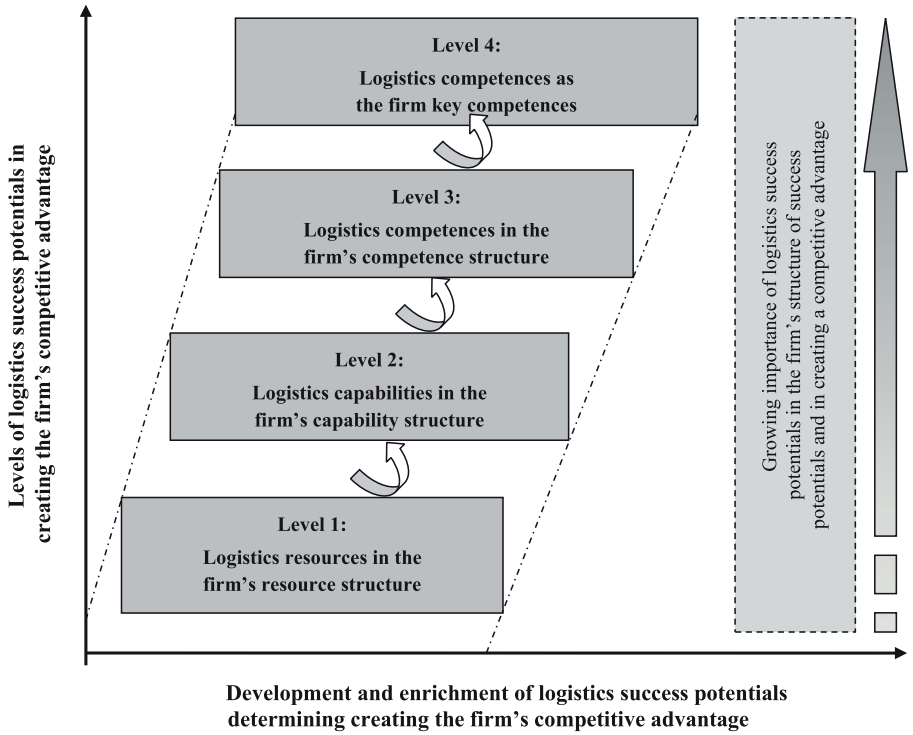

Figure 1. Hierarchy of logistics business success potentials.
Source: (Matwiejczuk, 2014)

When citing the results of the research conducted by the Technical University of Berlin and the German Logistics Association Blaik emphasizes that currently the business strategies related to planning and implementation of logistics systems often focus on key competences.

The most important place among the key success factors affecting achievement of the expected market and economic outcomes as well as gaining a business competitive advantage is occupied by logistics competences. As emphasized by Sennheiser and Schnetzler (2008), a condition for the development of logistics competences is the prior identification of appropriate logistics capabilities, which in turn are based on logistics resources.

Logistics competences are at the highest level in the structure of logistics potentials of business success (see Figure 1). They are developed based on the firm's logistics resources (compositions of resources) and capabilities (compositions of capabilities) to utilize them. Logistics resources and capabilities are required to form and develop logistics competences, nonetheless, it is the logistics competences which are the potentials 'spreading' on logistics resources and capabilities that have the greatest significance in achieving business success, and thus creating a lasting, long-term competitive advantage.

Conclusions

Logistics, and in particular logistics potentials of success, play an important role in creating the business competitive advantage. The article presented the most important characteristics of the concept of key success factors that can be used, *inter alia*, in logistics and supply chain management. Having in mind the constantly growing role of logistics in contemporary management, and particularly in strategic management, appropriately identified potentials of logistics success, including logistics resources, logistics capabilities and – above all – logistics competences, can be the key success factors contributing to the firm's achievement of the expected market and economic outcomes being the basis for creating its competitive advantage on the market.

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INTANGIBLE ASSETS AS A SOURCE OF COMPETITIVE ADVANTAGE FOR LOGISTICS SERVICE PROVIDERS

Abstract

The ever-shorter product life cycle, mass customization of production and constant pressure to reduce costs have a significant impact on the operating activity of modern companies, including logistics service providers. In order to achieve market success, they have to look for new sources of gaining or maintaining the competitive advantage. One of such sources are resources that relate to both the material and immaterial realms. The article assumes that intangible assets are the main source of competitive advantage. The aim of the paper is to identify the intangible assets and determine their impact on the competitive advantage of logistics service providers.

Keywords: logistics service providers, intangible assets, competitive advantage

Introduction

Logistics service industry enterprises have a rich history. For example, German Schenker was founded in 1872, and American-based UPS was established in 1907. For a long time services provided by these companies were mainly limited to transportation of shipments from the sender to the recipient. Faster development occurred in the 1980s, together with the emergence of the supply chain concept. Then, companies started more and more frequently to outsource not only transport processes, but also storage, picking and packing to external entities. At the turn of the twenty-first century, a rapidly growing trend of outsourcing (Marasco 2008; Soinio, Tanskanen, Finne 2012), but also a wave of consolidation in the form

of mergers and acquisitions, contributed to the growth of interest in the logistics services industry. In the former case, logistics service providers have become co-creators of logistics strategies of many companies. Over the last several years, the range of the services offered by logistics companies has significantly expanded and evolved towards advanced solutions for supply chain management (Czakon, Kawa, 2018). Recent research results (Soinio, Tanskanen, Finne, 2012) confirm this trend and indicate that customers today demand more value-added logistics services (Wagner, Franklin, 2008). In turn, the trend towards mergers and acquisitions has been the reason for the emergence of large global companies offering comprehensive services in the areas of transport, shipping, storage, and related services as well as those supporting logistics processes.

Today, the logistics service industry is known as the 'bloodstream' of economy, which points to a strong correlation between the condition of the economy and the demand for logistics services. The demand for logistics services is, in fact, secondary in relation to the demand for products transported and stored. The logistics services industry is also referred to as a 'Stimulator' of economic development. Logistics companies are important partners of contemporary organizational entities. Without their services, many companies would find it difficult to expand into other markets, or even deliver products to customers located in different regions of a single country. This is particularly noticeable in e-commerce, whose dynamic development is one of the most important trends in the modern economy. Without express delivery services, parcel lockers, and pick up & drop off points, Internet sales would be almost impossible. The largest enterprises of this industry are present in even more than 200 countries and territories. At present, the development of the largest logistics enterprises proceeds in accordance with the one stop shopping concept, connected with offering comprehensive services by one organization (Kawa, 2017).

Logistics enterprises, however, do not always have the right resources that would enable them to carry out all the services offered. This resource scarcity is particularly conspicuous in the case of the means of transport, but also, increasingly, warehouses or transshipping facilities. The reasons are twofold. Firstly, providing comprehensive logistic services requires a well-developed logistic infrastructure, it is time-consuming and capital-intensive. Secondly, possessing excessive material resources is connected with a risk of uneven use thereof, especially in the case of strong fluctuations of demand. In connection with the realization of more and more extensive logistic tasks, providers often take advantage of the help of other enterprises, which co-operate with other, usually smaller, logistic entities (Kawa, 2017).

Access to resources is therefore a prerequisite for the provision of comprehensive logistics services. The aforementioned resources are mainly material in nature. Intangible resources, which not only facilitate better functioning, but also influence the competitive advantage of logistics service providers, are also increasingly often required.

The aim of the paper is to identify the intangible assets and determine their impact on the competitive advantage of logistics service providers.

Approach to resources

The resources concept used in this paper is derived from the resource-based view (RBV) which has been a foundation for a lot of research in the strategic management literature (Human, Naudé, 2009). Resources are treated very differently. Apart from the division into tangible and intangible resources (Barney, 1991), there is a distinction between broadly understood resources (assets) and skills (capacities) (Amit, Schoemaker, 1993). The material resources consist of material, human and financial resources. Additionally, Barney (1991) also includes organizational and information resources. Intangible assets are the remaining resources, such as knowledge, skills, abilities, experience, reputation. In terms of assets, in turn, resources are stocks of available factors which are possessed or controlled by the enterprise. These resources are processed or they co-create products (services) (Amit, Schoemaker, 1993). Skills (capacities) relate to the collection, use and exchange of information between members of the company. This makes it possible to distribute and pool resources accordingly. Kay (1996) also indicates the distinguishing abilities of the company. These are: innovation, reputation, strategic resources and the so-called architecture, i.e. relationships between people and relations of the company with customers, suppliers and other companies from the industry.

The key assumption of the firm resource-based theory is that thanks to its resources and skills, the company can gain a relatively sustainable competitive advantage (Kunasz 2006). However, not all resources have the same impact, which is why it is important to focus attention on those resources that are useful for creating instruments for effective competition on the market.

According to the RBV, some kind of resources lead to a sustainable competitive advantage. Such resources should meet the following conditions (Barney, 1991):

– they are strategically valuable due to their ability to add financial value to the companies;
– they are characterized by rareness because only some enterprises have them;
– they are inimitable by other firms;
– there is no possibility to substitute them with other resources.

Examples of these resources are knowledge and relationships. Knowledge-based assets are hard to imitate and substitute. At the same time, people with critical knowledge may also have enormous bargaining power. In turn, a company's relationships are important resources in themselves (Gadde, Huemer, Hakansson, 2003). Other resources of this kind are: capabilities, organizational processes, the firm's attributes, information, technology, experience, etc. (Rose, Abdullah, Ismad, 2010).

These assets are intangible. Some researchers have been pointing out for some time that tangible resources cease to be regarded as a source of competitive advantage (Kawa, 2017), and managers should focus their attention on intangible assets. However, this requires major changes in companies, particularly in those where material resources are still important. Nevertheless, we should not completely abandon the idea that material resources can be a source of competitive advantage. Sometimes material resources are a carrier of intangible assets. Niemczyk (2013) even points out that by acquiring human resources, for example, a company can acquire relational resources together with them in the form of contacts with customers and suppliers.

Moreover, Hammel and Prahalad (1994) suggest that in order to achieve competitive advantage it is necessary to be able to use resources, i.e. be competent. This is considered to be the capacity to ensure coordinated use of resources in order to achieve the company's objectives. In turn, Krupski (2009) believes that a company does not have to possess resources and skills; it is enough for managers to know how to acquire them if needed.

As previously noted, consolidation, mergers and acquisitions have been a trend in the logistics services industry for several years. With these activities, LSPs (logistics service providers) are given access to new resources such as hubs, warehouses, terminals, IT systems, as well as to customers, expertise, experience and qualifications of employees (Wong and Karia, 2010). It is not always that all these resources are needed. It is not clear whether these resources are used efficiently and which of them are the most important ones. The reason for this lack of knowledge is limited research in this area. Most of the research into resources in logistics concerns manufacturing, commercial and distribution companies. The resources of logistics service providers are investigated relatively rarely. There is a need for studies based on the perspective of provider resources in order to enhance the understanding of LSP resource and competitive advantage (Gunasekaran, Ngai, 2003; Wong, Karia, 2010).

Resources of LSPs and their impact on performance

The resources of a logistics company are classified in different ways. Karia and Wong (2013) used the RBV theory to develop the resource-based logistics (RBL) theory, which argues that logistics resources and capabilities are the determinants of LSP performance. RBL classifies intangible logistics resources into three categories (management expertise, relational and organisational) (Alkhatib et al., 2015). A similar division is proposed by Aziz et al. (2015), i.e. physical, management expertise, technology, relational and organizational resources.

We assume that there is a strong link in the logistics service industry between having strategic resources and the firm's performance. The ways to increase efficiency focus firmly on the acquisition and management of strategic resources and capabilities. The development, maintenance and growth of the firm's resources contribute to the competitive advantage and, ultimately, to the firm's performance (Human, Naudé, 2009).

For the purposes of this article, we have developed a simple model to test the relationship described above. It consists of two constructs: exogenous and endogenous. The former is the resource advantage, the latter is performance related to the competitive advantage of the enterprise.

In the case of 'the resource advantage', several indicators that correspond best with the construct were selected. For their construction an in-depth literature study was carried out. Intangible resources were taken into account, which can be a source of competitive advantage due to their strategic importance, rarity, difficulty in imitation and substitutability (Barney 1991).

One of the most important intangible resources of the contemporary enterprises is knowledge of employees. It is a crucial part of the management expertise resource

which determines the performance of LSP (Ellinger et al., 2008). The amount of research shows that the quality of the human resource is significant to the new solution, especially adoption of technology. According to Mentzer et al. (2004) management skills, knowledge, and logistics expertise are intangible resources which lead to capabilities.

Logistics service providers are very often "asset-free logistics intermediaries offering expertise for the establishment and control of complex logistics systems, including logistics consulting and the organization of the information infrastructure, transport, logistics as well as financial services that are needed" (Schramm, 2012, p. 154). For this reason, organizational skills are required. The management methods used are also associated with cooperation with other entities. LSPs, in particular 4PL (fourth party logistics), are compared to supply chain integrators that select and manage the resources, capabilities and technologies of their own organization and complementary service providers in order to provide comprehensive supply chain solutions. They are also referred to as hybrid organizations, formed from a wide range of entities and usually constituted in the form of a long-term contract. They are also called supply chain architects because they are responsible not only for planning logistics operations, process restructuring, but also for developing the supply chain vision (Cezanne, Saglietto, 2015).

4PL operation is based on outsourced outsourcing. It has access to up-to-date information about the resources and logistic processes implemented by its partners. This is possible thanks to IT systems and their integration with the 4PL operator. It can thus manage the supply chains of different products not only regionally but also globally. Customers additionally get some added value in the form of shorter delivery times and a better offer of logistics services. For this reason, technology is as another group of strategic resources for LSPs (Beinstock et al., 2008). In the logistics literature, the technology resource refers to "advanced technology, advanced equipment, information equipment, resources and information systems and improvement in information technology" (Chapman et al., 2003).

Apart from the aforementioned knowledge, qualified and experienced employees, who cooperate with smaller logistics service providers and other contractors, are needed in logistics companies. Bagchi and Virum (1996) suggest that 3PL is characterized by long-term formal or informal relationships between a particular enterprise and a service provider for all or a significant part of logistics activities. Special emphasis is put here on the long-term relationships between the recipient and the logistics provider. Murphy and Poist (1998) have similar opinions. According to them, cooperation of experienced partners results in a more tailored offer, a wider portfolio of services offered and a longer period of time which is more beneficial for both parties to the relationship.

Another issue is the brand of the company (Davis et al., 2008). The largest logistic companies are well-known and valued brands around the world. The firm's image is associated with marketing and business identity. It reflects how the organization is perceived by customers, suppliers and competitors. Positive associations with the firm inspire trust among employees, increase the sense of security and reduce the risk of cooperation failure. The image is used in the partner selection in the logistics services industry (Skjoett-Larsen, 2000). In addition, some scholars consider

the reputation and corporate image resource as organizational resources which may have a positive impact on the strategy and objectives of an LSP (Brah, Lim, 2006).

In the case of cooperation with various entities, relations with them are very important (Chapman et al., 2003; Aziz et. al., 2015). Currently, companies offering comprehensive logistic services operate in multi-level structures, in accordance with the one stop shopping concept. They coordinate the work of many direct as well as indirect entities. These entities are both suppliers and customers, but also, more and more frequently, competitors, as well as customers' suppliers, suppliers' suppliers, customers' customers, competitors' suppliers, etc. These entities form a bundle of links with a direct or indirect impact on the enterprise that participates in the network. Relationships are a key factor that unites the actors, resources and networking activities. They are the key to achieve resources complementarily among business partners (Amit, Schoemaker, 1993). Langley and Capgemini (2007) claim that relationship is the next strategic weapon for LSPs to achieve and maintain competitive advantages.

In the analysis presented above, seven key indicators have been identified which will determine the intangible resources of logistics service providers. They include the following: knowledge, business organization, management methods, technology, experience, brand, relationships.

The second construct included in the model is the 'performance' of the enterprise. It is also treated very differently by researchers. Some of them relate performance to financial results and others to non-financial performance. We have adopted a mixed approach for the purposes of this article; namely, a four-item scale of performance from Fynes and Voss (2002), Homburg et al. (2004) and Hooley et al. (2005), who supported the use of perceptual measures of firm performance. It consists of: market share, sales income, profit and ROI (return on investment).

Empirical research design

For the needs of this paper we carried out the quantitative research with the use of the Computer-Assisted Web Interview (CAWI) and Computer-Assisted Telephone Interview (CATI). The database of companies operating in the field of logistics services in Poland was used as the sample. It included data from the Regon database kept by the Central Statistical Office in Poland.

In the design of the sample size the lack of awareness of the resource advantage and performance was taken into account. Next, the intensity of research projects is currently high and managers do not have time or simply do not want to participate in studies. Finally, an e-mail or call with a request to take part in a study may be unnoticed among the numerous messages employees receive every day. In order to compensate for this possibility the survey was sent to approx. 23 000 people – managers with knowledge of storage. A total of 58 questionnaires were received, giving only a yield of approx. 0.25%. In addition to the above-mentioned lack of awareness of the exclusionary constraints in storage, such a low percentage could have been affected by quite an extensive size of the questionnaire and its complexity.

In the next step the CATI was used to collect more data. Approx. 30 000 people were interviewed by telephone. In this case a total of 248 questionnaires were received, giving a yield of approx. 0.82% only. Due to errors and incomplete information, some surveys were rejected. Finally, 300 correctly completed questionnaires were qualified for further analysis, which, assuming the same level of confidence, gives an acceptable measurement error of 5.6%. It should be emphasized that according to the literature (Bazarnik et al., 1992), 300 observations are sufficient to be able to come to conclusions about a population consisting of about 94 000 entities (Eurostat, 2016).

The managers who participated in the study and completed questionnaires represented (taking into account the size of employment) mostly micro (49.7%) and small (36.7%) enterprises (see Table 1). In terms of the legal form the largest group consisted of sole-traders (54.3%) and limited liability companies (25.3%). The majority of the surveyed companies provided services for customers from the construction (41,7%) and food (29%) industries.

Table 1. Sample characteristics

Characteristics	Share in the sample (%)
Employment	
0–9 employees	49.7
10–49 employees	36.7
50–249 employees	9.0
250–999 employees	2.0
1000–4999 employees	0.7
More than 5000 employees	0.0
No data available	2.0
Legal form	
Sole-trader	54.3
Civil law partnership	7.7
Registered partnership	3.7
Professional partnership	0.7
Limited partnership	2.6
Limited liability company	25.3
Joint stock company	1.7
Cooperative	0.0
Others	2.0
No data available	2.0
Serviced industry	
Food	29.0
Electric	13.0
Construction	41.7
Textile	8.0
Paper	13.3
Chemical	15.3
Agricultural	13.7
Telecommunications	4.0
Medical	6.3
Furniture	15.3
Financial	1.3
Logistic	14.0

Source: (own elaboration)

In our research we adopted a five-point Likert-type scale to assess the resource and performance and capture the evaluation of our respondents. In the measurement tool, the respondents were asked to compare their resources with those of their direct competitors, using a scale of 1–5, where 1 meant 'much worse' and 5 meant 'much better'. Although such a comparative approach to the evaluation of the indicators may raise questions about the validity of use, it is increasingly often applied in research. We assumed that if an LSP had a competitive advantage, it meant that it had something that others did not have, it did something better than others or did, something that others could not do (Aziz et al., 2015) (see Table 2).

Table 2. 'Resource advantage' indicators

Please compare the following types of resources of your company with those of direct competitors:
Knowledge
Business organizations
Management methods
Technology
Experience
Brand
Relationships

Scale of assessment: five points from 1 to 5, where 1 is 'much worse' and 5 is 'much better'.
Source: (own elaboration)

As in the case of the 'performance' variable, the respondents were asked to compare their performance with the performance of their direct competitors in the last financial year. The work of such researchers as: Fynes and Voss (2002); Homburg, Krohmer and Workman (2004) was used. These authors advocate the use of perceptual indicators to measure company performance (see Table 3).

The quality of the results was verified using validity and reliability measures (all convergent factor loadings and Cronbach's alpha coefficients of constructs were higher than 0.90).

Table 3. 'Performance' indicators

Please compare the following parameters of your company with those of direct competitors in the last financial year:
Market share
Income
Profit
ROI

Scale of assessment: five points from 1 to 5, where 1 is 'much worse' and 5 is 'much better'.
Source: (own elaboration)

Results

All intangible assets were rated fairly highly by the respondents, i.e. above 3.4 (see Figure 1). The resource evaluated best is experience (4.14). This means that LSPs perceive their experience better or considerably better in relation to the experience of direct competition. Knowledge, skills and best practices gathered for

years are precious strategic resources that are certainly valuable, rare, inimitable, and non-substitutable (Barney, 1991; Eisenhardt, Martin, 2000). The second type of resources rated highly were relationships (3.77). Managers of logistics companies value good relations with their partners and take care of their development. They are also linked to the experience mentioned above, as lasting relationships are built for years.

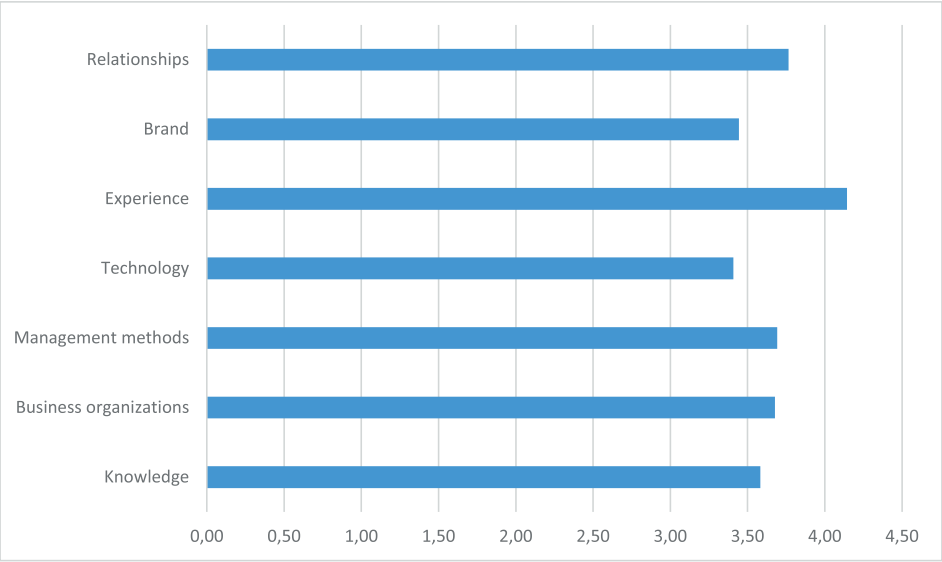

Figure 1. Assessment of 'resource advantage' indicators
Source: (own elaboration)

The lowest rating was given to technology. The assessment was above 3.41, which meant that the respondents rated the applied technologies similarly or slightly better than the competition. The level of this assessment proves that managers of logistics companies either perceive technology as the factor that distinguishes them least, or they believe that their competitors apply similar solutions.

Different results were obtained in the case of the evaluation of performance. All values were lower than 3.0, but three out of four were at least 2.92 (see Figure 2). This means that in the opinion of managers of logistics companies, the performance of their companies is at a comparable or slightly worse level. Financial results such as income and profit were rated most highly (2.94). The lowest rating was given to ROI, which meant that the respondents rated it less favourably than their direct competitors.

The statistical analyses revealed a correlation between the size of the surveyed enterprise (measured by the number of employees) and its resources and performance (see Table 4 and 5). The larger the company, the greater the resource advantage and the better the results. Both correlations are moderate in strength and are statistically significant: 0.16 for resources ($p < 0.001$) and 0.34 for performance ($p < 0.001$). However, there is no such correlation with the other control

variables, such as the legal form and serviced industry, which means that the form of the business and the industries served are irrelevant to the competitive advantage achieved.

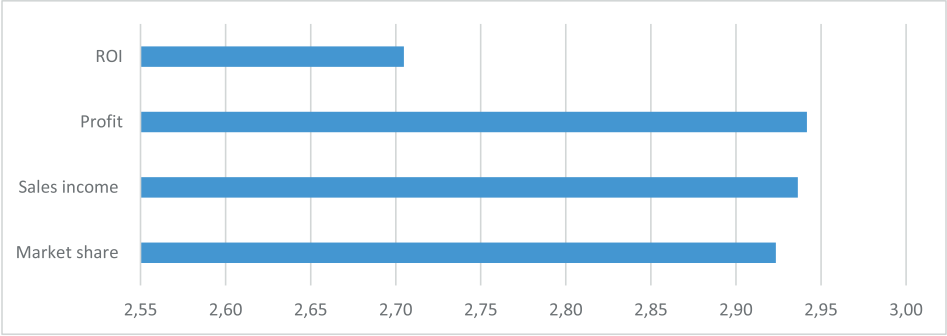

Figure 2. Assessment of 'performance' indicators
Source: (own elaboration)

Table 4. Relationship between the size of the surveyed enterprise (measured by the number of employees) and its resources

Employees/ resource	Knowledge	Business organizations	Management methods	Technology	Experience	Brand	Relationships
0–9	3.44	3.55	3.57	3.26	4.14	3.27	3.76
10–49	3.66	3.83	3.82	3.45	4.15	3.55	3.69
50–249	3.87	3.65	3.70	3.74	4.09	3.65	3.87
250+	3.80	3.80	3.80	3.80	4.50	4.00	4.20

Source: (own elaboration)

Table 5. Relationship between the size of the surveyed enterprise (measured by the number of employees) and its performance

Employees/ performance	Market share	Sales income	Profit	ROI
0–9	2.66	2.58	2.68	2.53
10–49	3.08	3.22	3.09	2.86
50–249	3.43	3.43	3.30	2.84
250+	3.80	3.25	4.20	3.33

Source: (own elaboration)

The next stage of the study was to test a hypothesis indicating a positive relationship between the resources and performance of logistics companies. Since the first construct consists of seven factors and the second one – of four, it was decided to average these factors so that each of the constructs was represented by one size. Thanks to this procedure it was easier to collate the data of both constructs.

The statistical analysis supported the hypothesis. Namely, there is a positive link between resources and performance. The strength of this correlation is moderate and statistically significant (0.38; $p < 0.001$). This means that the higher the company's resources are rated, the greater the competitive advantage it has and thus outperforms its competitors.

Conclusions

The logistics services industry continues to develop. New requirements and expectations towards logistics service providers arise. The range of services, in terms of their type and geographical coverage, is growing. Competition between companies is also increasing. It is not enough to own resources such as fleet, warehouses, and transshipment facilities to achieve market success. Nowadays, companies are increasingly competing by means of strategic resources that are valuable, rare, inimitable, and non-substitutable. The research shows that these are mainly experience and relations with other companies. The disposition of appropriate intangible assets is directly reflected in the performance achieved, and this in turn translates into the competitive advantage (Alkhatib et al., 2015). However, one should be aware that the competitive advantage is always temporary; that is why LSPs will need to continue the resource structuring, accessing and bundling activities (Wong, Karia, 2010).

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DEVELOPMENT OF MARITIME CONTAINER TRANSPORT IN SOUTHEAST ASIA

Abstract

The article presents the role of marine container transport in the present-day world economy, taking into consideration the position of China, Japan, South Korea and India in the global system of containerized cargo transport. Transshipments in the largest container ports of Asia in the period 1990–2016 are discussed. The container ship tonnage in China, Japan, South Korea and India is analyzed in the studied period. The main institutions financing the transport infrastructure development in the Europe-Asia transport corridors are described.

Keywords: maritime transport, container transport, transshipments in ports

Introduction

The maritime transport plays a very important role in the modern global economy, handling over 80% of the global trade volumes. Its carriage potential is very diverse in technical, technological, operational and freight type terms, whereby a wide variety of services can be provided, ranging from small cargoes of several hundred kilograms to large shipments of several hundred thousand kilograms.

Movement of cargo mass by sea has been revolutionized by containerization which has been introduced into transport and which in recent years has contributed to the transformation of vessels in terms of technology and design, changes in port areas, reduction of transport costs and manufacturing process globalization. Container ships which are among the youngest vessels in operation are successively rejuvenated. Newly built vessels have increasingly greater dimensions and their capacity is expanding as well (from 1250 TEUs in 1990 to more than 20 000 TEUs in 2017). The latest and largest container ship, OOCL Hong Kong, built in South Korea in 2017 by Samsung Shipbuilding & Heavy Industries Company Limited,

with a DWT of 191 422 can transport up to 21 413 TEUs (vesselfinder, 2018). Owing to new technological solutions CO_2 emissions per 1 TEU are expected to be reduced by 50% compared to the current average on the Asia-Europe route (Mindur, 2014).

Two basic types of vessels will be used in maritime container shipping, using the lo-lo vertical and ro-ro horizontal handling systems. These ships sail in the designated maritime corridors, also used by China, Japan, South Korea and India, whose share in the global foreign trade in goods is very substantial.

In 2016, China had the largest share in the global exports (13.5%, compared to 13.8% in 2015). Japan took fourth place (after China, the United States and Germany) with a share of 4.1%, and the fifth place was taken by South Korea (3.4%) In terms of imports China came in second place following the United States (the value of goods imported to China was 10% of the value of global imports), and the 4th place was taken by Japan (3.8%) following Germany. South Korea (2.8%) taking the 7th place and India in the 12th position (2.3%) were also ranked among the world major importers. It is maritime transport that is commonly used for freight transport in these countries due to the geographical location (CSO, 2017).

Container ports in China, Japan, South Korea and India

Asian countries hold an important place in the global containerized freight system. Low costs of manufacture of goods in Asia and lower transport costs owing to the containerization are the reason why the ports of this region of the world dominate among the container transshipment tycoons. Table 1 shows the ranking of 10 largest container ports of Asia by shipping volume in the years 1980–2016 against the background of world ports.

The largest ports play the role of transshipment and logistics centres for ocean-going vessels (hubs), while smaller ports handling smaller container ships (feeders) provide feeder services for major ports. Thus, ships can reach a substantially greater number of ports located in a given region. Container ports are continuously dredged and upgraded with the use of automation and electronics to reduce the ship berthing time.

Table 1. Shipping volume in largest container ports of Asia in 1980–2016 (thousands of TEUs)

Rank in Asia	Rank in the world	Port	Volume	Rank in the world	Port	Volume	Rank in the world	Port	Volume
1980				1985			1990		
1	3	Kobe	14.7	3	Hong Kong	22.9	1	Singapore	52.2
2	4	Hong Kong	14.7	4	Kaohsiung	19.0	2	Hong Kong	51.0
3	5	Kaohsiung	98.0	5	Kobe	18.6	4	Kaohsiung	35.0
4	6	Singapore	9.2	6	Singapore	17.0	5	Kobe	26.0
5	12	Yokohama	7.2	7	Yokohama	13.3	6	Busan	23.5
6	15	Keelung	6.6	11	Keelung	11.6	10	Keelung	18.3
7	16	Busan	6.3	12	Busan	11.1	11	Yokohama	16.5
8	18	Tokyo	6.3	14	Tokyo	10.0	13	Tokyo	15.6

Rank in Asia	Rank in the world	Port	Volume	Rank in the world	Port	Volume	Rank in the world	Port	Volume
9	19	Jeddach	5.6	21	Jeddach	6.8	20	Manila	10.4
10	24	Manila	4.0	26	Manila	4.8	21	Bangkok	10.2
2000				2005			2010		
1	1	Hong Kong	181.0	1	Singapore	231.9	1	Shanghai	290.7
2	2	Singapore	170.4	2	Hong Kong	226.0	2	Singapore	284.3
3	3	Busan	75.4	3	Shanghai	180.8	3	Hong Kong	237.0
4	4	Kaohsiung	74.3	4	Shenzhen	162.0	4	Shenzhen	225.1
5	6	Shanghai	56.1	5	Busan	118.4	5	Busan	141.9
6	11	Shenzhen	40.0	6	Kaohsiung	94.7	6	Ningbo	131.4
7	12	Port Klang	32.1	9	Dubai	76.2	7	Guangzhou	125.5
8	13	Dubai	30.6	13	Qindago	63.1	8	Qindago	120.1
9	15	Tokyo	29.0	14	Port Klang	57.2	9	Dubai	116.0
10	19	TJ Priok	24.8	15	Ningbo	52.1	11	Tjanjin	100.8
2011				2012			2013		
1	1	Shanghai	317.4	1	Shanghai	325.3	1	Shanghai	336.2
2	2	Singapore	299.4	2	Singapore	316.5	2	Singapore	326.0
3	3	Hong Kong	243.8	3	Hong Kong	231.2	3	Shenzhen	232.8
4	4	Shenzhen	225.7	4	Shenzhen	229.4	4	Hong Kong	223.5
5	5	Busan	161.8	5	Busan	170.4	5	Busan	176.9
6	6	Ningbo	147.2	6	Ningbo	168.3	6	Ningbo	173.5
7	7	Guangzhou	144.2	7	Guangzhou	147.4	7	Qindago	155.2
8	8	Qindago	130.2	8	Qindago	145.0	8	Guangzhou	153.1
9	9	Dubai	130.0	9	Dubai	133.0	9	Dubai	136.4
10	10	Tjanjin	115.9	10	Tjanjin	123.0	10	Tjanjin	130.1
2014				2015			2016		
1	1	Shanghai	352.9	1	Shanghai	365.4	1	Shanghai	371.3
2	2	Singapore	338.7	2	Singapore	309.2	2	Singapore	309.0
3	3	Shenzhen	240.3	3	Shenzhen	242.1	3	Shenzhen	239.8
4	4	Hong Kong	222.3	4	Ningbo	206.3	4	Ningbo	215.6
5	5	Ningbo	194.5	5	Hong Kong	200.7	5	Hong Kong	198.1
6	6	Busan	186.9	6	Busan	194.7	6	Busan	194.6
7	7	Qindago	165.8	7	Guangzhou	176.3	7	Guangzhou	188.6
8	8	Guangzhou	163.9	8	Qindago	174.4	8	Qindago	180.5
9	9	Dubai	152.5	9	Dubai	155.9	9	Dubai	147.7
9	10	Tjanjin	140.6	10	Tjanjin	141.1	10	Tjanjin	146.0

Source: (Hal, 2018)

At the present time, the largest container ports in the world are centres located mainly in China (Table 1). They have dominated, *inter alia,* the Japanese ports, including the largest Japanese port of Tokyo which was ranked among the world leaders still in 2000 (taking the 9th position at that time). Attention should be paid to the stable situation of the South Korean port of Busan which was incessantly ranked 5th until 2013 and which is taking the 6th place now.

China has over 2.000 seaports of which 130 serve the world fleet. As more than 90% of the trade exchange takes place by sea, the shipbuilding industry has been developing rapidly including the expansion of container terminals. The largest container ports include: Dalian, Guangzhou, Lianyungang, Ningbo, Qingdao, Shenzhen, Shanghai, Tianjin, Yingkou and Xiamen. Figure shows the handling volume in Chinese container ports in 2016.

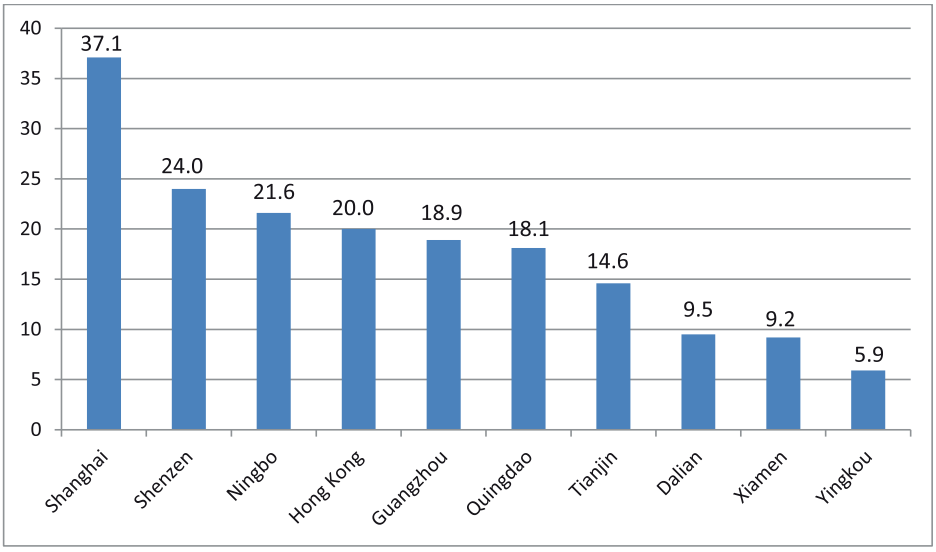

Figure 1. Container transshipments in largest Chinese seaports in 2016 (millions of TEUs)
Source: (Statista, 2018)

Shanghai has been the largest container port in the world since 2010. Transshipments in the port have been growing each year since 2000 – increasing by 80.600 TEUs in the period 2010–2016 only. The hub, consisting of several interconnected ports, is constantly expanded and upgraded. It owes its rapid development chiefly to the construction of the Yangshan Deep Water port which was opened in 2005 and which can handle the largest container ships in the world (Figure 2). This port is located on an island and it is connected to the mainland by the Donghai bridge which is 32.5 km long (one of the longest bridges in the world). In 2018 the next stage of the port's expansion consisting in testing a fully automated container terminal was started. The terminal will be equipped with an automatic management system, automatic loading and unloading devices, including 26 bridge cranes, 120 gantry cranes and 130 AGVs. The expansion of the Yangshan Deep Water Port will have been fully completed in 2020. The total budget of this project is over 500 billion yuans.

Figure 2. Yangshan Deep Water Port
Source: (topchinatravel, 2018)

The first fully automated container terminal in Asia operating since 2017 is the terminal located in the eastern port of Qingdao which is operating round the clock (Qingdao, 2018).

The rapid development of China's economy took place in the late 1970s owing to its marketisation and opening out to the world. It was the gradual liberalization of foreign trade, establishment of special economic zones, business facilitation for foreign entities as well as relocation of manufacturing operations to this country due to the low cost of manufacture that were the main reasons contributing to the development of maritime container transport.

Japan has 1020 ports, including 22 special-purpose ports, 106 main ports and 892 local ports. The main container ports include ports located in Tokyo, Yokohama, Nagoya, Kobe and Osaka. In 2011, the Japanese government designated strategic hubs for international sea-going vessels combining the ports of Yokohama, Tokyo and Kawasaki into the so-called Keihin ports and the ports of Osaka and Kobe into the so-called Hanshin ports. Moreover, a hub comprising the ports of Osaka, Kobe, Sakai-Semboku and Amagasaki-Nishinomiya-Ashiya is located in the Gulf of Osaka.

Government measures aimed at increasing transshipments in Japanese ports include state subsidies and loans to equip ports with specialized facilities and devices so as to compete with other Asian ports in the future, especially with the port of Singapore and the Korean port of Busan which have been increasing their handling volumes significantly thanks to the support received from their

governments (nikkei, 2018). The implementation of this policy as of 2010 resulted in an increase in the container traffic by 2.4% in 2016 – for the first time in 2 years (joc, 2018).

4.7 million TEUs were transshipped at the largest Japanese port in Tokyo in 2016 (Figure 3). The port of Kobe and the port of Yokohama handled 2.8 million TEUs, the port in Nagoya 2.7 million TEUs, and the port of Osaka 2.2 million TEUs.

The top ten Japanese container ports in 2016 included also Hakata, Naha, Shimizu, Kitakyushu and Tomakomai which handled 966.300 TEUs, 541.500 TEUs, 517.300 TEUs, 571.300 TEUs, and 316.700 TEUs, respectively. Hiroshima, which was ranked 11th, handled 257.100 TEUs (joc, 2018).

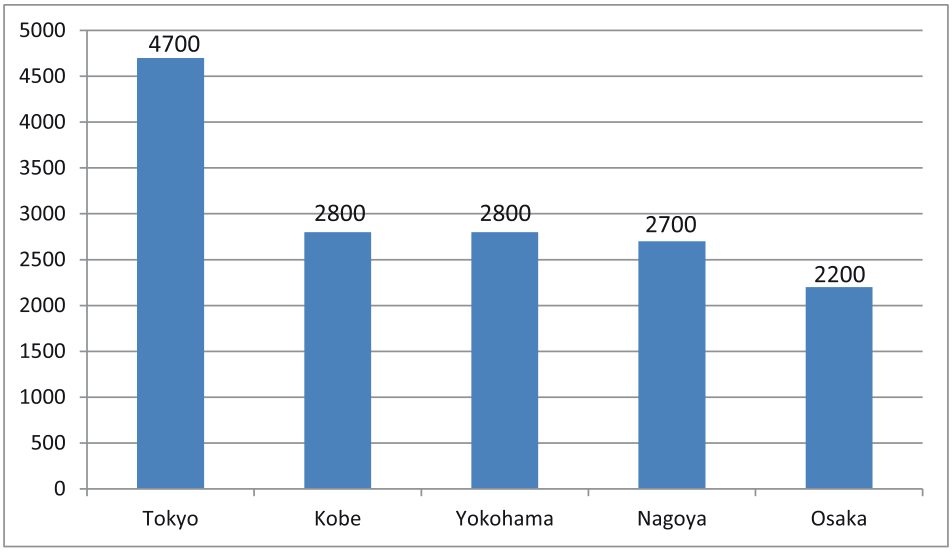

Figure 3. Container transshipments in largest Japanese ports in 2016 (millions of TEUs)
Source: (joc, 2018)

South Korea is among the highly industrialized countries with robust industrial sectors in the area of new technologies. The country is ranked 13th on the list of the largest economic powers in the world. The Korean economy is included among economies that are most open to business. According to the Index of Economic Freedom (IEF) the country was ranked 5th in Asia and 23rd in the world in 2016 (joc, 2018). The main ports of South Korea are: Busan, Incheon, Mokpho, Musan, Ulsan and Phohang.

The priority of the South Korean government was to have a logistic centre with a global status. Duty free zones were established in ports which made it possible to transform the main Korean container ports into logistic centres of Northeast Asia. As a result, a new port in Busan was created in 2011 with the annual handing capacity of over 8 million containers and which is managed by the public corporation, Busan Port Authority (BPA).

The port of Busan handles 80% of container transshipments in the country, and its share in international trade with respect to South Korean ports exceeds 75%.

The location on the south-eastern end of the Korean peninsula and the deepwater and tidal conditions have made it the largest port of Korea and the sixth largest port in the world. In 2016, the container handling volume at the port of Busan was 194.600 TEUs. The port has introduced the Landlord Port system whereby terminals are leased to shipowners and transport companies. It is planned to develop the port further with the target of having 60 container terminals by 2020. The port of Busan has four fully equipped modern ports – the North Port, the South Port, the Gamcheon Port and the Dadaepo Port – an international passenger terminal and six container terminals. Owing to the long coastline (26.8 km) it is possible to moor 169 ships at the same time and handle 91 million tonnes of freight per year. The port's advanced loading/unloading equipment, such as high-speed container cranes that can handle the largest container ships in the world, provides the capacity to serve as many as 130 ships per day (Port of Busan, 2018).

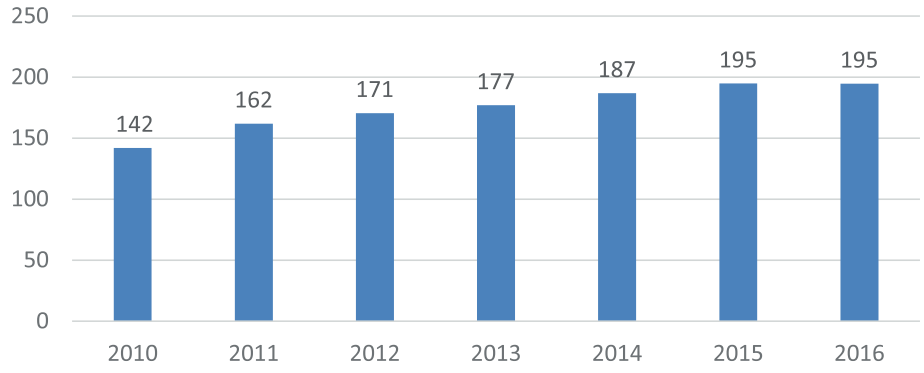

Figure 4. The number of containers handled at the port of Busan in the period 2010–2016 (thousands of TEUs)
Source: (Mardep, 2018)

The Indian Peninsula has one of the largest coastlines in the world, extending for over 7.500 km, accommodating around 200 Indian ports including 13 largest ones. The major ports handle over 70% of the whole freight traffic.

The most important international container ports are in Jawaharlal Nehru, Chennai, V.O. Chidambaranar, Calcutta and Cochin. The ports of Jawaharlal Nehru and Chennai account for 80% of the container traffic in India.

The largest container port in India – JNPT Jawaharlal Nehru handled 4.5 million TEUs in 2016, ultimately by 2020 it will be capable of handling 10 million TEUs per year. The JNPT container terminal is equipped with the latest devices that meet all the international standards. It also has excellent rail and road connections with the rest of the country (jnport, 2018). The terminal has been upgraded recently and additionally equipped with modern cranes and other port facilities which has increased its throughput capacity by approximately 12%.

The port of Chennai which is located in the south-eastern part of the country is one of the oldest ports in India. It is well linked with the rest of the world and it is called the Gateway of South India. The port has railways approx. 40 km long and 8 sidings to handle loads such as granite or grain. The Chennai Container Terminal (CCT) is adapted to serve deep draft ships. Containers are handled using a railway platform with two lines 725 m long. The wharf is equipped with seven cranes, 18 bridge cranes and six reach stackers (chennaiport, 2018; worldportsource, 2018).

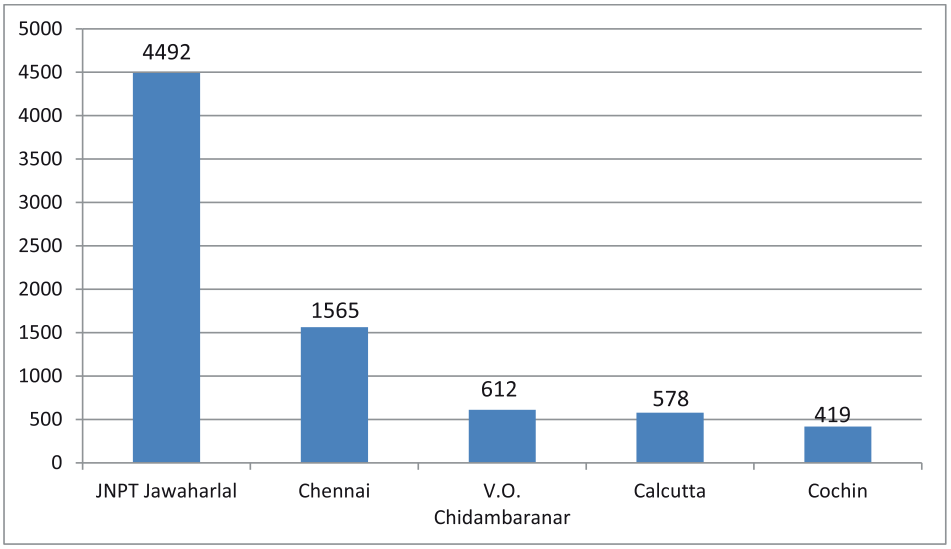

Figure 5. Container transshipments in largest Indian ports in 2016 (thousands of TEUs)
Source: (India Ports Association, 2018)

The activities of major Indian ports are based on trust funds managed by the government. Nonetheless, many local ports are in private hands or they are leased from the state.

Container transport in China, Japan, South Korea and India

The dynamic development of the maritime trade in recent years is owed to China which is the largest importer of crude oil in the world, and moreover, the commodities imported to this country include huge amounts of copper, iron ore and coal. In 2016, the Chinese shipyards were the third largest shipbuilder in the world (following Greece and Japan) receiving 50% of the global orders along with Germany and Singapore. It should also be noted that in 2016 three economies only, i.e. South Korea, China and Japan built 92% of the world tonnage, with Korea having the largest share of 38.1% (unctad, 2018).

China has 5206 ships with a DWT of 1000 tonnes and more (Maritime Executive, 2018). The total tonnage of Chinese container ships more than doubled in the period 1990 to 2010 – reaching a DWT of 32,833,000 at that time. A further increase in the DWT up to 38,099 was noted in the period 2011–2016. Table 2 shows the growth of the Chinese container ship fleet in size (DWT).

Table 2. Chinese fleet by vessel type in 1990–2016 (thousands of DWT)

Country/Province	Ship	1990–2000	2001–2010	2011–2016
China	Oil tankers	35 071	63 008	73 627
	Bulk carriers	110 111	149 446	253 792
	General cargo	77 835	63 472	26 308
	Container ships	15 758	32 833	38 099
	Other	10 839	11 076	27 694
	Total	249 614	319 835	419 520
Hong Kong	Oil tankers	12 690	101 247	157 856
	Bulk carriers	102 160	316 753	474 396
	General cargo	7 332	24 340	15 727
	Container ships	9 453	49 480	116 721
	Other	1 859	5 066	20 937
	Total	133 494	496 886	785 637
Taiwan	Oil tankers	9 752	14 487	2 460
	Bulk carriers	26 733	27 092	14 806
	General cargo	1 584	1 610	822
	Container ships	14 963	10 470	7 161
	Other	322	811	920
	Total	53 354	54 470	26 169

Source: (UNCTAD, 2017)

By the end of 2015, one of the most important maritime container shipping companies on the Chinese market was China Shipping Container Lines (CSCL), established in 1997 and based in Shanghai, which had international container agencies and terminals worldwide, and which provided a full range of intermodal freight shipment services supported by electronic data exchange. Due to the reduced demand for container transport in 2013, which triggered a wave of mergers and acquisitions, CSCL initiated talks on establishing cooperation with the state-owned Cosco Group. In late December 2015, both parties announced a formal merger, establishing Cosco Containers Lines, renamed later to Cosco Shipping Development (unctadstst, 2018).

The largest shipping operations in Japan in terms of both exports and imports of goods are carried out by sea due to the island location of the country. The major shipping routes in the world include those connecting Japan with the United States, Australia, Europe and the Persian Gulf (UNCTAD, 2017).

Japanese container ships had the largest tonnage in 1990–2000, 13.6 million DWT at that time, while a regular decline was observed in the later period (Table 3). It should be assumed that the factors contributing to this situation included but

were not limited to natural disasters that affected Japan (earthquakes, tsunamis) as well as the global economic crisis.

Table 3. Japanese fleet by vessel type in 1990–2016 (thousands of DWT)

Ship	1990–2000	2001–2010	2011–2016
Oil tankers	10 684	21 123	5 226
Bulk carriers	74 485	92 576	76 259
General cargo	12 420	13 720	9 579
Container ships	13 648	11 440	7 545
Other	8 920	8 049	11 632
Total	120 157	146 907	110 240

Source: (UNCTAD, 2017)

The Japanese government allocated funds to build environmentally friendly new generation ultra-large container vessels (ULCVs) to maintain and improve the quality of services and reinforce both the efficiency and cost competitiveness of its fleet on the international market. Moreover, Japanese companies (Mitsui OSK Lines, Nippon Yusen and others) intend to make investments in the development of unmanned, remotely controlled cargo ships. The first Japanese unmanned vessel will appear on ocean waters after 2035 (The Guardian, 2018).

The Republic of Korea has 1907 vessels in total, of which 89 are container ships (indexmundi, 2018). The total tonnage of Korean container ships was regularly declining. It fell by more than half in the period 1990 to 2016. Table 4 shows the growth of the Korean container ship fleet in size (DWT).

Table 4. Korean fleet by vessel type in 1990–2016 (thousands of DWT)

Ship	1990–2000	2001–2010	2011–2016
Oil tankers	10 684	21 123	5 226
Bulk carriers	74 485	92 576	76 259
General cargo	12 420	13 720	9 579
Container ships	13 648	11 440	7 545
Other	8 920	8 049	11 632
Total	120 157	146 907	110 240

Source: (UNCTAD, 2017)

Shipping companies in the Republic of Korea are mostly fragmented. At the same time, the long stagnation in the container transport market and intense competition have created a crisis among South Korean shipping companies. In 2017 Hanjin Shipping – the seventh largest container carrier in the world went bankrupt. The Korea Shipping Partnership – a coalition of 14 South Korean container carriers was established in order to strengthen the domestic maritime shipping sector and, most of all, make the Korean companies credible to their existing foreign trade partners. The companies forming the partnership were: Hyundai Merchant Marine, CK Line, Dongjin Shipping, Doowoo Shipping, Dong Young Shipping, Hansung Line, Heung-A Shipping, KMTC, Namsung Shipping, Mr. Continental Shipping,

Mr. Ocean, Sinokor Shipping, SM Line and Taiyoung Shipping. The objective of the alliance is to increase the competitiveness of the domestic container transport sector, *inter alia*, by opening new joint connections, cooperation in developing the fleet, providing joint services at international terminals, and consultations with the aim to reduce the operating costs.

Approximately 95% of the Indian trade is carried out by sea. At the end of 2015, the Indian fleet consisted of 1246 vessels with a total DWT of 15.3 million. However, the Indian fleet needs urgently to be replaced, since as many as 42% of the vessels are more than 20 years old, and 12% of them are between 15 and 19 years old (The Economic Times, 2017).

The tonnage of Indian container ships is regularly growing. In the period 2001–2010, it went up to 1.876.000 DWT, more than 2.5 times more than, for example, in the period 1990–2000, when the DWT was 730.000. The tonnage continued to grow in the years 2011–2016 – reaching the DWT of 2.056.000 (Table 5).

Table 5. Indian fleet by vessel type in 1990–2016 (thousands of DWT)

Ship	1990–2000	2001–2010	2011–2016
Oil tankers	43 444	72 332	49 995
Bulk carriers	55 579	39 633	29 622
General cargo	11 769	4 489	6 017
Container ships	730	1 876	2 056
Other	8 060	9 392	8 026
Total	119 578	127 721	95 716

Source: UNCTAD (2017)

The growing cargo container transshipment and shipping volumes in India have been triggered by liberalization of the domestic transport market. It is also the incentives introduced by the government in the form of tax exemptions that have a positive effect on the development, extension and maintenance of sea ports.

Port infrastructure funding in China, Japan, South Korea and India

The main institutions financing the transport infrastructure development in the Europe-Asia maritime corridors are the Asian Development Bank, the European Bank for Reconstruction and Development, the World Bank and the European Investment Bank.

The Asian Development Bank (ADB) was established in the Far East in 1960 with a vision to support economic growth and regional cooperation in this part of the world. It associates 48 Asian countries and 19 countries from outside the region. The headquarters of the Bank are in Manila, Philippines, while the main branches are based in Bangladesh, India, Nepal, Pakistan and Vanatau (ADB, 2018). The bank lends funds to governments, national banks and also to state-owned enterprises and private individuals for specific purposes. ADB invests mainly in the industry, agriculture, energy, transport and telecommunications. The bank manages special funds:

– Asian Development Fund;
– Special Technical Assistance Fund;
– Special Japanese Fund.

The Asian Infrastructure Investment Bank is a new institution established on the initiative of China, which started to operate in January 2016. It was founded to provide financial support to build the infrastructure in Asia and beyond. This bank is the response of the emerging economies, led by China, to the financial institutions dominated chiefly by the United States. The member states include but are not limited to China (26.5% of the shares), India (7.7%) and the Republic of Korea (3.6%). Some countries, like e.g. Japan, have decided not to join the Asian Investment and Infrastructure Bank (Asian Infrastructure Investment Bank, 2018).

The World Bank provides support through direct financing of investment projects, participation in financial consortia and providing guarantees for countries eligible to the aid programme. The amount of USD 1.2 billion was provided for the Indian infrastructure development including upgrading and extension of roads and ports as part of the loan of USD 4.3 billion granted by the World Bank. Many infrastructure projects in India are financed by loans from the World Bank and the Asian Development Bank (biznes.pl, 2018).

The European Bank for Reconstruction and Development (EBRD) co-financed transport infrastructure projects in the period 1991–2007 providing over EUR 5 billion, while the total value of completed investment projects amounted to approx. EUR 17 million. The European Bank for Reconstruction and Development actively supports also public-private partnership projects, which are an alternative to the limited possibility of financing infrastructure investment projects from public funds. By the end of 2006, the value of 138 PPP projects in transport co-financed by the EBRD amounted to EUR 4.7 billion, of which 18.3% was private capital. In 2016, the bank allocated a record amount of EUR 9.4 billion to implement 378 investment projects in over 30 emerging economies (EBRD, 2018).

The European Investment Bank (EIB) supports projects that contribute to increasing the regional integration. Its participation cannot exceed 50% of the investment cost, and the minimum direct support in the form of loans is EUR 25 million. In addition to financial aspects, the bank also provides consulting services addressed to the authorities of the EU Member States and institutions, in particular, in the field of development and use of PPP instruments. The countries qualified by the EIB for financing in 2014–2020 included China, India and South Korea (EIB, 2018).

Conclusions

The level of transport and handling volumes in seaports depends chiefly on the global economic phenomena. In 2009, which was the year starting the period of global economic slowdown, global maritime container shipments decreased by more than 10% (123 million TEUs) (Obserwator Morski, 2018). It was also at the beginning of 2013 that the largest shipowners serving the most important sea routes between Asia and Europe suspended operation of approx. 6% of the world

container fleet (Obserwator Morski, 2018). At that time the CKYHE maritime alliance reduced the traffic of container vessels on lines representing almost 17% of its transport capacity. No recovery in the sea transport was noted in 2014 despite the expectations – although the demand for this type of transport grew, however, the emergence of new vessels with a capacity exceeding 10.000 TEUs on the global market was the reason why the supply increased. Heavy-lift vessels have become most effective in financial terms, particularly in view of the fact that the freight rates in container transport are relatively low.

It should be noted that this market is highly competitive, with almost a constant surplus of the supply of transport services over the demand. This surplus was reduced with the opening of the Panama Canal which made the Panamax container ships redundant. This led to massive scrapping of vessels of this type, which included seven-year old Indian Rickmers, which was the youngest ship ever to be scrapped. The forecasts of Maersk Line predict that the demand for services and container ships will be balanced by 2022. The Boston Consulting Group is of a different opinion assuming deterioration (probably doubling) of excess capacity over the demand by 2020 (joc, 2017). When considering which of these forecasts will come true, one should take into account the weaker balance between supply and demand, due to the prices for container handling or the declining trade volume between China and the United States. However, the main reason for the global uncertainty are the customs duties imposed by the US on China for new goods, and the retaliation tariffs that will be introduced for American goods by their trading partners. The maritime container transport should continue to develop because of the price discipline implemented by carriers manifesting itself in the fleet consolidation, the growing trade in South America, maritime transport of containers at shorter distances or the expected GDP growth in developed economies in the forthcoming years. It is a fact that the world container fleet is growing, for example, in 2016 it grew by 1.1% compared to the preceding year (joc, 2018).

The largest sea trade region is definitely Asia. In 2016, Asian sea ports reported 4.1 billion tonnes of cargo shipments and 6.3 billion tonnes of unloading operations, which accounted for 61% of all such operations (the remaining continents recorded less than half of these volumes) (UNCTAD, n.d.). At the same time, Southeast Asia is one of the most important container regions in the world, which is why both China, as well as Japan, South Korea and India are striving to increase the importance of their ports in global transshipments. They are the main driving force behind the development of the country's economy, affecting the entire logistics system of supply chains and networks.

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DEVELOPMENT OF MARITIME TRANSPORT IN THE UNITED KINGDOM, 2005–2016

Abstract

The article presents the significance of the maritime sector for the UK economy. The rank of the country in the international maritime community in the field of business and financial services is indicated. The contribution of transport by sea to the trade exchange and to the Exchequer is discussed. The growing transshipments of goods in the major seaports in the United Kingdom in the period 2005 to 2016 and measured taken by the ports to increase productivity are analyzed. The state policy favouring the maritime sector development and integration with related sectors so as to contribute to achieving long-term development goals of the country, especially after leaving the European Union in 2019 is also discussed.

Keywords: United Kingdom, maritime transport, ports, trade exchange

Introduction

The global volume of trading in goods by sea transport is determined to a significant degree by international trade and globalization. This industry handles 80% of the world trade. According to the UNCTAD data, transport of goods by sea increased by 2.6% or 260 million tonnes in 2016, and according to the forecasts, it will continue to increase by 3.2% per annum by 2022 (The Economist, 2018). Sea transport accounts for almost 100% of the total trade volume in island countries, such as the United Kingdom.

The United Kingdom plays the role of a leading centre of business and financial services for the international maritime community. The companies based in London include Lloyd's Market Association – the world's oldest insurance institution associating the largest group of shipping insurance agents. It is also banks offering financial services for maritime economy institutions such as the Royal Bank of Scotland,

numerous brokers including Clarksons as well and professional law firms providing services to shipowners, e.g. Norton Rose Fulbright that have their headquarters in London (logistyka, 2018). The International Maritime Organization (IMO) – a specialized agency of the United Nations responsible for the safety and security of shipping and the prevention of maritime and atmospheric pollution caused by ships is also based in the capital of the United Kingdom. As at 2017 the IMO had 172 Member States and Associate Members. 40 intergovernmental organizations have signed agreements of cooperation with the IMO, and 61 non-governmental organizations are in consultative status (IMO, 2018). The Baltic Exchange, one of the most important sources of maritime market information, regularly presenting the basic indicators of the dry cargo and oil tanker market and on the sale and purchase of merchant vessels is also based in London (Maritime London, 2018).

The development of maritime transport in the United Kingdom is directly related to its location close to the major shipping routes such as:

– Europe – North America;
– Europe – South America (directly linked with the above mentioned route);
– Europe – Suez Canal – Far East, with a branch to Australia;
– Europe – Africa, with the two most important regions for the United Kingdom – the Gulf of Guinea and South Africa.

The UK merchant fleet of 441 vessels with the DWT totalling 15.2 million is one of the largest in the world. The total port freight tonnage in ports is 484 million tonnes, including almost 473 million tonnes in major ports and over 11 million tonnes in smaller ports (Department of Transport, 2016).

Significance of maritime transport for UK economy

International trade traditionally plays a major role in the United Kingdom's economy. The country is the tenth largest exporter and the fourth largest importer by volume in the world. The major trading partners of the United Kingdom are presented in Tables 1 and 2.

Table 1. Major import partners of the United Kingdom

No.	Country	Imports, 2016 (US$)
1.	Germany	88 077 491 043
2.	China	59 575 883 133
3.	United States	57 103 332 370
4.	The Netherlands	47 382 169 489
5.	France	35 949 856 996
6.	Belgium	31 522 505 629
7.	Switzerland	26 596 303 166
8.	Italy	24 155 104 768
9.	Spain	21 251 195 907
10.	Ireland	18 158 772 440

Source: (globaledge, 2018)

Table 2. Major export partners of the United Kingdom

No.	Country	Exports, 2016 (US$)
1.	United States	61 568 659 268
2.	Germany	43 797 383 589
3.	France	26 461 827 772
4.	The Netherlands	25 484 748 059
5.	Ireland	22 901 408 456
6.	Switzerland	19 774 332 505
7.	China	18 142 280 186
8.	Belgium	15 715 522 064
9.	Italy	13 123 471 995
10.	Spain	13 029 685 111

Source: (globaledge, 2018)

The most important commodities in the UK imports structure are fuels, machinery and highly processed products. The exports include highly processed products, fuels, chemicals, foodstuffs, beverages, tobacco.

In 2016, 95% of British imports (243 million tonnes) and exports (138 million tonnes) were transported by vessels, where 40% of these operations were carried out with the European Union (UK Chamber of Shipping, 2018). At the same time, the United Kingdom remained the leading EU country in short sea shipping, with more than 14% of the total EU tonnage, i.e. 315.5 million tonnes (Eurostat, 2018).

A growing demand for qualified employees in the maritime sector in Western European countries was observed as of 2005. Such a situation had been observed by 2009, when the international trade volume decreased following the global economic crisis which resulted in reductions in employment. Despite a decrease in the number of jobs after 2009, the number of employees in the maritime sector remained relatively stable in 2010–2015 as the British government implemented a number of measures to stabilize the financial market and boost the economy (European Parliament, 2009) (Figure 1). In the last five years, the British maritime sector has recorded an increase in turnover by 12.7%, an increase in the gross added value by 6.6% and an increase in employment by 3.9%. Currently, the sector contributes nearly £40 billion a year to the British economy and provides almost a million jobs in total (britishmarine, 2017).

According to the estimates of the Centre for Economic and Business Research (CEBR), one job in the maritime sector supports the creation of five new jobs in other segments of the UK economy (Cebr Maritime Sector Report, 2017). In 2015, 185.700 people were employed in this sector, including 23.000 seafarers (Department for Transport – Seafarer Statistics, 2016).

In 2015 the whole maritime sector contributed £4.7 billion in tax revenues to the UK Exchequer. For example, taxes from the shipping industry accounted for 12.8% of the total revenues of the maritime sector, which remained basically stable for six years (Cebr, 2017). Figure 2 shows the shipping industry's tax contribution to the UK Exchequer (Income Tax, National Insurance Contributions of employees and employers, Corporation Tax, National Non-Domestic Rates (Business Rates) – business tax rates on real property such as warehouses, stores, offices).

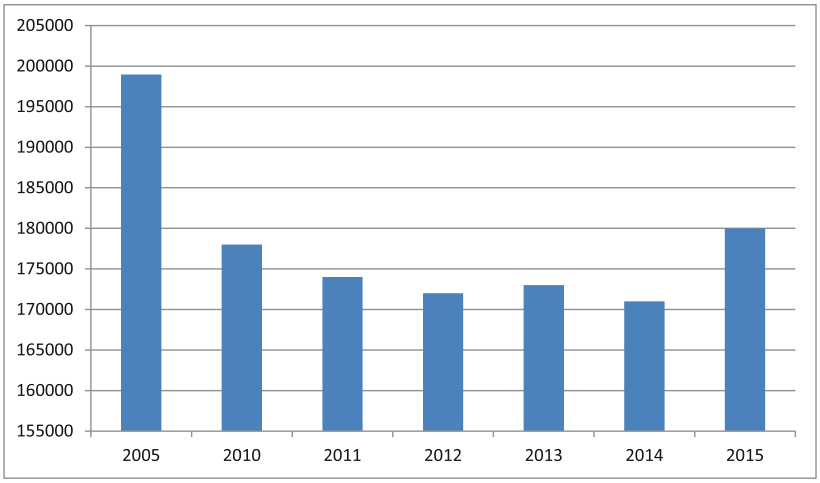

Figure 1. Employment in maritime sector, 2005–2015
Source: (maritimeuk.org, 2018; ec.europa.eu 2018)

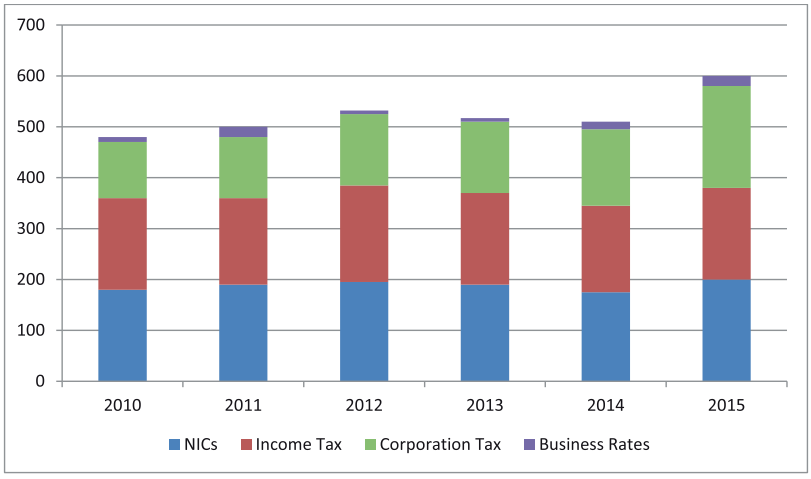

Figure 2. Contribution of the shipping industry to the UK Exchequer, 2010 to 2015 (£ million)
Source: (maritimeuk, 2018)

It is estimated that in 2015 the shipping industry generated almost 600 million pounds in tax revenues in the United Kingdom, with the contribution increasing steadily since 2010 – when it amounted to approx. 480 million pounds.

Port structure in the United Kingdom

The process of deregulation has been the reason why the port sector in the UK has changed significantly over the past twenty years and it is unique within the EU. British ports have one of the three ownership categories:

– private;
– municipal;
– cartel (britishports, 2018).

All these three models are free-market and operate as independent, self-financed enterprises that do not benefit from regular government support or subsidies. These entities belong to port groups representing common interests of port owners, as well as operators of terminals and port facilities that are members of groups operating in the port areas. These include but are not limited to: the UK Major Ports Group (a trade association that owns most of the commercial ports, including but not limited to DP World, Forth Ports, PD Ports, Peel Ports, Hutchinson Ports, Associated British Ports, Port of London Authority), British Ports Association, European Sea Ports Organisation.

In addition to the traditional functions related to cargo handling and passenger service, the port industry offers a number of other services, for example, supporting offshore energy and maintaining ferry connections with island communities.

The most heavily loaded British ports are: Immingham (ranked 11th in the EU), London (ranked 13th in the EU) and Southampton, Milford Haven, Liverpool, Felixstove and Dover ranked beyond the top 20 in the EU (Eurostat, 2016).

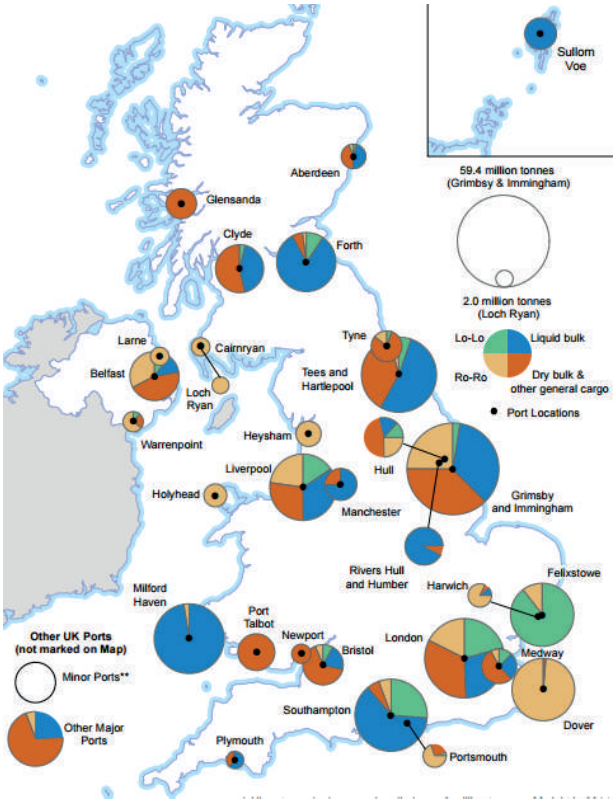

Figure 3. Major UK ports by cargo
Source: (gov.uk, 2015)

Table 3. Major UK ports by cargo in terms of weight of goods handled (million tonnes)

Port	Port group	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Grimsby & Immingham	Associated British Ports	60.7	64.0	66.3	65.3	54.7	54.0	57.2	60.1	62.6	59.4	59.1	54.4
London	Port of London Authority	53.8	51.9	52.7	53.0	45.4	48.1	48.8	43.7	43.2	44.9	45.4	50.4
Southampton	United Kingdom Major Ports Group	39.9	40.6	43.8	41.0	37.2	39.4	37.9	38.1	35.8	36.7	37.7	36.0
Milford Haven	British Ports Association	37.5	34.3	35.5	35.9	39.3	42.8	48.7	39.8	41.1	34.3	37.7	34.8
Liverpool	Peel Ports	33.8	33.6	32.3	32.2	30.0	30.0	32.7	33.0	31.1	31.0	31.3	32.0
Felixstove	PD Ports	23.1	24.4	25.7	25.0	24.3	25.8	26.8	26.3	26.2	28.1	28.0	28.2
Dover	British Ports Association	21.1	23.8	25.1	24.3	25.1	24.1	24.3	22.9	25.3	27.6	27.3	27.3

Source: (Department of Transport, Transport Statistics Great Britain, 2017)

An analysis of the growth in transhipments of goods in major UK seaports in the period 2005 to 2016 shows a fairly high homogeneity. A slight slowdown in 2009 resulted from the global economic crisis. Regular growth of the transshipment volume can be observed in Felixstove, handling the largest container vessels, and Dover that specialises in handling, storage and shipping of temperature-controlled products.

Port Immingham is the largest port in the United Kingdom by tonnage (handling around 55 million tonnes of commodities per year) and it is the major port on the east coast, located on the south bank of the Humber River mouth. The port has two freight terminals – the Immingham deepwater container terminal to handle container transhipments from deep sea vessels, and DFDS Seaways 'Nordic Terminal' serving over 30 connections a week with Northern Europe and Scandinavia. The port is well connected with the main trade routes in the country with access to modern roads (M180, M18 and M1 motorways), railways (a modern railway infrastructure to ship/receive more than 260 freight trains per week including daily connections to/from Southampton and Felixstowe) and the inland waterway infrastructure (the Humber River). In addition to crude oil and coal it is general cargo, forest products, foodstuffs and steel that are transhipped and stored in the port. The international terminals, Humber 1 & 2, handle and store solid fuels for producers of energy, as well as other dry commodities such as biomass, animal feed, road salt and cereals (ABP Associated British Ports).

The port's throughput capacity is continuously growing, nevertheless, the storage facilities should be expanded and investments in high-quality equipment have become indispensable to ensure further development. The port authorities have allocated almost 30 million pounds for upgrading the Hull container terminal, including the purchase of four new Liebherr cranes, two of which were delivered in 2016, and two more will enhance the machinery park in 2018. In the meantime, the Immingham Container Terminal, which was also retrofitted with a new Liebherr crane in 2016, will be additionally expanded owing to substantial investments in new

equipment and technology. In 2017, a 50-hectare area near the port was purchased. The area is well connected with route A180 and motorway M180 and is intended to accommodate the infrastructure which will be then offered to tenants.

The Port of London is the largest port in South East England and the third largest port in the United Kingdom (Port of London, 2018). It handles over 50 million tonnes of freight per year, mainly containers, timber, paper, vehicles, aggregates, crude oil, petroleum, oil products, liquid gas, coal, metals, cereals and other dry and liquid bulk materials.

The Port of London comprises about 680 former or existing quays, docks, piers and terminals, most of which are located in the Tideway of the Thames. Many docks were shut down following a massive increment in container transport. Currently, there are about 70 active terminals in the port area, however, the largest and main marine terminal built from scratch and commissioned in 2014 is the DP World London Gateway Port (DP World London Gateway, 2018). This technologically advanced deepwater port (16.5 m deep), adapted to receive the largest container vessels in the world, will ultimately occupy an area of over 6 km^2 with a wharf 2.7 kilometre long. The port has road connections in all directions (north, south, east, west) with access to an eight-lane motorway, and the railway terminal is linked to the main railway junctions in the country. At the present time, the port facilities comprise:

– three berths and a wharf 1250 m long;
– coastal cranes 138 m high, with high strokes;
– 60 automated double-deck cranes, including 30 cranes for on-shore operations;
– 180 transaction bays for trucks;
– the longest rail terminal in the United Kingdom with three rail gantry cranes.

The natural deepwater port of Southampton, located on the south coast of England, plays the role of both a passenger and freight port to which the largest container vessels can call. The container port covers 210 hectares of land and 152 hectares of older western docks – available for port operations. Constructing a new 500-meter wharf and dredging the main container terminal channel made it possible to carry out loading/unloading operations simultaneously on four large deep sea container vessels. The railway line between the Southampton container port and the Birmingham terminal has been upgraded to allow free movement of rail vehicles transporting higher than standard containers which have a wide range of applications now. The port has facilities for imports and exports of automobiles as well as five multi-level car parks in the eastern docks which play the role of ground warehouses, 12 ha in area. Moreover, the port has a multifunctional terminal for bulk cargo (glass cullet, wheat, aggregates, gravel, sand, fertilizers, grain, scrap, salt for biomass production), refrigerated warehouses for storing perishable food products and a terminal for vessels transporting crude oil processed at Esso, the largest refinery in the UK, located near Southampton (ABP Associated British Ports, 2018b).

The Port of Milford Haven specializes in transhipments of crude oil and natural gas as well as processed products made of these raw materials. The port which is located in the south-west part of the UK has access to the Welsh pipelines, gas pipelines and power grid. Currently, the port operates five major energy terminals:

the Valero Refinery, Puma Energy, South Hook LNG, Dragon LNG and SemLogistics, the largest oil terminal in the UK. Shipments to all terminals arrive from the North Sea, North and West Africa, the Middle East, Asia and Europe and are reshipped after processing. The port focuses on continuous development of the port infrastructure and services ensuring sustainable economic growth of the region, it also focuses on renewable energy sources. In recent years, 3 billion pounds have been invested in the private sector owing to the initiatives of the port authorities helping to support 4.000 local jobs.

The Port of Liverpool is one of the largest, busiest and diversified ports in the UK located on the north-west coast of the UK, on both sides of the Mersey River. In 2016, Liverpool 2, a new deepwater container terminal which can receive the largest container vessels was opened. The port has direct connections to motorways M53, M57, M62 and M6 (M58) and to the railway terminal. The port is used for transhipping automobiles, containers, dry bulk (including but not limited to biomass, aggregates, chemicals), energy, forest, mass liquids products, metals and steel, oversized loads. Recently, the port has been expanded to include a new biomass storage facility worth 100 million. The port owns and runs its own unique inland logistic node – the Manchester Ship Canal (Peel Ports Group, 2018).

The Port of Felixstove, located north-east of London has two main container terminals: Trinity and Landguard, and also a ro-ro terminal. Each terminal has a railway terminal connecting the port with a railway line to Felixstowe. The wharf, which is more than 2.3 km long, is fitted with 29 overhead cranes. As the main navigation canal has been dredged, the largest container vessels can call at the port. The port is used by approx. 30 shipping lines, offering approx. 90 services to/from 400 ports around the world. By 2019, the port will have been additionally equipped with Ship-to-Shore gantry cranes. In the same year, it is planned to complete the construction of a new container storage area. The project includes ten warehouses for stacking containers to a height of 6 lines. The storage capacity will then increase by 18.000 TEUs expanding the already available 130.000 TEUs (Hutchison Ports, 2018).

The Port of Dover – one of the busiest passenger ports in the world, located in South East England near all major shipping routes – at a distance of only 34 km from France. The port is divided into two parts: east and west docks. The east docks accommodate a cargo terminal specializing in handing, storage and shipping of controlled-temperature commodities which can be quickly delivered to other parts of Europe. The natural conditions of the port enable efficient and fast mooring of vessels at any time of the day. At the present time, the cargo terminal has three berths fitted with specialized equipment for handling a wide variety of freight, ranging from fresh products to design loads as well as oversized freight for the power industry. The Port of Dover is considered to be the largest international ro-ro ferry port in Europe. The first stage of reconstruction of the Dover Western Docks Revival wharf, which was started in January 2017, will make it possible to use a new freight terminal and an innovative port-centric distribution centre, which will increase the port's capacities in terms of cargo and logistics. The project, estimated at USD 330 million, is co-financed by the European Union (Port of Dover, 2018).

State policy concerning maritime transport development

The United Kingdom's policy is aimed at ensuring the maritime sector development and integration with associated sectors so as to contribute to achieving the country's long-term development goals.

One of the measures aimed at facilitating further development of ports and boosting the economy within the country was to prepare the report entitled *Transport Infrastructure for our global future* commissioned by the Department of Transport (2017). This document, published in early 2018, will help influence financial and planning decisions to improve road and rail connections that can ensure more efficient movement of goods between key economic areas and ports. It is assumed that these works are intended to contribute to increasing productivity, reducing costs and ensuring greater access of distributors and manufacturers to international markets. As the report shows, the already implemented wide-scale government projects (£235 million allocated in 2014–2019 to improve railway connections and £23 billion to upgrade and develop roads) improve access to ports, unblock private sector investments and stimulate economic growth across the country. The private owners of British ports also develop the pipeline infrastructure (a project worth £1.7 billion). It should also be noted that members of the UK Major Ports Group invest in the British ports and infrastructure more than £0.5 billion a year.

Transport Infrastructure for our global future also contains a number of recommendations for the government and the industry, encouraging, *inter alia*, closer cooperation in the field of freight transport and improving the exchange of information. According to the authors of the report, this will provide an ambitious prospect for port connections, integrated with Maritime 2050, the government's long-term strategy (Department of Transport, 2018).

The Maritime 2050 strategy is aimed at exchanging views on the priority tasks enabling development in areas of fundamental importance for the British maritime sector, which include: technologies, trade, infrastructure, environment, people and security. As part of the strategy, a series of objectives will be set up to help examine the progress in each of these areas. A team of industry and academic experts has been also appointed to advise on the future of the UK maritime sector, including employment of new technologies such as autonomous ships and digital ports. In addition to the panel of experts, also British entrepreneurs operating in the maritime sector can submit innovative ideas that will secure the future of the UK maritime sector.

At the same time, the United Kingdom will strive to implement a strategy to reduce greenhouse gas emissions in the process of shipping, including the call for the fastest possible implementation of zero-emission shipping in the entire maritime sector.

Conclusions

The United Kingdom is the undisputed world leader in professional maritime services, having extensive experience in vessel chartering, insurance, legal, financial and educational services. At the same time, the maritime sector makes a significant macroeconomic contribution to the UK economy through the turnover, gross added value, employment and so-called employee compensation (including, but not limited to, employer contributions for social, health or pension insurance). It is estimated that in 2015 the direct participation of this sector in the trade was over £40 billion, and the gross added value was £14.5 billion. The marine and shipping industries extended the greatest influence on the economy among all industries in the United Kingdom, contributing 6.5 billion pounds to the Exchequer and 4.3 billion pounds in gross added value, as well as directly supporting around 99.900 and 50.800 jobs, respectively (Maritime UK, 2018).

In 2017 the Global Innovation Index recognized the United Kingdom as one of the most innovative countries in the world and a world leader in innovation in the field of communication technologies. Innovations and new technologies are continuously introduced in the British maritime sector. The United Kingdom is at the forefront of the development of autonomous vessels.

Having decided to exit the European Union, the United Kingdom has to prepare to solve new problems related to the maritime sector, including customs and trade arrangements. A specifically painful issue seems to be the introduction of customs duties, as most of imports and exports between the EU and the UK are by sea. The UK government intends either to pursue a 'highly streamlined' or enter into a new customs partnership with the EU. Nonetheless, before finalising the agreement, they would like to apply a transitional period that would be in line with the applicable procedures to the closest possible extent (World Maritime News, 2017). The concerns raised claiming that possible customs and bureaucratic border checks may cause delays in some ports increasing the cost paid by traders, manufacturers and consumers are justified. Another problem concerns British seafarers who are uncertain whether they will still be able to work on vessels registered in other EU Member States based on the training and qualifications acquired in their country. According to some of the leading operators – port owners (Peel Ports, ABP) the United Kingdom's exit from the EU will decrease the container traffic in British ports.

The United Kingdom will cease to be part of the Union on 29 March 2019 and there is no guarantee that the European Commission and the British government will reach an agreement for a transitional period. European ports are currently getting prepared for increased obstacles to trade that may result from a 'hard Brexit', employing more customs officials and inspectors, and the port of Rotterdam expects that they will have to hire more than 100 extra agents (The Maritime Executive, 2018).

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THE STRATEGIC DIMENSION OF LOGISTICS IN THE FOURTH RAILWAY PACKAGE

Abstract

The importance of the Fourth Railway Package for the development of rail transport is discussed in this article. Attention is drawn to the role of logistics in the aspect of interoperability and nodal infrastructure development. The importance of the technical pillar from the Fourth Railway Package for the rail freight logistics is indicated.

Keywords: transport economics, sustainable transport, logistics, Fourth Railway Package

Introduction

Investments in the transport infrastructure have a positive effect on the economic growth, they make it possible to create prosperity and jobs, expand trade, geographic accessibility and mobility of citizens. They should be planned in a way maximizing the positive effect on the economic growth and minimizing the negative impact on the environment (European Council, 2011).

The rail transport in Poland suffered a decline in the freight volumes for several years in the period from 2011 until 2017 (except for 2013 when a slight revival could be seen). Growth was forecasted in 2017. Increased freight volumes were predicted mainly due to the launch of infrastructure projects. These involve increased freight volumes of construction materials and rising imports of coal. The growing operating costs incurred by railway companies, the change in the railway organizational structure in Poland, market liberalization and the emergence of new carriers and infrastructure managers are just a few factors affecting the rail transport operations in Poland. There was also a change in the structure of the goods carried where the transport of bulk materials was reduced including but not limited to coal

or steel products. Significant promotion and financial support have contributed to the development of the intermodal transport market in the last few years. The development trends in intermodal transport are presented in Tables 1 and 2. The changes are significantly rapid and very beneficial both in terms of transport and the natural environment.

Table 1. Units in intermodal transport in 2015–2017

	1st quarter	2nd quarter	3rd quarter	4th quarter
2017	258 661	265 626	269 223	287 008
2016	206 599	227 287	243 387	273 685
2015	184 141	171 803	181 113	208 284
Change 2017/2016	25.20%	16.87%	10.62%	4.87%

Source: (study based on materials including an intermodal transport summary of the President of the Rail Transport Office, Warsaw, 2018)

Table 2. Mass of goods carried in intermodal transport (thousands of tons)

	1st quarter	2nd quarter	3rd quarter	4th quarter
2017	3 560.0	3 569.9	3 659.7	3 898.2
2016	2 831.4	3 176.3	3 262.8	3 559.3
2015	2 588.3	2 458.2	2 514.4	2 825.5
Change 2017/2016	25.73%	12.39%	12.17%	9.52%

Source: (study based on materials including an intermodal transport summary of the President of the Rail Transport Office, Warsaw, 2018)

Nevertheless, land transport has been dominated by road transport which has resulted in the emergence of new locations for manufacturing companies, warehousing centres and distribution companies with good access to the road infrastructure. All these circumstances directly translate into changes in the conditions of the transport sector operation. The European Union has been endeavouring to develop environmentally friendly transport modes in its policy for many years. This may be realized by the concept of 'sustainable development' that has been promoted recently and translates directly into potential developmental effects. The measures proposed by the EU are supposed to bring about a status where the needs of the present generation can be satisfied without downgrading the prospects of future generations to satisfy them. In line with this idea, the EU transport system should bring improvement, or at least non-deterioration of the environmental conditions and the quality of life of the current and future societies (including human health). The slogan of sustainable development in respect of transport came into being and was defined in 1987 in the report of the World Commission on Environment and Development (WCED) – Our Common Future (European Parliament, 2012). When analysing the history of the European Union's policy, as well as the implementation executive tool, which is the EU legislation with reference to the effects of the European Union's activities within the framework of the idea of sustainable development, it can be concluded that the actions taken have not yielded the expected results. The policy pursued by some Member States,

including Poland, was the reason why the transport system definitely fostered the development of road transport. Environmentally friendly railways were successively displaced from the market. We can wonder whether future generations will be able to function normally in a degraded environment if this trend persists. The European Union's transport policy, announced and also written in the strategic documents (e.g. the White Paper) sets a specific roadmap to be followed to a large extent, nonetheless, the implementation of some of the strategic guidelines by individual Member States and the reality of the transport market operation have caused this road to be substantial different. Although the *White Paper* does not refer directly to logistics, nonetheless, it refers to supply chains and to the concept of multimodality in particular (Hajdul, 2017). It is precisely by reason of the rapid globalisation of the world economy that logistics gains in importance in its international dimension. It is defined as the epicentre of business transformation. Increasing integration of the sources of supply, production and trade between companies from different countries and continents is observed. The integration and internationalisation of enterprises are considered as foundations for the creation and development of international logistics[1]. New EU regulations are aimed at a fuller linearisation of the European rail transport market. This direction of development assumes that the rail transport operation will improve due to integration and interoperability by increasing the competitiveness resulting from the implemented changes.

The aim of the article is to show how the proposed new solutions stipulated in the Fourth Railway Package can affect the rail transport development within the logistics dimension.

1. Impact of the Fourth Rail Package regulations on rail transport and logistics

Implementing the European Union regulations stipulated in the Fourth Railway Package will be of key importance for PKP SA and the PKP Group in the forthcoming years. The Fourth Railway Package is supposed to lift the remaining barriers that have not been eliminated by the existing regulations and hinder the creation of a single European railway area. The legal acts adopted within the package belong to the two segments: the technical pillar and the market pillar.

The technical pillar, adopted on 11 May 2016, includes the following legal acts:

a) Regulation of the European Parliament and of the Council (EU) 2016/796 on the European Union Agency for Railways;
b) Directive of the European Parliament and of the Council (EU) 2016/797 on the interoperability of the rail system within the European Union;
c) Directive of the European Parliament and of the Council (EU) 2016/798 on railway safety.

[1] International logistics is understood as processes of planning, controlling and implementing flows of goods and information between individual countries, as operating, on an international scale, on material flows originating from outside, between suppliers and subcontractors, taking place in-house (materials, raw materials, semi-finished products), recipient-oriented flows of ready-made goods, services and products.

The technical pillar is designed to boost the competitiveness of the railway transport by harmonizing the technical requirements and safety rules between railway systems of individual EU member states (Siudecki, 2017). At the present time, individual EU member states use different safety standards and different technical systems. In order to provide international transport services, it is required to obtain permits from various national authorities and have knowledge of the operation of various signalling systems, which is complicated and costly. The fragmentation of railway systems is a legacy of the national railway monopolies operating on the market before the liberalization being detrimental to the competitive position of the railways with respect to other modes of transport, especially in international traffic. The inconsistency of the regulations at the European level increases the administrative barriers and makes it difficult for new rail operators to enter the market. The technical pillar eliminates the administrative barriers by enabling the European Union Rail Agency to grant common permits for rail vehicles, permits for control subsystems and safety certificates for railway operators valid throughout the EU. The Agency has also been granted powers tightening supervision over the technical coherence of the implemented ERTM systems (the Agency approves the technical solutions before each tendering procedure – preauthorisation). Pursuant to the regulations, the Agency is supposed to act as a 'one-stop-shop', i.e. a point of comprehensive services for all processes related to certification and supervision. The Agency's task will be to monitor the national railway regulations and the activities of national authorities in the field of railway interoperability and railway safety. The implementation of the Fourth Railway Package objectives in the technical pillar is illustrated in the figure below:

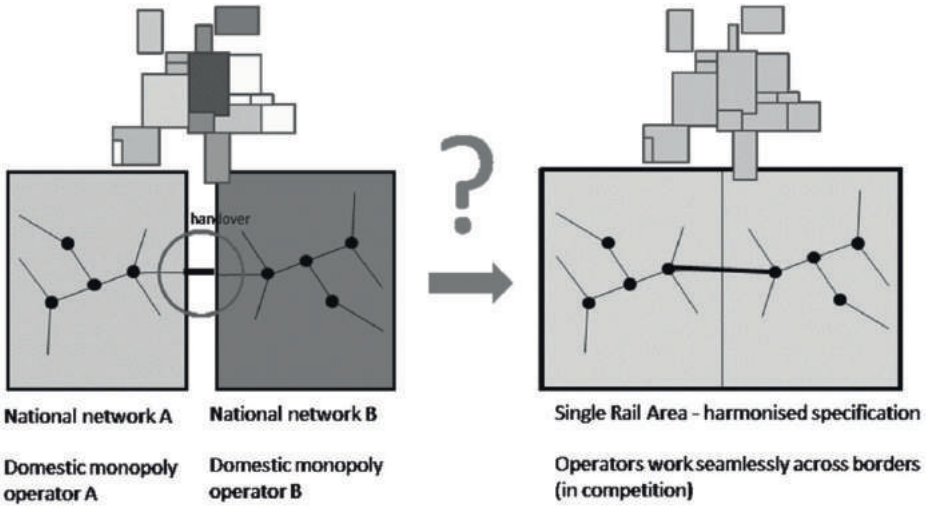

Figure 1. Implementation the Fourth Railway Package objectives in the technical pillar
Source: (Doppelbauer, 2017)

The market pillar, adopted on 14 December 2016, includes the following legal acts:

1) Directive of the European Parliament and of the Council (EU) 2016/2370 amending Directive 2012/34/EU as regards the opening of the market for domestic rail passenger services and the governance of the railway infrastructure;
2) Regulation (EU) 2016/2338 of the European Parliament and of the Council concerning the opening of the market for domestic public services by rail;
3) Regulation (EU) 2016/2337 of the European Parliament and of the Council repealing Council Regulation (EEC) No. 1192/69 on common rules for the normalisation of the accounts of railway undertakings.

The market pillar completes the process of opening up the rail passenger market to competition in terms of 'open access' and the public service obligation (PSO) (Raczyńska, 2017). The implemented regulations assume the full opening of domestic passenger transport for all EU carriers as of 1 January 2019, appropriately in advance before introducing the timetable effective as of 14 December 2020. In the context of PSO tenders, a transitional period has been established in which public service contracts can be executed on a non-tender basis for a period of up to 10 years (possibly up to 2033 at a maximum). The provisions of the Fourth Railway Package also introduce additional safeguards regarding the infrastructure manager's independence in the case of vertically integrated enterprises, including but not limited through:

– separated accounts of the infrastructure manager and other legal entities;
– no influence of other entities on the infrastructure manager's decisions regarding the basic functions;
– a ban on holding functions in corporate bodies of the company (boards of directors and supervisory boards) with the infrastructure manager and the carrier at the same time;
– the financial transparency in the integrated structure (including the ban on granting loans between infrastructure managers and railway undertakings). The amendment of Directive 2012/34 introduced by Directive 2370/2016 (European Parliament, 2016) also provides for strengthening the independence and impartiality of the railway infrastructure manager in order to guarantee equal treatment of railway undertakings (Engelhardt, 2017).

It is the technical pillar of the Fourth Railway Package that is of particular importance in the context of logistics. These regulations will increase the level of interoperability of European railways whereby cross-border transport within the European Union will be simplified. This is of major significance for Poland as it will improve the supply chains. The essence of the issue is presented in Figure 2. The implementation of common permits and safety certificates will accelerate introducing new rolling stock and rail transport technologies, including also combined transport solutions. It should also be hoped that greater supervision of the European Union Railway Agency over the implementation of the ERTMS/ETCS will accelerate the process of equipping the TEN-T network railways with this technology. An effect of introducing the ERTMS/ETCS system will be increasing the level of safety and reducing the risk of railway accidents. The railway traffic management will be more efficient, which will positively affect the capacity of railways and train

punctuality. This system is based on three levels of development and impact range. When the system is implemented, trains will be able to freely cross railway borders in Europe.

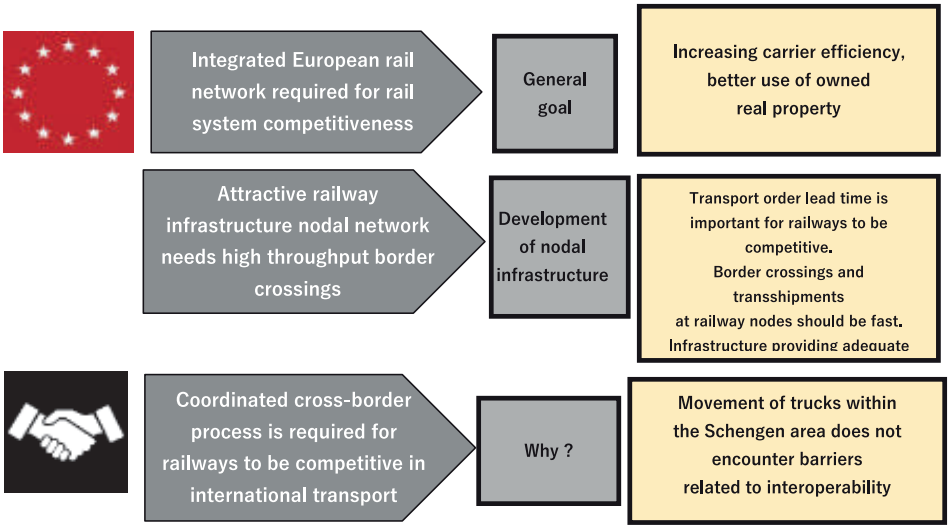

Figure 2. Improved interoperability on the eastern border
Source: (own elaboration based on a paper from a conference at the University of Gdańsk, 2017)

All the above factors will enhance the competitiveness of rail transport without the need for train operators to learn about different traffic control systems. Ensuring the interoperability of the European rail system is an important factor in its development and regaining the transport market. It should be remembered that there are 5 power supply methods for the conductor rail systems in Europe, 5 loading gauges for a 1435 mm track, 14 train control systems, 11 pantograph widths, 4 track gauges, different axle loads on the rail, therefore much time and considerable outlays are required to unify the railway systems.

A new plan (European Deployment Plan) for its implementation on the TEN-T core network in the Member States was established in the ERTMS Implementing Regulation adopted by the European Commission on 5 January 2017. According to the plan, about 50% of the lines located in the corridors of the core network should be equipped with ERTM systems by 2023, while all lines of the core network – by 2030. This is important for the development of the railway industry and it has been included in the Europe 2020 strategy – the Innovation Union (Góra, 2018). The assumptions of this strategy include the application of modern technologies improving the competitiveness of rail transport.

2. Development of nodal infrastructure[2]

It should be noted that some of the European rail regulations, important for the development of rail logistics have already been introduced by Directive 2012/34. Therefore, it is worth considering the Directive and the Fourth Railway Package (which amends it in part) jointly. It is the provisions of Article 13 of Directive 2012/34 that are of key importance. These provisions, which are coming into force in Poland now, define the conditions of access to the service facilities[3] including the nodal transhipping and warehousing infrastructure. The Act of 16 November 2016 amending the Railway Transport Act and some other acts, which is aimed at adjusting the national legal system concerning railway transport to the changes stipulated in Directive 2012/34/EU of the European Parliament and of the Council of 21 November 2012 establishing a single European railway area, has introduced a number of new regulations in respect of the operation of the railway nodal infrastructure, including all types of terminals, both conventional and intermodal. As of December this year the service infrastructure will become publicly available for rail carriers. Before the changes in question were introduced, railway carriers had often decided to have different types of terminals, treating them as an element of a competitive advantage in the fight to win customers. In many cases an important factor to gain a competitive advantage is a comprehensive range of services. Any change in the regulations in this respect may make transport companies resign from providing these types of services, and thus limit their investment activities in a significant way. As the market of terminal operators has not developed in Poland so far, except for operators of intermodal and conventional terminals at railway crossings on the eastern border, it is very likely that there will be a gap in this segment of services. An additional factor favouring such a scenario is the fact that it is costly to build properly equipped terminals, and much time is required to commission them and use their handling capacities in an optimum way.

In the last few years, considerable funds originating from EU programmes have been expedited in Poland to improve the condition of the railway infrastructure. These activities are very important, however, they will not suffice for the rail transport to regain the position on the freight market. Many railway stations and customer service points were built when the market was divided in a different way at the time of the heyday of the bulk transport industry. The approach to organizing the supply chains was also different. At the present time, many facilities using the old technology have been shut down or restructured, and some stations have lost the sources of freight. This situation is the reason why these stations are less profitable as freight generation points. Limiting the operation of stations, or even closing them is the reason why the railway sector has significant reserves of land which can be used for projects related to the development of the logistics infrastructure. The change

[2] A nodal infrastructure is understood as spatially identifiable facilities for handling of loads (generally available unloading facilities, stations, transhipping yards and points, logistics centres).

[3] Pursuant to the amended Railway Transport Act, a service infrastructure facility is a structure including the land on which it is located, and installations and equipment, intended in whole or in part for providing one or more services referred to in par. 2 and 3 of Annex No. 2 to the Act amending the Railway Transport Act. Pursuant to the provisions of Annex No. 2 to this Act the services are provided in service infrastructure facilities, e.g. freight terminals.

in the preferences for using the transport modes has been the reason why the logistic infrastructure for the modern industry is usually provided far away from railway lines, close to a well-developed road infrastructure and investment areas. The new economic conditions have a significant impact on forming the flows and segments of the transported freight, and thus on the transport infrastructure, which is why changes should also take place in respect of the railway loading yards in the broad sense of the term. Poland has good resources to provide a logistics platform for the neighbouring countries. Two rail transport systems i.e. railways with the track gauges of 1435 mm and 1520 mm have a point of contact on the eastern border. Broad-gauge tracks in Poland can be found not only in the form of the LHS line, but also as well-developed track systems at railway border crossing points. Poland is crossed by four pan-European transport corridors the routes of which were established during the Pan-European Transport Conference in Crete in March 1994, and then supplemented at the 3rd Pan-European Transport Conference in Helsinki in 1997. The European Commission have also set two railway transport corridors running through Poland, i.e. Corridor 5 and Corridor 8. At the request of several institutions including the Polish Ministry of Infrastructure and Construction, the European Union agreed to launch a new freight corridor, Corridor 11, the so called Amber Railway Rail Freight Corridor within the period of several forthcoming years which will supplement the already existing routes. Having in mind the trade exchange between China and Europe and the development of the New Silk Road, it seems reasonable to create a large international logistics centre close to the place where it is planned to build the Central Transport Port.

The containerisation of freight, mostly in international transport, has forced the development of the terminal infrastructure. Terminals of this type were built successively as the freight flows were forming on the already existing loading and unloading yards. Most of these terminals were makeshift, and then, they were upgraded and developed using the aid funds. There are currently 36 land terminals operating in Poland. The number of terminals is changing, as some operations are discontinued, while temporary terminals, often serving one client only are created on other sites. Points of concentration of transhipping operations and logistics services that would act as loading points for the so-called dispersed transport should be provided. The terminal operating at such a point should be universal comprising storage yards, small warehouses with loading yards, with the option of handling small intermodal freight flows. Systemic measures and consistently implemented changes in respect of using the transport infrastructure and creating state-of-the-art freight generation points are required to regain the position held by the rail transport several dozen years ago. The State aid for the development of the railway point-to-point infrastructure should be provided until the costs of access to the transport infrastructure are equal for all modes of transport. Activities of this kind can even be hardly called public aid, they should be regarded rather as an attempt to compensate for the unequal treatment in this field only. Quick introduction of the principle of full payment for transport operations would certainly affect the economy. A sudden increase in the cost of production would lower the competitiveness of EU products. However, ultimately, the principle of internalisation of costs should be introduced for the transparent operation

of transport modes[4]. When framing the transport policy of Poland, we have to consider the European Union's recommendations regarding the directions of changes in respect of the transport market division.

The directions adopted by the EU are rather long-term activities, however, they should be gradually implemented at every stage of planning already today. The development and subsequent implementation of the programme to increase the share of rail transport should be started as soon as possible as it will make it possible to avoid problems that will undoubtedly arise if this is delayed. It should be remembered that the direction of changes indicated by the EU requires many companies to reorganize to include the employed staff. A good example of the lack of a forward-looking approach to this issue is the fact that industrial areas are located far away from railways or no space is left for the rail infrastructure and future loading terminals at the stage of planning the development of these areas.

The decision on the future transport infrastructure and the intended purpose of specific plots of land for investment at the stage of planning is made by local governments. They play an important role in the shaping of the transport policy. Therefore, changes in the approach to the role of rail transport in Poland should take place at all levels of the administration. Many local authorities can see the road transport nuisance and actions aimed at establishing multimodal terminals are taken, nonetheless, without the State's support and financial instruments, they are not able to carry the financial burden related to the construction of multimodal ports including the accompanying infrastructure. Having in mind the new regulations introduced by the amendment of the Railway Transport Act, and particularly by Chapter 6, related to the service infrastructure facilities and the rules for providing these facilities to railway carriers, one of the directions of development of facilities of this type will certainly be that they are going to be constructed by entities in which a stake is held by the public sector, the private sector or the railway authorities, as they are independent with respect to the carriers. Access to the logistics infrastructure facilities will certainly be the most transparent in terms of equal treatment for all the railway market players.

Conclusions

The Fourth Railway Package is aimed at improving the competitiveness of the sector by way of lifting the barriers to the creation of a single European railway area. The existing fragmentation of systems is detrimental to the competitive position of the railways with respect to other modes of transport, especially in international traffic. The inconsistency of the regulations at the European level increases the administrative barriers and makes it difficult for new rail operators to enter

[4] Internalization of costs, including external costs, consists in forcing the perpetrator to include the costs originated by him into his economic calculation. It is applied mainly in the environment protection economics, where environmental pollution costs should be covered by perpetrators (mainly the industry and business). Internalization of external costs (internalisation of the effects of one's own economic calculation). It is applied mainly in the environment protection economics, where environmental pollution costs should be covered by perpetrators.

the market. A number of both economic and social aspects, as well as the environmental impact should be taken into account when framing the transport market. Railways and water transport are among the most environmentally friendly modes of transport. This does not mean that only these modes of transport should be used when building the supply chains. State-of-the-art transport systems should use all types of transport in an optimal manner in terms of all costs generated in the process, including external costs. Nonetheless, modern points connecting individual modes of transport are needed to accomplish this task. The amendment to the Railway Transport Act has introduced a number of changes in the railway service infrastructure operation, including all types of terminals and loading yards. In addition to that, changes are needed in the approach to the construction and management of such facilities. The principle of independence of operators of these facilities from railway carriers indicates the directions for future solutions in this respect.

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ANALYSIS OF START-UP ENVIRONMENT IN WROCLAW AND THE ROLE OF THE URBAN INFRASTRUCTURE IN DEVELOPMENT OF INNOVATION PROJECTS

Abstract

The study aims to analyze the start-up environment in Wroclaw and describe the role of the infrastructure in the development of innovation ventures. In her deliberations, the author deploys both the quantitative and qualitative research carried out in the period between December 2016 and August 2017 in cooperation with the Wroclaw Agglomeration Development Agency, (Agencja Rozwoju Aglomeracji Wrocławskiej S.A., ARAW). The results of the research constitute added value as this is the first study in Poland dedicated exclusively to Wroclaw start-ups. The author hopes to continue her research, hence the obtained data is dynamic in its nature.

Keywords: start-up, innovation, city, urban space, infrastructure, Wroclaw

Introduction

More and more innovation projects, i.e. start-ups, are beginning to emerge globally as well as in Poland. The solutions that they propose are highly likely to launch breakthrough innovations in various fields. Start-ups are perceived as drivers of economic growth. According to the forecasts of Deloitte, in 2023 the added value generated by start-ups may amount to as much as PLN 2.2 billion (Deloitte, 2016). This is strictly connected with the role that innovations play in fuelling a competitive economy. With this assumption in mind, economic strength on the long run will rely on two key elements: the number (development scale) of start-ups and their quality measured as the likelihood of success (the percentage of companies that are successful on the market). Given the aforementioned classification of economies, the strongest economy features a large number of flourishing start-ups. The strongest economies include the United States and Israel (inc, 2017).

Whether a start-up will be successful hinges on several factors. According to Bill Gates, who analyzed 200 innovative companies from the perspective of business success factors, the key factors include: the idea behind a start-up, team (work, commitment), business model, financing and the moment of market launch (rozwijamy, 2018). One of the additional elements that cannot be overlooked is the available infrastructure understood as R&D, cultural and social resources intended to foster the growth of innovation projects. The quality of the resources is to a large extent conditional upon the way in which the urban policy is pursued by local authorities and upon the approved course of development of the urban space management strategy.

In her study, the author analyzes the start-up environment in Wroclaw against the background of the existence of innovation ventures in urban space. The author elaborates on the role of the city's spatial planning method in the growth of start-ups. In her concluding remarks, the author proposes recommendations for the city based on the quantitative and qualitative research conducted in the period between December 2016 and August 2017 in cooperation with ARAW.

1. Definition of the terms: start-up and infrastructure

In the paper and in the aforementioned research alike, the author defines a start-up as a small entity (not necessarily a company in commercial terms), primarily (but not exclusively) operating in the field of new technologies.

Eric Ries, one of the major figures in the start-up sector, defines a start-up as follows: a start-up is a human institution designed to deliver a new product or service under conditions of extreme uncertainty. Against this background, the author's research refers to a start-up in a broad sense, without restricting it to the technological sector. This approach is elaborated upon in detail in the book entitled *The Lean Start-up. How Today's Entrepreneurs Use Continuous Innovation to Create Radically Successful Businesses*, recognized by New York Times to be of crucial significance for the understanding of start-ups (Ries, 2012).

Compared with other entities, a start-up is characterized by a higher level of risk, mainly owing to its operation in the sector of technological innovations. A higher risk is usually associated with a higher return on investment provided that the venture is successful.

According to an encyclopaedia entry (Great Universal Encyclopaedia, 1965), the infrastructure means the basic, underlying facilities and systems providing services necessary for the manufacturing sectors of the economy to function. The infrastructure can be split into economic and social. According to Ginsbert-Gebert (1976), the economic infrastructure means the physical basis associated with a specific area, which serves both production and consumption needs in a broad sense. It consists of facilities and institutions necessary for the economy and population to function (Dziembowski, 1966; Ginsbert-Gebert, 1971). The economic infrastructure includes facilities and systems providing transport, communication, power supply, irrigation, farmland drainage services etc.

The social infrastructure refers to facilities, institutions and assets offering services in the area of law, safety, education, healthcare etc. When describing the role of the infrastructure in the development of start-ups, the author considers both meanings of this term, by analyzing the importance of the socio-cultural and institutional resources for innovation projects.

2. Methodological assumptions

The data shown in the paper was obtained in a research project divided into three stages, conducted by the author. The first stage consisted in gathering and analyzing the available data from secondary sources (the so-called desk research). On the basis of the gathered information, a quantitative survey, addressed to start-ups, was prepared and conducted under the second stage of the project. The third stage included qualitative research taking the form of individual in-depth interviews.

The quantitative survey was intended to provide possibly the most precise description of the start-up environment in Wroclaw. Thus, the survey included questions about the registration year, employment and industry.

The individual in-depth interviews added to the statistics. The purpose of the qualitative modules of the survey is to acquire information about topics that have hardly been examined so far. The qualitative research is an attempt to capture a hidden sense which offers a structure to what is said as opposed to what is actually done, as well as to explore, describe more specifically and systematize the real meaning of the discovered social phenomenon (Banister et al., 1994). This is of great significance if start-up entrepreneurs' genuine needs and expectations from the city are to be analyzed.

Both the quantitative and qualitative parts had separate and strictly assigned functions. The quantitative research was based on a survey composed of 16 main questions. In some questions, after choosing a 'yes' answer, the respondent was asked to elaborate on it or make an additional statement.

The respondents were recruited through five channels:

1) a Facebook event (FB);
2) mailing;
3) direct contact;
4) during a selected event – in this case a conference dedicated to start-ups, Start-up Wroclaw: Evolutions in November 2016;
5) www.wroclaw.pl website.

The snowball method was deployed to recruit the target group. It is used if the surveyed population members are difficult to reach. In the method, the researcher looks for a few members of the surveyed population and then asks them to get in touch with their friends who are also members of the population (Babbie, 2007).

Ultimately, n = 108 start-ups took part in the survey, both registered and those operating without registration. It should be pointed out that the difference between the total number of respondents and individual numbers of answers to questions e.g.

about the registration place or the registered office results from the fact that start-ups already in operation, but not registered yet were also admitted to the survey.

It was relatively difficult to define the target group for the research sample. As the notion of a start-up is not unambiguously defined (see Chapter 1 for details), the approach of Ries, an authority for the start-up sector, was assumed.

The qualitative part involved individual in-depth interviews with seven industry experts and start-up owners associated with Wroclaw. The interviewees were selected owing to their discernibly proactive approach in the start-up sector, as well as owing to their role of mentors and authorities for other representatives of innovation projects.

In the study, the author refers to the results of both quantitative and qualitative surveys. The former provide a better picture of the condition of start-ups in Wroclaw, while the latter are an attempt to define the role of the infrastructure in the development of innovation projects.

3. Description of the start-up environment in Wroclaw

A detailed analysis of the environment for innovation ventures in Wroclaw indicates that 71% of the start-ups were established in 2015 and 2016. Hence, they are no more than three years old. 16% were founded between 2013 and 2014, which means that they have been in operation in this form for three to four years. Until now, a business operating in the market for three or more years has been regarded to be a relatively stable enterprise in the European Union. In accordance with the above criteria, 16% of the start-ups have already been through the toughest period, and their offer can be considered to have been accepted by consumers.

Registration place and area of operation. Wroclaw is the key registration place for the start-ups (almost 99%); more than half of them (almost 56%) operate countrywide, while almost 40% carry on business on an international scale (including less than 4% in Europe). Almost one fifth of them indicate both Poland and other countries as their area of operation. What matters is that almost 14% of them carry on business globally, while only 12% of the start-ups are focused on the Wroclaw market.

Start-ups are established mainly by two people (41%) or one (36%) person. Almost a quarter of them have three to six founders. The businesses are most frequently established by males (73%). In the other cases (27%) one or two females were among the founders.

Over half (53%) of the start-ups are sole traders, without any additional personnel. Less than 50% (47%) are registered as Polish limited liability companies, one third (34%) are sole proprietors and 15% of the respondents are limited partnerships or operate in Academic Entrepreneurship Incubators (AIP). 34% of the respondents employ one to nine people (microbusiness category).

Period of employment. The period of employment in the start-ups (in 82% of the cases) usually lasts from one to three years, which can be concluded from the registration period of start-ups. For 10% of the respondents the period

of employment is longer and amounts to 4–9 years. 50% of start-ups hiring personnel employ 1–5 females.

Start-ups are mainly engaged in technology (59%) such as website services (36%), applications (20%) and ICT (3%). Services in a broad sense rank second with 27%. Other much less frequent types of operation include an R&D lab, computer game development, telemedicine and digital learning. The predominant answer to the question about the industry in which start-ups operate (47%) is 'other'. This answer comprises areas associated with technologies, such as nanotechnology, service applications, business platforms, software/computer games, electronic devices, biotechnology, products (diagnostic sets) and (diagnostic) services in healthcare, veterinary science, food quality, pharmaceutical products or Internet of Things, e.g. smart home, CAD modelling and 3D printing, consumer electronics, technology/photography, dedicated mechanical and civil engineering or manufacturing of technological fillers. If the respondents failed to identify their industry in the survey, this may mean that the existing sector designations are insufficient. This may also mean that, according to the reports on jobs of the future prepared i.a. by Deloitte, almost half of the current jobs will cease to exist. This is also evidenced by the research discussed in this study. Slightly above one quarter of the respondents indicated e-commerce. 23% of the start-ups operate in business in a broad sense. 18% of the respondents operate primarily in education, other respondents prefer lifestyle and sports (17% each). 12% of the respondents focus on health. Lifestyle, sports and health also affect the created products and are connected with building environmentally friendly attitudes.

A vast majority of the respondents (almost three quarters) finance their business activity with their own funds. As few as 11% of them indicated EU grants, 6% benefited from the venture capital and 3% received financial support from business angels or accelerators.

The main sales model is reselling (over one quarter of the respondents) or subscription (23% of the companies) 21% of the companies indicated sales models such as B2B, sale of applications per event, sale of a product via a global reseller network, manufacturing model, sale of their own products via the internet (e-stores or online auction and shopping websites), sale of electronic modules with an integrated licence for a service or sale through their own sales team.

Start-up owners' perception of the innovative aspect of the offered product. 58% perceive the offered product as innovative, 42% developed an existing product on the market. The offer by start-ups is mainly addressed to individual customers, microenterprises and SMEs. It should be noted that the offer is also targeted at large businesses (56%), multinationals (37%), institutional clients (34%) and NGOs (17%). This is proved by the declared geographical area of operation for start-ups.

Over 70% of the start-ups are either at an early stage (41%) with a very high operational risk, at the stage of growing sales profitability, or at an earlier stage (33%), i.e. seed (the start-up already has a prototype of its own product or has already placed a finished product on the market).

Almost 40% of the surveyed businesses did not generate any income at the moment of survey. On the other hand, 62% of the businesses declared occasional or irregular income. Over the last six months since the survey, their income

has increased from 20 to 50% for one third of the businesses, less than 20% for 38% of the businesses and over 100% for one fifth of the businesses.

Over one third of the respondents indicate cooperation with higher education institutions/research centres/laboratories. Knowledge sharing and inspirations are considered to be a major driver for the development of start-ups. It should be stressed though that large companies (including multinationals) are more and more interested in a model of cooperation with start-ups. They consider this model to be an innovation and development method for the R&D department.

4. The role of the infrastructure for the development of start-up organizations in Wroclaw

As a result of an analysis of the available reports checking the attractiveness of individual cities for investors, it can be stated that Wroclaw is a business-friendly place. Wroclaw not only boasts of dynamic growth, but it is also a good place to live in. This benchmark looms large on the list of "attractiveness" features evaluated by start-up owners from Wroclaw.

According to PwC's *Report on Polish Metropolitan Areas 2015*, Wroclaw was the most dynamically developing metropolis between 2005 and 2015. According to the results of the study Global Cities of Future 2016/17, prepared by fDi Intelligence, a specialist division from FT Ltd., Wroclaw ranks first among European medium-sized cities in terms of its strategy to attract foreign investment. The city's indisputable strengths include the aforementioned investment attractiveness, the improving infrastructure and the growing level of human capital. What distinguishes Wroclaw from other metropolises is the high quality of education and a valuable labour market.

In the 2017 *Quality of Living* ranking by Mercer Wroclaw holds strong in the top half of the list. It claimed 100th place among 231 surveyed cities. This may be the result of the city's activity. The city gets involved in various events to promote its image on an international scale. In 2012, Wroclaw was one of the host cities for UEFA Euro 2012 and in 2016, it was the European Capital of Culture. The authors of the report see the following as major challenges for the city: improvement of public safety, improvement of public transport and increased social engagement of Wroclaw inhabitants (PWC, 2015).

The dependencies between the start-ups and the available infrastructure go both ways. On the one hand, the available infrastructure affects the development level of start-ups. On the other hand, a growing number of start-ups has a positive impact on the development of the entire urban infrastructure, which provides labour and cultural resources for innovative businesses. A growing number of start-ups means a growing demand for co-working space or HORECA establishments to enable both individual work and group meetings. Hence, the development of start-ups also involves increased employment in other retail and service establishments.

Start-ups promote working standards, which at the same time impacts the business culture; this is demonstrated by expert statements in qualitative surveys.

Moreover, the existence of innovation ventures has a positive effect on the general image of the city, influences the space management method and attracts specific social groups.

Owing to the innovative nature of start-up organizations, they contribute to increased entrepreneurship in local communities. Their existence also affects the way in which urban policy is pursued; more and more frequently, cities offer programmes and tools to support innovation projects. Although start-ups are gaining more and more importance both for national and regional economy, they keep encountering typical issues and adversities which hinder growth such as infrastructure barriers.

In the qualitative survey, the respondents analyzed Wroclaw in detail from the perspective of its benefits and drawbacks as a city where an innovative business can be set up and run. The experts stressed the benefits, but also indicated areas with room for improvement.

Being a university city is Wroclaw's definite advantage. Owing to extensive academic resources, companies gain easy access to the talent pipeline. The experts are not unanimous as to the costs of hiring specialized staff. Some of them consider the costs to be relatively low, in particular compared to the United States, while part of them claim that it is difficult to hire staff. The position of the latter group of experts will be presented in the next part of the study, dedicated to areas for improvement.

The image of the city has a crucial impact on the selection of the place for running a business. Wroclaw boasts of having a good atmosphere which is conducive to creativity. This is a friendly, well-designed and 'green' city. It is perceived in this way by residents and newcomers alike. People are also part of the city's image. The way in which Wroclaw is perceived to a large extent up depends on them.

Wroclaw is an active city offering a broad range of initiatives dedicated to start-ups. The initiatives enable networking, which is of crucial importance for the development of innovation projects. The events organized in Wroclaw include Start-up Wroclaw: Meetup, Start-up Wroclaw: Evolutions, Geek Week (technology weeks during which various local groups interested in IT meet) or the Start-up Weekend.

Start-ups in Wroclaw can count on the support of selected institutions. The Wroclaw Technology Park (WPT) supports start-ups by office space lease at a favourable price. WPT offers the opportunity to rent laboratory equipment within *de minimis* assistance, i.e. for 20–40% of the market price. Moreover, the Lower Silesian Academic Incubator of Entrepreneurship (DAIP), a joint venture of WTP and 12 Lower Silesian higher education institutions, offer training courses. The positive aspects of cooperation between the start-ups and WPT have been stressed by one of the experts who is an active beneficiary of WPT's offer.

The initiative of the Wroclaw Agglomeration Development Agency (ARAW), a municipal company, is also highly appreciated. In cooperation with the Municipal Office, under the Smart City project, the company launches a number of projects addressed to Wroclaw start-ups, including regular events such as "Start-up Wroclaw. Evolutions" and industry meetings such as MeetUp or "Wroclaw Start-up. Beer".

When evaluating Wroclaw from the perspective of running a business, the experts also indicated areas with room for improvement. When referring to the academic nature of Wroclaw, which is regarded to be an advantage, the experts admitted that a large number of graduates does not mean that it is easy to hire a qualified employee.

Not everyone is willing to run an innovative business with a higher risk of failure and a relatively lower salary compared with what multinationals can offer. Multinational corporations offer a safer and more stable environment compared to start-ups. Wroclaw has attracted a number of multinationals because the city's policy favours investments by large players. Hence, not everyone is attracted to start-ups.

What is more, a specific type of work in a start-up may be an issue; continuous learning, knowledge sharing, a flexible approach towards dynamic change, risk tolerance, creativity and an innovative look.

One of the entry barriers is limited access to office space. According to the report *Hot or not – Demand analysis [on the office market] in Poland* issued in March 2017 by JLL, Wroclaw is the third largest (following Warsaw and Krakow) office market in Poland. Permanent interest from the tenants makes the developers more active, which contributes to increased supply of office space in the city.

As mentioned before, what actually distinguishes the city is its ability to attract new investors such as Axiom Law, UBS, Red Embedded and Ryanair. Thus, the tenants in Wroclaw are increasingly active. The adequately developed office market is reflected in higher rental costs. As there are no reliefs for local businesses, beginning entrepreneurs with limited funds will find it difficult to find a good location for their businesses.

Although the respondents appreciate the role played by institutions which support start-ups (such as WPT, Wroclaw Research Centre EIT+, ARAW), they also point to issues related to their operation.

The main issue with WPT and EIT+ is that these organizations are mainly engaged in the lease of space rather than in the whole landscape associated with running an innovation project. What is more, some procedures with WPT are overly complex and formalized, which has an adverse effect on the everyday operation of a start-up.

Another expert mentions formal barriers also with reference to the operation of ARAW. As he sees it, there is too much administration work at the Agency. The Agency is unable to respond in a flexible and dynamic manner because it is a city company bound by all the resulting procedures. Its operation makes sense when addressed to larger entities, but not really to start-ups.

Wroclaw lacks the infrastructure supporting start-ups. The city has neither a campus nor other similar places where it would be possible to study, share knowledge and exchange experiences. It should be emphasized though that Wroclaw is an active city where a lot is going on. According to the experts, there are still too few activities and events focused on start-ups. In the opinion of one of the experts, there are not enough meetings with international guests who are prepared and willing to invest in innovation projects. There are also not enough serious speakers ready to share their experiences.

5. Conclusions and recommendations for further research

It seems that Wroclaw's infrastructure has great potential as regards the growth capacity for start-ups compared to other large cities in Poland. However, this requires certain steps to be taken. For example, Google Campus Warsaw can be a point of reference.

An adequate infrastructure involves pursuing a friendly policy related to the use of space for offices where industry consultations can take place. To this end, Wroclaw ought to allocate dedicated funds from the city budget. More places are necessary, where an office or an individual desk can be rented at an attractive price. An innovative bundle offer should be in place for start-up owners to rent flats accompanied by legal counselling and accounting services. This solution is offered i.a. by Clipster in Gdańsk and the Kielce Technology Park.

The city should actively support start-ups in knowledge sharing and networking i.a. by organizing meetings with authorities and decision-makers, e.g. from the USA, arranging expert consultations, organizing networking space (infrastructure adjustment). Creating a position of a start-up officer at the Municipal Office, in the role of an intermediary between city officials and young start-up owners, will definitely contribute to the exchange of knowledge.

Another way in which the city can support start-ups is the organization of thematic training sessions on the fundamentals of running a business, and administrative assistance. The city ought to take an active part in providing enterprises with basic education.

Closer cooperation with higher education institutions is strongly recommended. Liaising between various environments yields positive results since diverse approaches are introduced and added value is created. There must be trust between institutions and start-ups. A relationship of trust is built if the needs and expectations are clearly expressed by each party engaged in the dialogue. The city may bolster the achievements of individual start-ups by promoting them or publicizing their success stories. In this way, the city will contribute to information sharing and creating role models for other entities in the industry.

The city should also differentiate between various channels to reach start-ups. It is not enough to publish information on the website www.wroclaw.pl. Very few people visit it. Many more people visit Facebook. It seems to be a good idea to use social media in this context. Besides, information about events and projects can be provided during industry events. It is mandatory that the events should be really suited to the needs and expectations of start-ups.

The final message is primarily addressed to the representatives of the industry. Self-organization and facilitation of the start-up environment is a must. Also in this area, the city may actively support the activities of start-up owners, for example, by helping them use the available space in the best possible way.

The completed research forms a basis for continuing the analysis of the start-up environment. In order to make the research model more dynamic, the author suggests that the surveys should be carried out on a regular basis, with the use of a reviewed questionnaire and with more start-ups taking part in the survey.

Hence, a valuable database will be obtained that will help analyse in detail the changes in the Wrocław start-up environment over the years.

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SUPPLY CHAIN MODELS IN GARMENT INDUSTRY

Abstract

The paper presents the results of the study concerning supply chain models which was conducted by the author in Polish garment industry enterprises. The goal of the paper was to identify the types of supply chain models in this sector. The research methods were interviews and direct observations of manufacturing and logistics processes in clothing companies. Four types of supply chains models were characterized on the examples of supply chains of various companies. The criteria taken into consideration when characterizing the models included but were not limited to: the supply chain leader, the manufactured products (mass or individualized), the material flow strategy (push, pull), and the geographical location of the supply chain nodes. The factors differentiating these models were related to competitiveness – first of all, the price, the quality of products and services, the time of delivery, the accessibility of products, the extent of the product range.

Keywords: supply chain strategies, garment industry, supply chain models

Introduction

The term 'supply chain' can be defined in different ways (Ciesielski, Długosz, 2010; Szymoniak, 2010). In this paper it is understood as enterprises linked with one another, between which there is a flow of commodities – raw materials, semi-products, final products, information and funds connected with them (Witkowski, 2010). On the one hand, there are suppliers and sub-suppliers, on the other hand – recipients of these goods and trade intermediaries but also service companies cooperating with them – this is the so called extended supply chain (Hugos, 2011).

In the garment sector, the extended supply chain comprises manufacturers of thread, textiles and knitwear, manufacturers of garments (sewing factories),

distributors, clothing shops, but also subcontractors in such areas as dyeing of fabrics, embroidery and transport or logistics companies, etc.

Cao et al. studied (2008) the coordination practices in different textile and apparel supply chains in Hong Kong. According to the results of these studies, supply chains are generally coordinated by brand owners. This issue was also a subject of the studies carried out by the author of this paper. A general model of a supply chain in the garment industry is presented in Figure 1.

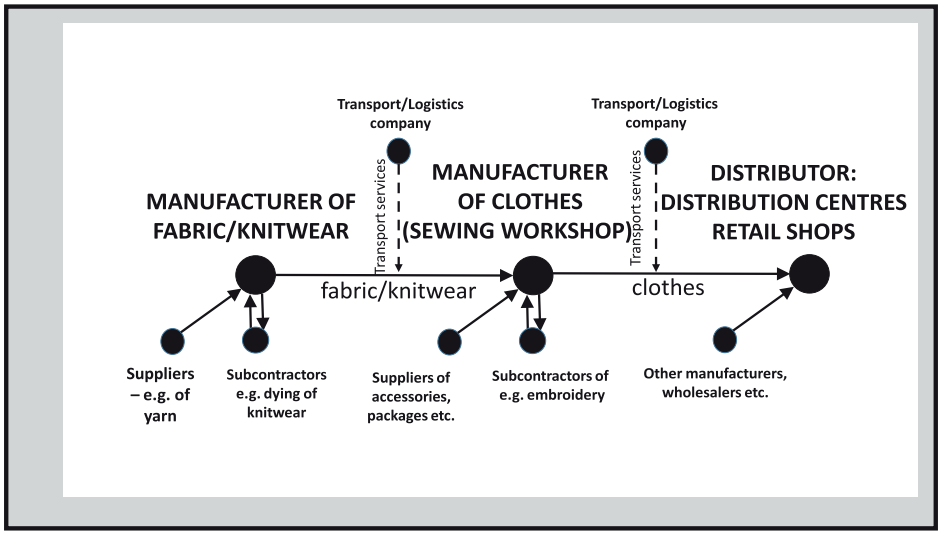

Figure 1. A general model of a supply chain in the clothing industry
Source: (own elaboration)

The paper presents the results of the research conducted by the author in the period between July 2017 and March 2018 in 15 companies from the garment industry[1]. Interviews were conducted with these enterprises and field research was carried out by observation of manufacturing and logistics processes. In the first part of the paper the theoretical background is presented including the criteria for the division of supply chains resulting from the study. In the following sections four types of models of supply chains in the garment industry are described – each on an example of one of the studied enterprises. In the final part a comparison of the models is made including competitiveness factors.

[1] Research conducted as part of the research project: "Modern methods of managing production and logistics processes and their impact on competitiveness on the example of the clothing industry" at the Faculty of Finance and Banking of the WSB University in Poznań.

1. Criteria for division of supply chain models in the garment industry

Creating supply chains is linked with making certain strategic decisions. These include but are not limited to (Ciesielski, 2009):
– Selection of suppliers, distributors and transport or logistics operators;
– Location of factories, warehouses, distribution centres;
– Distribution point and type of flow of materials and goods in the supply chain (pull, push);
– Relationships between participants in the supply chain (partnership, competition).

The logistics strategies of supply chains are formed by various factors, such as the nature of the demand (stable or variable), total delivery time, competition in the industry (price competition, product quality, logistic customer service level) and product characteristics (standard products or individualized) (Ciesielski, 2009; Ciesielski, Długosz, 2010).

These decisions and factors can be treated as criteria characterizing supply chains. The following criteria have been adopted in this article to identify the types of supply chains in the clothing industry:
– Supply chain leader – the manufacturer or an outsourcing company;
– Manufactured products – mass or individualized;
– Flow of materials – sections with the push or pull type flows;
– Location of main warehouse stocks in the supply chain;
– Geographical location of supply chain members, e.g.:
  · production – in low-cost countries, regionally or locally;
  · distribution centres and stores.

Based on the adopted criteria, different types of supply chain models can be distinguished. This article will describe four typical models, on the example of supply chains for specific enterprises.

2. A supply chain model for mass production with a manufacturing outsourcing leader on the example of LPP S.A.[2]

LPP S.A. is the largest clothing company in Poland, designing, distributing and selling clothes under five recognizable brands – Reserved, Cropp, House, Mohito and Sinsay – in 20 countries. The sales network covers the whole of Poland and countries of Central and Eastern Europe; stores are located also in Germany, the United Kingdom, the Balkans and the Middle East. LPP S.A. earns revenues of almost EUR 1.4 billion. The company has been listed on the Warsaw Stock Exchange since 2001, and in 2014 it was included in the WIG20 index (http://www.lpp.sa.com).

[2] Based on information obtained at the LPP S.A. Logistics Center in Pruszcz Gdański in December 2017.

LPP S.A., as a leader in the supply chain, commissions the production of a specific quantity of clothing products according to its own designs and under its own brands to external companies. Therefore, it does not have its own manufacturing plants. It outsources the manufacture of clothing:
– in the low-cost countries (Far East – mainly Bangladesh and China);
– locally or regionally (mainly in Poland and Turkey).

Currently, LPP S.A. strives to increase the share of products manufactured in Poland. Every year, Polish companies are commissioned to manufacture increasingly more clothes – it was already 5 million pieces in 2017. However, compared to the total sales of LPP S.A. (140 million items per year), this is still a small percentage.

The clothes, both manufactured in the low-cost countries, as well as locally or regionally, go to the Logistics Centre in Pruszcz Gdański. The transport time by sea from Asia to Gdańsk is about 30 days. In cases where the priority is to shorten the delivery time, LPP S.A. also uses air transport. The transport time from countries with low production costs is shortened to 7–10 days in this case. Apart from that clothes sewn in Poland and Turkey arrive to the Centre by road transport.

LPP S.A. sells its products in its own stores. There are over 1 700 of them in Poland and in 20 other countries, mainly in Europe. All stores are linked to the Logistics Centre by an IT system, thanks to which information about sales in particular stores is available on an ongoing basis. Orders for individual stores (according to indexes – model, colour, size) are generated centrally. Therefore, stores do not place orders on their own.

In 2017, there was a change in the ordering system for stores, which is related to the change of the distribution strategy from push to pull. Before that, the goods were pushed out of the Logistics Centre as soon as possible and sent to individual stores to reduce the inventory in the Centre. However, this system meant that goods were in stores, and at the same time there was no space for goods that could sell faster. Currently, clothing is shipped to stores as needed. The IT system performs a detailed analysis of sales of individual models in a given store. Shipments of goods from the Logistics Centre are controlled by the actual demand, thanks to which the types of clothing in stores are now better adjusted to the market needs.

The change in the stocking system has improved the adjustment of stocks in stores to the demand, but unfortunately it has influenced an increase in the inventory level in the Logistics Centre. As a result, there was a shortage of space and it was necessary to rent additional warehouses. Presently, the major warehouse stocks are in the Centre and not in the stores. Until the warehouses have been expanded, LPP S.A. will still have to rent warehouse space.

The described model of the supply chain is presented in Figure 2. It is a model with:
– a leader mainly involved in the design and distribution of clothing;
– mass production;
– the push flow between manufacturers and the Logistics Centre, and the pull – between the Logistics Centre and stores;
– major warehouse stocks – in the Logistics Centre;

– the major part of manufacture located in countries with low production costs – in South-East Asia;
– distribution in the company's own stores throughout Poland and in many other European countries.

Similar models are also used by other large Polish clothing companies, such as the Redan Capital Group.

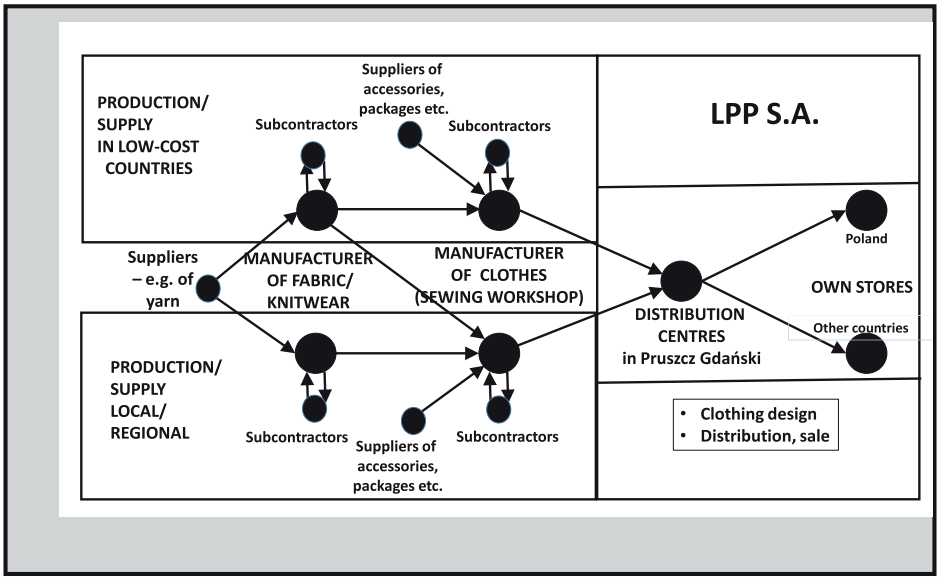

Figure 2. Supply chain model in the clothing industry in mass production with a leader ordering production outside on the example of LPP S.A.
Source: (own elaboration)

3. A supply chain model in individualized production with a manufacturing outsourcing leader on the example of Macaroni Tomato[3]

Macaroni Tomato was established in 2012. It sells exclusive men's clothing – mainly suits, but also jackets and shirts, sewn according to the company's own design and sold under the company's own brand. Also ties, scarves and other accessories imported from Italy are also sold under the company's own brand, while – shoes are sold under a foreign brand. The manufacturing systems for suits sold by Macaroni Tomato are as follows:

– MTM (Make To Measure). It is created for a specific customer already at the design stage. The process of creation begins with taking measurements and selecting the fabric and accessories by the customer (buttons, lining). The time from taking the measurements to the delivery of a sewn though unfinished suit

[3] Based on information obtained at Macaroni Tomato in December 2017.

is about 4 weeks. Then another try-on takes place. The suit is then tailored by a company based in Warsaw, what lasts for approximately 1.5 week. The share of these suits in the company's sales accounts for about 40%.
– MTO (Make To Order). Suits are sewn to an order of a specific customer, from materials selected by the customer (fabric, buttons, lining), but according to a typical pattern. This is recommended for customers who look well in standard suits. These suits also have a share of about 40% in the sales.
– RTW (Ready To Wear). These suits are sewn into stock, in larger quantities, in typical sizes and from typical materials. They are stored in the store and sold 'from the hanger'. Their share in the total sales is about 20%.

Most products are therefore sewn for a specific customer – MTM or MTO. Therefore, these products are individualized.

Macaroni Tomato designs suits, however, the process of sewing is outsourced. Since 2016, they have worked with one Polish manufacturer, sewing about 90% of their clothing. In addition to the Polish manufacturer, Macaroni Tomato also works with an Italian manufacturer. In Italy, about 10% of products are sewn in the MTM system only. The Polish manufacturer sews in the MTM, MTO and RTW systems.

Macaroni Tomato's main raw material for the manufacture of suits, jackets and shirts are Italian fabrics. They are bought in 2 systems:
– A 'wholesale' system – buying whole bales of selected, typical fabrics, ordered in Poland through agents, but manufactured in Italy to order. Such an order is carried out for about 3 months as it takes so much time to manufacture the fabrics. One bale of material usually suffices for sewing 15–18 suits. Fabrics in this system are delivered several times a year. These fabrics are therefore purchased to stock. Larger stocks are kept for better rotating fabrics, smaller ones – for worse. At Macaroni Tomato, 60–70% of fabrics are purchased in this way.
– 'The coupon system' – ordering less typical materials for a specific suit ordered by the customer. Therefore, in this system, it is not whole bales of material (50–60 m) that are purchased, but only as much as is needed (cut length). Fabrics are bought from large companies, which sell fabrics in small quantities. The price of a fabric ordered in this system is 3–4 times higher, but it takes about 3 days to complete an order. 30–40% of fabrics are bought in this way. This system is only used for tailored suits (MTM). Sewing from a coupon in the MTO system would be unprofitable due to the fact that the largest component of the suit price is the cost of fabric, and suits sewn in the MTO system are much cheaper than those made in the MTM system.

The purchased fabrics are transported by a courier company directly to the manufacturer – a company that sews suits.

The described supply chain model is presented in Figure 3. It is a model with individualized production (mainly MTM and MTO) and a leader commissioning production outside, locally (in Poland) and regionally (in Italy), exclusively from Italian materials. In the case of suits sewn in the MTM system, the pull type flow is between the manufacturer of the fabric and the sewing workshop, as well as between the sewing workshop and the store, so there are no stocks in a warehouse or in a sewing factory. In this case, the main warehouse stocks in a supply

chain are stored by the fabric manufacturer which sells them in the coupon system. In the case of MTO, suits are manufactured from previously purchased materials, therefore, the pull type occurs on the section between the sewing factory and the store only. Therefore, the main warehouse stocks are in the sewing factory where materials are stocked. However, in the case of suits sewn in the RTW system, the flow is of the push type on the whole-length and stocks of ready suits are kept in the store.

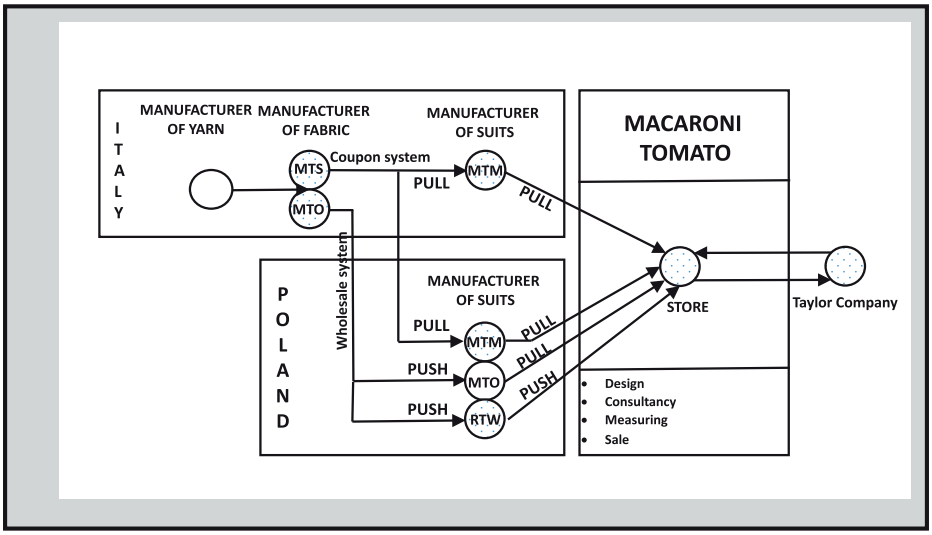

Figure 3. The supply chain model in individualized production with a manufacturing outsourcing leader on the example of Macaroni Tomato
Source: (own elaboration)

4. Supply chain model for mass production with the manufacturer as the leader on the example of Unikat[4]

Unikat, Civil Partnership, is a Polish manufacturer of women's lingerie, sewing products according to their own designs and selling them under their own brand. The company has operated since 1995. Currently, it employs approx. 50 people, 35 of whom work directly in the manufacturing department. However, the company does not have its own stores.

It takes about 6 months to design a collection. New collections are created twice a year. Sewing a new collection starts about a month before the sale begins. Catalogues are delivered to stores by sales representatives. If the ordered goods are in stock, they are shipped on the second day. If a shape or a size is missing, Unikat will manufacture it, however, it can take even up to a month to fulfil such an order.

Logistic operators organize the transport of ordered goods to stores. Products are sold in several hundred stores throughout Poland. These are stores that also sell

[4] Based on information obtained at Unikat in November 2017.

underwear of other brands. Information from the market (from stores) is obtained through visits of sales representatives and through telephone and e-mail contacts when placing orders. Each store is visited once a month by a sales representative who collects orders in stores.

Most of the manufacturing materials are imported from Italy and Switzerland. Some of the materials are also purchased in Poland from importers. The delivery time of materials for manufacturing is 3 to 6 months.

Large stocks are kept in the company's warehouse:

– finished products – rotation of these stocks is 3–4 months or even more;
– work in progress (interoperational stocks, which results from the way in which the manufacturing process is organized and from the human factor – high absenteeism);
– materials and additions for manufacturing (stocks of most materials are maintained for 1–2 manufacturing batches.

Products are sewn in batches. A typical production batch sewn before the season is 50 pieces from each of the thirty sizes. Sewing usually lasts for about 2 weeks. Such a batch does not block the production capacity for too long, but it allows examining the interest of customers in a given model. Later, as the stocks run out, the missing sizes are sewn.

The described supply chain model is presented in Figure 4. It is a model with mass production where the manufacturer plays the role of the leader, selling products in foreign stores throughout Poland. Suppliers of materials are located abroad (Italy, Switzerland), the order execution period is long. Finished products are manufactured mainly on the basis of forecasts and not actual demand. There is no current information from stores – hence, stocks of finished products in the company's warehouse are very large.

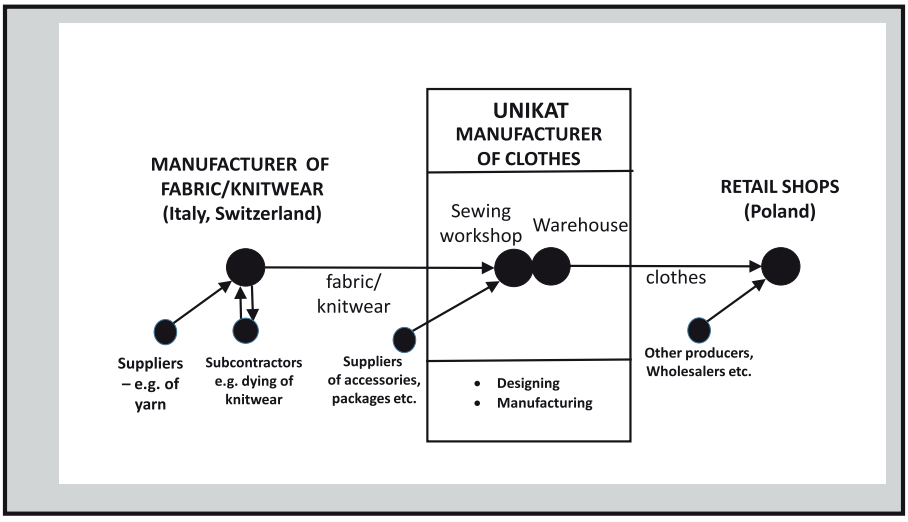

Figure 4. Supply chain model in mass production, with the leader as the manufacturer of clothes, on the example of Unikat
Source: (own elaboration)

5. Supply chain model in individualized production with the manufacturer as the leader on the example of Keia[5]

Keia is a small manufacturer of specialist, mainly medical cosmetic and protective clothing based in Szczecin, operating in the West Pomeranian region since 2007. The company's customers are both institutions (e.g. hospitals, clinics, beauty stores), as well as individuals (e.g. students of medicine, nurses).

The company sews clothes mainly on individual orders, according to its own unique design or according to the client's design; it also designs and sews clothes for oversized or undersized people. The original collection of clothing is presented at exhibitions and medical fashion shows. The product range is wide, and typical sizes are treated only as a starting point in the course of the sewing process of a product for a specific person – clothing is sewn for a specific customer.

Measurements are taken from each person for whom the clothes are sewn in the company – thanks to this, the clothes fit well and the company saves on the costs of corrections, while maintaining the principle of quality management – 'do everything right the first time'. The time of completion of small orders (up to 10 items) is short (up to 48 hours), while a large order, such as medical clothes for employees of a hospital takes about a month.

The goods are manufactured on a specific order. After the order is accepted, the material requirement is calculated and the necessary components are ordered and delivered on the next day. When the garments have been sewn, they are shipped to the customer.

A certain, very small portion of the production, typical sizes and styles, is sold 'from the hanger' – thus, it is in stock in the company's store. However, the main portion of the production is regulated by the actual demand – it is a pull type flow, both between the manufacturer and the customer, as well as between the supplier and the manufacturer. Therefore, stocks of both finished products and materials are very small.

The company makes free alterations and repairs. Also, customers, who buy typical sizes 'from the hanger' online or in the company's store, have the option of free matching of selected clothes on the spot.

The described supply chain model is presented in Figure 5. It is a model with mainly individual production, low stocks and with the manufacturer as the leader.

[5] Based on information obtained at Keia in September 2017.

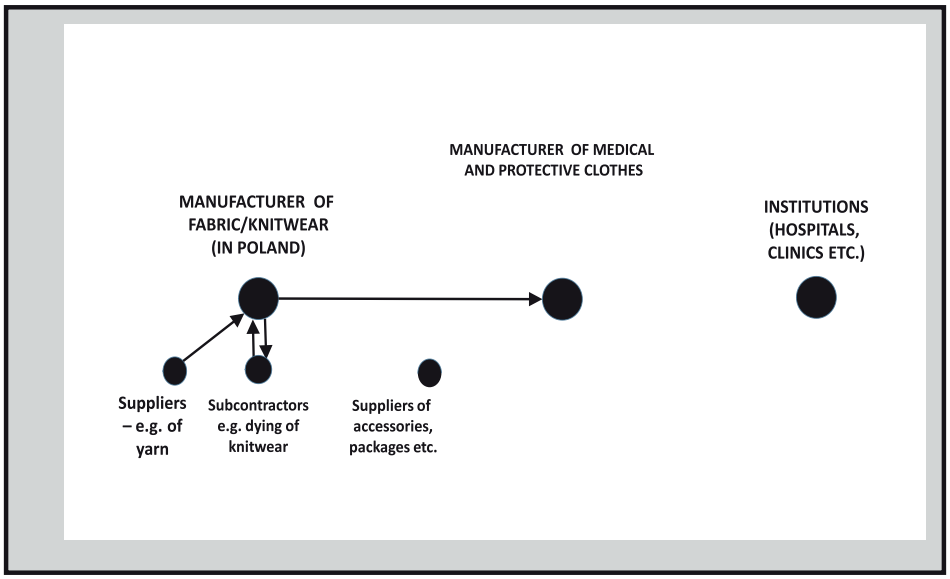

Figure 5. The supply chain model in individualized production with the leader as the manufacturer of clothes on the example of Keia
Source: (own elaboration)

Conclusions

There are both similarities and differences between the characterized models of supply chains in the clothing industry.

Leaders in supply chains in the clothing industry are often companies that design, distribute and sell products, but do not have their own sewing workshops. In this way, the largest Polish clothing companies, such as LPP S.A. outsource production mainly in countries with low production costs. Although due to the desire to increase the response to changes in fashion, there is a tendency to increase the share of production locally and regionally. The share of air transport from manufacturers located in countries with low production costs to Poland is increasing. The supply chains of the largest clothing companies are characterized by manufacture of standard products. The material flow between manufacturers and the Logistics Centre is of the push type. However, there is a tendency to change the flow from push to pull on the section between the Logistics Centre and the stores – companies are increasingly trying to adapt this flow to the demand. The positive aspect of such adjustment of goods to the demand is a reduction in stocks in stores. However, this entails increasing stock levels in the Logistics Centre. An advantage of using this model are low costs, mainly due to the mass production in countries with low production costs – and thus the ability to compete on price – and a well-developed distribution system, increasing the spatial accessibility of goods. A disadvantage is a long response time to the market needs, but also sensitivity to an increase

in the transport costs (especially – in maritime transport), exchange rate fluctuations and increasing manufacture costs in Southeast Asian countries.

Supply chain leaders in the clothing industry are sometimes small companies that do not have their own sewing workshops that design and sell products, such as Macaroni Tomato. Such companies, operating on a small scale, can focus on the individual customer, designing and selling tailor-made clothes, exactly according to the customer's order. As these products are relatively expensive, and customers care about high quality, production is outsourced locally or regionally. The individualized production is associated with shifting the main stocks up the supply chain – e.g. in the case of tailored clothing – to the fabric manufacturer. The waiting time for a finished product is relatively long, the sale price is high, but it is compensated by the high quality of the design and workmanship, exceptional service and the ability to adapt the products to the customer's individual wishes.

The supply chain leader is often also a company with its own sewing workshop, which also designs products. If such companies, like the described Unikat, sew standard products for the warehouse, and they do not have their own stores, they may have problems with obtaining current information from the market, which is associated with the risk of excessive stocks of finished products. However, there is no such risk if production is individualized for a specific customer, as is in the case with Keia. However, the delivery time is longer with larger orders.

The features of a typical supply chain model in the clothing industry in Poland are presented in Table 1.

Table 1. Comparison of supply chain models in the clothing industry in Poland

Supply chain leader; activities	Distribution and sale	Characteristics of production	Place of main storage in supply chain
LPP S.A. – design, distribution and sale	Logistic centre; network of the company's own stores in Poland and in 20 other countries; online sales	– Mass – Outsourced – Mainly – in countries with low production costs	Logistics Centre, From manufacturers to the Logistics Centre – push, from the Centre to stores – pull
Macaroni Tomato – design, sale	Own sales store Online sales	– Mainly individualized (MTM 40%, MTO 40%, RTW 20%), – Outsourced – Sewing factories in Poland and Italy	MTM – at the fabric manufacturer MTO – in sewing workshops RTW – in the store
Unikat – design, manufacture	Warehouse of finished products, sales in several hundreds of foreign stores, online sales	– Mass – Own sewing workshop – In Poland	Warehouse of finished products
Keia – design, manufacture, sale	Delivery to customers, company's store, online sales	– Mainly individualized – Own sewing workshop – In Poland	Fabric supplier

Source: (own elaboration)

In all the studied supply chains the leader was a company with its own brand, both when the manufacturing was done by the company and when it was outsourced.

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KEY CHANGES TO THE ISO 9001, ISO 14001, ISO 27001 MANAGEMENT STANDARDS IN THE APPROACH TO THE ORGANIZATIONAL CONTEXT INCLUDING RISK MANAGEMENT

Abstract

The aim of the publication is to show new areas required for use in the organization according to the quality management, environmental and information security management systems and to show how the new requirements of the organizational context analysis, inclusive of risk assessment, affect the activities of small and medium-sized enterprises.

Key words: ISO 9001, ISO 14001, ISO 27001, organizational context, risk assessment, ISO standards

Introduction

The standards for management systems described by the ISO standards are amended every 8–10 years on average, in line with the principle of continuous improvement. The last significant amendment was made in 2015. The ISO 9001 quality management, ISO 14001 environmental management, and ISO 27001 information security management systems were extended to include components of analysis of the impacts of the organization' external and internal environment on its operation. Additional requirements for analysing the organization's context, identifying threats and opportunities and risk assessment were adapted to the existing process approach of the ISO standards. These requirements are naturally to be met by large organizations and corporations, as it is companies of such type that base their management mechanisms on documented activities of such type. Nevertheless, micro and small enterprises already have problems with implementing this requirement into their organizational cultures. Although they carry out

threat assessments and environmental analysis as every organization operating on the market, nonetheless, these activities are often conducted on an *ad hoc* or even incidental basis. These are not systemic activities and they are not documented in structures of this type. Hence, the requirements of the 2015 ISO standards are difficult to adopt and document in small and medium-sized enterprises.

1. Evaluation of ISO management systems over last 20 years

The ISO 9001, ISO 14001 and ISO 27001 management standards are formal organizing system, a set of requirements related to the implementation of management systems in enterprises, including but not limited to, management with respect to quality, environment or information security. They unify the approach to systemic management applied by companies of various types. This allows organizations, without any specialized background support, to learn the basic directions of development of quality, environmental and information security systems and gives them the opportunity to develop their own systems. In the eighties of the last century, enterprises in Europe developed rapidly and it became necessary to define unified and universal requirements for the customer-enterprise, enterprise – supplier relations. This need lay at the basis of the development of the British BS 5750 standard adopted in 1979. The British standard was the basis for the development of international requirements contained in the ISO 9000 series of standards adopted in 1987. This standard was changed in 1996 (PN-ISO 9001:1996) which was followed by international editions in 2000 (PN-EN ISO 9001:2001) and 2008 (PN-EN ISO 9001:2009). The currently applicable latest standard is from 2015 (PN-EN ISO 9001:2015-10). The environmental management standard which is originally derived from the Rotterdam Charter prepared in 1991 underwent an analogous history of changes. This Charter was the basis for the development of the ISO 14001 standard for the environmental management system in 1998 (PN-EN ISO 14001:1998). Similarly to the quality standard, the environmental management standard was amended by the ISO in 2004 (PN-EN ISO 14001:2005) and the currently applicable standard was amended in 2015 (PN-EN ISO 14001:2015-09).

The same path was taken by the information security management standard dating back to the British standard BS 7799-1 of 1995, which was a set or a code of practices to be implemented for information security purposes. In Poland, this standard was reflected by the PN-ISO/IEC 1799:2003 and PN-I-07799-2:2005 standards. The key amendment to this standard in 2014 (PN-ISO/IEC 27001:2014-12) in the English version was indeed the basis for the amendments to the quality and environmental standards. It was exactly the information security standard that introduced the requirements for identifying the organizational context as well as opportunities and threats into the ISO 9001 and ISO 14001 standards, thus mobilizing the organization to conduct risk assessment and take actions in respect of business continuity planning. Nonetheless, the currently applicable standard published by the Polish Committee for Standardization originates from 2017 (PN-EN ISO/IEC 27001:2017-06) – however, this is not the date on which the international standard was issued (as the standard is from 2014), but it is the date of the translation into Polish.

2. The idea of amendments to management standards in 2015

It should be noted that the fundamental premises for the quality management, information security and environmental management standards are the following:

- organizing the formal and legal status – compliance or greater likelihood of compliance with the legal requirements;
- better cooperation and relations with the society, the authorities and the inspection bodies;
- increasing the company's competitiveness – a better image of the company in the eyes of potential customers and investors;
- increasing the company's stability and security;
- rational calculation of insurance costs;
- motivating the employees;
- saving time and human effort;
- limiting the impact on the natural environment.

The above premises, implemented over a period of 5 years, in respect of the management standards were based on the following management model – the Deming Cycle.

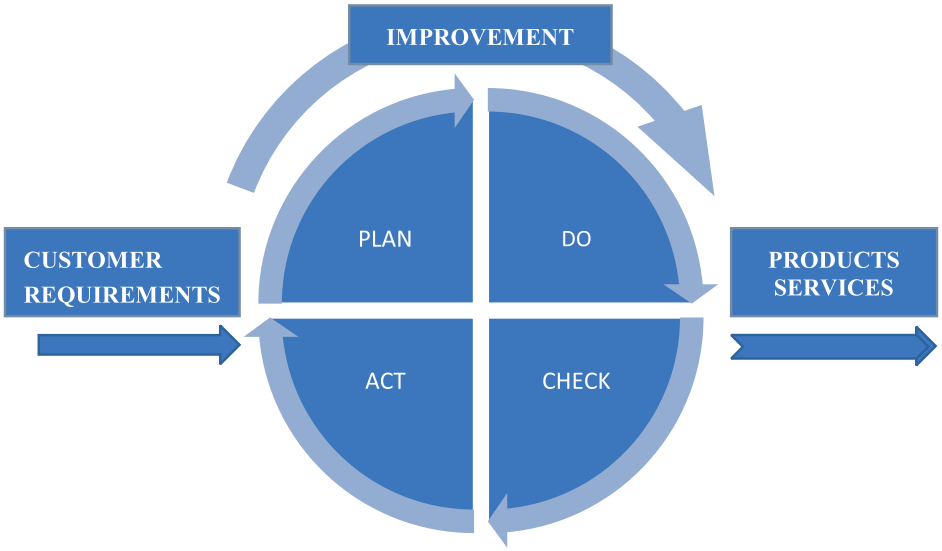

Figure 1. The management system idea: Plan-Do-Check-Act (PDCA) according to PN-EN ISO 9001:2009
Source: (PN-EN ISO 9001:2009 – Quality management systems – Requirements)

The key change in the system management model is placing leaders/managers in the management centre of the organization, and not only at the planning stage as was the case before. Another change is also the indication of additional components affecting the management system, such as the organizational context as well as opportunities and threats. The new management system model according to the arrangements of 2015 is presented in the following diagram.

Figure 2. The management system idea according to the new PN-EN ISO 9001:2015-10 standard
Source: (PN-EN ISO 9001:2015-10 – Quality management systems – Requirements)

A fundamental condition to successfully fulfil the requirements of the management system standards is commitment of the top management and the belief that involved leadership is an important factor in the organizational development whereby the organization can well perform the tasks assigned to it. Without this conviction the system can become an unnecessary burden that does not bring the expected results.

3. New requirements for management standards in 2015

Obviously there were more changes to the standards of 2015 that described above. The changes included the method of documenting the functioning of management systems, relations with suppliers and particularly supervision over them, overseeing non-compliant products and requirements regarding auditing. These changes do not significantly affect the functioning of the systems but they are rather more specific for them in terms of details. However, the new requirements in respect of the organizational context and identification of opportunities and threats introduce major changes to the approach to management. Hence, what is currently implemented by large organizations is often a problem for smaller enterprises. Analysis of external and internal strategic factors affecting the organization is not a one-off task following the requirements for the system, but it is a task regularly performed by the management. The organization supervises and checks, on a currents basis, where significant changes occur and ensures that significant changes have resulted from the management system functioning. The tool for such assessment for small organizations it the SWOT analysis. This allows easy assessment of external and internal factors as well as strengths and weaknesses of the organization. In respect of the discussed systems this will concern the quality of products/services, environmental impact and the possibilities of ensuring information security. The stakeholders of the company are all entities that may have requirements and expectations, and thus affect the company.

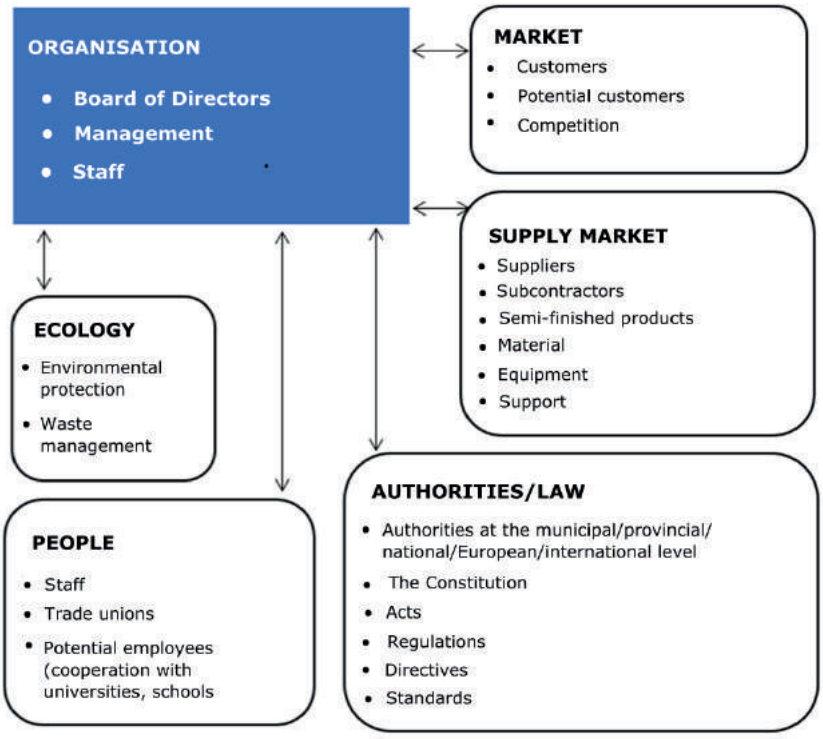

Figure 3. Components of the environment – stakeholders interested in the organization's operations (based on PN-EN ISO 9001:2015-10)
Source: (own elaboration)

The mutual relations between the stakeholders and the organization should be defined for all identified stakeholders in each system. Significant threats and opportunities should be identified for specific elements. The enterprise should assess the risk for each link, by analysing the impact of threats and their possible occurrence. The identified documented risks should be estimated by the organization and then, depending on the criteria, corrective and preventive actions, security measures or established business continuity plans should be introduced. In small enterprises these activities are carried out by teams appointed for this task. The team consists of the owner, his/her assistant or secretary, the contact person for customers, the contact person for suppliers, an accountant and often external advisors such as OHS, IT or environmental experts. The most common result of the brainstorming of this team is a SWOT analysis.

4. Application of new ISO 2015 requirements in small and medium-sized enterprises

Quality, environmental, information security management systems basically have one common idea – to regularly identify threats, assess risks and undertake

preventive and improvement actions. In practice, the introduction of these systems significantly helps small enterprises in their daily operations. The following results were obtained from surveys conducted among micro and small enterprises.

In the area of identification of legal requirements and assessment of their compliance, the requirements stipulated in the standards were the reason why most entrepreneurs have already successfully implemented the already familiar legal requirements in their organizations.

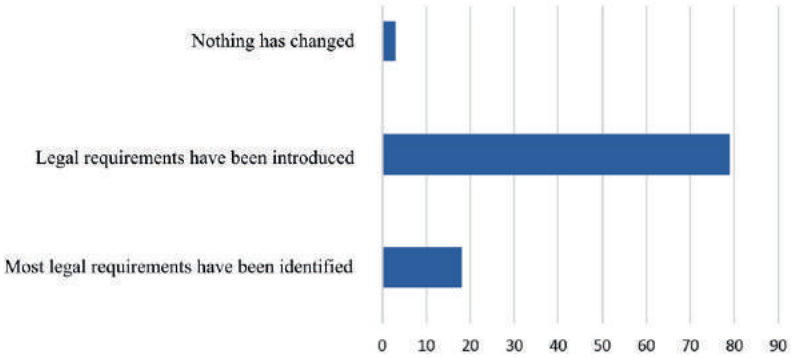

Figure 4. Percentage results of the survey in answer to the question: What has changed in your organization with the obligation to identify the legal requirements?
Source: (own elaboration)

In respect of identification and documenting of threats, small entrepreneurs indicated problems with carrying out these activities because the issue had not been known or used by them so far. The following results were obtained in answer to the question asked about problems in this area.

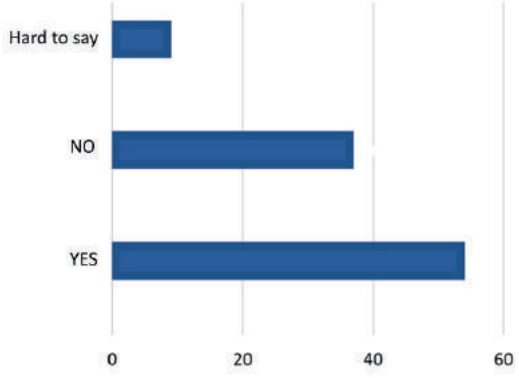

Figure 5. Percentage results of the questionnaire survey in answer to the question: Have you had any problems in identifying threats and documenting them?
Source: (own elaboration)

Importantly, it can be seen that small entrepreneurs are visibly satisfied from the implementation of the risk monitoring tools. It follows from the conducted interviews that the monitoring has given them a sense of control and overseeing, which often escaped them before – which is admitted by them now.

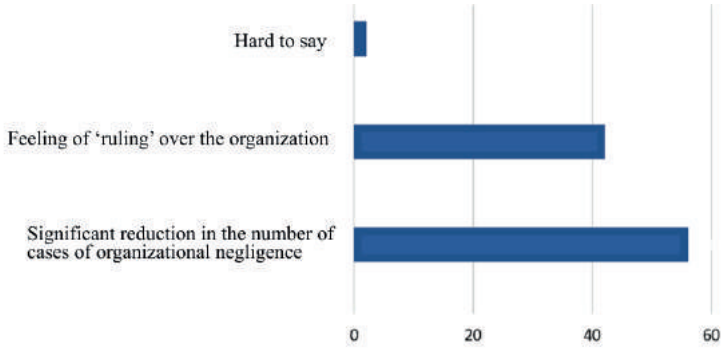

Figure 6. Percentage results of the questionnaire survey in answer to the question: What has been gained by monitoring the risks?
Source: (own elaboration)

The surveyed entrepreneurs also drew attention to the fact that after the implementation of management systems their enterprise is perceived differently on the market. They have obtained the attributes of a 'reliable company', a 'stable enterprise', a 'safe business partner'.

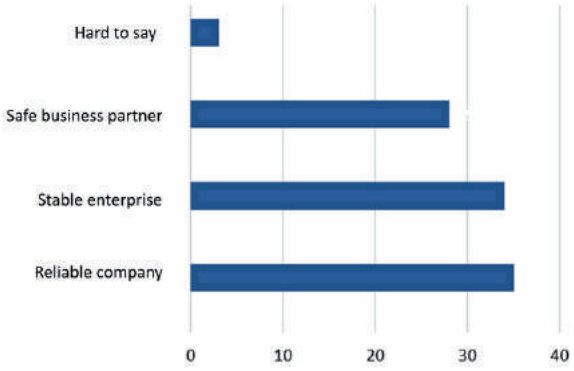

Figure 7. Percentage results of the questionnaire survey in answer to the question: How is the organization perceived by the environment after implementation of management systems?
Source: (own elaboration)

A change in the requirements of the standards is also a change in the way of documenting the system activities. The surveyed enterprises have indicated that 'documented information' in accordance with the new requirements stipulated

in the standard also includes all information currently contained in the IT systems. Such documentation of work has made it possible to discontinue entries in the paper form – which was often an artificial form of documenting activities in the system. This flexibility stipulated in the requirements of the standard and implemented in the enterprise has allowed developing management systems that efficiently monitor and oversee all activities. This has been confirmed by small entrepreneurs in the survey and in the interviews.

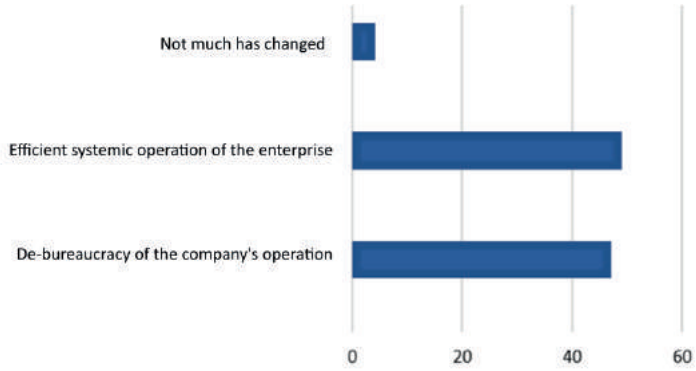

Figure 8. Percentage results of the questionnaire survey in answer to the question: What has changed in your organization after implementation of the new requirements of the 2015 standards?
Source: (own elaboration)

It is also worth noting that the new standards emphasize the HR relations and caring for the employee. The questionnaire survey results clearly show that due to the changes in the 2015 standards, there has been a significantly growing sense of value and safety of employees.

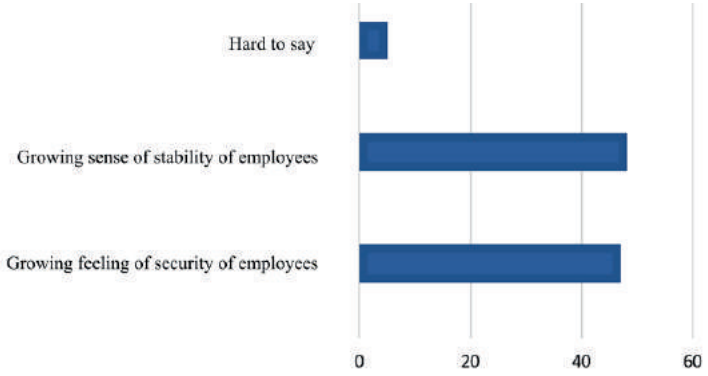

Figure 9. Percentage results of the questionnaire survey in answer to the question: What has changed in your organization after implementation of the new requirements of the 2015 standards?
Source: (own elaboration)

5. Effects of implementing the new ISO 9001, ISO 14001, ISO 27001 requirements in small and medium-sized enterprises

In practice, the introduction of these management systems significantly helps small enterprises to:

- identify the legal requirements, understand them and apply them in the enterprise;
- identify significant (business, security, environmental, quality) threats;
- introduce system solutions for monitoring threats and procedures for responding to threats;
- achieve a stable position on the market and have the organization perceived as safe by third parties;
- organize regular ongoing work;
- give the feeling of value and security to employees.

Most of the small entrepreneurs surveyed indicate that despite problems with understanding and documenting the activities aimed at identifying the environment and the threats, they are satisfied with the path that they have covered. They have realized that superficial analyses conducted 'in mind' are not as objective as risk assessments conducted in a reliable way. Having implemented and certified their management systems, most small entrepreneurs are satisfied with the path which they covered and with the business effects that they have achieved, although, as they emphasize, 'it was not easy'.

Conclusions

In 2015 the requirements of the ISO standards concerning quality, safety and environmental management significantly changed. The process approach was extended to include components of organizational context identification, including external factors and internal factors affecting the functioning of the organization. The component of identification of opportunities and threats, risk estimation and business continuity plans have been introduced to the standards on a permanent basis. The above-mentioned components had been in place in larger organizations for a long time and they had been heavily documented. However, the introduction of these requirements was quite a challenge for the micro and small enterprises sector. It seemed a difficult but not impossible thing to implement. Representatives of small and medium entrepreneurs admit that they had intuitively some of these actions in place, however, they were not systematized. As a result, entrepreneurs from the SME sector have very positively accepted the requirements of the new standards and they have become convinced as to the effectiveness of system management.

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SUPPLIER PARKS AND AGENT-BASED TECHNOLOGIES AS EFFICIENT SOLUTIONS FOR COMPLEXITY MANAGEMENT IN AUTOMOTIVE INDUSTRY

Abstract

Due to their geographical dispersion and multi-national supply networks global supply chains are not able to manage logistics without proper technologies and organizational solutions. In the last two decades, few solutions have appeared which would change the traditional logistics management concepts. These include, but are not limited to, supplier parks (and their successors) and agent-based technologies. These concepts support implementing the BTO strategy in the automotive industry and help to manage complexity, especially in the area of variant management in the case of multi-variant products.

Keywords: software agents, supplier parks, automotive, complexity management

Introduction

The development of international business has resulted in a number of changes in the global market. Capital concentration, caused by a series of mergers and acquisitions, has led to the creation of transnational corporations (TNCs), which later transformed into network organizations. The technology development has simplified communication at a distance, which has allowed carrying on business simultaneously in different parts of the world. This development should be supported by process solutions (coordinating the order and performance of individual activities) and technical solutions to support them.

Network organizations, the latest stage in the evolution of network solutions, move operations to countries with less expensive factors of production. Processes of regional specialization, creating industrial monocultures, globalization of business

and its fragmentation have started on the global market. Business ecosystems of network organizations, bringing together whole supply chains and elements of the external environment (e.g. competitors), due to their size, must be based on a smooth flow of data and apply the latest information technologies.

The development of information technologies and a growing role of intangible resources in shaping the competitive advantage of enterprises has led to the development of flexible forms of knowledge-based organizations (including flexible supply chains) that are focused on an effective use of knowledge as a critical resource, e.g. through diffusion of knowledge (see Table 1).

Today, companies pursue the concept of a learning organization closely related to the information society and knowledge-based economy concepts. Learning in such an organization is a continuous process, such as improvement of information and knowledge management. An organization may be called intelligent when it has reached a state of perfection as a result of learning processes. This entity is able to respond to changes in the environment and also understands and avoids shortcomings in its activities. The intelligence of an organization is described as a synergy effect of cooperation of the intelligence of its employees and various bits of functional intelligence.

The concept of 'fractal organization' means an independent business unit which has specific, certain objectives and its activity can be described as separate from other units. From this perspective, a fractal can be, for example, one of the organization departments (microfractal) or a whole organization (macrofractal). Microfractals are parts of the entire fractal organization (macrofractal). Global equity groups are macrofractals and subordinate subsidiaries – microfractals. However, the structure of capital relations in the global market is so complicated that there are often microfractals that are at the same time macrofractals for subsequent subsidiaries and subunits (one organization is both micro- and macrofractal). A virtual organization can be understood in many ways (as a network of interconnected computers between which there is a transfer of information; as an organization acting on the boundary between reality and fiction, etc.). Mostly, in the context of global market changes, it is defined as temporary cooperation of organizations that are separate but depend on each other, or as an organization functioning in the virtual environment only.

Those features can be achieved by stimulating the so-called smart growth, sustainable development and social inclusion. Information and communication technologies are expected to contribute to the acceleration of economic recovery and creating a 'knowledge-based economy' and 'sustainable digital future' (European Digital Agenda, 2015). It will be accompanied by the development of flexible manufacturing systems (FMS), supported by data communication networks and by robotics and automation of processes resulting in a pursuit of 'unpopulated factories'. The work will be intellectualised for both people and advanced IT solutions (Goban-Klas, 1999).

Table 1. Characteristics of today's transnational organizations

Organization type	Characteristics
Learning organization	– continuous learning – continuous process improvement – openness to criticism – flattened organizational structure – collective learning system – willingness to take risks – high innovation level – gaining new competencies – involving all staff in learning processes – delegation of power – expanded expert knowledge – management commitment – use of employee potential
Intelligent organization	– full internal information openness – investing in core competencies of professionals – focusing on multiplication of knowledge and exponentiation of convergence and synergy – organizational culture based on mutual respect, trust, willingness to co-operate with other employees in various configurations – IT infrastructure supporting communication in permanent and temporary teams – collaborative organizational forms (project organization, matrix organization) – creating innovative ideas through synergy of work of all team members (especially interdisciplinary teams) – full internal openness to sharing information – blurred boundaries between different types of information used, but also technologies, tools and information distribution channels (convergence) – pressure on multiplication of knowledge and competencies
Fractal (self-similar) organization	– structural, strategic and managerial similarity – freedom of decision-making – self-organization – self-optimization – system of objectives resulting from fractal targets – dynamism – orientation to create added value for the customer – developing synergy effects through fractal interaction – horizontal communication – removal of space-time barriers
Virtual organization	– task nature (project nature), dynamic project groups and virtual teams – intangible nature – a large role of the planning of communication processes and implementation of accompanying technologies – telecommuting (geographic dispersion of workers) – simultaneous use of modern communication techniques (Internet, Intranet and Extranet) – minimal possession and consumption of physical resources

Source: (own elaboration, referring to Kłak, 2010)

The main objective of this paper is to prove that supplier parks and agent-based technologies are ideas to help complexity management of logistics systems in an era of rapidly growing global network organizations in the automotive industry, one of the most dynamic and innovative sectors of the global economy. The secondary purpose is also to indicate these solutions as a support for building effective communication networks in supply chains in this sector, hence – logistics support of the primary (production) processes. The article is a typical review paper and contains the author's viewpoint on the current state and role of supplier parks and agent-based technologies in the chosen industry. For this purpose, the author has used a literature review and critical analysis of the open source reports of the global research and consultant agencies. Firstly, the current state of the automotive industry is described. The next section presents the complexity management approach. Two following parts of the paper are focused on the two mentioned solutions, namely supplier parks and agent-based technologies. The last part concludes the paper.

1. Automotive industry

The automotive industry has shown high sensitivity to any fluctuations in the global economy for many years. Therefore, the greatest effort in this sector is put on reducing costs and increasing the innovation level in order to avoid the problems that occurred after the last global financial crisis. The size of assets held in the industry and the turnover generated are the reason why implementation of complex system solutions is needed to enable improvement of financial results in the long term. Stagnation of demand in the standard market segments can be seen mainly in the Triad, i.e. the US, Japan and Western Europe. In the early 21st century, the profitability of car sales decreased from 5.5% to 4% (Woźniak, 2011). The level of share of the BRIC countries (Brazil, Russia, India, China) in the industry production and in the creation of the production value of the industry has been constantly increasing since 2000, other developing countries have followed this trend. Additionally, other legal issues are introduced, mainly governing the safety of passengers and environmental protection. Increasing investments in product development can be noticed (coupled with growing changes in customer preferences) by more than 5% with car manufacturers (OEMs – Original Equipment Manufacturers) and 9% with suppliers, to which the risk of supply chain activities is shifted more often. The product life cycles are getting shorter, so the time for which the manufacturer introduces a new product on the market should also be shortened. In addition, the complexity of logistics and production systems is further intensified by a large variety of products, due to a diversity of customer requirements concerning the product attributes.

Providing good communication becomes the main goal for improving processes in network organizations, including supply chains. According to Woźniak (2011), the majority of electronic components in cars today do not originate from manufacturers, but from suppliers of subsequent tiers (Tier 2, Tier 3), what complicates the communication network design in the global supply chains. The share

of electronic components in cars increases constantly. In the 1980s, the share of electronic solutions in cars was 16%, to increase to 25% in 2002 and 35% in 2010. It is expected to increase to 50% in 2020.

Therefore, communication in the supply chains of global corporations and mastering the product portfolio complexity will become the most important areas of logistics management in the industry in the forthcoming years. The following concepts can be realized to reduce the lead time and provide all kinds of flexibility in manufacturing systems:

– modularity of production;
– commonality of production;
– agent-based technologies;
– supplier parks.

2. Complexity management

The phenomenon of complexity in business ecosystems, built by global companies is a result of the impact of a number of internal and external factors (see Table 2). The most important internal factor have been an increase in the range of finished products offered to customers. The external factors that have shaped the long-term complexity of logistics systems are global macroeconomic volatility, volatility of raw material prices and the condition of the automotive sector (Marczyk, Czarnota, Gliński, 2014; Szmelter, 2017).

Notwithstanding the fact that complexity is described in the context of logistics management (Westphal, 2000; Baller, 2008; Mesjasz, 2014), there has been no universal, comprehensive definition of the term for over ten years. This is mainly due to the multidimensionality and ambiguity of the concept. For the purpose of this study the author's definition has been adopted stating that complexity is the number of states that are adopted by a system consisting of many components that interact with each other by building various types of single- or multi-directional relationships. The increase in complexity has its limits. In practice, each system has the so-called 'critical complexity' – a point beyond which the system cannot develop and further, it begins to totter. Then, it is necessary to introduce strategic changes to master complexity and in most cases – to limit it.

15% to 20% of the costs in the automotive industry depend on the product complexity. These, in turn, can be divided into the manufacturing area (30–40%), research and development (20–40%), logistics (10–20%), sales (10–20%) and procurement (5–10%) (Schoeller, 2009; Szmelter, 2017).

The system complexity is described in two dimensions – static and dynamic. The static dimension of complexity is its description at a given point in time (diversity), and the dynamic approach is considering this phenomenon over time (variability) (Westphal, 2000). Taking into account two characteristics of systems, namely, the dynamics of change and the diversity of components, four main types of systems can be distinguished. These system types are presented on Figure 1. Most logistics systems in the global automotive industry are systems in the upper right quadrant of the matrix.

Table 2. Major complexity drivers

Complexity driver dimension	Determined complexity area	Driver group	Drivers
External	Society complexity		Value changes
			Environmental awareness
			Legal factors
			Economic and environmental factors
			Political environment
			Sustainability
	Market complexity	Demand	Client expectation diversity
			Individualized demand
			Market dynamics
		Market competition	Number and strength of market players
			Market changes
			Competition dynamics
			Globalization
		Supply market	Supplier quantity
			Supplier diversity
			Variety of ordered materials
			Demand fluctuations
			Uncertainty of delivery dates and quality
Internal-external	Company complexity (connected with market and society)	Client structure	Quantity of clients and client groups
			Co-decision degree
			Heterogeneity of clients and client groups
		Products/Product range	Product structure
			Products and product variant quantity
			Frequency of new product launches and product mix changes
		Technology	Technological changes
			Availability of innovative technologies
			Innovation life cycle
Internal	Autonomous company complexity	Company objectives	Number and diversity of objectives reached simultaneously
			Dynamics of matching purposes to global market changes
			Timeliness of achievement of objectives
		Processes	Design and number of interconnection points in the process
			Degree of network density
			Degree of standardization
			Internal diversity and dynamics of the flow of inventories and financial and information resources

Complexity driver dimension	Determined complexity area	Driver group	Drivers
		Organization	Number of hierarchy levels
			Centralization degree
			Number of organizational units
		Structure	Number of distribution levels
			Number of warehouses, machinery, employees, etc.
			Vertical integration degree
			Communication systems

Source: (own elaboration based on: Giessmann, 2010)

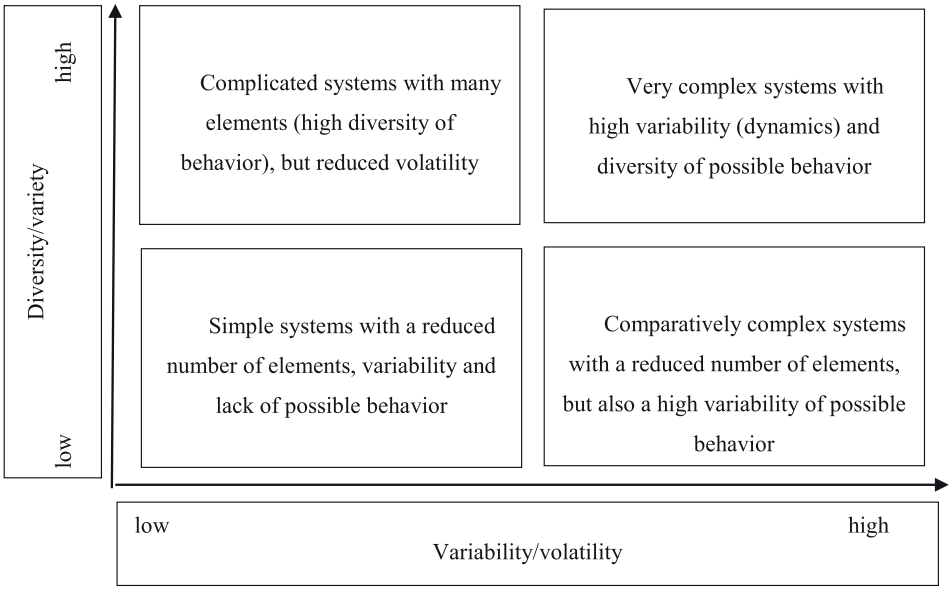


Figure 1. Types of systems with different complexity level
Source: (own elaboration based on: Krenn, Zsifkovits, 2007; Schoeller, 2009)

One of the dimensions of complexity is the product diversity. A distinction is made between internal and external variety. The external variety is a set of the same products in different variants to satisfy the customer. The more options to choose, the greater the chance of meeting the needs of all customers, and the higher the value delivered to the customer. The internal variety is determined by its external dimension and means a variety of processes and resources that are designed to meet the conditions of the external variety. Variant management should be designed to meet the external variety needs with the internal variety limited to a maximum at the same time (Zenner, 2006). It is part of complexity management, namely, the area is associated with a variety of products in the product portfolio of companies or capital groups.

The added value criterion in the automotive industry lies currently in meeting customer needs by offering a large variety of products that have the same functions but differ in details. An example of such a product differentiation concept is the Build-to-Order (BTO) strategy, which is reflected, *inter alia*, in the independent car design by the client in the configurator on the car (vehicle) manufacturer's website. The number of available product variants depends mainly on the segment in which the product is sold (see Table 3). Usually, car manufacturers allow the customer to select the preferred option from a few to a dozen or so kinds of options including the engine capacity, paint colour, type of rims, upholstery, dashboard and other parameters.

Complexity management of systems means activities aimed at (Szmelter, 2017):
– reducing complexity;
– mastering complexity;
– avoiding complexity.

Table 3. The number of standard variants offered in different car configurators of vehicle manufacturers

Model	Number of variants
Porsche Cayenne Tiptronic S	$2.53*10^{54}$
Audi A8 LWB	$6.67*10^{19}$
Volvo XC 60 Momentum	$1.65*10^{13}$
Ford All New Kuga	312004

Source: (own elaboration)

An important element of complexity management in logistics systems is the management of product variants. For this purpose, specific activities should be undertaken (Baller, 2008):
– determine the optimal number of product variants (which will satisfy the needs of customers without causing low profitability of the business at the same time);
– establish the principle of 'cleansing' the product portfolio in order to avoid product cannibalism;
– prepare a thorough analysis of costs (variant valuation);
– overcome the lack of information, resulting from incomplete and improper use of historical data about product variants.

Companies sometimes wrongly estimate the number of variants that will satisfy customer needs, so there is an excessively extended range of product variants. This situation takes place shortly after product launching. The optimum number of product variants can be estimated based on historical and forecast financial data, or analysis of costs and revenues. Too many product variants increase costs, while revenues are generated at the same level as in the case of smaller numbers of these variants. Therefore, such a number of variants should be established so as to ensure the highest possible profit from product sales. At the same time, an optimal number of variants may have different values and be in a certain range.

On the other hand, the increasing market competition requires that the product prices should be lowered, which is in conflict with offering an increasing number of product variants. Therefore, a conflict of objectives arises, which also poses

a challenge for the automotive industry, in order to reconcile the expectations concerning the number of product variants with the increased competition and a high volume of production, i.e. economies of scale. Production management in this industry is linked strongly with modularization and commonality of production (Meyer, 2007; Renner, 2007; Krumm, Rennekamp, 2008). On the one hand, a finished product is not made of single parts, but entire assemblies of parts (components, modules), on the other hand – some parts are common for different product variants, and even for different products, included in the manufacturer's portfolio. Therefore, a synergy between products occurs, which is a result of the use of joint projects, products, parts, technologies and manufacturing concepts to manufacture various products.

System complexity in the automotive industry is not solely due to the multi-variant product portfolio. Intensification of globalization leads to a geographical dispersion of the supply chain components, including a diversity of the car manufacture location. In addition, except for the number of product variants, the complexity of a single product grows, resulting from the technological development and the dynamic phenomena of digitization of the social and economic life. Product life cycles are significantly shortened, not only by the technical development but also due to the growing customer expectations. All these factors affect the supply chains that need to meet the increasing competition in the global market. In view of the overlapping various complexity dimensions (complexity of processes, products, networks of relationships, etc.), the overall complexity is not growing at a linear but exponential pace.

Trade-off situations are common between the two spheres: purchasing with production and research and development, marketing and sales departments. The main challenge for people in charge of these areas is to reconcile innovation, complexity and profitability. The main activities that can make this possible are reduction of multi-variant products, price recalculation (based on Activity Based Costing), an increase in the commonality of products and the appropriate determination of the decoupling point (delayed customization, postponement strategy). First, there is a need to analyze the brands offered by the company in terms of strategic value and profitability. The analysis should also cover market segments, product portfolio and storage units. The weakest products which do not generate sufficient positive financial results should be eliminated from the product portfolio and replaced by new or already existing products, but requiring additional funding to increase sales and the market share. Sometimes, it can become profitable to leave in the portfolio products that have a high strategic value, but generate small profits. Then, the company should increase the prices to encourage customers to pay for the complexity maintained (this is called complexity visible to the customer, external complexity). In turn, internal complexity management focuses on building common platforms for products and commonality of their components, raw materials and production processes (including technology). The most effective strategies include simultaneous manufacture commonality and customization of products (postponement strategy). This helps to reduce the supply chain costs and eliminates the time required for research and product development, while

providing the possibility of product differentiation. This solution allows minimizing the complexity and maintaining a high variability of products at the same time.

3. Supplier parks

The main determinant of the potential for complexity management of logistics systems is the ability to create flexible supply chains based on both mass production and order manufacturing. Howard, Miemczyk and Graves (2006) present the main dimensions of flexibility as the process, product and volume flexibility. The process flexibility includes the processes carried out in the whole value chain, also in the supply network. Integration of suppliers and their access to data on the actual demand will give a chance to build the process flexibility. The product customization must occur at a moment closer to the customer, which will ensure the product flexibility. The volume flexibility requires negotiations with employees and suppliers in order to reduce the dependence on the full capacity utilization.

One way to achieve the desired level of system flexibility is creation of supplier parks, located close to the OEM manufacturing plants. A classic example of such a park became the Dell plant in Limerick (Ireland) which operates exclusively on the BTO principle. It takes 5 to 7 days to deliver the product to the customer from the time of receiving a production order. The manufacturing facility maintains sufficient stocks for 4 hours of work on average, and orders are taken every 15 minutes (Davis, 2005).

A large distance between suppliers and customers has a negative impact on strengthening cooperation on joint production planning in relation to incoming customer orders. This means that any sudden changes in production mean significant financial losses that could be avoided if the provider were not far away. The main reason is the need to transport goods from the supplier to the customer. Therefore, supplier parks are one of the solutions to support implementation of the BTO strategy and optimizing the complexity management in the context of variant management.

Supplier parks are collections of different supplier manufacturing units located close to their customers. Howard, Miemczyk and Graves (2006) define supplier parks as a concentration of dedicated production, assembly, storage, carried out by suppliers or the service provider (third party) in close proximity (e.g. to 3 km) from the OEM (Chew, 2003; Szmelter, 2017). Parks are often described in the same way as industrial clusters, but this concept is much broader as it should not relate to the supply network of only one dominant recipient. However, it happens that recipients, and market competitors at the same time – run manufacturing plants close to each other and they have the same suppliers around them, simultaneously supporting competing companies.

In 2003 in Europe, there were 23 parks, centred around manufacturing plants of 8 automotive brands (VM-vehicle manufacturers): Ford, GM, Fiat, Peugeot, Renault, Seat, BMW and Volkswagen. All of them ranged from 7 to 24 suppliers (Howard, Miemczyk, Graves, 2006). Since that time a number of new units have been built, appearing to be subsequent at the planning stage, but there is no

available data on the current number of those parks in Europe or worldwide. Experts expect an increase in the importance of the just-in-time (JIT) strategy in the material flow in the automotive industry, which undoubtedly will also be associated with the placement of supplier factories close to OEM plants. In addition, the development of information technology (e.g. self-steering technologies) will affect positively the creation of subsequent parks.

There are three types of supplier parks with respect to the BTO strategy, strongly connected with variant and complexity management: parks implementing this strategy, parks with the potential for its implementation, and those that have very low potential (Szmelter, 2017). The first group includes parks in which production is carried out on a large scale, and most of the value is created by suppliers. In their case, the park started operation aided with public funds, and these parks are not in direct neighbourhood of OEM plants (Volvo, Audi, Seat parks). In parks of this type activities are coordinated by the OEM (Volvo) or the logistics service provider (Seat). These parks enable the implementation of BTO because of the need for the production volume and the portfolio flexibility. Low start-up costs are an additional benefit. The potential inflexibility is reduced by advantageous relationships with suppliers.

Supplier parks with a BTO potential (for example GM) are usually small factories located near a major manufacturing plant of the same OEM. They are too small to support the BTO. The exist mainly due to the need for using free capacity or support a sister unit within Europe (GM). A location close to the OEM in such parks is due to the lack of financial support from government institutions. They have the potential to introduce JIT and late product configuration (both suppliers and the OEM), however, the low production scale is the reason why BTO practices are not in place there.

Parks with very low, limited potential (Ford and Jaguar) are also small, moreover, generally they do not have the support of the local administration in the form of financing the infrastructure and providing tax advantages. In the case of Jaguar there was no external financing, and initially the purpose of building the park was the production volume. The 12-hour lead-time eliminated the need to locate supplier plants next to this OEM factory. On the other hand, in the case of Ford, only one supplier located its unit near the OEM factory, for other potential suppliers the benefits of placing their units near the Ford facility were unclear.

Groups of suppliers cooperating with the OEM can form various types of associations with a diversified level of intensity (see Table 4).

The evolution of forms of supplier association types, especially supplier parks, developed strongly since the 90s of the twentieth century, led to the emergence of the multi-customer supplier parks concept that supports a number of car manufacturers located within a radius of 400 km from the park (Sihn, Schmitz, 2007). This is an 'intelligent' supplier structure in which factories of multiple vendors are located. This intelligence resides in increased productivity of this geographically concentrated structure compared to the dispersion of individual suppliers operating in isolation. Another feature of these parks are well-developed communication networks and automation of processes using self-steering technologies, particularly between Tier 1 suppliers and suppliers of subsequent tiers.

Every MCSP consists of (Sihn, Schmitz, 2007):
– suppliers which manufacturing components for several OEMs;
– one central logistic hub which is supported by one or more logistics service providers and includes logistics services for all suppliers in the park;
– one central production hub that supports the manufacturing processes for all suppliers (e.g. painting factories);
– one central park operator managing the park infrastructure.

Usually, the location of this type of parks depends on the transport potential of the region. Due to its remoteness from various OEMs, the integration between suppliers and car manufacturers depends on the means of transport, mainly trucks and trains, supporting the flow of goods. The logistics service provider is in turn responsible for the logistics operations, mainly delivery and distribution. The MCSP concept has been included in the strategies of BMW (KOVP concept – customer-oriented distribution and production process) and Daimler-Chrysler (pearl-chain concept).

Table 4. Types (levels) of supplier and OEM integration

Level of supplier and OEM integration	Characteristics	Examples
Automotive supplier community	Allocating production plants of suppliers (Tier 1and Tier 2) close to plants of their clients (OEM) One supplier can deliver for two recipients (two plants of one or many OEMs) Can be geographically dispersed	BMW Innovation Estate in Wackersdorf (Germany) Automotive Supplier Park Rosslyn (South Africa)
Supplier park	Result of cooperation of OEM and local government Mostly a cluster of Tier 1 suppliers near the campus of one OEM Suppliers produce modules, pre-assemble products which can be customized There is also logistics service provider (LSP) which for example assembles lamps The park is connected with a final assembly line of OEM by conveyor belts, tunnels or bridges	Seat car plant at Martorell near Barcelona (Spain) Audi Ingolstadt logistics Centre (GVZ) (Germany)
Supply centre	The centre is located next to the OEM manufacturing plant Structures and equipment are financed totally or partially by the OEM (and sometimes partially by the LSP) All suppliers and the LSP are tenants in a specific location (this it the reason for high flexibility for OEMs to change partners) Allows late product customization and automation for line side deliveries	BMW Werk Leipzig (Germany)
Condominium	Suppliers work in the same manufacturing plant as the OEM Suppliers locate their own equipment on the plant (in-house supplier assembly) Low buffer stocks Final assembly is controlled by OEM	Ford Industrial Complex at Camaçari (Brazil)

Level of supplier and OEM integration	Characteristics	Examples
Modular consortium	The highest level of supplier and OEM integration The whole assembly process is split into separable modules, each of them has assigned a responsible supplier Suppliers responsible for modules are responsible also for the finished product (car) All workers at the final assembly stage are hired by suppliers OEM is focused only on planning, engineering, control and administration. OEM tests the finished product only.	Volkswagen Truck and Bus in Resende (Brazil)

Source: (Howard, Miemczyk, Graves, 2006; Bennett, Klug, 2009)

Three main features of supplier parks contribute to reducing the logistics systems complexity:
– operational cost reduction;
– component inventory reduction;
– reduction of the time needed to plan and implement a production plan, also for production on order (BTO).

Additional advantages of such parks also include:
– lower transport costs, due to a well-designed and maintained road and rail infrastructure, lower labour costs in the park;
– synergy effects through the cooperation of people, but also intelligent IT solutions;
– knowledge sharing and benchmarking (knowledge-sharing networks).

No company today has all the knowledge necessary to design, improve and manufacture finished products in the automotive industry. The geographical dispersion of car production is mainly due to the existence of the global car model (world car) (Morris, Donnely, Donnely, 2003), to which manufacturing parts are brought from the same suppliers, but from different locations. It is called a design follow/follow sourcing strategy (Wassermann, 2009). However, the location of their manufacturing facilities close to the customer eliminates a number of risks associated with the transportation of parts at large distances. It is particularly beneficial when Tier 1, 2 and 3 suppliers locate their plants in close proximity. In such event, Tier 1 supplier, with which the OEM has placed the responsibility for the product, can locally control the manufacture of parts and components.

4. Agent-based technologies

With the development of information technologies, the systems engineering concept was developed, which focuses on the design of hardware and software in such a way as to integrate internal and external communication systems of organizations, including network organizations. In the automotive industry, as well as in other industries, agent technologies as well as self-steering concept

and embedded systems increase in importance. Automation of communication processes and the use of information systems engineering has resulted in a significant improvement in the functioning of the organization. Wassermann (2009) cites the following benefits already achieved in this area:

– 19% greater chance to achieve the financial objectives (profit) than the average in the industry;
– 4.4 times more embedded systems than in case of market competitors;
– 50% fewer defects in embedded systems than before the introduction of systems engineering;
– shortened product development time (time-to-market) by 25%.

The use of this kind of technology has increased productivity, e.g. by 20% in Volkswagen AG.

One of the elements of modern communication and convergence phenomena are agent-based technologies, which in recent years have been successfully used and developed in organizations, especially those with an international structure.

Thanks to the wireless technologies (e.g. Bluetooth, GPS, WiFi) and mobile devices that support them, it is possible to send and receive messages almost anywhere in the world. The growing processing power makes it possible to store large amounts of data, what allows building a hardware and software network to process these resources. The concept of Ambient Intelligence is closely related to these trends. It is needed to combine the so far existing technologies and equipment to create complex systems, smart grids, so that automation of activities will become possible (Stanek, Żadora, Żytniewski, Kowal, 2012). Devices that support these networks have inherent powerful processors and are able to connect to wireless networks. These solutions include:

– smart materials;
– microelectronic systems, sensor technologies;
– embedded systems;
– input/output device technology;
– ubiquitous communications;
– adaptive software;
– self-steering systems.

Self-steering in logistics can be joined to a group of other logistics management philosophies (e.g. electronic data interchange, integrated information systems, radio-frequency identification) that use technology development, contribute to mitigating the effects of high dynamics of modern logistics systems and enable the use of the potential that they generate. However, the use of modern technology makes sense, if it is possible to identify precisely specific goods (including the history of their development in the form of stored data and events related to the flow), their location and the status in the system (Fischer, 2012). The idea of this concept is based on intelligent software agents, specially designed computer programs that base on previously introduced parameters and control their own behaviour. They operate autonomously and are able to interact with other programs (with the use of the enterprise server or cloud computing). In independent decision-making, they base on information relating to the events in the real processes. Self-steering paradigm assumes independent decision-making at the level of logistics objects

(Szmelter, Woźniak, 2013), however, for these decisions prior targets and limits shall be determined (Freitag, Herzog, Scholz-Reiter, 2004). Each self-steering item takes into account its parameters and the associated similar entities, in order to set all the action in the most optimal way. Thus, the self-steering characteristic in logistic systems is decentralization of planning and control.

Two dimensions – decentralization and autonomy describe self-steering in logistics systems. Decentralization of planning functions and decision-making is good for large fluctuations of demand or unexpected disruption on the market or in the supply chain. Therefore, it means that the decisions connected with logistics objects are taken at their level. In turn, the second characteristic of the self-steering systems, namely autonomy, is based on independent decision making, which, however, is in a set of possible decisions. Specific intelligence is necessary to implement this type of actions. The degree of decentralization and autonomy indicates the degree of self-steering (Szmelter, Woźniak, 2014). The aim of logistics management should not become maximization of self-steering but an increase in the current self-steering level to the optimum. The level of complexity of a logistics system which consists of but is not limited to a variety of products and their quantity as well as the quantity and variety of the relationships in the logistics system of enterprises (logistics microsystem), supply chain (metasystem) and the economy (macrosystem) should be taken into account with the determination of such an optimum level. The aim of self-steering is to achieve a higher level of efficiency of the logistics system by overcoming the complexity of the existing system and the dynamics of the changes that occur therein.

Self-steering significantly improves the efficiency of the logistics system with increasing complexity. The usefulness of self-steering is verified by measuring the impact of different methods of self-steering to achieve levels of the logistic target volume with the increasing size of the structural complexity of the system. It is very important in the system to simulate real events, what is carried out before executing specific tasks. Thus, self-steering is very suitable for standard processes, often encountered in a given activity, but on the other hand, exceptional situations require intervention of a logistics specialist.

Self-steering is primarily based on intelligent agents – software that independently controls the behaviour of logistics objects on the basis of the previously introduced algorithms and control parameters. Self-steering in logistics consists primarily of process automation of control processes to the point in which logistics objects take some decisions on their own (these are the only decisions which affect them). One example of the application of this concept was implemented in the 2004–2008 ILIPT project, also known as the 5-Day Car program. The main objective of this project was to improve the indicators of planning in supply chains implementing the BTO strategy so that the car ordered by the customer reached him or her within 5 days from the time of placing the order.

The agent concept was created in the 1970s and it is based on the theory of AI (artificial intelligence). Its author is considered to be C.E. Hewitt who described the concept of intelligent, parallel concluding and decision-making IT system components (actors) (Jakiela, 2014). In the context of logistics systems such agents

can be seen as interactive, self-contained, autonomous objects, carrying out logistics processes.

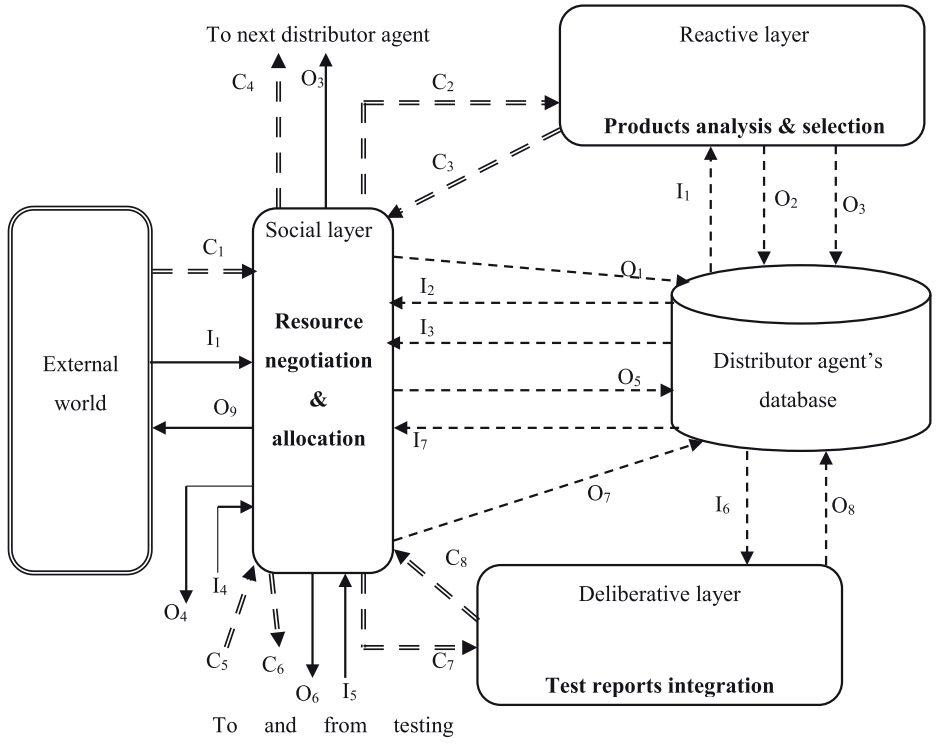
Software agents (softbots) are programs acting alone and reacting to environment changes in a similar way as humans. They consist of hardware and software architectures. They are able to communicate with people and other objects similar to them, therefore, they are reactive systems. After defining the task to be accomplished by the agent, it is able to tell which way of doing the task is the best (Jakiela, 2014).

Agents are goal-oriented, usually very complex (Wooldridge, 2002), pursue actively, constantly monitoring the variables that affect their decisions. They are able to quickly reconfigure a 'different way of thinking', if one or more of the variables have suddenly changed. What is more, they can select from the contradictory information that they often receive. Consequently, they are extremely flexible (Shirazi, Soroor, 2007). Normally they represent a specific department or position and they are able to perform one or more functions.

Softbots often take over price and other conditions of negotiations in supply chains, and they are also used for testing new network settings, new production line organisation, new software and many other issues (see Figure 2). Requirements for production materials are negotiated by the manufacturer (OEM) with suppliers, they, in turn, are conducting negotiations with their suppliers, and so on, throughout the supply chain. If the negotiations do not end with success, backward negotiation is made. In a situation where there are more bidders than the target number, the auction with the participation of softbots is carried out. Then the control parameters in the form of potential production, transport, storage, etc. and the financial scope of freedom are introduced by both the bidder and the buyer. If someone changes any of the control parameters, an immediate reconfiguration of other settings or even the entire supply chain is made (Müller, 2011). In every round of negotiations, the lower and upper price limits are introduced by both the supplier and the receiver. If one round is not completed with an agreement, the programs move to the next round of negotiating with new settings (Szmelter, Woźniak, 2014).

Agents can also be used in other situations, often requiring to take into account a large number of different variables, which would not be possible to do in a short time by a human. It is production forecasting and scheduling, calculations of material requirements, supply network design, scheduling of deliveries to customers that are often mentioned among such functions. However, the design process of this type of software is complex, as is the operation of solutions of this type. It is necessary to create algorithms that allow simulation and testing.

Agents allow connecting the already existing technologies in intelligent solutions, which are mainly based on synergy effects of the interaction of such technologies. The effects achieved by the use of agents are more far-reaching than traditional software types such as ERP, CRM and SCM. Therefore, development of agent-based technologies should be expected in the forthcoming years.



I_i – input information flow, O_i – output information flow, C_i – control flow

——————— information flow outside the agent

---------- information flow within the agent

═ ═ ═ ═ control flow inside and outside of the agent

Figure 2. A view of the distributor agent
Source: (Dhavachelvan, Uma, Venkatachalapathy, 2006)

Conclusions

The development of global supply chains has presented many new challenges to logistics management. One of them is the complexity of logistics systems, being a result of, *inter alia*, high product variability and a rich product portfolio of vehicle manufacturers. In response to these challenges, a number of organizational and technological solutions have appeared to help companies to manage the complexity, so that they can help to reduce, control and limit it.

Supplier parks are a solution facilitating movement of goods in supply chains in the automotive industry. Placement of supplier factories close to their customers, the OEM, significantly contributes to the proper implementation of the BTO strategy, which is a solution to many problems associated with too many product variants.

The evolution of the parks in the past twenty years has contributed to the creation of many production sites with well-organized production, allowing customer orders to be fulfilled in a very short period of time.

The information flow in the parks, as well as in the entire supply chains in the automotive industry is supported by modern IT solutions, among which agent-based technologies have very high efficiency. Software agents allow quick decision making without human intervention, implementation of price negotiations, purchasing, planning and rescheduling of production in a very short time. In the future, artificial intelligence will be the basis of modern supply chains, not just in the automotive industry. The symptoms of this trend can be seen already today.

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THE USE OF CIVIL DRONES IN FOREST DISTRICT LOGISTICS

Abstract

This article concerns a relatively new technology used in logistics, namely, civilian drones. The experience of various industries shows that drones can be treated as an important element of the organization's logistics support system (LSS).

It is forest districts that were adopted as the research environment. Drones are used in forest areas where research on a wider use of drones in forest management processes is conducted. In the article, a forest district is considered in the categories of a logistics system. The role of drones and their influence on the functioning of a forest district in which activities require to be coordinated and can be treated as logistics processes is also presented.

The main aim of this article is to determine the functionality of drones in terms of acting as one of the essential elements of a forest district system. Processes that can be improved by additional support of drones are identified. Conclusions regarding the integration of drones with the information system of the whole organization are universal and may also apply to other sectors of human activity, including those of a business nature.

Keywords: drones, forest districts, logistics support system, logistics process

Introduction

Unmanned aerial vehicles (UAV), which were originally used exclusively by the military to perform military operations, are becoming more and more available for civilian activities. Despite significant factors that are limiting a widespread use

of drones, they have much potential which can be exploited, for example, to collect data on monitored physical flows and to transfer such collected data to the traffic control centre. Including drones in the enterprise's system can be another major milestone in its development, such as wireless telephones or the Internet.

The article consists of a theoretical part which defines a logistics system and the LSS. The next part characterizes a forest district and the processes therein, identifying also the logistics system of a forest district. The drone technology and its types is presented in brief. Finally, the possibilities of supporting forest industry logistics processes by civilian drones are proposed and final conclusions are formulated.

The considered forest districts concern Poland, however, some user experiences from Norway are also included.

1. The logistics system of a forest district

Defining the logistics of a forest district and its basic concepts should begin with understanding the essence of the system itself. A Polish dictionary defines a system (a similar word to the Greek *systema* – a whole made from many pieces which acts as one) as, i.a., a coordinated arrangement of elements, a set that creates the whole, conditioned by a constant and logical ordering of its constituent parts (Polish Language Dictionary, 2004). The notion of a greater whole was already used by ancient philosophers, including the greatest ones, like Aristotle, who in his *philosophia prima* used a metaphor of a set of letters to understand this greater whole and its parts. A thing which is composed of something creates a whole in the sense of unity. In other words, a syllable is not just a set of letters because the word 'cat' is pronounced differently than the single letters of which it is made, namely 'c', 'a' and 't'. Together, they not only create a collection of consonants and vowels, but also a whole syllable, which is a part of a larger set called word. Therefore, as Krąpiec and Żeleźniak state (1966), there is no more expression by splitting the word into components, but syllables only.

According to Gołembska (1994) the logistics system in terms of the subject is a set of elements such as: production, transport, storage, recipient, along with relations between them and between their properties, conditioning the provision of a logistics service.

In terms of the object, the elements of the logistics system are material, financial and information streams in respect of which logistic operations are carried out. These operations combine individual elements together, starting from common goals and the criterion of effectiveness (Chudakov, 2001).

On the basis of the above definitions, it can be attempted to characterize a forest district in terms of logistics and its basic concepts.

A forest district is a basic economic and organizational unit in the structure of the State Forests National Forest Holding. Each of the forest districts is divided into 1-4 forestry sub-divisions, which in turn are divided into several or more forest sub-districts. According to the data of the Geographic Information System (GIS, 2018), there are 430 forest districts in Poland.

The key to a logistics approach to a forest district is to treat it as a warehouse with a production function. A forest district is indeed a warehouse in which animals, plants and various types of raw materials are kept. This peculiar 'natural warehouse' also reveals the characteristics of a manufacturing plant because trees are planted in it so that they can be felled and sold in the form of timber after some time (usually a dozen years or so). After cutting, wooden logs are temporarily stored on a previously separated piece of land, until they are transported to the recipient. Inside a traditional warehouse, objects are displaced in a controlled manner and periodic stocktaking is carried out from time to time. In contrast to goods stored in a traditional warehouse, forest animals (e.g. birds), move spontaneously around the complex, sometimes even beyond its boundaries, which makes it much more difficult to control their quantitative status, compared to a traditional storage facility, where there are physical boundaries, in the form of a fence.

The logistics system of the forestry inspectorate is used to rationally and effectively secure the functioning of this unit by:

– supplying people fit to work and materials such as: fertilizers, tree seedlings, plant protection chemicals, machinery and other equipment;
– distribution of plants and animal products;
– sustainable exploitation of fixed assets and responsible management of forest resources;
– protection of the natural environment including soil, water and air, as well as maintaining the natural state of specific ecosystems;
– providing information on quality and usability in terms of the condition of the forest district and its surroundings (e.g. technical, technological, economic).

Figure 1 shows the logistics system of a forest district.

At the input of the working subsystem there are raw materials, manpower, tools, machinery and financial resources. Processes like planting, taking care of plants and cutting down mature trees occur within a working subsystem. Forest animals need extra care only when they get sick or enter a dangerous area during the maturation process. Surplus animals are intended for hunting. Hunting licenses are issued by the forest district as a service. The output of the work subsystem includes end products (wood, hunted animals, plants, forest fruits), services and costs. Depending on its purpose, wood is transported to a sawmill or to the end user as fuel. Other recipients of animal products are: hunters, butchers, butcher shops, end customers.

Decisions are made in the management subsystem, which consists of registration, decision-making, reporting and planning areas. Factors, located in the (distant and near) environment of a forest district, can interfere with the decisions taken. There is an exchange of information between the management, working and security control subsystems. Therefore, it is important to operate logistics support processes dedicated to the entire forestry system, as well as an element that will coordinate and integrate all system activities. This refers to the LSS in all its glory.

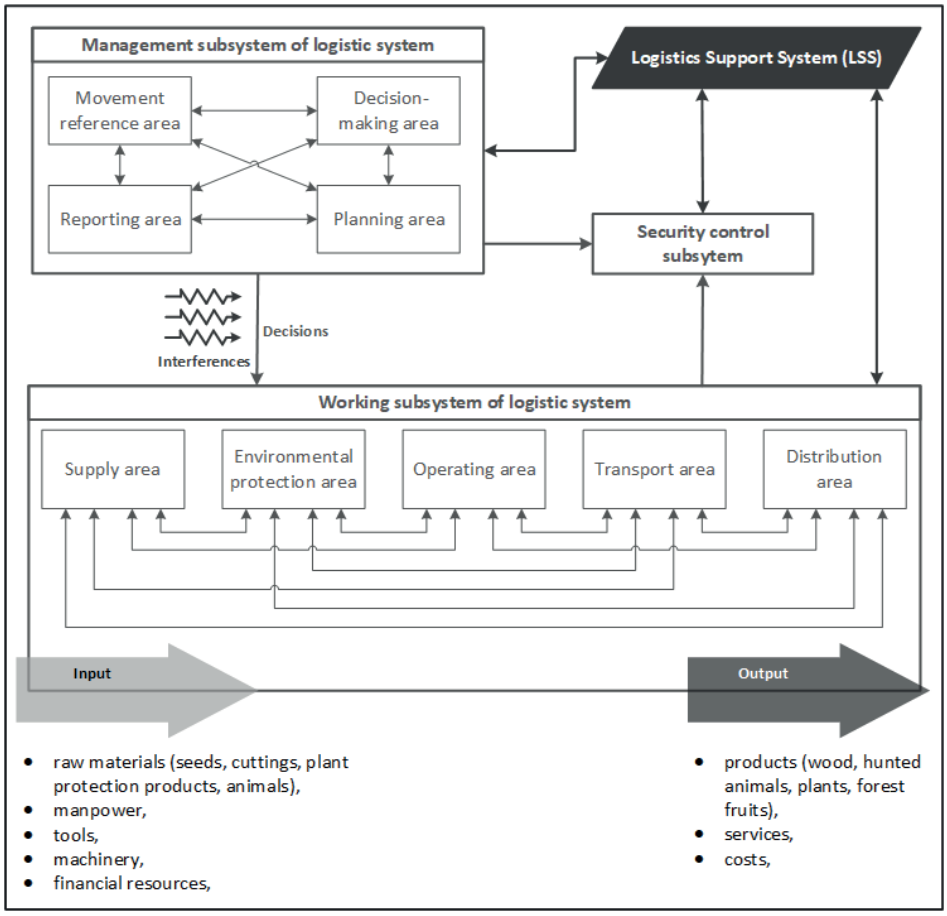

Figure 1. Logistic system of a forest district
Source: (own elaboration)

2. Logistics support system of a forest district

The LSS is responsible for integration of resources and coordination of activities supporting the manufacturing process. This system should be understood as an intentionally organized subsystem of any organization which supports its basic process of goods production by integrating all activities related to effective and beneficial flow of necessary resources to produce a basic asset and supporting the production process to provide the necessary equipment for this process, both in terms of its availability and reliability (Chaberek, 2002). Chaberek (2002) also claims that:

– every organization (be it market or non-profit) must have a system supporting its core business, based on the basic process;

– the system supporting the basic activity of the organization is a kind of reflection of the processes in the organization and its structure (elements and relations between them);
– the tasks of the system supporting the basic activity of the organization are focused on the logistics service of the production process of its product.

Figure 2 shows the LSS components.

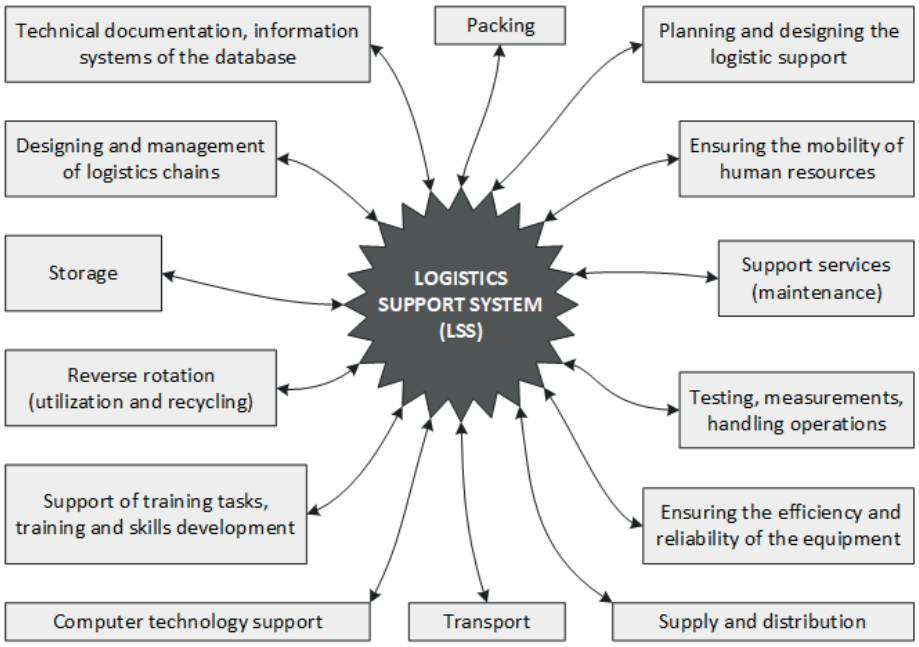

Figure 2. Components of LSS
Source: (own elaboration based on: Chaberek, 2002)

The forest district organization itself, as well as its internal structure (defined inputs and outputs, cause-and-effect relationships between elements) meet the conditions to be considered as flows that are basic for logistics.

The LSS of a forest district should be understood as the sphere of its operation, which supports all its activities (basic and auxiliary), by coordinating and integrating all processes related to an effective and optimal flow of resources which are necessary for the proper functioning of the organization. It also has to guarantee the necessary equipment in terms of availability and reliability. By shortening this definition to a minimum, the LSS of a forest district is responsible for the logistics support for the implementation of the forest district's objectives. The primary objective of every forest district is rational management of the forest space and resources. In addition, the forest district must ensure safety, determined by many negative biotic and abiotic factors such as: hurricanes, floods, droughts, fires and other natural disasters, pests, diseases (e.g. African swine fever virus), as well

as destructive human activities. The Forest District also plays the role of a public utility whereby it is necessary to ensure the accessibility of tourist routes.

The essence of the LSS lies in an integrated approach to the overall activities that support a specific process. The key elements are information and its proper management. The technology that supports the operation of the organization's information system including the logistics information system are drones.

3. Types of civilian drones

The term 'drone', commonly used for civilian purposes, means an unmanned aerial vehicle (UAV) which is remotely operated with no pilot on board (ICAO, 2011). A UAV is a component of an unmanned aerial system (UAS), which includes the UAV with its human operator and the communication system between them. The most important feature of the UAV is the ability to program the aircraft so that it can perform certain operations without the help of its human operator, and flying objects exactly of this particular type are called drones. With each subsequent generation, drones become more and more autonomous, what makes them easier to use and more accessible to people. Civilian drones, unlike military ones, do not serve military but only scientific, entertainment or commercial purposes.

Many various types of drones can be divided into (Custers, 2016):

– fixed-wing drones;
– multi-rotor drones.

Fixed-wing drones have one or more fixed-wings attached and resemble an airplane in appearance.

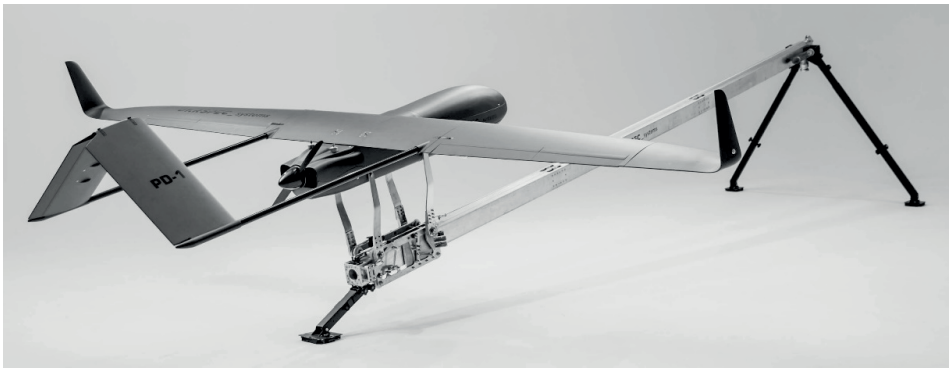

Figure 3. Fixed-wing drone on the launcher
Source: (UST, 2018)

A fixed-wing drone is driven by a rotor, usually placed at the rear of the vehicle. It has to constantly move forward to glide, and due to this, it is possible to manoeuvre it hovering in the air. A drone is launched into the air from a special launcher, and the landing process follows the same steps as is the case with larger aircraft.

Some models may have one or more pairs of wings. In such case, they are multiplane drones.

Multi-rotor drones are based on the helicopter's scheme, and their type depends on the number of installed rotors. Figure 4 shows the appearance of a multi-rotor drone.

Figure 4. Multi-rotor (quadcopter) drone
Source: (Phantom, 2018)

There are also hybrid drones, which are a combination of fixed-wing and multi-rotor drone features, making it difficult to classify them into one of the previously introduced categories. An example of a hybrid drone is shown in Figure 5.

Figure 5. Hybrid drone
Source: (BirdsEyeView, 2018)

Owing to their design hybrid drones can take off and land vertically. There are also hybrids equipped with wheels that allow them to drive on a surface.

4. Use of civilian drones in logistics

A UAV can be equipped with a range of sensors, cameras and other devices that expand the possibilities of its operation. In particular, global enterprises recognize the benefits of task automation. This was seen, *inter alia*, by the American commercial network Walmart, which replaced some of its employees with drones in distribution centres and warehouses. After attaching a special scanner to the body of the drone, it is able to make inventory up to 30 times faster than a human being. This not only improves the work efficiency, but also effectively reduces the number of errors, which in a broader way translates into better business results of the enterprise (Bołtryk, 2018).

Amazon has a model for delivering small packages up to 5 lbs. According to the assumptions, transport takes place within the city, and delivery time takes up to 30 minutes from the moment of placing an order. However, full implementation of this delivery method depends on appropriate legal regulations which have not been introduced yet. It is assumed that drones can successfully replace traditional couriers (Amazon, 2018). Drones could deliver not only parcels or letters, but also medical samples between research centres and human blood or even organs for transplantation between hospitals (Duszczyk, 2018a).

The tasks of unmanned aircraft in the supply chain may include picking, palletizing, confectioning and packaging of small goods in consumer packaging. This solution was developed and tested by the Dutch company Qimarox, a supplier of warehouse management solutions (Qimarox, 2018).

PKP Cargo used UAVs to monitor trains carrying coal that are stolen (TVN24, 2015). A drone equipped with a camera can notify appropriate services or scare looters. Furthermore, the material recorded on the internal disc of the device can be used as evidence against criminals.

In addition to uniformed and emergency services, civilian drones are also used in construction and agriculture. In the former sector, civilian drones can help, i.a., in verification of land surveying measurements by the so-called land surveying audit and in a periodic inventory of the construction site. Moreover, UAVs can constantly compare the current status of construction with the design and its objectives, thus reducing the risk of having extra adjustments added to the plan and the number of collisions between vehicles on the construction site. Data from the construction site collected by drones, plays a key role in making decisions (SkySnap, 2018).

Conversely in the agriculture, drones are used to take pictures in different bands of light, which are then sent to a program that creates indexes from them. On the basis of measurements of light reflected by plants, it is possible to evaluate the quality of crops and adjust the amount of spraying, which ensures savings for the farmer, who also has constant control over the cultivation (Świat Dronów, 2018).

Drones help to fight against the climate change. They can assess the scale of coral reef erosion and detect freshwater sources. Shortly, UAVs which are able to clean oceans, will enter an initial phase of production (Mazzini, 2018).

5. Use of drones by forest districts

Every operation performed by a UAV must be based on the current map of the area where the task is to be performed. The Forest Numerical Map (FNM) indicates the boundaries of specified areas for which many statistics can be read, such as the dominant tree species in a given area along with its harvesting age. In addition, the FNM takes into account linear infrastructure elements such as paths, roads, tracks, tourist and water trails, and point infrastructure elements (e.g. hunting facilities). The surroundings of forest districts and tree stands are constantly changing, therefore, the FNM should be constantly updated. For this purpose, forest districts need to create orthophoto maps using drones and update the FMN on such basis. They can do it themselves or outsource this task to specialized entities.

A drone equipped with a narrowband camera or a remote sensing device is able to collect data for an IT system that will count trees on its basis. As each object reflects electromagnetic radiation in a characteristic way, the system is able to determine the tree species and whether the tree is alive or dead.

Animals are counted following similar principles to the inventory of tree stands, with the difference that the drone is equipped with a thermal sensor. The UAV scours the area by taking thousands of photos in natural colours (RGB) and in infrared.

In the years 2013–2015, research under the name *The use of remote sensing to determine population of large game in selected forest complexes* was carried out. There were five research areas: *Puszcza Niepołomicka*, *Puszcza Białowieska*, *Lasy Janowskie*, *Beskid Niski* and *Pogórze Przemyskie*. The registered area was over 6.000 km2, the drone flight lanes were 2850 km in length, during which over 29.000 RGB images and 75.000 thermal images, were taken. The study made it possible to conclude that this method allowed a reliable and effective estimation of the population size of large animals. This animal group is the most important for forest management. A huge advantage of using drones for this task is the ability to cover a large area within 1 day, which would require a team of 100 people working continuously for 10 days in the traditional conditions. Moreover, this method is non-invasive and allows animals to be observed in their natural environment in a way that does not affect their behaviour (Okarma, 2015). Figure 6 shows the selected map of the drone flight route.

There are crimes committed in forests including illegal hunting, or leaving municipal waste. The drone acts as a trail camera which is able to monitor forest areas. In summer, when the likelihood of a fire is high, drones equipped with a heat sensor can detect fire early and alert the competent services. UAVs also carry out inspections of hard-to-reach areas and areas with an increased risk level, such as, for example, swamps.

Drones also help to estimate losses after cataclysms, such as storms. The Opoczno Forest District took advantage of this possibility after the storms in 2016. The safety of employees was greater because they did not have to overcome fallen trees or be careful to avoid falling branches. The results obtained during drone flights were compared to those obtained by employees to make sure that they were meaningful. Both results were similar and differed only as far as the time of their acquisition was concerned because the drone did it much faster than human workers.

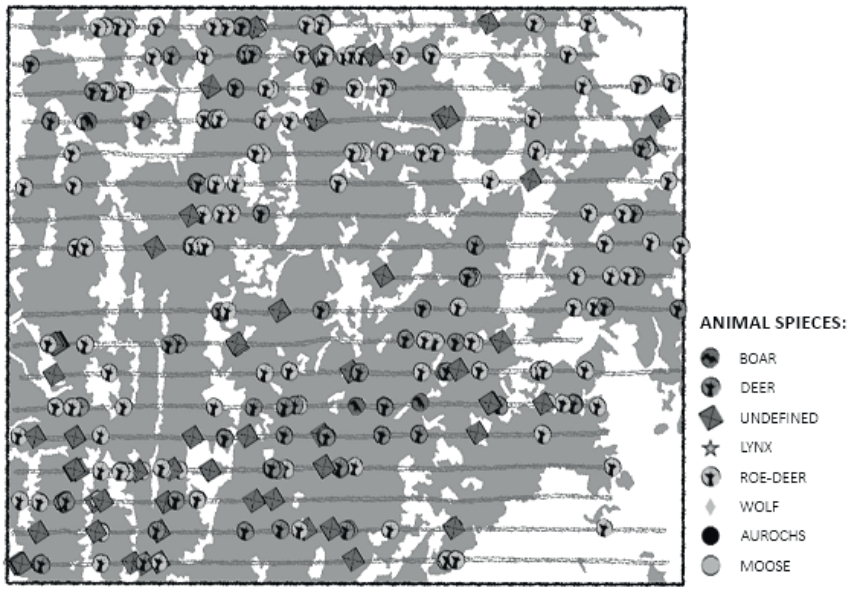

Figure 6. Results of drone flight over the Pogórze Przemyskie area
Source: (Okarma, 2015)

Some forest districts in Norway use drones as an element of monitoring and early warning. The drone is connected to the power line with a cable of such length that it allows it to move freely within a dozen or so meters. This maximizes the run-time of the drone. In Norway drones are included also in one of the forestry subprocesses in mountain areas. Originally, felled logs were transported, from the cut-off point (A) to temporary storage (B), where they were assessed and valued by employees. Then, the logs were loaded onto a truck and sent to the destination point. This process started to be supported by a drone, which was scanning the log with various sensors, during its transportation from point A to B. The collected data was sent to the system on an ongoing basis, which calculated the mass and price of the log, according to data received. As a result, employees receiving the log at point B could immediately load it onto the truck. In this way, the whole process (Figure 6) becomes faster and more efficient.

In Poland, all of the above-mentioned applications of drones are only tested in forest district conditions. Therefore, the use of drones on a large scale in Polish forest districts is out of question, at least for now. An exception are flights associated with creating orthophoto maps, as they are made in all districts, even several times a year. An orthophoto map can be used by the forest district to plan new transport routes and to facilitate fieldwork monitoring. The image from the drone camera enables a different perspective on activities such as soil preparation, planting, cleaning, logging and much more. This leads to better coordination of operations of individual cells and provides up-to-date information on the quality and progress of the work carried out, so hat it is possible to respond accordingly.

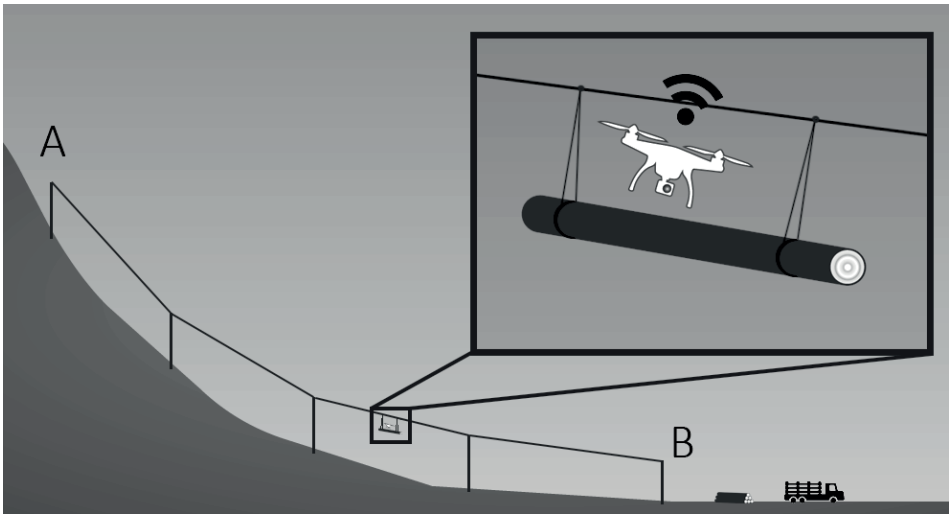

Figure 7. The process of felling a tree in a mountain area in Norway, supported by a drone
Source: (own elaboration based on: an interview with J. Duszkiewicz who has contacts in Norway forest districts, 2018)

6. Possibilities of supporting forestry logistics processes by civilian drones

It is worth considering to use one of the types of passive transponders (biochip) to mark (tag) animals encountered by the drone during the flight. The drone equipped with a scanner could count animals at a distance, just like goods in a warehouse, by sending a biochip stimulating a beam that would activate the chip and force it to send back information about the nearby presence of an animal. Such a solution would be possible, but difficult to implement, because animals walk their own paths, but similarly to fast-moving consumer goods in a warehouse, they are replaced by new younger specimens. Therefore, it should be treated more as an alternative to counting animals by remote sensing.

A drone can be used in log or timber transport. The situation in Figure 8 shows a vehicle carrying wooden logs that is heading towards a fork on the road.

Both roads lead to the same destination, but only one of them is passable. The second road is blocked by animals lying on it and a fallen tree a bit further up. Continuing driving on the route marked in white, would require the driver to turn back and it could cause a delay. The drone sent earlier for reconnaissance could warn the driver and plan an alternative route, so that the transport would reach the destination point on time. As the truck driver must focus on the road, an additional person would have to be the pilot who would take control over the drone and pass the information to the driver. However, once fully autonomous flights of drones (without any human intervention) are legalized in Europe, the drone itself

could fly out several hundred meters ahead of the vehicle and display an image of the current condition of the road on the screen of a tablet or GPS navigation installed in the vehicle. Furthermore, it should be borne in mind that timber transport is one of the most costly and complicated operations in the wood raw material production cycle (Greulich, 2003).

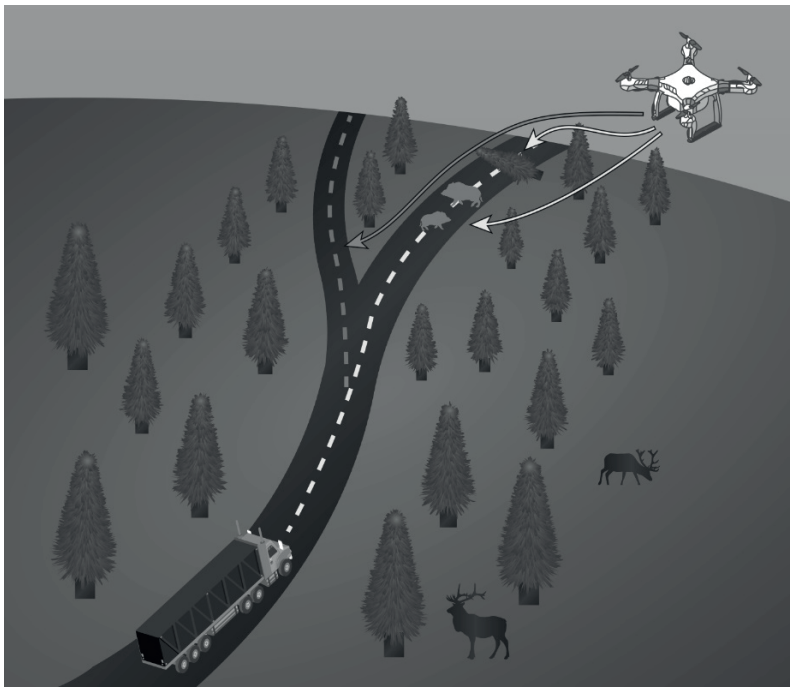

Figure 8. Early warning and alternative route planning system
Source: (own elaboration based on: Greulich, 2003)

Conclusions

Rzepin is one of the forest districts that have noticed the potential of drones and decided to establish the Central Training Centre for Drone Operators for Forestry Needs (Polish shortcut: COSODPL), which is the first centre of its kind in Poland. The employees of the Rzepin Forest District and the COSODPL instructors already now have considerable experience in the current possibilities of using drones, as well as new options for their wider application in forest area logistics. Drones are used also by other forest districts, including Szczecinek, Jabłonna and Bytnica. However, the current use of drones in Polish forest districts is mainly limited to the creation of orthophoto maps. Perhaps after the introduction of appropriate legal regulations, which are a key determinant for the use of drones

in Poland, local forest inspectorates will use their drone potential on a wider scale, such as in Norway.

The examples cited in the article show that civilian drones are able to improve the functioning of a forestry district, primarily by collecting data needed to ensure the continuity and fluidity of resource flows, those consumed (like information), and produced (like wood). Nonetheless, the condition for maximizing the benefits of using UAVs in forest districts is, skilful implementation of drones in the LSS, e.g. as data communication between different users. Drones could contribute to the improvement of processes, not only in individual forest districts, but also in the entire National Forests, by integrating the data transfer into a common server. The role and place of drones in the LSS of a given organization, such as the forest district, is an interesting direction for further research.

However, not every forest district needs support from drones. Some smaller units may not feel much of a difference because the equipment that they currently have is fully sufficient to perform the tasks on a smaller scale. Investing in the drone technology would be like moving around the city centre in a sports car which can reach a speed of over 180 mph, while the road signs and congestion limit the maximum speed of driving down to 30 mph. For such forest districts, it is recommended to outsource such tasks to a company that provides various services with UAVs. The value of the Polish drone market was over PLN 251 million in 2017 and two years earlier it was worth PLN 164 million. It is forecasted that this value in 2018 will amount to nearly PLN 320 million (Duszczyk, 2018b). Nevertheless, it is not the numbers that are most important here, but the increase in the value of the drone market in Poland, as well as the various possibilities of using UAVs, as shown in the article.

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THE SIGNIFICANCE OF REVERSE LOGISTICS FOR THE WASTE MANAGEMENT SYSTEM

Abstract

The aim of the article is to present the issues of the waste management system supported by logistic activities. The main emphasis was laid on the role of the systemic approach in the waste flow management concept. The article presents theoretical foundations related to the concept of reverse logistics, defines the waste flow directions in the waste management system and discusses the waste disposal chain.

Keywords: reverse logistics, waste management, system, waste

Introduction

The issues related to waste management are playing an increasingly important role. It should be noted that this is not a new phenomenon. The growth in global consumption is associated with growth in the production of goods which results in an excessive increase in the amount of generated waste. In prehistoric times, nomads produced organic waste that was subject to a natural process of disposal. The remains became a problem when man had started to lead a sedentary lifestyle. The change in the structure, quantity and type of packaging materials used, negatively influenced the condition of the natural environment. The transformation of packaging gave rise to scientific deliberations concerning its partial biodegradation, with the purpose to eliminate factors posing a hazard to the environment and affecting the life of inhabitants of today's urbanized areas.

Review of the literature

According to the Waste Management Act of 14 December 2012 waste management means 'waste production and waste disposal', while waste disposal means 'collection, transport, waste processing, including monitoring of such activities, as well as subsequent procedures for waste neutralization sites and activities of the seller or agent trading in waste.' (Waste Management Act, 2012). According to the above definitions, waste management and waste disposal can be said not to be equivalent terms. The former is a broader concept covering waste and ways how proceed with it, while the latter is about the possibilities of dealing with waste after it has been produced. Waste management and waste disposal issues should be addressed by both theoreticians and practitioners.

Waste disposal is supported by logistics activities which has contributed to the emergence of the reverse logistics concept. This concept has been continuously evolving since the 1980s of the 20th century (Gajewska, Szkoda, 2016). Attempts to systematize this term were made by Szołtysek who has defined the reverse logistics as "all processes of management of waste and information flows, from the place of origin to the place of destination so as to recover its value or dispose of it appropriately and store it on a long-term basis in such a way that these flows should be economically efficient and minimize the negative impact of waste on the human environment" (Szołtysek, 2009). The above definition of reverse logistics shows efficient and effective disposal of waste which is followed by development of waste collection and waste storage systems.

The essence of a systemic approach to the waste management concept

The 'whole-systems thinking' principle, otherwise referred to as the systemic approach is one of the leading principles of the logistics philosophy. It originated from the systems theory, and the *General System Theory* was created by Ludwig von Bertalanffy. This theory allows formulating rules that apply to all systems. There are certain models and laws that can be used for general systems (Bertalanffy, 1984). The systemic approach assumes that activities in respect of the physical flow and storage of raw materials, semi-finished products and finished products in the enterprise should be considered as a whole, and not on a separate basis (Kochański, 2003). The application of the principles of a systemic approach in logistics leads to suboptimization of specific areas and determining their share in the process of rationalization of activities of a logistic system approached on a holistic basis (Blaik, 2010). It is for this reason that the basic object of interest is a system that is the key to understanding the systemic approach. Attempts to define the term *system* were made by Mynarski who has described it as a purposefully ordered set of components and relations between these components and their properties. Properties should be understood as the features of each object, while relations are defined as relationships between specific parts and the whole (Mynarski, 1979).

As far as the systemic approach is applied to waste management, it is the concept of reverse logistics (which is derived from the general concept of logistics) that should be explained, as it is this concept that determines the application of logistic principles to the waste disposal system through the existence of a specific logistic system.

There is no unambiguous term used to define the reverse logistics in the Polish literature. It is such terms as reverse, utilization, waste, reversed, recirculation, recovery, post-sale, downcycling, reuse logistics and ecologistics that are used interchangeably (Kisperska-Moroń, Krzyżaniak, 2009). The approaches applied in the context of understanding the reverse logistics are presented in Table 1.

Table 1. Approaches applied in the context of understanding the reverse logistics

Approach	Author	Definition
Conceptual and functional	Bendkowski, Wengierek	Reverse logistics means applying the logistics concept with respect to the remains so as to bring about an economically and ecologically effective flow of remains including at the same time the spatial and temporal transformation with a change in terms of sort and quantity.
Entity-based and structural	Gołembska	Logistics in the area of waste utilization consists in developing logistics chains linking places of waste production and waste utilization. This covers the following measures: waste sorting, waste transport and storage, waste processing and production of secondary raw materials.
Object-based structural and efficiency-based	Council of Logistics Management	Reverse logistics is a broad term referring to logistics management of skills and activities engaged in recycling, management and disposal of product waste and packaging waste. It covers inverse distribution which makes the flow of goods and information proceed in the direction opposite to the normal logistics operations.

Source: (own elaboration based on: Council of Logistics Management, 1993; Gołembska, 1999; Bendkowski, Wengierek, 2002)

When formulating the definitions of reverse logistics the Polish authors use the conceptual and functional approach where they present logistics as a concept for the management of flows of goods and information based on an integrated system. In the light of the presented definition, waste should be understood as remains. The economic objective is related to reducing the logistic costs and improving the service level of reverse logistics, while the ecological objective should be understood as putting emphasis on the environmental protection with particular emphasis laid on the natural resources and reducing emissions of harmful substances produced as a result of logistics processes.

The entity-based and structural approach is represented by Gołembska et al. according to whom reverse logistics is an integrated process of flows of goods and information.

Foreign authors, on the other hand, use the structural entity-based or efficiency-based approach understood as orientation towards increased efficiency and offering the desired level of logistics services to clients (Szołtysek, 2009).

The subject of reverse logistics are flows of waste and waste-related information. The activities taken are aimed at integrating the flows in time and space to maintain the natural environment in a proper condition while optimising the cost of these flows (Starostka-Patyk, 2016).

A systemic approach to waste management in the economy can be seen in considering the issue in a holistic way, as well as recognizing specific components of the system (subsystems), including explanation of their role and determining the relations between them. Issues related to waste production, utilization and disposal should be considered in a comprehensive way. Environmental, technological, economic and social issues constitute an integral whole (Gajdzik, 2009).

Referring to the systemic approach, a logistics waste disposal system which is often constructed according to functional areas should be identified (Gajdzik, 2009). The main components of the logistics waste management system are shown in Figure 1.

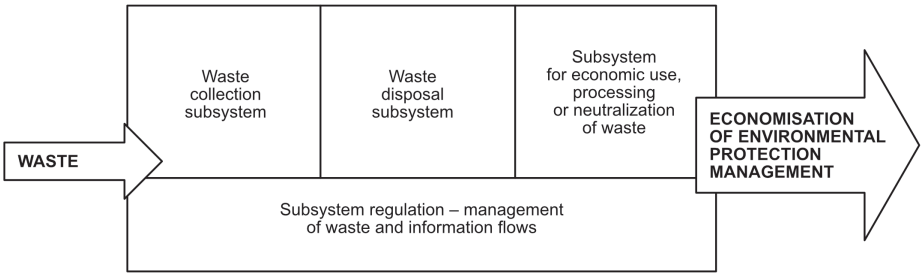

Figure 1. Logistics waste management system
Source: (Szołtysek, 2009)

Figure 1 shows that a logistics waste management system comprises a waste collection subsystem, a waste disposal subsystem, an economic waste utilisation, processing or disposal subsystem.

The system input component is waste, while the output components are: economic management and environmental protection. The logistics waste management system itself is a logistics subsystem of the entire enterprise in which there are interrelations between waste management and such processes as procurement, production and distribution. The directions of flows of generated waste are shown in Figure 2.

Figure 2. shows that products reaching the final consumer are produced as a result of successive technological processes, starting from the supply area, through the manufacturing and distribution areas, ending up with the service area. The recipient receives a small portion of unprocessed natural raw materials. Each phase of the process generates a different type and amount of waste.

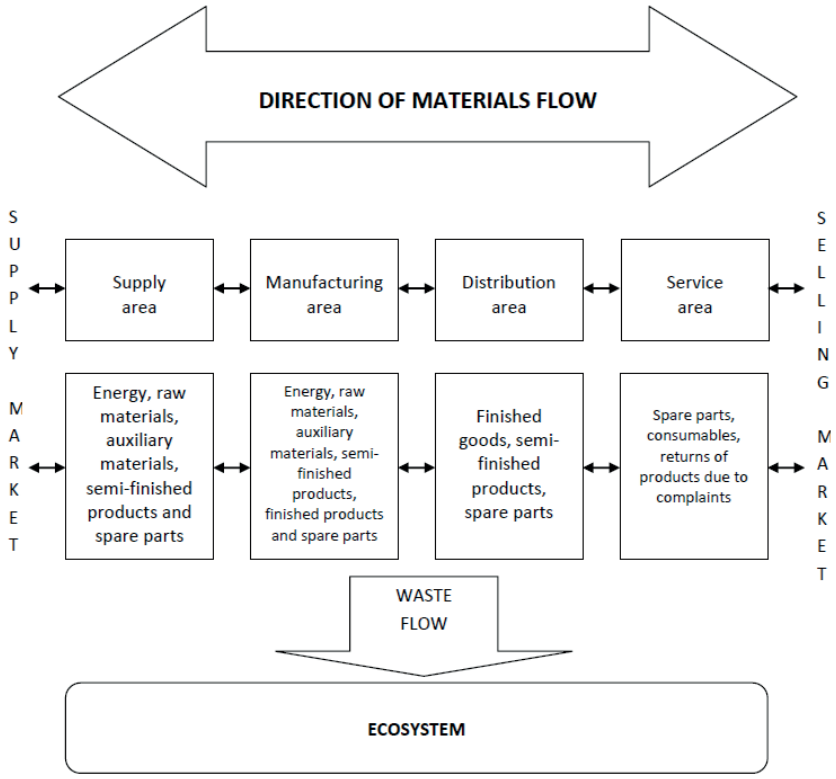

Figure 2. Directions of flows of generated waste
Source: (own elaboration based on: Kisiel, Zwolińska, Gara, 2011)

A logistics waste management system is at the same time one of the subsystems of the logistics system of an enterprise or another organizational unit. Flows of raw materials and waste cover all processes taking place in the enterprise, while the waste market creates residues produced within all the existing subsystems of the enterprise's logistics system, from the supply subsystem up to the subsystem of sales.

The following factors have impact on the functioning of the logistics waste management system (Korzeń, 1996):

1) Quantity, nature and spatial distribution of waste.
2) Regularity and dynamics of waste generation.
3) Binding environmental protection rules.
4) Spatial and urban planning factors.
5) Generally accepted assumptions and local requirements within the permissible loads of environmental components.
6) Strategies employed by supply chain entities.

The waste disposal system operational efficiency depends primarily on the way in which waste is collected, the size and location of the facilities and the adaptation of vehicles to the waste transport routes (Korzeń, 2001).

Reverse logistics and reverse supply chain as waste management components

If the supply chain in waste management is to be considered, the produced waste should be treated as a product that is transported in an efficient way from the place of production to the place of reuse or utilization.

A supply chain should mean a network of links between organizations, suppliers and customers wherein the goal is to develop products and services addressed to final consumers (Łupicka-Szudrowicz, 2004). Logistics provides waste management with solutions in the area of organization, information and technology, it also comprehensively affects the flow of materials whereby a supply chain is created as scheduled and it is referred to as the disposal chain in the waste management system (Przybycin, 2006).

The supply chain in waste management is made up by the following entities (Przybycin, 2006):

1) The resident of the municipality.
2) The waste collecting entity.
3) The waste sorting entity.
4) The landfill.

Having been sorted, the waste that does not go the landfill may undergo some other processing or may be used by third parties. The specific sequence of events in the disposal chain should be noted. Figure 3 shows a common configuration in the waste disposal chain.

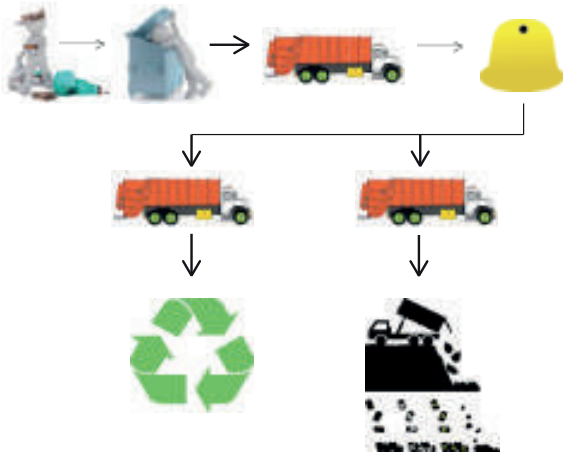

Figure 3. Example of a waste disposal chain
Source: (own elaboration)

Analysing Figure 3. it is possible to identify specific links in the supply chain. The waste produced by the resident is collected by specialized entities operating in the municipality from the place where it is produced. Then, the waste is transported to the place where mixed waste is sorted. Owing to this process it is possible to separate waste that can be used by third parties, therefore, this waste should be transported to places where it will be processed or reused as a raw material. Other waste that cannot be utilized, reused or recycled is transported to the landfill, which is the final link in this chain.

It should be emphasized that the waste is collected directly from the place where it is produced or from the curb. The most commonly used mode of transport for waste disposal is by road. The type of transport used depends largely on the type of containers and the waste collection system. It is also necessary to carefully plan the routes for vehicles collecting the waste which will translate into efficient municipal service and minimization of costs (Matulewski, Konecka, Wojciechowska, 2007). For larger distances, a transshipment station is required as direct transport by dustcarts is no longer profitable. While transhipment stations enjoy great popularity abroad, multimodal transport is rarely used in Poland (Korzeń, 2001).

The component which is a part of the logistics waste management system immediately after waste collection is the subsystem for economic reuse, processing or disposal of waste. The reuse of waste should be understood as the operation whereby "products or components that are non waste are used again for the same purpose for which they were conceived" (Directive 2008/98/EC). The reusable packaging which, in accordance with the applicable Community laws, must meet certain criteria regarding substances used for their production or appropriate labelling may serve as an example. The task of logistics is reduced to limiting the problems that occur in the model process for returnable packaging which can include the lack of detailed control of the condition of packaging, manual counting of packaging units and extended processing time which translates into higher costs (Directive 2008/98/EC). The recycling processes are the substance of reverse logistics.

Entities working together at specific stages aim at achieving the following benefits (Wengierek, 2009):

1) Unity of the existing research and technical capabilities, as well as reducing the research and development costs through participation in these costs.
2) Reaching a new group of customers followed by expansion into new markets.
3) Reaching a new group of customers existing on the already penetrated markets.
4) Extending the existing market by including new transport and logistics companies and new sales representatives.
5) Participation in the costs of distribution, promotion, advertising and transport with respect to the waste unit expressed in tonnes, kilograms, items.
6) Fewer problems and lower costs associated with obtaining waste from the place of its generation.
7) Growing financial potential in enterprises in the waste management system.

Logistic solutions in the waste management system and in the entire disposal chain allow optimizing the routes (setting the routes in such a way as to cover as few kilometres as possible within a defined period of time), use the loading capacity of vehicles for waste originating from sorted collection which is then

shipped to the transfer station, and select the appropriate containers to collect compacted mixed waste, to reduce the cost of transport and fully use the capacity of the containers (Przybycin, 2006).

Conclusions

The rationale for using logistic solutions in the waste management arises from the major logistics issues related to waste management. The area of interest in the waste disposal logistics covers the flows within which it is possible to restore the value from disposed products, and it is also possible to feed a new supply chain as part of the output. The waste disposal logistics is a much broader concept than waste management, which mainly involves waste processing and waste collection. The waste disposal logistics is focussed on processes related to waste management, collection systems, transport and disposal of waste, and particular attention is paid to ecological balances.

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ENVIRONMENTAL RESPONSIBILITY IN LOGISTICS ACTIVITIES OF SMALL AND MEDIUM-SIZED ENTERPRISES

Abstract

Logistics processes are a significant source of pollution of the natural environment. The fact that they are present in the activities of all enterprises means that also logistics processes implemented by smaller enterprises are not neutral to the natural environment. The article identifies the state of awareness of SME managers regarding the impact of logistics processes on the natural environment and classifies the surveyed SMEs in terms of the scope of implementation of green logistics practices.

Keywords: green logistics, environmental protection, SMEs, classification trees

Introduction

A wide-ranging discussion on the impact of logistics processes on the natural environment started in the world literature in the last decade of the last century. One of the first publications that explicitly indicated a new direction in this field was the special issue of the *International Journal of Physical Distribution & Logistics Management,* devoted entirely to the environmental aspects of logistics (Wu, Dunn, 1995; Murphy, Poist, 1995). Since that time, it has been possible to observe a rapid increase in the number of studies and research works devoted to the environmental aspects of logistics operations of enterprises. As a consequence, the concept of green logistics has appeared in the literature, the meaning of which has broadened the traditional logistics concept to include the environmental dimension (Sbihi, Eglese, 2007; Srivastara, 2007; McKinnon, 2010; Hentschel, 2012; Lai, Wong, 2012; Tacken, 2014; Kumar, 2015; McKinnon et al., 2015).

The starting point to correctly define 'green logistics' is correct interpretation of the phrase 'green logistics'. According to some authors, it means environment-friendly logistics practices (Chittyal et al., 2013). Rong writes that the word 'green' in the concept of 'green logistics' is the embodiment of the idea of environmental protection in the area of economic activities (Rong, 2011). A similar interpretation has been presented by Rodrigue, Slack and Comtois who think that 'green' is the key word regarding environmental aspects in a positive sense, and hence, the guidelines for 'green logistics' allow creating logistics systems compatible with the natural environment, friendly to this environment and logistically efficient at the same time (Rodrigue et al., 2001).

Nonetheless, irrespective of the way of interpreting the concept itself, for which no generally accepted definition has been offered to date, it should be emphasized that green logistics is a concept that applies not only to the largest enterprises. In the author's opinion, the fact that logistics processes take place in all enterprises means that also logistics operations carried out by smaller companies are not neutral to the natural environment. In this context, the aim of the article is to identify the state of awareness of SME managers regarding the impact of logistics processes on the natural environment. Moreover, an attempt will be made to classify the examined SMEs in terms of implementation of green logistics practices.

An empirical survey was conducted on a group of purposefully selected enterprises belonging to the Polish SME sector, using the electronic survey form in order to achieve the assumed research goal[1]. The research tool was developed based on an analysis of the world literature whereby it was possible to create a list of the most popular green logistics practices (Colicchia et al., 2011; Lau, 2011; Lin, Ho, 2011; Zhang et al., 2014). The empirical research was carried out at the turn of November and December 2015. A total of 59 complete answers were received, there was no dominant share of one enterprise type in the sample in terms of employment. The received answers were subjected to statistical analysis, using the methods and tools of descriptive statistics, the rho-Spearman correlation analysis and the classification trees method.

1. Impact of logistics processes on natural environment in small and medium-sized enterprises

The conducted empirical studies have indicated moderate or high significance of environmental protection issues during the implementation of logistics processes in the surveyed enterprises (47% and 14% of the answers, respectively). Environmental issues were of little or no significance to 12% of the respondents in total. Interestingly enough, in the prospect of the forthcoming five years, almost 3/4 of the respondents predict that the importance of environmental protection issues in the studied area will be growing.

[1] The survey was commissioned to the Research and Knowledge Transfer Centre at the University of Economics in Katowice.

Nevertheless, irrespective of how the impact of logistics processes on the natural environment is perceived in terms of significance, the respondents have unambiguously confirmed the fact that transport, storage and packaging waste management processes that are in place in their enterprises have a negative impact on the natural environment (Figure 1).

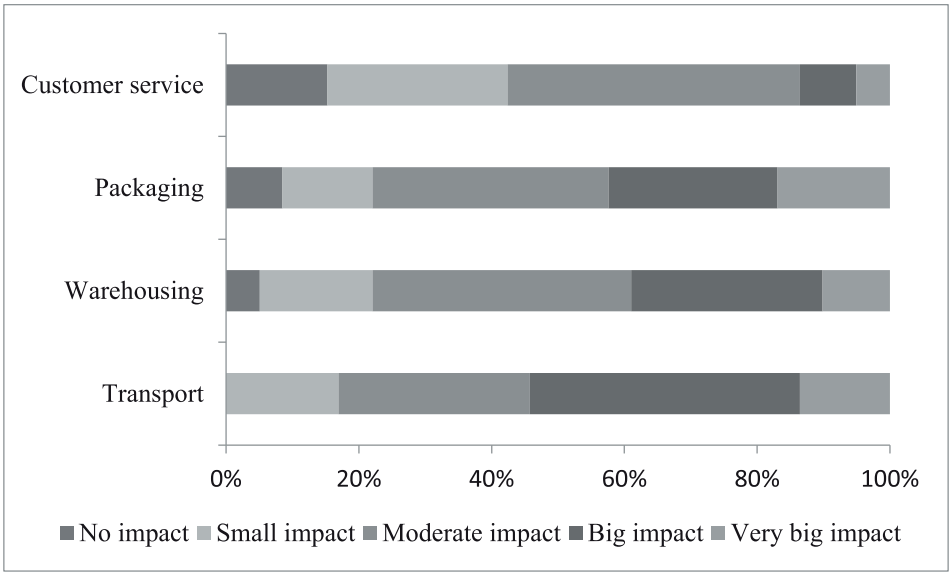

Figure 1. Impact of selected logistics processes on the natural environment in the surveyed SMEs
Source: (own elaboration)

According to the expectations, the greatest negative impact on the natural environment in the surveyed enterprises comes from the transport processes and operations related to the packaging waste management in the broad sense of the term. Nevertheless, the respondents can see a significant potential for reducing the negative impact of logistics processes on the natural environment in all the processes carried out by them (in particular in respect of transport operations) – Figure 2.

The performed analysis of the correlation between the impact of individual logistics processes on the natural environment and the potential for reducing this effect estimated by the respondents have shown a moderate positive correlation in all cases (Table 1). This means that the assessed potential for reducing the negative impact of logistics processes on the natural environment increases along with the increasing assessment of such negative impact.

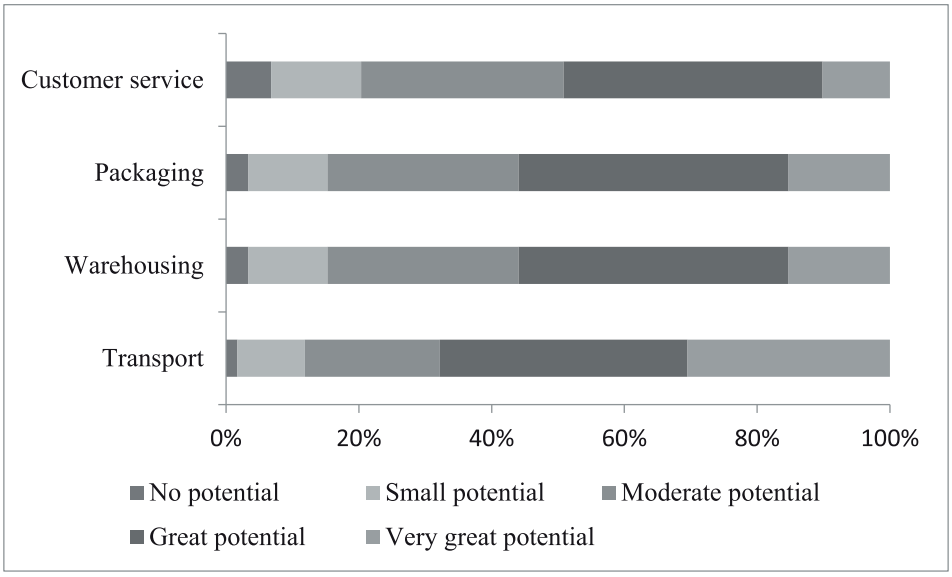

Figure 2. The potential for reducing the negative impact of logistics processes on the natural environment in the surveyed SMEs
Source: (own elaboration)

Table 1. Table of correlation between the impact of individual logistics processes on the natural environment, and the assessment of the potential for reducing this impact in the surveyed SMEs

	P1	P2	P3	P4
W1	,512**			
W2		,427**		
W3			,464**	
W4				,611**

** the correlation is significant at 0.01 (double-sided)
Legend:

Impact on natural environment	Potential for reducing negative impact	Logistics process
W1	P1	Transport
W2	P2	Warehousing
W3	P3	Packaging
W4	P4	Customer service

Source: (own elaboration)

2. Green logistics practices in surveyed small and medium-sized enterprises

In the author's understanding a catalogue of the so-called green logistics practices comprises a set of logistics activities and processes which are assumed to implement the guidelines of the green logistics concept, and hence, they are compatible with the natural environment being at the same time effective – creating the economic value. An analysis of the literature devoted to green logistics allows creating a comprehensive catalogue of activities, in the broad sense of the term, undertaken to reduce the negative impact of logistics processes on the natural environment. Nonetheless, there has been no consistent division line for these practices to date. When classifying green logistics practices, many authors still use the classical division of logistics processes by adding the adjective 'green' to each of these processes. Consequently, it is the terms: green transport, green storage, green packaging waste management, etc. that are used. (Chang et al., 2008; Lau, 2011). Due to the key share of transport processes in the environmental pollution, all the implemented green logistics practices can also be divided into those related to transport practices and all other practices (Martinsen, Huge-Brodin, 2010). On the basis of the analysed world literature, the author has identified a list of 10 most often indicated green logistics practices. These are the following:

– (A) use reusable packaging;
– (B) use alternative propulsion technologies and alternative fuels;
– (C) upgrade the fleet towards environmentally friendly vehicles;
– (D) optimise the routes;
– (E) use intermodal transport;
– (F) train drivers in 'eco-driving';
– (G) upgrade the technologies used in warehouses towards energy-efficient solutions;
– (H) optimise the use of warehouse space;
– (I) reduce paper documents;
– (J) apply the 'green' criteria in selecting suppliers/business partners.

The results of the conducted empirical research have shown that not all green logistics practices are equally popular in the activities of the surveyed SMEs (Figure 3).

The most frequently indicated green logistics processes in the surveyed SMEs include: optimisation of routes and optimisation of storage space utilisation. Not too many fewer answers were received for practices related to the use of reusable packaging and reduction of paper documents. The other solutions were much less popular in the group of the surveyed SMEs. For example, the very little significance attached to the green criteria in selecting suppliers/business partners may result from the fact that the so-called green supply chains where these criteria in selecting business partners are of key importance have only started to appear in the Polish conditions.

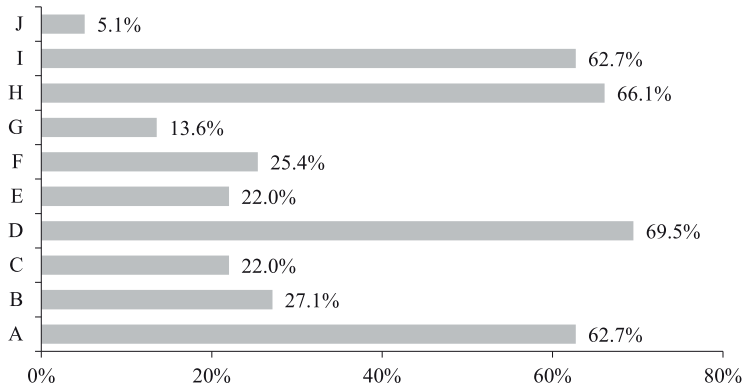

Figure 3. Scope of green logistics practices applied in the surveyed SMEs
Source: (own elaboration)

3. Classification of surveyed small and medium-sized enterprises

In the first step, based on the answers to the question about green logistics practices implemented by the surveyed enterprises, the author identified two types of enterprises. The first group (38 respondents) are *Green* enterprises implementing at least one of the following green logistics practices (B, C, E, F, G, J). The second group (21 respondents) are *Grey* enterprises that do not follow any of the above listed practices. In the second step, the author was looking for an answer to the question whether it was possible to describe the differences between the selected types of enterprises using other features. Table 2 presents a list of features distinguished based on an analysis of the literature (Murphy, Poist, 1995, 2000; Zhu, Sarkis, 2007; Lin, Ho, 2011; Carbone et al., 2012; Kumar, R. Chandrakar, 2012; Wu et al., 2012; Glover et al., 2014), which were analysed using the classification trees method (Breiman et al., 1984). The classification tree created an a result of the modelling is shown in Figure 4.

The classification error of the constructed model is 3%, which means that the classification rules correctly identify the class membership of 97% of the surveyed enterprises. The graphical form of the model shows that 8 rules for enterprises to belong to the Green group are identified. The shortest of the rules is that these are enterprises whose annual revenues do not exceed PLN 5 million (1 in answer to Q2) and they are suppliers of semi-finished products (1 in answer to Q6.2). Another rule, which can be derived from the right side of the tree is that these are enterprises with the annual revenues not exceeding PLN 5 million (1 in answer to Q2), at the same time, these enterprises are not suppliers of semi-finished products (2 in answer to Q6.2), but they have implemented ISO 14001 (1 in answer to Q.7). By analogy, the remaining 6 rules for the surveyed enterprises to belong to the *Green* group can be defined.

Table 2. The set of features used for classification-trees analysis

Q1. Employment		Yes	No
1	Micro	1	2
2	Small	1	2
3	Medium	1	2
Q2. Annual sales			
1	(0–5 million)		
2	(5–10 million)		
3	(10–50 million)		
4	(50–100 million)		
5	(100–300 million)		
6	(300–500 million)		
7	(500 M–1 billion)		
8	>1 billion		
Q3. Type of enterprise		Yes	No
3.1	Manufacturing	1	2
3.2	Trade	1	2
3.3	Services	1	2
Q4. Industry		Yes	No
4.1	Construction	1	2
4.2	Automotive	1	2
4.3	Pharmaceuticals and cosmetics	1	2
4.4	Raw materials and fuels	1	2
4.5	Food products	1	2
4.6	Chemical	1	2
4.7	Wood and paper	1	2
4.8	Electrotechnical	1	2
4.9	Machine	1	2
4.10	Metal	1	2
4.11	Clothing	1	2
Q5. Position in the supply chain		Yes	No
5.1	Indirect supplier of supply chain leader	1	2
5.2	Direct supplier of supply chain leader	1	2
5.3	Supply chain leader	1	2
5.4	Direct customer of supply chain leader	1	2
5.5	Indirect customer of supply chain leader	1	2
Q6. Position in the supply chain		Yes	No
6.1	Supplier of raw materials	1	2
6.2	Supplier of semi-finished products	1	2
6.3	Supplier of finished products	1	2
Q7. Implemented ISO 14001		Yes	No
7	ISO	1	2
Q8. Implemented CSR		Yes	No
8	CSR	1	2

Source: (own elaboration)

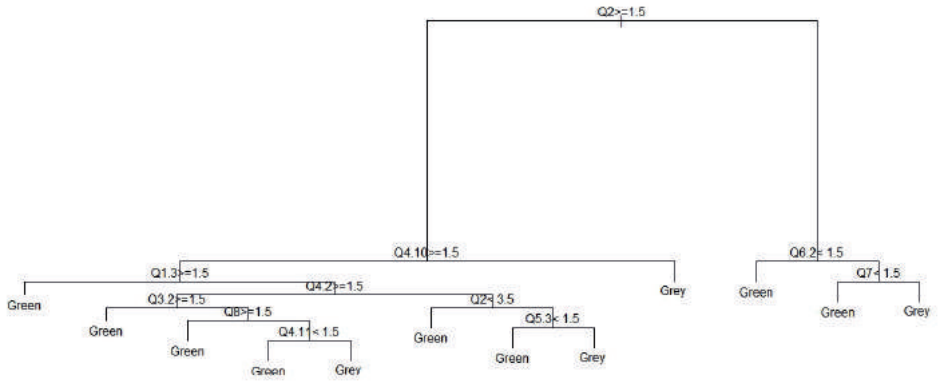

Figure 4. Classification of surveyed SMEs – classification tree
Source: (own elaboration)

Conclusions

The conducted research has shown that managers of the surveyed enterprises are aware of the negative impact of logistics processes on the natural environment and they can see the potential for reducing this impact, especially in the area of transport operations and packaging waste management in the broad sense of the term. In the prospect of the forthcoming years, according to the respondents, the importance of environmental protection in the design and implementation of logistics processes is expected to grow. Environmental awareness of managers of the surveyed SMEs is not always reflected in specific activities, as demonstrated by the results of the analysis carried out using the classification trees method. In addition to *Green* enterprises, quite a large group of *Grey* enterprises has been identified, i.e. enterprises that have not implemented even one green logistics practice. In consequence, the author is of the opinion that the basic motives for the development of green logistics practices in small and medium-sized enterprises should be identified taking into account, for example, such variables as: the size of enterprises, the industry in which these enterprises operate, the role they play in the supply chain, or their place in the supply chain. Therefore, it is postulated to undertake further research towards the possibility of broader development of the concept of green logistics in SMEs. The following specific premises indicating this necessity should be mentioned:

– the ever-growing role and importance of small and medium-sized enterprises in the modern economy;
– the rapid growth of the importance of issues related to environmental protection and the principles of sustainable development in logistic strategies of companies

and the creation of the so-called green supply chains the participants of which are also small and medium enterprises;
– the insufficiency of research and scientific studies on the implementation of the concept of green logistics in small and medium-sized enterprises.

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IDENTIFYING THE IMPACT OF INFORMATION LOGISTICS ON CONTEMPORARY CONCEPTIONS OF LOGISTICS

Abstract

The contemporary economy is characterized by high reliance on modern technology, IT systems, and analyses of large amounts of information and data. This reliance promotes creation of new, innovative logistics concepts. Many practitioners and scientists have described the current situation as a logistics revolution, logistics 4.0 or logistics of the 21st century. This article attempts to systematize this terminology and present the foundation of modern strategies within logistics. What influenced the creation and functioning of the contemporary logistics strategies was the logistics of information and rationalization processes occurring within it. The aim of the article is to identify the impact of information logistics on the development and functioning of selected, contemporary logistics concepts.

Keywords: logistics of information, information logistics, logistics concepts

Introduction

Contemporary economy is characterised by variability, a fast pace of growth and great competitiveness. These circumstances render the task of building a competitive advantage a challenging one, and even once such advantage is attained, its maintenance raises significant issues. The economic environment of the 21st century necessitates a search for new and often innovative means of company management, including production, storage, and distribution. This, in turn, fuels the development of logistics and logistics strategies. The logistics strategies that have been created and evolved within the last 20 years are based primarily on technological advances and implementation of modern means of acquiring, storing and processing data, as well as on ensuring the quality of information used in managerial and decision-making processes.

The sources of obtaining a competitive advantage are rapidly changing, which means that to remain competitive, company owners need to make accurate, on-the-spot decisions, deviate from their previously established habits and make fundamental changes to the assumptions underlying the functioning of their businesses (McGrath, 2013). Hence, the importance of logistics of information, which plays a crucial role in the way in which companies operate on the market and build a competitive advantage (Weiland, 2016).

The purpose of the article is to identify how information logistics affects the growth and functioning of the contemporary logistics strategies. Furthermore, the article foregrounds information logistics as a key component of selected, contemporary logistics strategies, and discusses the importance of information as a vital resource utilized in building a competitive advantage. The author attempts to give structure and coherence to the terminology relating to contemporary logistics, information and data, all of which are crucial in the emergence of information.

The aim of the article has been attained primarily through theoretical research tools, such as analysis of the relevant literature, including text analysis, a bibliometric study and drawing comparisons. Thus, the article may serve as an introduction to further research into how information logistics shapes innovative means of production and distribution.

1. Information Logistics

Information ought to be viewed as a full-fledged resource, since – in parallel to all other resources – it is produced, stored and sold by businesses. However, it must be emphasized that – aside from the above-mentioned characteristics – information does possess qualities that differentiate it from traditional resources (Skrzypek, Grela, 2005):

- it is non-exhaustible and does not get depleted whilst it undergoes processing;
- it is substitutable;
- it is complementary;
- it is objective;
- it is virtual;
- it is synergistic;
- it is diverse;
- finally, information may be multiplied and transferred across space and time without any limitations or subjectivity of assessments.

One of the most important properties that differentiate information from other resources is the fact that it does not get depleted whilst it undergoes processing or when it is used during production (for instance, in the decision-making process). In consequence, information can be used by multiple agents simultaneously and does not require restoration. However, the inexhaustibility of information does not mean it cannot become outdated – the speed at which information is currently being produced dramatically reduces the span of its lifecycle.

Another equally important quality setting information apart from other resources is its virtuality, which means that it is not inextricably tied to any given storage

medium. The same information may be carried by multiple storage media without affecting its value to the recipient. The mentioned virtuality is closely connected with its ability to be multiplied *ad infinitum* across both time and space. Information can be transferred from one storage medium to another, as well as between recipients regardless of the distance that separates them.

Appropriate logistics is required for information to be processed as a resource. Logistics refers to any intentional human activity, whether it is business-related or not. The aim of logistics is to direct the flow of resources within a company, as well as between collaborating organizations along the logistics chain and channels (Chaberek, 2005). Information is one of these resources. At present, every action taken by a business involves a wave of information. The way in which a company uses this resource should be profitable, efficient and effective. The turbulent nature of today's economy makes these goals particularly challenging, hence, for a business to build a competitive advantage, it is crucial to utilize logistics as a means of rationalizing the base processes (Szmelter, 2013).

Information handling within logistics leads primarily to the emergence of systems designed to ensure acquisition, flow and storage of information; further, these systems facilitate appropriate realization of the primary and ancillary processes. However, it needs to be stressed that acquisition, flow and storage of data also fall within the scope of the logistics of information. The process of creating information requires data as one of the most crucial inputs, which justifies the inclusion of data as part of information logistics. For data to be utilized within information logistics, multiple sources of acquiring / creating data need to be integrated with multiple recipients of the said data, which process often occurs in real time. This frequently manifests itself as *telematics*, that is systems of data acquisition and transfer. These processes cannot be appropriately performed unless there is adequate equipment required for their realization, as well as appropriate technical and organizational solutions. The aim of the logistics of information and data is to provide the required information of appropriate quality, at an appropriate time and place, in an adequate amount and at an acceptable price. If stores of information are to be used profitably, efficiently and effectively, it is necessary for a business to design its own system of supplying information. Such a system would support the decision-making processes by supplying appropriate information – i.e., resources – necessary for the realization of this process. It is impossible to acquire the necessary repository of information without specifying its source first. By analyzing the information used by companies, it is clearly observable that only a fraction of the said information is understood and processed. Thus, business-owned information may be likened to an iceberg, whose greater part remains unseen and thus unused (Wit, 2008). Logistics of information brings to the fore the importance of making businesses aware of the potential that information holds and demonstrates means of acquiring and processing data with the goal of obtaining information. If obtained in accordance with the fundamental assumptions laid out by information logistics, information may contribute to the process of building a competitive advantage.

2. Contemporary logistics – evolution or revolution?

The starting point for any discussion regarding the evolution – or, possibly, revolution – in logistics is, first, to define the primary phenomena relating to it, that is, innovation, revolution and evolution, and second, to juxtapose them in reference to strategies used in logistics.

There are multiple definitions of the term *innovation* within the relevant literature, which often raises doubts as to whether a given solution or strategy can be described as *innovative*, or whether it merely bears hallmarks of innovativeness. Literary sources often refer to the concept put forward by Schumpeter in the 1960s, who defines *business innovation* by enumerating the following qualities:

– it should either better the existing products and introduce new ones;
– it should improve the existing means of production and introduce new ones;
– it should rejuvenate the existing sales markets, as well as search for and open new sales markets;
– it should improve the processes underlying the organization of production;
– it should utilize new means of sales and improve the existing ones;
– it should use new resources and materials.

Rogers and Pichlak suggest an alternative definition, specifically, they view *innovation* as consisting in an introduction of a new idea, behaviour, product, service, strategy, project or any type of solution, which – from the perspective of the target user or the innovator – is perceived as novelty (Kruczek, Przybylska, Żebrucki, 2015). Hamel (2006) furnishes yet another concept of *innovation* and its effects on the process of building a competitive advantage, namely, he claims that *innovation* ought to:

– reduce the costs and increase the operational speed without altering the performance of tasks – operational innovation;
– design and create new products and services – product and service innovation;
– introduce a new perspective on the relationship obtaining between a business and the sales, distribution and supply markets – strategy innovation;
– introduce groundbreaking, novel strategies of organizing labour within a business by rearranging the methods of control, motivation, decision-making, etc. – management innovation.

Bujak and Zając (2011) offer a summary that is highly pertinent to the views presented herein, as they tie innovation inextricably to such phenomena as change, novelty, reform or unprecedented ideas. According to these researchers, what qualifies as innovative is a wide spectrum of technical, organizational and societal facts, processes and phenomena.

The competitiveness of contemporary markets makes innovations indispensable in the following domains of operation: managerial, economical, manufacturing, processual, etc. The primary goal of introducing innovations is to acquire a competitive advantage whilst maximizing the satisfaction of the customers and recipients of the said innovation, both within and outside of a given company.

It is innovations that have been the driving force behind the rapid growth of marketing strategies in management, organization, economy and, finally, in the interdisciplinary domain referred to as *logistics*. However, as already

mentioned, *innovation* does not equal *novelty*, rather, it may manifest itself as a fundamental reorganization of the already existing processes, systems, components, products, services and the like. Hence, it is crucial to investigate in detail whether what we are witnessing within the sphere of logistics may be more aptly described as a revolution or an evolution.

The Polish Language Dictionary (www1) defines evolution as (self-translation):

– a process observed in the natural environment across generations consisting in changes in the structure of the existing organisms and creation of new organisms;
– a process of transforming, transitioning into more complex states;
– a process of gradually-occurring social changes, from simple forms towards perfected ones.

These definitions share certain similarities, such as: emphasis on the gradual nature of the said changes, improvement of the existing components (products, services, processes, systems) and their transformation into new forms that imbue them with new properties. On the opposite end of the spectrum there is *revolution*, which is defined by the Polish Language Dictionary (www2) as "a process of precipitous changes in a specific area, which changes are accompanied by a rejection of the existing solutions and introduction of new, better procedures in their place".

While analyzing the definitions adduced above, it is salutary to refer to the history of industrial revolutions. It is commonly assumed that the invention of the steam engine towards the end of the 17th century constitutes the first industrial revolution. This invention mechanized and automatized labour to the exclusion of animals and human workers, which was undoubtedly revolutionary. The second industrial revolution dates back to the beginning of the 20th century and was brought about by the implementation of the means of mass production – primarily the conveyor-belt – and the adoption of electrical energy to drive motors. Similarly to what happened throughout the first industrial revolution, the new inventions replaced the existing technologies.

The third industrial revolution happened relatively recently, that is in the 1970s, and it was strictly connected with the introduction of electronic systems and modern information technologies that allowed manufacturing process to be automated.

The fourth industrial revolution – under the name of Industry 4.0 – is said to have begun several years ago (Hanower, 2012). According to many global market practitioners, the fourth industrial revolution will be based on: i) artificial neural networks that enable machines to learn, ii) a widely accessible and highly-developed RFID technology, iii) already existing information technology systems that assist the design procedures, iv) optimization and bolstering of the decision-making processes. However, the greatest emphasis here is placed on intelligent artificial agents, that is, "the Internet of Things" (IoT).

At this stage, it is necessary to elaborate on the aforementioned distinction between economic revolution and evolution, which raises the question whether the already existing and fully-operational solutions and procedures are going to be replaced altogether, or whether they are going to be merely updated and reorganized.

Many of these components already exist, and their underlying concepts were created primarily through the process of change and evolution. The analogous invention – that of the internal combustion engine – is a telling exemplar of such developments. It was undoubtedly transformative in many domains of life, however, it did not initiate another industrial revolution, rather, it represented merely a step in the evolution of the steam engine. In a similar vein, the current changes in economy – such as the increasing reliance on the Internet, RFID, EDI and multiple other technological and informational solutions – have been in operation for many years and were connected primarily to the third industrial revolution. What we are witnessing at present and what will, in all likelihood, continue to impact the economy for the coming decades is innovative means of utilizing the web, intelligent, self-learning networks, and the emergence of smart devices which are part of the Internet of Things. All this, however, is a long-term, gradual process that does not disrupt the existing system, but rather updates it.

3. The role of logistics of information in selected contemporary logistics strategies

As observed by Borowiecki, Jaki and Kaczmarek (1998), some of the distinguishing elements of the business operating with the contemporary market are:
- changeability resulting from the need to constantly adapt to the fluctuating situation on the market;
- operating in an environment characterized by a high degree of risk and uncertainty;
- economic rationality of the constant, professional operations performed by a business;
- the need to incessantly self-improve and retain innovativeness and the entrepreneurial nature of operations.

Businesses that want to satisfy the demands of contemporary markets have to expand beyond their standard operational procedures, habits and manufacturing schemata, since stagnation is likely to either leave them behind their competitors, or lead to bankruptcy. The necessary consequence of these circumstances is the pursuit of innovation across multiple domains and implementation of modern technologies.

According to Borges (1985), the contemporary economy should focus increasingly on the process of rationalization, placing an emphasis on the following phenomena in concordance with the pace of technological advancement:
- mechanisation and automation;
- organization of activities and structures;
- controlling and planning of the manufacturing process;
- planning employment;
- informing and communicating.

In times of technical and technological growth, rationalization revolves not only around the rationalizations of technology, but also around ancillary rationalization, which is primarily concerned with the domain of information supply.

This has two causes: first, the role of information stores is becoming increasingly important in the functioning of businesses; second, there is a growing awareness of the impact that processes subsidiary to the main process (such as manufacturing), must be equally efficient (Chaberek, 2011). What integrates all flows is the logistics of information.

Logistics, including the logistics of information, is defined by M. Chaberek (2011) as "a process that aims at servicing any rational human activity which comes into being with a purpose of actualizing a certain objective; this process consists in providing the necessary resources (…) in such a way as to make the means of attaining the primary goal efficient, effective and profitable".

Taking into account this definition in relation to logistics, what needs to be identified first is the overall business strategy; only then it is possible to start building and adjusting a logistics strategy designed to support realization of the goals of the overall business strategy. According to Bujak (2014), contemporary innovative concepts and strategies should take into consideration the following factors:

– growing customer expectations;
– development of new technologies;
– globalisation;
– development of online economy;
– emphasis on cost reduction;
– changeability and the necessity to deal with information deficiencies;
– increase in risk and emphasis on security;
– efforts towards a well-balanced development;
– lack of qualified personnel.

However, as reported by Wieczorek (2015), one should bear in mind that, in practice, it is impossible to create a perfect logistics strategy, therefore, businesses ought to focus only on the most important components while creating the said strategy and adjusting it to their needs. Selecting and modifying a strategy in such a way is likely to enable a company to build a stable competitive advantage.

Table 1 included below presents five selected strategies within logistics that have been created and implemented over the last 20 years. The goal of this juxtaposition is to offer a profound insight into how information logistics affects the emergence and form of innovative means of production and distribution.

Contemporary logistics strategies that have emerged within the last 20 years – as well as the latest ones, the prime example of which being the aforementioned Internet of Things –- are founded on acquisition and processing of data and information. The changes that are currently occurring in the business environment foreground the importance of the logistics of data and information, which – although heretofore playing merely an ancillary role – has now become a crucial, integrating and leading factor.

Table 1. Juxtaposition of contemporary strategies in logistics

Strategy	Basic assumptions	Desired results for the company	The importance of information logistics for the implementation and functioning of the strategy
Ambient Intelligence	Fusing the already existing technologies and devices in order to create complex systems and intelligent networks that will enable automation of operation.	Automation of the production line, self-renewing storage supplies. Automation of process management.	The logistics of information is of crucial importance as a result of the necessity to acquire and process data in real time from multiple sources of measurement. This data is subsequently forwarded to numerous recipients (systems, databases, etc.) in order to derive useful information from them.
Manufacturing process modularity	A fusion of standardization and elasticity comprising the final product assembly composed of a limited number of prefabricated subcomponents (modules). The process of assembling subsystems into a complex product or process, which subsystems may be developed irrespectively of one another and which offer the additional benefit of being amenable to disassembly and reconstruction.	Utilization of the economics of scale, manufacturing of multi-variant products within time frames satisfactory to the customer. Introduction of systems expediting and facilitating product design and updates, process optimization and the resulting cost-reduction throughout the lifespan of a product.	Information logistics plays an important role in the product design process and allows a more efficient flow of information between the units responsible for the delivery of particular product components awaiting assembly.
Leagile (a "lean and agile" hybrid strategy)	A combination of "lean" – efficient at physical transfers – and "agile" – efficient at responding to the demands of the market – strategies.	Delivery chains are shortened and the ability to manufacture different products in the factory is retained.	Delivery chains based on the idea of leagile are characterized by highly-developed infrastructure, control over and sharing of information along the entire chain (usually managed by the chain leader), as well cooperation between the suppliers.
Omnichannel	This strategy constitutes the next step in the development of e-commerce. It integrates all channels of information flow across all sales platforms in such a way as to enable the customer to derive the same amount of pleasure from shopping regardless of which sales platform he chooses to initiate and finalise his purchase.	The goal is to build a competitive advantage, improve the information flow between the customer and the company, and to focus all attention on the customer.	Omnichannel strategy involves using a unified database in order to integrate all flows of information between the customer and the company, which renders logistics of information crucial.

Strategy	Basic assumptions	Desired results for the company	The importance of information logistics for the implementation and functioning of the strategy
e-fulfilment	This strategy was created for the purposes of e-commerce, and its primary goal is to handle all aspects of delivering logistics services ordered online, including their realisation and monitoring of the entire process.	The goal is to make work less time-consuming, reduce the amount of manual labour and length of maintenance breaks, to constantly monitor the process, supply the customer with information, provide satisfactory security while handling customer information, personal data and documents.	Information logistics lies at the very core of this strategy and manifests as information flow between the customer and the logistics operator.

Source: (own elaboration based on: Gershenson, Prasad, Allamneni, 1999; Starr, 2010; Mikkola, Skjott-Larsen, 2004; Borgstrom, Hertz, 2011; Prońko, 2012; Przybylska, 2012; Stanek, Zadora, Żytniewski, Kowal, 2012; Zhang, Wang, Wu 2012)

Conclusions

The contemporary economy is developing at a rapid pace, which – in combination with its fluctuating state – promotes creation of conceptually and structurally innovative logistics strategies and solutions. These are largely based on cutting-edge technologies, and complex systems enabling data acquisition and its subsequent conversion into information. For today's businesses, the said information plays a crucial role since – if handled appropriately through well-organized logistics – it facilitates communication and makes a company more competitive on the market. The facts presented herein portray the current global market as a synthesis of evolutionary and revolutionary phenomena that cannot be definitively described as belonging exclusively to either of these categories. This, however, in no way precludes emergence of innovative logistics strategies that draw on the existing solutions, nor does it prevent creation of entirely new concepts whose basic assumptions will be based on the logistics of information.

Further research is going to investigate logistics-related factors shaping innovative and semi-innovative methods of production and distribution.

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APPLICATION OF BLOCKCHAIN TECHNOLOGY IN INFORMATION MANAGEMENT IN SUPPLY CHAINS

Abstract

The aim of the article is to present the essence of information logistics in supply chains including a review of the literature referring to the information management strategy. The information is presented as one of the key resources of enterprises. The great importance of efficient and effective exchange of information is identified as a key factor in the context of building partner relations within supply chains. The article also presents the way in which the blockchain technology works and the possibilities of using it. Projects in which the blockchain technology will be used and which will refer to information management within the supply chains are also presented. An already existing application tool using the blockchain technology is also discussed. Owing to this, benefits derived from using tools based on the blockchain technology to improve information management within supply chains are identified.

Keywords: information logistics, supply chain, supply chain management, partnership, blockchain technology, application platforms

Introduction

Globalization, changes occurring in the economic environment, growing competition and more demanding requirements of customers as regards a higher service level are the main determinants stimulating the development of logistics services for modern economic processes. The increasing volume of flows of goods on global markets leads to a greater complexity of relations between enterprises operating within supply chains. Wishing to attain a competitive advantage, economic entities operating in the contemporary realities are forced to incessantly search for solutions aimed at more efficient and more effective operation of logistics services for

manufacturing and transport processes. One of the basic ways to develop effective supply chains has been to build partnership relations between enterprises.

A very substantial role in supporting economic processes within supply chains is played by information management systems. Information is currently one of the key resources of enterprises. Efficient acquisition and processing of information is one of the basic factors increasing the efficiency of logistics activities. Continuous improvement and development of modern information systems directly reflects the realities and directions of development of the modern economy, showing the importance of information management within the supply chains.

The aim of the article is to present the possibilities of using the blockchain technology in information management of supply chain operations.

1. Partnership as a key factor in the development of supply chains

A supply chain is defined as any activity related to the movement and transformation of goods and the information accompanying these processes. In the case of supply chains, it is necessary to consider activities related to the flows and transformation of products starting from the point where raw materials are extracted, until the final product is supplied to the end consumer. All the intermediate phases of movement and creation of the product value should be taken into account, as well. All the activities within the supply chain involve also satisfying the requirements of the operation profitableness, efficiency and effectiveness. Should the cooperating entities wish to attain this objective, they would need to focus on improving the mutual relations (links) throughout the entire product delivery cycle. Management flows in a supply chain are currently perceived as one of the strategic areas of business operation of enterprises (Chaberek, 2002). Certain assumptions should be made to define the supply chain concept. For this reason, the author assumes that a commodity chain is a group of enterprises working together at processes related to the manufacture of specific goods or material groups. Specific goods including, but not limited to, raw materials, components, spare parts or semi-finished products incessantly flow at the contact points of commodity chain links. The physical movement of goods is always accompanied by a certain information resource. If processes related to flows of this type are to be performed effectively and efficiently, they must be accompanied by logistic services. The relationships having been presented in this way, it is concluded that the commodity chain is served by specific logistic processes that can be systemically called a logistic chain. If this line of thought is employed, it can also be said that the commonly accepted and applied concept of the supply chain reflects the coexistence of commodity chains and the accompanying logistic processes (Chaberek, 2015a).

The evolution associated with the implementation of logistics processes is inextricably linked to the development of strategies relating to the partnership between entities involved in flows of resources. In response to the growing global competition and the increasingly progressive shortening of product life cycles, enterprises need to pay more attention to the integration of activities within supply chains. Partnership in supply chains is a specific relationship between

the cooperating enterprises. This relation should be characterized primarily by mutual trust, openness and a mutually accepted division of risks and benefits among all partners. The ability to define and improve components of processes related to mutual cooperation is crucial in improving the efficiency of activities carried out within supply chains. According to the author, the most beneficial form of partnership is P3. Chaberek defines it as establishing cooperation whereby each organization perceives the partner's activities as a natural extension of their business. Establishing such a strong partnership, enterprises that are links in the supply chain must analyse the impact of the regulators and external factors that may affect the formation of such mutual relations (Chaberek, 2015b). The most vivid challenges for optimum organization of flows of goods and information are the following (Christopher, 2000):

– new rules of competition, competition between entire supply chains;
– increasing significance of management related to the sphere of customer service;
– globalisation of the industry;
– the need to compress the time of activities;
– organization of processes related to the product quality control;
– improvements related to the transparency of operations in the supply chain;
– improving the flow of information in the supply chain.

According to the author, the above presented aspects of management activities should be a specific determinant for a template of actions to be taken when implementing new solutions in the supply chain management. Referring to problems formulated in such a way, it becomes increasingly obvious that enterprises cooperating within supply chains have a chance to survive only when they are able to introduce innovations to become a component of their current and future operations, at the same time improving the processes of integration and coordination of jointly undertaken activities.

2. Information as a resource in the supply chain

In addition to physical flows of goods there are also flows of information between participants in supply chains. In addition to the work, capital and land, it is information that has become one of the most important resources managed by enterprises. The dynamic development of the world based mainly on the growing importance of modern technologies determines the situation in which enterprises that do not have adequate information resources have no chance of gaining a competitive advantage. However, business entities may have a problem with incompetent use of information resources. In such a situation, appropriate logistics is required for information resource management to achieve the company's goals, and thus gain a competitive advantage (Weiland, 2016). The competitive advantage these days is gained chiefly through cooperation of partners who jointly plan and implement projects aimed at delivering goods to the end consumer. Hence, supply chain links should efficiently provide each other with information regarding customer needs, customer requirements, stock levels, manufacturing plans and demand for the goods that they produce (Wieczerzycki, 2009). Having access to relevant information, all

participants to the exchange have greater knowledge about the processes carried out jointly. This makes it possible to solve the emerging problems effectively, respond to the market changes faster and efficiently respond to the requirements of customers related to their needs. Reliable information is also a resource necessary to draw up action plans and build a future strategy for managing the flows of resources. Therefore, enterprises continuously develop and improve their IT systems to ensure access to reliable data. Nevertheless, these systems support integration and improve the organization of supply chains, enabling appropriate planning and making the right decisions regarding coherent goals and effective coordination of activities (Ciesielski, 2010).

One of the most probable ways to develop the management of information resources in supply chains is the increasingly widespread use of IT technologies. They help efficiently and effectively support communication over long distances. They also make it possible to replace paper documents, which are still very common, with databases collected and processed in an electronic form. When ICT technologies are adapted in the supply chain management, it is possible to reduce the spatial, time and cost constraints which are barriers to establishing cooperation and running a business. Thus, taking into account the objectives and principles of supply chains operation which are based on partnership, the desired outcome is to combine individual information management modules which are increasingly often used by mining, manufacturing and trading enterprises (Ciesielski, 2010).

Hoverer, investments in IT technologies which improve business management do not always result in automatic improvement in performance. When investigating the reason for failing to successfully implement information technologies which would translate into better efficiency of management processes, a scheme for effective application of IT in business was discovered. Enterprises achieving growth effects resulting from implementation of IT technologies decided to make certain simplifications to their portfolios of specialized applications striving at the same time to create and use one integrated application platform. Such a platform reflects the operating system of a single computer. Fragmentary solutions included in the structure of such a platform are standardized. Owing to this, integrating many software components becomes even simpler whereby the risk of separating the information contained in separate technology silos can be eliminated. The activity aimed at integrating individual components of application platforms creates possibilities of a free data flow between the users of such systems. The role of such IT management systems is currently most frequently played by the ERP software. The use of specific technologically-engineered management systems based on information technologies is becoming one of the key foundations to go one step further in the management of material and information resources. This is done by extending the existing IT infrastructure to include the environment of the enterprise. The ERP class platforms had to be joined by platforms targeted at solving problems related to customer service and transport in supply chains for management decision-makers to be able to take into account what is happening in the environment of the enterprise. It was the need to illustrate the economic environment of individual links in the supply chain that made the ERP, CRM and SCM systems coexist with each other (Samól, 2012).

Information in an information flow concept structured in this way, where ERM, CRM and SCM systems are jointly used via the Internet, can be immediately accessed by all the cooperating entities. Thus, the two streams, the physical distribution of goods and the flow of information can be separated. The decision-making processes are significantly shortened owing to such separation. When using the Internet, the geographical distance is not an issue, and the physical location of data processing does not matter. It also gives the possibility of developing a centralized information processing system while eliminating at the same time the flow of data through intermediate links of supply chains. The possibility of processing information on a global basis provides better conditions for optimising the processes of enterprises working together within a supply chain (Cellary, Strykowski, 2002).

State-of-the-art IT systems that can be applied to logistics should improve and support the processes of physical flows of goods, through enhancements related to the provision of information. To fulfil the task, IT systems should be based on databases being sets of items of information covering the environment of logistics processes taking place to support the main processes. In order to effectively move goods in time and space, the enterprise should have information (Szymonik, 2011) which is:

– correct, consistent with the actual physical condition;
– reliable, the sources of its origin should not arouse any doubts;
– selective, satisfying the user's need for information in a specific area of interest;
– complete, to the extent that an optimal decision can be made with the amount of available information;
– available on time, as expected by the system user;
– useful, supporting decision-making by logistics managers.

Appropriate conditions for the collection of information should be provided to be able to guarantee access to the above described relevant information to include (Szymonik, 2011):

– a detailed description of products, materials from which they were made and their life span;
– marking products with bar codes or electronic markers to be able to distinguish them in an unambiguous manner and automatically identify them;
– the ability to track products in real time, at any time during storage or relocation, so that the location, quantity, parameters and the type of goods can be determined.

In practice, the best tool for gathering information resources is Automatic Data Capture (ADC), which usually employs specific techniques of description of goods on information carriers. The most common information carriers used in logistics include tools such as: the group of optical signs to which bar codes are assigned and the group of electromagnetic carriers to which tags, electronic labels read using the RFID technology and biometric signs, e.g. watermarks are assigned (Szymonik, 2011).

3. Blockchain technology and its possible applications

According to the European Commission the blockchain technology is supposed to significantly influence the transformation of business models in such areas as: healthcare, insurance, energy, intellectual property rights management, public administration and logistics. When the project called *Observatory and Blockchain Forum* was launched, it confirmed the extent to which the blockchain technology can change IT systems supporting management in various types of organizations. This initiative of the European Commission, supported also by the European Parliament, aims to highlight the most important advances in the field of technology development and to support entities interested in developing and using the blockchain technology in their operations (rp.pl, 2018).

The first application of the technology was the launch of the Bitcoin cryptocurrency in 2009, the value of which is based on the computing power, in contrast to other currently functioning currencies, the value of which has some reflection in the gold parity, state or international regulations. Less than a year ago the value of 1 Bitcoin exceeded the price of an ounce of gold (about PLN 4.330) which is the best way to illustrate how strong a currency based on the blockchain technology can become. Blockchain is a concept that is usually translated into Polish as "łańcuch bloków". As mentioned before, it was used for the first time as the basic value of the Bitcoin cryptocurrency. The blockchain application involved public recording of transactions conducted with the used of the currency. The chain is saved chronologically, it is shared among all the currency users. Literally speaking, a blockchain if made of chains of blocks also defined as blocks of information linked with each other into chains, where each successive link depends on the preceding one. Thus, the technology allows each of its users to have full information which is in the system database whereby it is possible to create a completely dispersed and decentralized data register. Owing to theses specifics of data collection, it is not possible to modify or falsify the information contained in the data block (jagiellonski24.pl, 2018).

It is the notion of dispersed databases that should be used to better understand the operation of the distributed registers technology, as it is also this Polish name that is used when referring to the blockchain technology. Such databases are used mainly to store information. On the other hand, information concerns transactions conducted between entities operating on the market. The original data stored in blocks is the basis for writing each subsequent block of the register to which a time stamp is attached. In addition to the time stamp, the process of creating a new block of data takes into account the imprint of the previous block and confirmation of the reliability of the changes made by other participants to the transaction. Owing to such a system of processing, it can be concluded that subsequent transactions lead to the formation of subsequent data blocks, which together with the previous ones form an information chain that is a large register of information. As the information database concerning transactions is of a public nature, hence, it is not possible to modify the historical data, as it would be reflected in all the subsequent blocks following the block in which the information would be modified (Garrett, 2017). For the very idea of a blockchain, it is also important to maintain a joint and collective

transaction register. The database itself has a digital form and it is distributed over the network in identical copies. The data chain technology works through a peer-to-peer network, so it does not use databases based on central computers. Therefore, every computer with access to the Internet has the right to participate in the transmission or authentication of information related to completed transactions (lazarski.pl, 2018). When describing the blockchain technology system, reference should be also made to the credibility of the authentication process. Every new item of information that is sent to the public transaction register has to be properly encrypted for which a pair of public and private keys is used. The keys themselves are electronic signatures of a kind, generated with the use of cryptography. The public key is best compared to the recipient's correspondence address, while the other private key can be identified as a password to confirm the authenticity of the data and to read the previously encrypted content. The private key is also a peculiar unique signature of the sender of information containing the content of the change introduced, its time and the identifier of the person who made the modification. The private key is generated by means of a special cryptographic algorithm, it is also unique for each set of data sent by a user or a computer. The need for continuous synchronization and updating of a distributed database may give the impression of being a nuisance. However, authorizations of the credibility of information do not have to be entered by humans. It is also computers or other devices being components of the system (such as e.g. machines used in a technology park of a factory manufacturing goods) responsible for the creation of new information blocks that can be used to confirm the authenticity of data. Based on the calculations made, machines or computers can 'vote' for the database version, which is most up-to-date according to them, being therefore also the most reliable one. Using such 'democratic elections', where the decision on the credibility of the new information block version is made by a majority of machines, it is very easy to improve the system of verifying the authenticity of information contained in data blocks. Such a system may also enable a database containing a lot of information to function in an efficient way, being at the same time a dispersed base characterized by universal access to information for all entities participating in transactions concerning flows of goods (jagiellonski24.pl, 2018).

4. Blockchain technology application projects for information management in supply chains

An example of applying the blockchain technology in information management within supply chains is the joint project of DNV GL and VeChain. The venture is aimed at developing a new Digital Assurance Concept, based on an application platform created basing on the blockchain technology. DNV GL is an organization certifying management systems by performing security audits of the conducted operations. By providing consulting services, GNV GL enables companies to ensure sustainable development of business, basing their services on applying international

standards such as ISO 45001[1] or ISO 13485:2016[2]. The main mission of the organization is to protect life, environment and property (dnvgl, 2018). VeChain is a platform based on the blockchain technology in which the medium of exchange is the VEN digital currency. The main goal of the organization is to develop an application platform enabling the creation of secure and transparent contracts entered into by enterprises which are links in global supply chains. One of the partners of VeChain is the Chinese government. In its operations, the platform focuses mainly on developing a business ecosystem, where an efficient and transparent information flow system is supposed to form a basis for strengthening the partnership relations between supply chain links (coincentral.com, 2018). The purpose of cooperation between DNV GL and VeChain is to develop a tool to improve the management of flows of goods and the accompanying information. The tool will also improve processes related to identification of transported products. The reliability of information concerning the quality of goods will also increase, whereby it will be possible to measure customer satisfaction more effectively. The tool created by partners can be used in the food, clothing, power, high-tech and automotive industries. Enterprises very often turn to third parties to efficiently manage the flows of goods and information in their business. Working together, organizations wish to provide their customers with the possibility to independently verify the quality, effectiveness and efficiency of processes related to the manufacture and movement of goods using an application platform which can operate owing to the blockchain technology. The tool is supposed to allow tracking of goods, raw materials and semi-finished products in real time. The technology is supposed to be based chiefly on peaking the information stored in RFID tags, NFC chips and QR bar codes. When such technical tools are used, it is possible to collect complete information on a single product. The product history will include data related to all manufacturing, storage and transport processes carried out. This will also make it possible to efficiently determine the current condition and quality of the product. The information included in the product history will be automatically peaked and later made available to all enterprises involved in creating the product value. In this way transparency and reliability of the collected data will be possible with simultaneous common access to such data by all authorized and interested parties (PR Newswire US, 2018).

Another example of cooperation aimed at improving information management using the blockchain technology is the cooperation between Moller-Maersk and IBM. Moller-Maersk is the largest enterprise in the world in the shipping and global trade services industry, with the main activity being the organization of container and intermodal transport including comprehensive logistics services (maerskline.com, 2018). IBM is a company manufacturing products and providing services in the high-tech industry in the broad sense of the term. IBM supports the activities of enterprises in the management of resources, risk, compliance, performance, planning, business analytics and application of IT technologies (maersk.com, 2018). The joint project is aimed at developing a system of handling international transport processes based on chains of data blocks in the blockchain

[1] An ISO standard referring to the occupational safety and health management system.
[2] An ISO standard applying to the medical product industry concerning quality management.

technology. At the initial stage of development, the system is supposed to play the role of a tool for registration and management of shipments transported by sea. The main reason for the cooperation between Maersk and IBM is the observed gap in the services sector related to cargo transport management systems and related shipping processes. The main motive for cooperation is an attempt to reduce the use of paper documentation related to transport and forwarding. According to Maersk representatives of a logistics service process related to movement of an average cargo currently involves of about 30 people and nearly 200 process and communication steps. Such a state of affairs is the reason why the cost of preparing the documentation alone and completing all formalities becomes very high, representing on average approx. 20% of the actual cost of transporting an average cargo (itwiz.pl, 2018). When a new data logging system based on the blockchain technology is used, it will ultimately integrate whole supply chains into one digital platform. Owing to such a platform, participants to the exchange will be able to share all the information about the products they manufacture and the required flows of goods in a safe and digital way along the entire supply chain length. The platform developed by Maersk and IBM is also supposed to be a source of information for entire industry sectors and final recipients of products. When the solution of Hyperledger Fabric from the Linux Foundation is used, all information on transactions will be available only to the relevant entities being the trading parties to such transaction. Authorized entities, responsible for processes of creation and flows of goods will be allowed to overwrite the information in new data blocks. Hence, the platform is supposed to enable joint work of many trading partners and give a uniform view of the transactions carried out, while maintaining specific details of the data, their privacy and confidentiality (maersk.com, 2018). The platform itself has two basic functionalities for tracking the product itself and the documentation related to its transport. The pilot application of the platform having been fully implemented by its partners, Maersk intends to commercialise the service created jointly with IBM. Extending of the use of the platform based on the blockchain technology is intended to include such enterprises interested in this system as: Procter & Gamble, APM and General Motors. Hence, the project representatives count that other transport companies, commodity exchanges, port operators and customs services will be interested in implementing and using the project. Already now interest in the project has been expressed by entities providing port and customs services in the US, the Netherlands, Singapore and the Chinese province of Guangdong (itwiz.pl, 2018). The example of cooperation between IBM and Maersk shows how extensive the application of the blockchain technology in logistics can be. The mechanism ensuring a reduction in the operating cost interrelated with a reduction in paper documentation and the costs attributed to its flow indicates that all documents related to container trading can be digitised. It also shows the great possibilities of tracking shipments in real time, which can also bring significant benefits to the supply chain management (Ksheri, 2018). An example of cooperation of a high-tech enterprise and a transport and forwarding company shows a great opportunity to improve processes related to the collection, storage and sharing of information accompanying the movement of products

while at the same time reducing the costs by limiting the use of paper documents and providing a possibility of sharing information with all the links in supply chains.

The solution applied by the Wal-Mart supermarket chain is a confirmation that application of the blockchain technology in the management of global supply chains is not just about plans but that it is reality. Wal-Mart is chiefly a retail trader. It a trading giant with a network of 11,600 retail stores under 59 different banners in 28 countries and e-commerce websites in 11 countries, serving around 260 million customers each week, while employing 2.3 million employees (corporate.walmart.com, 2018). The product range of Wal-Mart stores includes but is not limited to products in such categories as: home, electronics, clothing and jewellery, health and beauty, toys, video games, food, medicines, automobiles, home furnishings, gifts, pets, garden and much more (walmart.com, 2018). Wal-Mart has introduced the 'Smart Package' application tool which is tracking goods using RFID tags and barcodes with a simultaneously dispersed data structure in the blockchain technology. The reason for introducing the product tracking system is first of all care for the quality of products which should result in increased customer safety. The solution improves the processes of identifying the origin of goods in cases of detecting defective products and allows identifying the flow section where the product was damaged. The solution is also supposed to preclude human errors by preventing shipment of goods with quality defects. Product originality verification is another issue with which the tool introduced by Wal-Mart is related. It is estimated that 20-30% of the supplied products may be counterfeit to a smaller or larger extent. The solution is based on the use of unique product identifiers including information about their specific attributes. This information is modified and updated by all commodity flow agents along the entire supply chain (trans. info, 2018). In addition to the information on the product itself, subsequent supply chain links also update information on the condition of its packaging, environmental conditions of transport and exact location. The 'Smart Package' application itself is described in the patent application as a recorder of key addresses along the supply chain containing information on the seller's address, the courier's address and the buyer's private address. In addition to the current application the package will be used in the future also with modern means of transport such as autonomous vehicles and unmanned drones (cointelegraph.com, 2018). In addition to the 'Smart Package' application, Wal-Mart was already involved in the development of a technology for tracking products based on the blockchain technology at an earlier date. In collaboration with IBM and jointly with the world's largest suppliers of food products such as: Kroger, Nestle, Golden State Foods, Tyson Foods, McLane Company, Unilever, Dole, and McCormick and Company, Wal-Mart decided to develop a tool to reduce the time needed to locate sources of food-borne diseases. A consortium comprising such a large group of companies began to operate in 2017. The cooperation was coordinated through an integrated corporate-class platform based on the blockchain technology. If the project is successful, it is expected to provide significant improvements in security and traceability of threats by reducing the time needed to verify the sources of contaminated food, from several weeks down to even several seconds. The tool which is based on a dispersed transaction data register is supposed to bring savings to world

food suppliers by improving the process of tracking their products. The better efficiency in terms of safety is aimed at reducing not only the costs associated with the immediate threat to the health or even life of customers, but also the costs related to withdrawing defective products from shelves in stores. The cost reduction also applies to protection against the loss of value of products that are potentially at risk of contamination. The process of verifying the source from which the defective product batch originates, which takes a very long time at the moment, may lead to a decrease in the demand for products and, consequently, falling prices of all articles in a given sector, even those of the highest quality (coindesk.com, 2018). During the initial phase of testing the tool developed by the cooperating companies, the products subjected to comprehensive tracking were pork imported from China and mango fruit originating from the US. These tests confirmed the potential for cost reduction and elimination of supplies of contaminated goods. It also confirmed the measurable benefits of applying this solution to other products. The tests also showed significant differences in the time of verification of product sources, the quality of which was not in line with the expectations of distributors or customers, between the entities participating in the project and their other competitors which needed much more time to verify the sources of the problem related to the quality or contamination of the product (gazeta online, 2016). Therefore, the above mentioned organizations, as part of their cooperation, want to create an application based on specific standards and methods of gathering information using the blockchain technology. This is aimed at increasing the level of safety and authenticity of the origin of food products and ensuring full traceability of the product and the place of its origin. This cooperation is also supposed to provide brand owners with sufficient privacy of data while strengthening the cooperation within global supply chains (forbes.com, 2018).

Conclusions

Information logistics is one of the key factors creating a competitive advantage of modern supply chains. In the author's opinion combining the automatic product tracking technology with the possibility of providing easily accessible and highly reliable information, stored and made available in subsequent blocks of the blockchain technology data, is an excellent solution to problems related to management of information within supply chains. The partner relations of all supply chain participants can be closer owing to an efficient information flow system. The supply chain links, starting from miners of raw materials, Tier 1 and Tier 2 suppliers, manufacturers, assembly plants, ending with the final consumer of products will be able to work together even more efficiently and effectively owing to the application platform. Quality control of products covering their composition, manufacturing processes, transport and warehousing systems can eliminate the procedure of counterfeiting and decreasing the quality of goods. The application platforms also offer a great chance of reducing the use of paper documentation regarding production and transport processes which at the same time would reduce the cost of business operations. On the basis of the conducted

analysis and the cited examples, the author has concluded that the information systems and application platforms based on the use of blockchain technologies have a high chance of development and widespread use in the field of information logistics and in the sphere of supply chain management.

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