

# The relational embeddedness as the differentiator of the cluster supply chain collaboration – a multidimensional comparative analysis

Cluster supply chain collaboration

59

Received 14 November 2019  
Revised 2 April 2020  
8 September 2020  
27 November 2020  
Accepted 30 November 2020

Marzena Frankowska  
*University of Szczecin, Szczecin, Poland, and*

Katarzyna Cheba  
*West Pomeranian University of Technology, Szczecin, Poland*

## Abstract

**Purpose** – The purpose of this paper is to fill the research and cognitive gap by comparative analyzing of the cluster supply chain (CSC) and supply chains not belonging to the clusters to examine the relational embeddedness as the differentiator of supply chains operating in the clusters.

**Design/methodology/approach** – The conceptual model was tested with data collected from 475 industrial companies cooperating with their partners within supply chains, including 135 CSC. To identify the livraisons between different indicators, the correspondence analysis was applied.

**Findings** – The division of enterprises participating in this study into groups allows for the determination of relatively clear boundaries between enterprises belonging to the cluster and those that do not declare such affiliation. The obtained results confirmed that the relational embeddedness is the differentiator of the CSC collaboration.

**Research limitations/implications** – The main limitations are referred to as the static character of the data.

**Practical implications** – The paper contains implications for cluster facilitators, as well as for cluster policy decision makers, to better design support for cluster organizations.

**Originality/value** – This research is a contribution to the literature on inter-organizational structures, such as clusters and supply chains, and in particular, contributes to the creation of the scientific ground of SCS theory. The research allowed to better understand the nature of collaboration taking into consideration the fact of the relational embeddedness of the companies operating within supply chains located in clusters. It proves the existence of a new type of inter-organizational form that is CSC.

**Keywords** Collaboration, Supply chain, Industrial cluster, Relationship quality, Relational embeddedness, Cluster supply chain

**Paper type** Research paper

© Marzena Frankowska and Katarzyna Cheba. Published by Emerald Publishing Limited. This article is published under the Creative Commons Attribution (CC BY 4.0) licence. Anyone may reproduce, distribute, translate and create derivative works of this article (for both commercial and non-commercial purposes), subject to full attribution to the original publication and authors. The full terms of this licence may be seen at <http://creativecommons.org/licenses/by/4.0/legalcode>

This paper forms part of a special section “New Insights Regarding Clusters and Industrial Districts”, guest edited by Francisco Puig.

The project is financed within the framework of the program of the Minister of Science and Higher Education under the name “Regional Excellence Initiative” in the years 2019-2022; project number 001/RID/2018/19; the amount of financing PLN 10,684,000.00.



## 1. Introduction

The literature argues that networking and operating within supply chains became an increasingly distinctive feature of market actors (Kanter, 1994; Dyer, 2000; Marco-Lajara and García-Lillo, 2004; Lee, 2005; Camarinha-Matos and Afsarmanesh, 2008; Cao and Zhang, 2011; Graça and Camarinha-Matos, 2017). This ever more pronounced new imperative determines the necessity of collaboration with other entities in various inter-organizational arrangements. The emerging relations of collaboration determine the system of mutual dependencies and connections, both with recipients of manufactured products (products and/or services) and with suppliers of raw materials, consumables, components or production and logistic services. That is why enterprises look for appropriate knowledge and useful solutions that will enable them to cope better in such a complex and uncertain economic reality. In addition, more and more often, the key aspect of collaboration between partners is basing their relationship on social capital (trust, reputation, legitimization, etc.), which undoubtedly facilitates coordination of collaboration and reduces its uncertainty.

The problem of a collaboration of companies has long been present in research in the field of strategic management, but currently it takes on a new dimension and became the main category of management sciences (Czakon, 2017). The difficulty in understanding the nature of this exchange results from the fact that more and more often partners are not bound by either hierarchy or authority-based relationships (Pelletier *et al.*, 2017). This situation reveals new managerial problems and research challenges, which obviously require answers to questions and doubts, provided on scientific grounds. Nowadays, clusters, and in particular cluster initiatives, are examples of network structures in which collaboration of enterprises is aimed at gaining benefits primarily from geographical proximity, sectoral concentration and social factors. Owing to achieving positive effects, a significant increase in interest in clusters has been observed. A review of theoretical achievements on clusters indicates a justified need to develop a unified theoretical approach that takes into account the complementary nature of agglomeration and social factors such as network, institutional and behavioral dimensions (Westlund and Bolton, 2003; Molina-Morales *et al.*, 2012). Supply chains, on the other hand, are one of the key forms of collaboration of enterprises, enabling not only improvement of operational capacity, but also gaining competitive advantage by partners. At the same time, turbulent environment conditions increase the complexity of supply chains both in the configuration and in the process system, which poses significant challenges at all levels of organization management. The analysis of literature proves that there is a diagnosed theoretical gap at the interface of the mentioned research areas, which are the supply chains and the clusters. The models of collaboration between cluster enterprises developed and presented in literature do not really explain what the actual role of a cluster in the formation of supply chains is (Markusen, 1996; Porter, 2003). Recent research started to focus on the recognition the role of the cluster initiative in the inter-organizational collaboration of enterprises belonging to clusters, including supply chains (Jizi and Chunling, 2007; Xue *et al.*, 2011; Yu, 2012; Lin *et al.*, 2012; Tolossa *et al.*, 2013; Lian, 2014; Frankowska, 2018). A relationship between the membership of an enterprise to a cluster and the manner in which it cooperates with cluster partners in a supply chain has been proved. Moreover, the research indicates that the quality of relationships in supply chains turned out to be the strongest link with achieving benefits by cluster enterprises (Frankowska, 2018). These findings suggest that the cluster supply chain (CSC) differs from other supply chains in the way that they are embedded in a cluster inter-organizational network, however, no such comparative studies have been conducted so far.

On the other hand, it should be noted that the literature argues that managing relationships across a supply chain can help a business establish a distinctive advantage. The first research in the area of supply chain relationships was aimed at explaining the nature of relationship processes themselves rather than their effect on performance. Nowadays, the scholarly work provides evidence for the impact of the quality of the relationship between the members of the supply chain on their business performance (Tsanos *et al.*, 2014). Simultaneously, conducted research did not take account of the different types of supply chains, including the existence of a new type of supply chain formed from enterprises belonging to cluster organizations, known as the CSC. The collaboration of the cluster enterprises within a supply chain is significantly affected by their relational embeddedness in the cluster. Therefore, previous research on the CSC was deprived of the possibility of making a comparative analysis with other supply chains (Jizi and Chunling, 2007; Xue *et al.*, 2011; Yu, 2012; Tolossa *et al.*, 2013). Thus, there exists an urgent need to examine whether, in fact, relational embeddedness in the cluster is a distinctive feature of companies cooperating in CSCs.

The purpose of this paper is to fill the research and cognitive aforementioned gap by comparative analyzing of the CSC and supply chain not embedded in the clusters in terms of the diversity of communication between partners, the quality of their relationships and the benefits of collaboration in both supply chains to examine whether the relational embeddedness as the differentiator of supply chains operating in the clusters. The paper is organized as follows. Section 2 presents the theoretical background on the CSC and its relational embeddedness in the cluster, as well as the hypotheses development. Section 3 provides the research methodology including an overview of the research object and study stages. In Section 4, the authors present the survey results. In this part of the paper, the conceptual model is tested and advanced methods of multidimensional comparative analysis are applied. In Section 5, the authors present conclusions and remarks.

## 2. Theoretical background and hypotheses development

### 2.1 Concept of cluster supply chain

Despite the significant interest and numerous research on inter-organizational relations in networks and supply chains, there is still not enough information on mechanisms that trigger and affect contextual efforts made during the inter-organizational collaboration process (Cao and Zhang, 2013; Cooper *et al.*, 2016; Tarifa-Fernandez and de Burgos-Jiménez, 2017). The term CSC combines two research areas that have not been considered in the system of interrelations so far, namely:

- supply chains, defined as the collaboration of companies in the strategic and operational dimension as a part of organizational and functional structures including mutual relations and flows of products, information, and financial resources to achieve synergy effects by each partner; and
- clusters, understood as geographically and sector concentrated inter-organizational networks of companies with associated institutions and companies from complementary sectors that are connected with economic and social ties, the activity of which is based on building and strengthening relationships as well as consistent collaboration to achieve mutual benefits.

It should be noted that an antecedent of cluster studies is the theory of industrial district introduced by Marshall (1890) and then developed by Becattini (1979), who included its socioeconomic notion. According first to the theoretical developments and later to the empirical ones, small- and medium-sized enterprises (SMEs) located in an industrial district

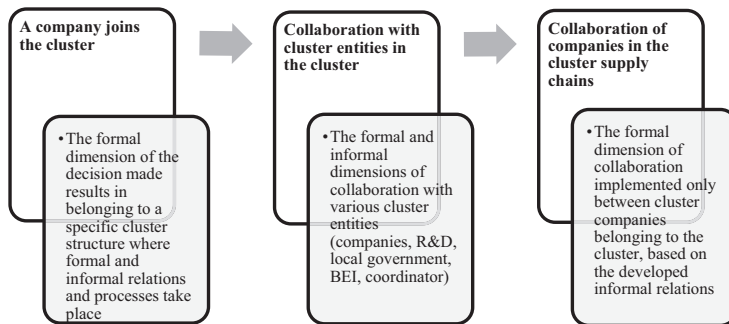
obtained better results than those located outside it because of the appearance of certain externalities related to geographical concentration, what is called as “district effect” (Claver-Cortés *et al.*, 2019).

From the general perspective, companies voluntarily join the cluster, where they establish relationships with other entities, which in turn may lead to collaboration in supply chains. This means that a company, i.e. a link in the supply chain, takes part in the cluster, while cooperation, i.e. supply chain processes, is carried out in the region of the cluster’s operation (geographical concentration). However, such an approach seems simplified as it does not take into account clusters understood as a complex environment, where collaboration between entities is initiated and implemented (Figure 1).

Establishing a complex link between the abovementioned areas is possible within the concept of embeddedness first published by Granovetter (1985). The concept of embeddedness derived from the need for a broader understanding of the conditions of business cooperation, and plays an important role in the network approach used to explain inter-organizational mechanisms. Today, embeddedness has become a multidimensional concept (Moody and White, 2003), which opens up a broad cognitive perspective for the study of particular aspects of inter-organizational cooperation. As indicated by Harrison and van Hoek (2010), the shape of inter-organizational relations always to some extent determines the specific properties of the environment in which the partners operate.

On the one hand, an entity initiates, chooses and shapes the world they perceive, whereas on the other, they are subject to limitations as well as being shaped by external factors. This creates a specific situation that necessitates permanent collaboration (fight), survival and coping. Companies are connected with their environment through diversified direct and indirect relations that form the environment where economic activity is carried out (Nyholm, 2011).

The concept of embeddedness has been adopted to explain the issue of collaboration of enterprises in supply chains located in a cluster. One can accordingly identify a localized symbiotic effect between entrepreneurial and social components thanks to which firms can obtain a competitive advantage over the firms that do not share this specific environment. This suggests a certain degree of homogeneity in the behavior of companies that share the same competitive environment, which in practice has led to comparisons between populations of firms (district-cluster/non-district-non-cluster) and even between districts/clusters (Claver-Cortés *et al.*, 2019). It was found that four dimensions of embeddedness are of key importance for CSC cooperation (Frankowska, 2018):



**Figure 1.**  
Process approach to  
the emergence of a  
cluster supply chain

Source: Frankowska (2018)

- structural embeddedness – which defines systems of cooperating enterprises, including supply chains in a cluster;
- geographic location – determined by belonging to a specific area of the activity of a cluster;
- institutional setting – indicating the impact of a cluster as an organized cluster structure; and
- relational embeddedness – illustrating the role of relations and ties in the collaboration of enterprises in the cluster, as well as initiating collaboration in supply chains.

The conducted research allowed to formulate the definition of a CSC, according to which it is an organized form of structurally, geographically, institutionally and relationally co-operative enterprises embedded in a cluster, using the opportunities and chances to reduce inter-organizational transaction costs and benefit-oriented and synergic increase of operational efficiency of physical, information and financial flows (Frankowska, 2018). The enterprises cooperating in CSC should be considered as one of the most advanced types and forms of collaboration relations (collaboration at the strategic and operational level, in terms of physical, information and financial flows) and constitute a new kind of inter-organizational system of collaboration in supply chains.

### *2.2 Relational embeddedness of supply chains in the cluster*

Relational embeddedness of supply chains in the cluster illustrates the importance of relations and links in collaboration between cluster companies within a supply chain, as well as the initiation of such cooperation.

Researchers underline that CSC is characterized by socialization that helps build trust in exchange relations, which, in turn, leads to an increase in the relational capital. This may be used to strengthen the relations with suppliers as well as support supplier base located within the cluster (Bozarth *et al.*, 2007). So far, theories that have explained collaboration in a supply chain have commonly assumed that the mechanism initiating collaboration is based on the initiative of at least one of the companies and regulation of collaboration covered by a contract. However, embedding supply chains in an inter-organizational network also requires social capital generated by this network. The conclusions from previous considerations suggest that entities operating in inter-organizational networks are “richer” in terms of social capital produced within this network. The capital of trust and credibility of particular entities, as well as the entire cluster community, can be used to initiate the collaboration of these entities. Importantly, collaboration in supply chains embedded in the network may result from two mechanisms that are characteristic of social networks, namely (Sztompka, 2007):

- mechanism of a contract signed between companies that regard each other as companies worthy of cooperation, and thus regulate their collaboration in this way (the so-called classic mechanism initiating collaboration in supply chains); and
- mechanism of a link in the development of the inter-organizational network in the context of building bridges in actors’ trust chains.

In a supply chain embedded in a cluster, there can be observed a mechanism of trust transition, where an important role is played by the third actor being an intermediary in the chain of trust. This is carried out following the principle “a friend of my friend is my friend.” This actor may be a cluster coordinator, whose function refers to the already indicated role of *tertius gaudens* described in the works of Burt (2000) and clarified as *tertius iungens* by Obstfeld (2005). In the presented

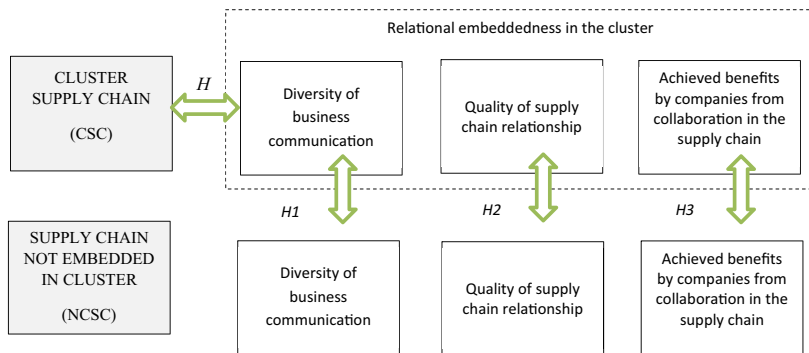
situation, the cluster network becomes an important, if not the most significant, the context for collaboration between these companies, ergo, the collaboration of companies assumes the attributes of the cluster network while remaining the construction of the supply chain. Close competition and collaboration allow the creation of a unique network of relationships and cultural atmosphere, whereas the cluster becomes a regional communication platform for the exchange of knowledge and information (Han, 2009). A factor distinguishing entities forming CSC is thus a special relationship with suppliers and clients, whose basis is formal agreements and informal commitments based on trust (Yu, 2012). Companies in the cluster become closer and share common goals, which is the main factor stimulating collaboration between the supply chain links. Owing to geographic proximity and close ties between the management, as well as the fact that the mechanism in the cluster is based on human factors, such as trust and commitment, companies within the cluster form a common formal or informal code (communication and behavior) and establish close relationships of collaboration with each other. Sufficiently high quality of relationship reduces opportunistic behavior and minimizes the risk and cost of cooperation. Such collaboration brings together suppliers, producers, customers and even competitors in the supply chain to share their resources and skills (Han, 2009), which in turn fosters the competitive advantage of the supply chain partners. Furthermore, the effect of knowledge spillover is often considered one of the benefits of supply chains embedded in the cluster (Bozarth *et al.*, 2007). Han (2009) points out that embedding supply chains in a cluster help reduce the transaction costs of enterprises. The system of trust and collaboration between companies leads directly to a significant reduction of internal costs of negotiations and monitoring contract performance, which in turn minimizes transaction costs throughout the supply chain. Furthermore, the costs of communication and obtaining information as well as opportunism risk are limited, thus transaction costs in a cluster may be lower than the costs of market transactions, which in turn increases the efficiency of companies' activities. Low costs of operations conducted by companies in the CSC ultimately lead to an increase in the overall level of profits and competitive opportunities. The research also shows that the quality of relationships in supply chains turned out to be the strongest link with achieving benefits by cluster enterprises. It is a finding that confirms the importance of relationships in shaping the synergy of supply chains, and at the same time, indicates relations as a relevant mechanism for coordinating collaboration (Frankowska, 2018). Thus, researchers agree that clusters are a favorable environment for establishing and developing collaboration and creating supply chains. As a consequence, the company favors mutual market relations as a result of offering favorable terms (Han, 2009).

Relational embeddedness in the cluster triggers a social mechanism (link mechanism) of initiating CSC. This should be reflected in more diverse communication (communication within the exchange relationship in the supply chain and within the cluster network) than in the case of other supply chains, as well as translate into a higher level of quality of relationship between cluster partners. As a consequence, easier communication and sharing of knowledge, greater trust of cluster partners and less opportunistic behavior should result in obtaining greater benefits from collaboration in the CSCs. The abovementioned considerations have been illustrated in Figure 2. This has become a basis for the following formulated main hypothesis:

- H1.* The relational embeddedness is the differentiator of the cluster supply chain collaboration.

### *2.3 Communication between partners in the supply chain*

Because information flows constitute the basis for collaboration in the supply chain, of key importance for efficient integration and coordination of partners is the scope of transferred

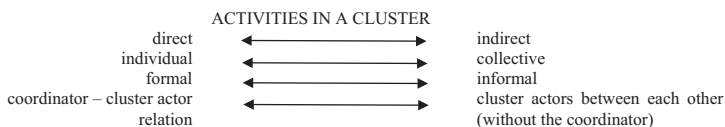


Source: Own elaboration

Figure 2. Conceptual framework

information, as well as ways and forms of communication. Companies engaged in supply chain relationships, as customers, suppliers or providers of services need to share a great deal of information in the course of their interactions (White *et al.*, 2004; Marco-Lajara and García-Lillo, 2004). Therefore, the right approach primarily necessitates identification of the data requirements mainly concerning the following areas: manufacturing process and time information, inventory control policies information, procurement and logistics information, demand information and strategies information (Cutting-Decelle *et al.*, 2007). Over the years, companies have managed these types of information flows in a number of ways, including telephone calls, letters, faxes and electronic data interchange (EDI).

Supply chains created in clusters are distinguished from other chains by the way of establishing collaboration and its character. A cluster coordinator plays an important role, as they are responsible for animating the climate of cooperation, as well as building good relations and mutual trust by combining common goals of enterprises (collective and mutual actions). Link mechanism brings together cluster actors, bridges the gaps in the cluster and encourages to carry out joint initiatives. Therefore, communication between companies within the CSCs is more diverse, as it includes not only the management of information flows in the supply chain, but also is related to the activity of the cluster network, as shown in Figure 3. An example illustrating the complexity of interaction and communication in cluster structures can be the organization of a foreign mission for cluster members. The cluster coordinator undertakes collective and formal actions, using direct and indirect forms of communication. This is accompanied by individual informal arrangements with the coordinator and between the companies themselves. Activities in the cluster are therefore related to communication between its actors. In turn, the scope and method of this communication reflect in a sense the type of activities carried out in the cluster. The greater



Source: Own elaboration

Figure 3. Nature of activities undertaken by cluster actors

---

variety of forms and ways of communication of companies gives them more opportunities to build relationships with other actors and strengthens social capital.

To cooperate within supply chains, of key importance is the form of communication in the formal–informal system (personal contacts) and the method of communication broken down into direct (direct meetings and telephone calls) and indirect forms (transmission of paper documents, via e-mails and EDI). The following hypothesis reflects these considerations:

- H2.* CSC is characterized by a greater diversity of communication between partners than in the case of the supply chains not embedded in the cluster.

#### *2.4 Quality of supply chain relationship*

For many years, the relational approach has been accepted by researches investigating supply chain management (Autry and Griffis, 2008). The relational perspective has entered the canon of supply chain definitions, whereas diversified forms of relationships in the supply chain (Cooper and Gartner, 1993) have an impact on the choice of the ways in which companies cooperate (Bowersox *et al.*, 1999) as well as their results (Kautonen *et al.*, 2010; Yu and Huo, 2019).

The concept of measuring the quality of relationships has its roots in relationship marketing (Ellram and Cooper, 1990). As far as relationships in the supply chains are concerned, this issue has stirred many debates from the very beginning and brought about various concepts owing to numerous structural and functional sides of the supply chain, as well as the use of various theoretical grounds for explaining collaboration in supply chains. Today, the quality of relationships in the supply chain is described as a higher-order construct comprising lower-order subconstructs (Dorsch *et al.*, 1998; Walter *et al.*, 2003). The study of the literature allowed to develop a set of components that make up the quality of relationships in the supply chain (Table 1).

The research results presented in Table 1 allow making the conclusion that the relationships in the supply chain are most often described as trust, commitment and satisfaction. Taking the above and the paper objective into consideration, the following components of the relationship between partners in the supply chain, constituting observable variables, were indicated:

- Trust. Its importance in shaping collaboration in supply chains is explained mainly on the ground of the theory of trust based on rationality (Sako, 1992; Cao and Zhang, 2013), although other theories also use this concept (especially the network theories). Trust is defined as a positive belief, attitude or expectation of one of the parties regarding the probability that an action or result of the other party will be satisfactory (Zacharia, 2009). This study adopted a literal understanding of this concept by respondents, without exploring its nature; and
- Opportunism. It is a behavioral factor widely discussed in economic theories, which is considered an undesirable behavior that occurs during cooperation (Williamson, 1991; Olson, 1965; Kumar *et al.*, 1998). It is defined as putting individual objectives before previously agreed common goals. Opportunism poses a threat not only to a given exchange but also to parallel exchanges, whereas the very occurrence of risk may cause defensive attitudes. Empirical research shows that trust is in opposition to opportunism (Karpacz, 2014).
- Commitment. It is defined as a belief that exchange carried out together with a partner in the supply chain is so significant that it requires maximum effort to



Author	Components of relationships
Kumar <i>et al.</i> (1995)	Conflict, trust, commitment, willingness to invest in cooperation, expectation of continuity
Dorsch <i>et al.</i> (1998)	Trust, satisfaction, commitment, opportunism, customer orientation, ethical profile
Walter <i>et al.</i> (2003)	Customer satisfaction, trust, commitment
Woo and Ennew (2004)	Cooperation, adaptation, atmosphere
Benton and Maloni (2005)	Commitment, trust, cooperation, conflict resolution
Lages <i>et al.</i> (2005)	Information sharing, communication quality, long-term orientation, satisfaction
Fynes <i>et al.</i> (2005)	Communication, trust, adaptation, commitment, dependence, cooperation
Rauyruen and Miller (2007)	Trust, commitment, satisfaction, quality of service
Skarmeas <i>et al.</i> (2008)	Satisfaction, trust, commitment
Su <i>et al.</i> (2008)	Communication, trust, institutionalization, cooperation, adaptation, atmosphere
Payan <i>et al.</i> (2010)	Satisfaction, trust, commitment, cooperation, coordination, specific resources
Ferrer <i>et al.</i> (2010)	Strength, sharing, interdependence, trust
Svensson and Mysen (2011)	Satisfaction, commitment, trust, opportunism, cooperation, coordination, continuity expectation, formalization, interdependence, specific resources
Mohaghar and Ghasemi (2011)	Communication, trust, adaptation, commitment, interdependence, cooperation, atmosphere
Collins <i>et al.</i> (2012)	Trust, commitment, adaptation, shared values, communication, opportunism, satisfaction, cooperation
Kühne <i>et al.</i> (2013)	Trust, satisfaction, reputation, coordination, conflict, strength, dependence
Tsanos <i>et al.</i> (2014)	Trust, commitment, common goals, cooperation, satisfaction, reciprocity

Source: Frankowska (2018)

**Table 1.** Components shaping the quality of partners' relationships in the supply chain

maintain its implementation (Morgan and Hunt, 1994). In the relationships, which are characterized by commitment, partners achieve such a level of satisfaction from the exchange process that other partners, who could bring similar benefits, are excluded (Tsanos *et al.*, 2014). Research also indicates a positive relationship between organizational commitment and coordination mechanisms used in supply chains (Fawcett *et al.*, 2006). Organizations build and maintain long-term relationships if they see results that are mutually beneficial for both parties (Morgan and Hunt, 1994). Moreover, commitment helps maintain relationships in the face of unforeseen problems (Hudnurkar *et al.*, 2014). Thus, commitment is a significant variable for long-term success, as supply chain partners are willing to invest into resources while devoting their short-term benefits to long-term success (Mentzer *et al.*, 2000a). This study will measure the level of engagement of the analyzed company and assess the involvement of its partners in CSCs.

- Adaptation. This term means that something is changed in such a way, as to fit something else. According to Håkansson(1982), suppliers by investing into specific assets to implement individual exchange transactions (e.g. product technology, processes and human resources) adapt to the needs of specific important clients, whereas clients adapt to the capabilities of specific suppliers. Researchers underline various reasons for adaptation, starting from the legitimacy in the environment, enforcement of power (Łupicka, 2016), to justification for ongoing investments (Fynes *et al.*, 2005). In the conducted study, it will be important to verify both the possibility of adapting the surveyed companies to their partners, as well as the

---

respondents' opinion on the tendency of the partners to adapt to their way of operation or requirements, without specifying reasons for adjusting.

- Satisfaction. It is understood as contentment of suppliers from the supply chain as a sense of equality in the supply chain relationships, regardless of the imbalance of power between the buyer and the seller (Benton and Maloni, 2005). Particular companies are supply chain links in the supply chain, which are as strong as their weakest link. Without satisfaction, supply chain members are not able to evoke psychological factors such as trust, commitment and goodwill that are necessary to maintain the partnership. This study will verify the variable corresponding to the accepted definition of satisfaction from the relations in the supply chain, as well as investigate the will to recommend collaboration with partners from CSCs, which should constitute the highest degree of approval from the conducted cooperation.

To summarize, in the course of the conceptualization of the “quality of supply chain relationships” construct, it has been described by eight variables that can be measured as part of quantitative research. This leads to the following hypothesis:

- H3. In CSC, there is a higher quality relationship between cooperating partners than in the case of the supply chains not embedded in the cluster.

### *2.5 Benefits of supply chain collaboration*

The essence of cluster functioning is the fact that companies voluntarily take part in it, as well as willingly start a collaboration with other entities, including companies within the supply chain. On the other hand, the essence of the collaboration of companies in the supply chain is collaboration for the implementation of a specific goal. Mentzer *et al.* (2000b) use the concept of consequences of supply chain management in the developed model of supply chain management, which, in other words, are the effects of collaboration of partners. The consequences are directly related to the implementation of set goals of supply chain. The fundamental objective of collaboration in supply chains is to achieve a lasting competitive advantage, which is the key category of modern strategic management. In the literature on the subject, there are different approaches to measuring the supply chain activities, as presented in Table 2. Furthermore, many authors suggest measuring the effectiveness of the supply chain through reference points, i.e. benchmarking (Kisperska-Moroń, 2000; Christopher *et al.*, 2006).

To measure the results of the supply chains, one should be aware that this is a multi-faceted and complicated issue (Beamon, 1999). Therefore, Tsanos *et al.* (2014) indicate that the approach toward evaluation of supply chain functioning should depend first and foremost on the objective of the conducted research (Tsanos *et al.*, 2014). And so, if the goal is to calculate the efficiency of the entire supply chain, appropriate measurement methods, which take into account such a wide range, should be used. In turn, if the goal is to verify or reference the supply chain at a strategic level in conjunction with other elements, such as supply chain integration, then no detailed measurement of the results is required. Quite the contrary, the choice of measures should be characterized by relative simplicity and limited quantity, as well as omit the so-called sensitive data so that respondents are able and willing to make a subjective or objective assessment (Witkowski, 2003; Tsanos *et al.*, 2014). Based on the literature studies, Elrod *et al.* (2013)

**Table 2.**  
Categories of measurements of the results of the supply chain

Author	Measurement categories
Beamon (1999)	Efficiency, resources and flexibility
Gunasekaran <i>et al.</i> (2001)	Measurement at the strategic, tactical and operational level
Brewer and Speh (2000)	In accordance with the recommendations of a balanced scorecard, from the perspective of finance, processes, client and development
Kleijnen and Smits (2003)	
Melnyk <i>et al.</i> (2004)	Financial measures: achieved, anticipated Operational measures: achieved, anticipated
Li <i>et al.</i> (2011)	In accordance with the supply chain operations reference model, measures in decision areas: planning, procurement, execution, distribution, returns
Simangunsong <i>et al.</i> (2012)	Financial measures (e.g. various cost categories, sales revenue) Non-financial measures (e.g. cycle time, customer service level, inventory level, resource consumption, quality)

Source: Own elaboration

add that proposals for measuring the supply chain, which take into account the ease of understanding of measurement indicators by managers of industrial companies, are rare.

Therefore, it is crucial to decide what should be the subject of the measurement and how it should be carried out. As Jarillo (1988) points out, the purpose of the arrangement of entities with market characteristics is expressed in the expectation of benefits generated by this system. The benefits result from the advantages provided by supplier alliances as opposed to relationships based on rivalry, which were presented by Ellram (1995). The concept of benefits is often used by researchers to assess the supplier–producer relationship results, both for companies themselves and for the supply chains being formed (Banchuen *et al.*, 2017). There are examples in the literature also researching the benefits of a relational supply chain is based on financial disclosures (Zhao *et al.*, 2019).

Therefore, owing to the objective of the conducted study, an assessment of the benefits obtained by the company from collaboration in the supply chain is applied. This assessment also shows the results achieved by the CSCs (Collins, 2012). To select measurement categories, particular measures are accepted as representatives of a balanced scorecard, which is a recommended research tool for supply chain companies (Brewer and Speh, 2000). A balanced scorecard developed by Kaplan and Norton (2007) is a method of specifying strategic goals and indicators that enable measuring their achievements, translating strategies into operational goals and selecting appropriate actions and measures for their implementation. The goals, as well as financial and operational measures included in the balanced scorecard, allow managers to monitor the company's operations in four key organizational perspectives: financial, processes, client and development (Table 3).

Taking the postulate of a limited number of indicators to study the results of supply chains, eight observable variables representing four perspectives of the balanced scorecard were adopted. Therefore, the following hypothesis is suggested:

- H4. Collaboration in clustered supply chains results in greater benefits for partners than in supply chains not embedded in a cluster.

### 3. Application of correspondence analysis as a tool of identification the ways of collaboration in the cluster

#### 3.1 Characteristics of statistical data

The assumptions presented in the previous part of this paper were the basis of the analyses where the results have been presented in this section. The main purpose of this section was to confirm the theoretical considerations presented in the previous parts of this paper. *H2–H4* were the basis of the selection of statistical features to this study.

In this paper, the research material that was carried out on a nationwide sample of production enterprises divided into two groups was used. To the first group, enterprises belonging to clusters and simultaneously cooperating in supply chains with other cluster enterprises were classified. Whereas, to the second group, these ones operating within supply chains but not belonging to the clusters were analyzed. The main study (data was collected using a quantitative research method using computer-assisted interview) was preceded by a pilot study among 20 companies. After calculating the minimum size of a research sample and taking into account the low response in this type of research, the authors decided to send questionnaires to 20,000 respondents. Finally, the number of correct and completely filled-in questionnaires amounted to 475, including 135 cluster companies. It means that return ability was 0.7% for cluster companies and 1.7% for companies not belonging to the clusters (2.38% in total). The main reason for the relatively low value of return ability was the need to verify the real functioning of enterprises in cluster structures. In recent years, it is quite common practice to create new clusters as a part of projects funded from European Union (EU). These clusters after the incubation period, still in the so-called embryonic phase, in principle do not continue their activities. This means the need for more detailed verification of the membership of enterprises in clusters. It was also the reason for the elimination from the survey of enterprises that do not really operate in cluster structures that joined the cluster, but in fact do not carry out any activities together. Hence, the research results presented in the paper can also be treated as a kind of verification of the actual activity of clusters. This activity is lower than it appears from official statistics. These observations are also confirmed by other authors ([Holub-Iwan and Malachowska, 2008](#)). There is no reliable information on the actual activity of this type of organization in the literature and various types of statistical databases describing the activity of clusters operating in Poland. As also presented in the paper, clusters are created as part of various types of projects, and after the project durability period, their activity is still not continued.

It is worth noting that those are studies carried out on one of the largest nationwide research trials of enterprises, and the result of the research sample corresponds to the size of

**Table 3.** Representation of variables that are observable in the perspectives of a balanced scorecard and in terms of benefits obtained by companies from collaboration in supply chains

Perspective of a balanced scorecard	Observable variables
Finance	Increase in sales revenue Lowering company costs Increased use of assets
Processes	Improving the coordination of activities Introducing product or process innovations
Client	Better market position of the company Increasing the quality of customer service
Development	Building company competence

**Source:** Own elaboration

the research on cooperation in supply chains. The detailed description of the sample is given in [Table 4](#).

Collaboration in supply chains is one of the crucial areas of the functioning of companies in today's reality. The skill to create relationships between partners in a supply chain can influence on the position taken by these enterprises on the market and their competitive advantage. Thus, the authors decided to examine the relational embeddedness as the differentiator of supply chains operating in the clusters taking into account different aspects and benefits from supply chain relations considered from the perspective of the companies belonging and not belonging to the clusters. To verify the formulated assumptions, presented in the previous chapter, the following variables were selected based on the questions from the survey:

- (1) cluster membership: CF1 – company being the member of the cluster, CF2 – company not belonging to the cluster;
- (2) the manner, frequency and form of using various communication channels as a part of cooperation with partners are as follows:
  - Direct communication: DC1 – the use of direct communication as a part of cooperation with other companies, more frequent than in the case of other companies participating in the research, DC2 – the use of direct communication as a part of cooperation with other companies, less frequent than in the case of other companies participating in the research;
  - Indirect communication: IC1 – the use of indirect communication as a part of cooperation with other companies, more frequent than in the case of other companies participating in the research, IC2 – the use of indirect communication as a part of cooperation with other companies, less frequent than in the case of other companies participating in the research;
  - Formal communication: FC1 – the use of formal communication as a part of cooperation with other companies, more frequent than in the case of other

Characteristics of the sample	Cluster membership	
	Company being the member of the cluster <i>N</i> = 135	Company not belonging to the cluster <i>N</i> = 340
1. Enterprise size		
a) Micro and small enterprise	84	175
b) Medium	42	139
c) Large	9	26
2. Geographical distribution		
a) Northwestern region	47	118
b) Eastern region	21	54
c) Central region	40	100
d) Southwestern region	27	68
3. Origin of capital (dominant capital)		
a) Polish capital	123	299
b) Foreign capital	12	41

**Source:** Own elaboration

**Table 4.**  
Main characteristics of the sample

companies participating in the research, FC2 – the use of formal communication as a part of cooperation with other companies, less frequent than in the case of other companies participating in the research; and

- Informal communication: IF1 – the use of informal communication as a part of cooperation with other companies, more frequent than in the case of other companies participating in the research, IF2 – the use of informal communication as a part of cooperation with other companies, less frequent than in the case of other companies participating in the research.

(3) Evaluation of the quality of relations between partners in the following areas:

- Trust: T1 – an assessment of the quality of relations with the company's partners in the area of trust, higher than in the case of other companies participating in the study, T2 – an assessment of the quality of relations with the company's partners in the area of trust, lower than in the case of other companies participating in the study;
- Opportunism: O1 – an assessment of the quality of relations with the company's partners in the area of opportunism, lower than in the case of other companies participating in the study, O2 – an assessment of the quality of relations with the company's partners in the area of opportunism, higher than in the case of other companies participating in the study;
- Commitment: C1 – an assessment of the quality of relations with the company's partners in the area of commitment, higher than in the case of other companies participating in the study, C2 – an assessment of the quality of relations with the company's partners in the area of commitment, lower than in the case of other companies participating in the study;
- Adaptation: A1 – an assessment of the quality of relations with the company's partners in the area of adaptation, higher than in the case of other companies participating in the study, A2 – an assessment of the quality of relations with the company's partners in the area of adaptation, lower than in the case of other companies participating in the study; and
- Satisfaction: S1 – an assessment of the quality of relations with the company's partners in the area of satisfaction, higher than in the case of other companies participating in the study, S2 – an assessment of the quality of relations with the company's partners in the area of satisfaction, lower than in the case of other companies participating in the study.

(4) Evaluation of benefits achieved through cooperation with partners in the following areas:

- Finance: F1 – an assessment of benefits obtained from cooperation with partners in the financial perspective, higher than in the case of other companies participating in the study, F2 – an assessment of benefits obtained from cooperation with partners in the financial perspective, lower than in the case of other companies participating in the study;
- Processes: P1 – an assessment of benefits obtained from cooperation with partners in the processes perspective, higher than in the case of other companies participating in the study, P2 – an assessment of benefits obtained from cooperation with partners in the processes perspective, lower than in the case of other companies participating in the study;

- Client: CP1 – an assessment of benefits obtained from cooperation with partners in the client perspective, higher than in the case of other companies participating in the study, CP2 – an assessment of benefits obtained from cooperation with partners in the client perspective, lower than in the case of other companies participating in the study;
- Development: D1 – an assessment of benefits obtained from cooperation with partners in the development perspective, higher than in the case of other companies participating in the study, D2 – an assessment of benefits obtained from cooperation with partners in the development perspective, lower than in the case of other companies participating in the study.

Respondents participated in the study evaluated all indicated areas on a five-point Likert scale. In the next step on the basis of their responses, the median value for every assessed variable describing various areas of cooperation was calculated. The median value as a criterion of division into two groups of respondents separately for every considered areas (presenting above in 1–4 points) was applied in the next steps of analyses.

### *3.2 Preparation of input data to the correspondence analysis and description of the research method*

The correspondence analysis is one of the multidimensional analyses. The main advantage of this method is the ability to compare variables measured on different scale (including the nominal scale) and characterized by coexistence, i.e. in the set of examined variables one cannot clearly identify the dependent variable. This method can also be used to analyze the results obtained from non-random sample. The starting point in the multidimensional correspondence analysis is the proper preparation of the set of input data. This means identifying the dependent variable that will be of the greatest interest to the researcher when examining relationships between categories of variable and identifying typological groups (clusters). In the paper, cluster membership as dependent variable was indicated. Other variables described in detail in the previous paragraph can be treated as independent variables describing the behavior of enterprises belonging and not belonging to the cluster.

The correspondence analysis was started by developing the complex matrix of markers (Bağ *et al.*, 2018). In this matrix, the number of lines was equal to the number of examined units (firms), whereas the number of columns corresponded to all of the variables selected in the study, which was exchanged into 0–1 variable, where 1 means the first case in every analyzed area and 0 means the second transformed according the following principles:

- for stimulants:  $xs_i = \begin{cases} 1 & \text{when } x_i \geq Me \\ 0 & \text{when } x_i < Me \end{cases}$
- for destimulants:  $xs_i = \begin{cases} 1 & \text{when } x_i \leq Me \\ 0 & \text{when } x_i > Me \end{cases}$

The authors decided to divide all selected areas describing the relationships and quality of cooperation between partners belonging to the cluster and firms operating outside the cluster into two groups owing to the large diversity of answers received in the survey. It means that, e.g. in the first group for the variable DC1, the firms that confirmed the use of direct communication as a part of cooperation with other companies, more frequent than in the case of other companies participating in the research, were classified.

The procedure of multidimensional correspondence analysis was carried out in the following stages (Greenacre, 1984; Stanimir, 2005; Bağ *et al.*, 2018):

- preparing the complex matrix of markers;
- determining the dimension of the real coexistence space based on the following formula:

$$K = \sum_{q=1}^Q (J_q - 1) \quad (1)$$

where  $J_q$  is the number of categories of the variable  $q$  ( $q = 1, 2, \dots, Q$ ) and  $Q$  is the number of variables;

- checking to which extent eigenvalues (main inertias) of the lower-dimension space explain total inertia ( $\lambda$ ).

For this purpose, the Greenacre's criterion was used, according to which main inertias larger than the inverse of the number of analyzed variables are regarded as important for this study ( $1/Q$ ). Total inertia is the  $K$  total of eigenvalues, where  $K$  is the dimension of genuine coexistence space.

- Improving the quality of representation through the modification of eigenvalues according to Greenacre's proposal (Greenacre, 1984):

$$\tilde{\lambda}_k = \left( \frac{Q}{Q-1} \right)^2 \cdot \left( \sqrt{\lambda_{B,k}} - \frac{1}{Q} \right)^2 \quad (2)$$

where  $Q$  is the number of analyzed variables and  $\lambda$  is  $k$  eigenvalue ( $k = 1, 2, \dots, n$ ).

The effect of conducted correspondence analysis is the graphic presentation of simultaneous occurrence of categories of variables (Greenacre and Hastie, 1987). If the space with the dimension larger than three is the best form of the presentation of variables' coexistence, another method of analyzing the results should be selected. For this purpose, one can use classification methods in the space of both low and high dimensions. Classification methods are also useful when the number of all variants of variables is large and the spread of points on the diagram does not allow to clearly distinguish classes (Bağ et al., 2018). New values of coordinates are determined as follows:

$$\tilde{F} = F^* \cdot \Gamma^{-1} \cdot \tilde{\Lambda} \quad (3)$$

where  $\tilde{F}$  is the matrix of modified values of coordinates for the category of examined variables with the  $K \times k$  dimension,  $F^*$  is the matrix of original values of coordinates for the category of examined variables with the  $K \times k$  dimension,  $\Gamma^{-1}$  is the diagonal inverse matrix of specific values ( $\gamma k$ ) with the  $k \times k$  dimension,  $\gamma k$  is the  $k$ -specific value, which is the square root of the  $k$  eigenvalue ( $\lambda k$ ),  $\tilde{\Lambda}$  is the diagonal matrix of modified eigenvalues with the  $k \times k$  dimension and  $K$  is the dimension of the genuine coexistence space.

#### 4. Study results

The correspondence analysis was carried out by stages described in the previous paragraph (total inertia is the  $K$  total of eigenvalues where  $K$  is the dimension of genuine coexistence space). Owing to this fact, the dimension of the genuine coexistence space amounted to 28 (formula 1). Next, the extent to which eigenvalues with a lower dimension explain total inertia ( $\lambda = 1.0000$ ) was checked.

In accordance with the Greenacre's criterion, the main inertias larger than  $\frac{1}{Q} = \frac{1}{14} = 0.07143$  were taken into account as important for the study. According to the results



presented in Table 4, it means that the inertias for  $K$  taking values to and including 5 have to be considered. The results for  $K > 5$  need to be ignored because for these dimensions, main inertias did not exceed 0.007143. It means that these dimensions were not important in the study. For these dimensions, the level of explanation of inertias in two-dimensional space amounts to 38.22% and in the five-dimensional, it is 64.19%. This measure determines the inertia share of a selected dimension ( $\lambda_k$ ) in the total inertia ( $\lambda$ ). To improve the quality of representation in the five-dimensional space, the modification of eigenvalues according to formula (2) was carried out. Original and modified eigenvalues together with the level of total inertia explanation were presented in Table 5. As a result of conducted modification, the level of total inertia explanation significantly increased. The first two eigenvalues constitute 47.06% of the modified total inertia and in the five-dimensional space, the level of inertia explanation is 73.20%. It should be noted that owing to a large number of analyzed variables and their variants, the interpretation of results obtained in the five-dimensional space is practically impossible. To achieve clearer interpretation of results, Ward's method was applied that enabled identification of connections between variants of variables (Figure 4). This figure presents the combinations of categories into classes and the stage in which the combination of classes was interrupted was marked with a horizontal line. Ward's method is one of agglomeration methods of grouping. It is used in empirical studies both in reference to classification of objects and variables. In this method, the distance between groups is defined as the difference module between totals of squares of points' distances to centers of groups to which these points belong (Malina, 2004). New values of coefficients in the five-dimensional space for categories of variables were determined with the use of Formula (3).

The division of enterprises participating in the study into three groups is the effect of the computational algorithm used in the paper.

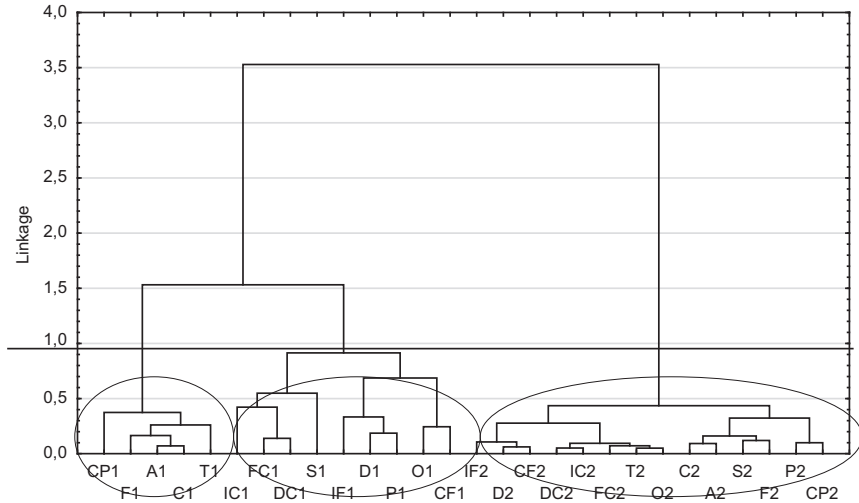
To the *first group*, companies belonging to the cluster and those that operate outside of this kind of structure are qualified. Companies from this group rank higher than others (above the median of all results obtained for individual assessment criteria), the quality of their relations with partners in areas such as adaptation, commitment and trust. These

K	Eigenvalues $\gamma_k$	Singular values $\lambda_k$	(%) of inertia $\lambda_k/\lambda$	Cumulative (%) $\tau_k$	Eigenvalues $\tilde{\lambda}_k$	(%) of inertia $\tilde{\lambda}_k/\tilde{\lambda}$	Cumulative (%) $\tilde{\tau}_k$
1	0.2461	0.4961	24.61	24.61	0.2091	31.57	31.57
2	0.1361	0.3689	13.61	38.22	0.1027	15.49	47.06
3	0.1040	0.3226	10.40	48.63	0.0731	11.04	58.10
4	0.0839	0.2897	8.39	57.02	0.0553	8.34	66.44
5	0.0718	0.2679	7.18	64.19	0.0448	6.76	73.20
6	0.0637	0.2525	6.37	70.57	0.0380	5.74	78.93
7	0.0620	0.2490	6.20	76.77	0.0366	5.52	84.45
8	0.0488	0.2208	4.88	81.64	0.0259	3.91	88.36
9	0.0448	0.2117	4.48	86.12	0.0228	3.44	91.80
10	0.0413	0.2032	4.13	90.25	0.0201	3.04	94.84
11	0.0342	0.1850	3.42	93.67	0.0150	2.26	97.09
12	0.0261	0.1617	2.61	96.29	0.0094	1.43	98.52
13	0.0203	0.1425	2.03	98.32	0.0059	0.89	99.41
14	0.0168	0.1297	1.68	100.00	0.0039	0.59	100.00
					$\tilde{\lambda}_k = 1.0000$		

Source: Own elaboration

**Table 5.**  
Eigenvalues and singular values with characterizing the distribution of the variables studied the degree of explanation of total inertia in the original and modified versions

**Figure 4.** Presentation of the results of correspondence analysis concerning all categories of variables including the modification of eigenvalues



**Source:** Own elaboration based on Table 5

enterprises confirm the benefits of cooperation with their partners more often than others, especially in the client and financial perspective. The study shows that the ratings obtained in these criteria are not affected by the affiliation of the surveyed companies to the cluster. The separation of two successive groups has got key importance for the research hypotheses posed in this paper. These groups allowed for the division of enterprises participating in the research taking into account their affiliation to the cluster and their functioning outside such structures.

The *second group* includes mainly enterprises belonging to the cluster, which use different ways and forms of communication in contacts with their partners. These companies use for this purpose both direct and indirect communication as well as formal and informal communication. The frequency of using these kinds of ways and forms of communication with partners is also greater than in the case of companies not belonging to the cluster. At the same time, these companies assess higher than enterprises not belonging to the cluster structures, the quality of relationships occurring in contacts with partners with whom they cooperate in the area of satisfaction. They grant lower marks in the category of opportunism, which in this case is more advantageous. They also assess better the benefits of these contacts, which are made from the perspective of processes and development.

In turn, the *third group* was made up of enterprises not belonging to the cluster, which declares the use of various forms and methods of communication in contacts with their partners, but the frequency of using them is less frequent than in the case of companies classified to the second group. These enterprises assess lower than the companies in the first and second groups, the quality of relations occurring in contacts with partners with whom they cooperate. The lower ratings in this area of research concern – trust, commitment, adaptation and satisfaction and higher (which means worse results) – opportunism, as a criterion measuring the quality of relations in contact with partners. The companies from this group assess their benefits as lower, which they achieve as a result of cooperation undertaken with partners, considered in all evaluated perspectives: financial, processes, clients and development.

The results of the study allow for positive verification of all the detailed hypotheses put forward, especially in the case of *H2*. This is confirmed by the features describing the second of the distinguished groups indicating the more frequent use of all the analyzed ways and forms of communication in relation to partners. This is also confirmed by the lower ratings granted to these areas in the case of enterprises qualified to the third group, which mainly include enterprises that do not function in cluster structures.

*H3* and *H4* can be considered partially confirmed. In this case, we can talk about lower grades awarded in all assessed areas describing both the quality of relationships with partners, as well as the benefits achieved as a result of this cooperation in relation to enterprises not belonging to the cluster and qualified for the third group. On the other hand, a better quality of relations with partners in the case of enterprises belonging to the cluster, from the second group, in the areas of satisfaction and opportunism, two out of five assessed aspects of the quality of relations, was confirmed. At the same time, the companies from this group rated higher, the benefits of this cooperation in two of the four assessed perspectives: processes and development. Confirmation of the hypothesis is also lower ratings awarded by enterprises not functioning in cluster structures, and they are included in the third group, in the case of possible benefits from cooperation with partners in all assessed perspectives.

In view of the fact that detailed hypotheses have been confirmed, it can also be stated that *H1* has been confirmed.

The presented research is a contribution to the literature on inter-organizational structures, such as clusters and supply chains, and in particular, contributes to the creation of the scientific ground of CSC theory. The theoretical considerations addressed in the paper and empirical research carried out help to better understand the nature of collaboration taking into consideration the fact of the relational embeddedness of the companies operating within supply chains located in clusters.

It should be emphasized, however, that owing to the non-random selection of the sample (despite the large number of surveyed enterprises), the obtained results should be interpreted as some kind of regularity. Owing to the inability to select randomly a sample for the study, the authors controlled mainly the size of the surveyed enterprises and their geographical distribution. The study also included information on the origin of capital. Thus, the results presented in the paper relate to a sample whose some characteristics correspond to the structure of the population of enterprises in Poland. Owing to the lack of detailed databases on the affiliation of enterprises to the cluster, it was not possible to ensure random sampling. The results presented in the paper describe probable trends. Many clusters in Poland and in the world are created only for the needs of various types of projects funded by EU and after their incubation period, their further activity is not continued. This is the reason for the lack of real information confirming the functioning of enterprises in the cluster and significantly hindering the possibility of random sampling.

Attention should also be paid to some limitations of the findings. They concern both the research process itself and the data obtained. The CSC study is a complex process because it covers two research areas: supply chains and clusters whose interaction has been described on the basis of the concept of embeddedness. Identifying the differences between CSC and supply chains not belonging to the clusters (NCSC) requires defining a precise research framework that can simultaneously become some kind of limitation in the desire to deepen knowledge.

The conceptual framework (Figure 2) provides a comparative analysis of two types of supply chains in relation to selected aspects of their cooperation, which include “diversity of business communication,” “quality of supply chain relationship” and “achieved benefits by companies from collaboration in the supply chain.” It is worth emphasizing that constructs are not analyzed as a process, which is reflected in the empirical testing. Therefore, it cannot be directly

determined which variables and how affected the benefits of CSC actors. Similarly, it is not possible to make an objective assessment of the benefits (which the benefits are greater in CSCs or NCSs?). The survey only indicates that CSC companies rate their benefits higher than NCS participants. In the context of the adopted research assumptions and the results obtained, this is explained by relational embedding in the cluster.

The limitations are referred to as the static character of the data, too. The survey was conducted on a sample of Polish enterprises, therefore in the future, it should be extended to other markets.

## 5. Conclusions

The significant literature on supply chains describes their particular type, namely CSC, to a very modest extent. Their uniqueness lies in the fact that they operate only when certain conditions are met, which include, among others belonging of enterprises to a cluster network and cooperation with other cluster enterprises.

Nevertheless, the division of enterprises participating in the study into three groups allows for the determination of relatively clear boundaries between enterprises belonging to the cluster and those that do not declare such affiliation. In many areas considered in the paper, such differences exist. They are most visible in the case of the frequency of using various forms and ways of communicating with partners. More frequent formal and informal contacts made directly and indirectly are declared by companies belonging to the cluster. We can talk about a clear border between the surveyed enterprises owing to the frequency of using such forms and methods in contact with partners. In the case of quality assessment of relations taking place in contacts with partners, higher ratings for companies belonging to the cluster were received for areas such as trust and adaptation. The quality in the area of opportunism was also assessed better. However, assessments regarding aspects such as commitment and satisfaction are not dependent on or not belonging to a cluster and can be rated higher by both belonged to the cluster and non-cluster companies. It is worth noting, however, that despite the lack of possibility to determine such a clear division in these aspects, the lower rating is more often awarded by companies not belonging to the cluster. Similar regularities have also been identified when assessing the benefits of partnering. Higher benefits, in this case, identified more often by enterprises belonging to clusters, relate to assessments from the perspective of processes and development. At the same time, lower ratings, taking into account all the assessment-considered perspectives, are much more often awarded by companies not belonging to the cluster structures.

The empirical results presented in the study based on the theoretical assumptions allowed to describe the relation existent between the companies belonging or not belonging to the clusters. The study proves that the collaboration of the cluster enterprises within a supply chain is significantly affected by their relational embeddedness in the cluster, and the relational embeddedness is the differentiator of supply chains operating in the clusters. This is important from the point of view of building social capital among cooperating actors in CSC. Relational embeddedness defines the type of personal relations that develop during interactions between individuals and are reflected in friendship and respect, which translates into the behavior of actors. It is expressed in the role of social relations and the structure of these relations in building trust and weakening the occurrence of opportunistic behavior. It is worth emphasizing that the bonds between CSC actors can, therefore, perform a coordinating function for their cooperation, regardless of the use of formalized forms.

What are more, enterprises participating in the cluster operate in a specific geographically and sectorally concentrated inter-organizational network. Thus, it is the cluster and the way it operates that is not only the context for CSCs, but to some extent impose their spatial and sectoral

framework of operation. This, in turn, points to another important aspect of CSCs identification that applies to both regional production systems and global manufacturing networks. According to the concept of cluster sourcing (Frankowska, 2016), sectoral and geographically concentrated clusters allow to create common ground for both globalization and regionalization of supply chains, the performance of businesses from the SMEs sector with transnational corporations and it integrates the competitive and cooperative actions. According to Carrie (2000), the competition will take place rather between regional clusters than individual enterprises and their supply chains. It results from the fact that a supply chain built on the basis of a cluster initiative has more benefits resulting from the very nature of the cluster than a geographically dispersed supply chain. Thus, he predicts that CSCs will dominate individual industries in the future. This seems to be of particular use in modern times characterized by high uncertainty and dynamics of market changes. Long and complex global supply chains are characterized by a lower resistance to interference. Thus, geographically concentrated CSCs may have more advantages and be more stable over the long term. It is worth considering that CSCs become a new unit of analysis if in the future an agreement is reached between the scientific community, the sphere of politics and cluster (business) associations.

As the EU announces, the goal of the next long-term EU budget for 2021–2027 will be to modernize cohesion policy – the EU’s main investment policy and its most concrete manifestations of solidarity. In the documents announcing the introduction of this budget, attention is drawn to the need to support the creation and operation of pan-European clusters in priority areas such as large data set technology, circular economy, advanced production technologies and cyber security.

Research shows that CSCs are the most advanced form of cooperation, in particular for SMEs, which bring them tangible and intangible benefits. Hence, the following recommendations can be made for policymakers:

- Supporting clusters should refer not only to their sectoral specialization, but also be directed to the improvement of processes in the strategic and operational dimension, as this way SMEs are strengthened.

- When creating a cluster policy, it should be remembered that cluster organizations play an important role today, because they support building social capital, which enables building relationships and facilitates coordination of cooperation. This is important, especially in conditions of high market uncertainty.

It is also worth noting that cluster coordinators should understand to a greater extent the importance of operational activities for better cooperation of cluster enterprises. It is important to include improving competences in the field of supply chain management when animating the cooperation of cluster members. This will result in higher efficiency achieved by cluster companies.

The research shows that the way of building relationships between enterprises forming clusters can be more advanced and developed. Knowledge about how to build relationships between enterprises in clusters, taking into account their growing importance in the economy, provides new evidence confirming the legitimacy of supporting development this type of organization.

## References

- Autry, C.W. and Griffis, S.E. (2008), “Supply chain Capital: the impact of structural and relational linkages on firm execution and innovation”, *Journal of Business Logistics*, Vol. 29 No. 1, pp. 157-173.
- Bąk, I., Cheba, K. and Szczecińska, B. (2018), “The impact of transport on the quality of the environment in cities of Poland – a statistical analysis”, *Green Cities 2018 Conference, Szczecin*.

- Beamon, B.M. (1999), "Measuring supply chain performance", *International Journal of Operations and Production Management*, Vol. 19 No. 3, pp. 275-292.
- Banchuen, P., Sadler, I. and Shee, H. (2017), "Supply chain collaboration aligns order-winning strategy with business outcomes", *IIMB Management Review*, Vol. 29 No. 2, pp. 109-121.
- Becattini, G. (1979), *Scienza Economica e Trasformazioni Sociali*, La Nuova Italia, Florence.
- Benton, W.C. and Maloni, M. (2005), "The influence of power driven buyer/seller relationships on supply chain satisfaction", *Journal of Operations Management*, Vol. 23 No. 1, pp. 1-22.
- Bowersox, D.J., Closs, D.J. and Stank, T.P. (1999), *21st Century Logistics: Making Supply Chain Integration a Reality*, Council of Logistics Management, Oak Brook, IL, pp. 35-42.
- Bozarth, C., Blackhurst, J. and Handfield, R.B. (2007), "Following the thread: Industry cluster theory, the new England cotton textiles industry, and implications for future supply chain research", *Production and Operations Management*, Vol. 16 No. 1, pp. 154-157.
- Brewer, P.C. and Speh, T.W. (2000), "Using the balanced scorecard to measure supply chain performance", *Journal of Business Logistics*, Vol. 21 No. 1, pp. 75-93.
- Burt, R.S. (2000), "The network structure of social Capital", *Research in Organizational Behavior*, Vol. 22, pp. 345-423.
- Camarinha-Matos, L.M. and Afsarmanesh, H. (2008), *Collaborative Networks: Reference Modeling*, Springer Science and Business Media.
- Cao, M. and Zhang, Q. (2011), "Supply chain collaboration: Impact on collaborative advantage and firm performance", *Journal of Operations Management*, Vol. 29 No. 3, pp. 163-180.
- Cao, M. and Zhang, Q. (2013), "Supply chain collaboration", *Roles of Interorganizational Systems, Trust, and Collaborative Culture*, Springer, London, 20-21.
- Carrie, A.S. (2000), "From integrated enterprises to regional clusters: the changing basis of competition", *Computers in Industry*, Vol. 42 Nos 2/3, pp. 289-298.
- Christopher, M., Peck, H. and Towill, D. (2006), "A taxonomy for selecting global supply chain strategies", *The International Journal of Logistics Management*, Vol. 17 No. 2, pp. 227-287.
- Claver-Cortés, E., Marco-Lajara, B., Seva-Larrosa, P. and Ruiz-Fernández, L. (2019), "Competitive advantage and industrial district: a review of the empirical evidence about the district effect", *Competitiveness Review: An International Business Journal*, Vol. 29 No. 3, pp. 211-235.
- Collins, R., Sun, X. and Li, C.G. (2012), "Are supply-chain relationships more influenced by buyer-supplier relationships or the business environment of the country itself? Evidence from the 'China-Australia' trading relationship", *Asia Pacific Business Review*, Vol. 18 No. 3, pp. 391-405.
- Cooper, S., Watson, D. and Worrall, R. (2016), "Managing supply chain networks: a framework for achieving superior performance through leadership capabilities development in supply chain node", *PMA International Conference 2016 Performance Measurement and Management: New Theories for New Practices, Edinburgh*, pp. 1-19, available at: <http://sure.sunderland.ac.uk/id/eprint/6556/>
- Cooper, M. and Gartner, J. (1993), "Building good business relationships – more than just partnering or strategic alliances?", *International Journal of Physical Distribution and Logistics Management*, Vol. 23 No. 6, pp. 14-26.
- Cutting-Decelle, A.-F., Young, B.I., Das, B.P., Case, K., Rahimifard, S., Anumba, C.J. and Bouchlaghem, D.M. (2007), "A review of approaches to supply chain communications: from manufacturing to construction", *ITcon*, Vol. 12, pp. 73-102.
- Czakov, W. (2017), "Klimat współpracy międzyorganizacyjnej", *Studia Oeconomica Posnaniensia*, Vol. 5 No. 9, pp. 7-20.
- Dorsch, M.J., Swanson, S.R. and Kelley, S.W. (1998), "The role of relationship quality in the stratification of vendors as perceived by customers", *Journal of the Academy of Marketing Science*, Vol. 26 No. 2, pp. 128-142.

- Dyer, J.H. (2000), *Collaborative Advantage: Winning through Extended Enterprise Supplier Networks*, Oxford University Press, New York, NY.
- Elrod, C., Murray, S. and Bande, S. (2013), "A review of performance metrics for supply chain management", *Engineering Management Journal*, Vol. 25 No. 3, pp. 39-50.
- Ellram, L.M. (1995), "A managerial guideline for the development and implementation of purchasing partnerships", *International Journal of Purchasing and Materials Management*, Vol. 31 No. 1, pp. 9-16.
- Ellram, L.M. and Cooper, M. (1990), "Supply chain management, partnerships and the shipper-third party relationship", *The International Journal of Logistics Management*, Vol. 1 No. 2, pp. 1-10.
- Fynes, B., Voss, C. and Burca, S. (2005), "The impact of supply chain relationship quality on quality performance", *International Journal of Production Economics*, Vol. 96 No. 3, pp. 339-354.
- Fawcett, S.E., Ogden, J.A., Magnan, G.M. and Cooper, M.B. (2006), "Organizational commitment and governance for supply chain success", *International Journal of Physical Distribution and Logistics Management*, Vol. 36 No. 1, pp. 22-35.
- Ferrer, M., Santa, R., Hyland, P.W. and Bretherton, P. (2010), "Relational factors that explain supply chain relationships", *Asia Pacific Journal of Marketing and Logistics*, Vol. 22 No. 3, pp. 419-440.
- Frankowska, M. (2018), "Współdziałanie w klastrach łańcuchach dostaw", CeDeWu, Warszawa.
- Frankowska, M. (2016), "Cluster-sourcing – the concept of enhancing internationalization and efficiency of cluster companies", in Kaczmarek, J. and Żmija, K. (Eds), *Expectations and Challenges of Modern Economy and Enterprises. Problems – Concepts – Activities*, Cracow University of Economics, Cracow.
- Graça, P. and Camarinha-Matos, L.M. (2017), "Performance indicators for collaborative business ecosystems – literature review and trends", *Technological Forecasting and Social Change*, Vol. 116, pp. 237-255.
- Granovetter, M. (1985), "Economic action and social structure: the problem of embeddedness", *American Journal of Sociology*, Vol. 91 No. 3, pp. 481-510.
- Greenacre, M. (1984), *Theory and Applications of Correspondence Analysis*, Academic Press, London.
- Greenacre, M. and Hastie, T. (1987), "The geometric interpretation of correspondence analysis", *Journal of the American Statistical Association*, Vol. 82 No. 398, pp. 437-447.
- Gunasekaran, A., Patel, C. and Tirtiroglu, E. (2001), "Performance measures and metrics in a supply chain environment", *International Journal of Operations and Production Management*, Vol. 21 Nos 1/2, pp. 71-87.
- Han, X. (2009), "Research on relevance of supply chain and industry cluster", *International Journal of Marketing Studies*, Vol. 1 No. 2, pp. 127-130.
- Harrison, A. and van Hoek, R. (2010), "Zarządzanie logistyką", PWE, Warszawa.
- Håkansson, H. (Ed.) (1982), *International Marketing and Purchasing of Industrial Goods – An Interaction Approach*, IMP Project Group, Wiley, Chichester.
- Hołub-Iwan, J. and Małachowska, M. (2008), "Rozwój klastrów w polsce. Raport z badań. Szczecin".
- Hudnurkar, M., Jakhar, S. and Rathod, U. (2014), "Factors affecting collaboration in supply chain: a literature review", *Procedia - Social and Behavioral Sciences*, Vol. 133, pp. 189-202.
- Jarillo, C. (1988), "On strategic networks", *Strategic Management Journal*, Vol. 9 No. 1, pp. 31-41.
- Jizi, L. and Chunling, L. (2007), "Study on management model of cluster supply chain based on time-competition", *International Conference on Wireless Communications, Networking and Mobile Computing, WiCom 2007, IEEE*, pp. 4859-4862.
- Kanter, R. (1994), "Collaborative advantage: the art of alliances", *Harvard Business Review*, pp. 96-108. July–August.
- Kaplan, R.S. and Norton, D.P. (2007), *Strategiczna Karta Wyników. Jak Przełożyć Strategię na Działanie*, Wydawnictwo Naukowe PWN, Warszawa.

- Karpacz, J. (2014), "Oportunizm w relacjach międzyorganizacyjnych w teorii i praktyce", *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu nr*, Vol. 366 No. 366, pp. 236-247.
- Kautonen, T., Zolin, R., Kuckertz, A. and Vijamaa, A. (2010), "Ties that blind? How strong ties affect small business owner-managers' perceived trustworthiness of their advisor", *Entrepreneurship and Regional Development*, Vol. 22, pp. 189-209.
- Kisperska-Moroń, M. (2000), "Benchmarking jako narzędzie zarządzania logistycznego", Akademia Ekonomiczna, Katowice.
- Kleijnen, J. and Smits, M. (2003), "Performance metrics in supply chain management", *Journal of the Operational Research Society*, Vol. 54 No. 5, pp. 507-514.
- Kumar, K., Van Dissel, H.G. and Bielli, P. (1998), "The merchant of prato revisited: toward a third rationality of information systems", *MIS Quarterly*, Vol. 22 No. 2, pp. 199-226.
- Kühne, B., Gellynck, X. and Weaver, R.D. (2013), "The influence of relationship quality on the innovation capacity in traditional food chains, supply chain management", *Supply Chain Management: An International Journal*, Vol. 18 No. 1, pp. 52-65.
- Lages, C., Lages, C.R. and Lages, L.F. (2005), "The RELQUAL scale: a measure of relationship quality in export market ventures", *Journal of Business Research*, Vol. 58 No. 8, pp. 1040-1048.
- Lee, P.D. (2005), "Measuring supply chain integration: a social network approach", *Supply Chain Forum: An International Journal*, Vol. 6 No. 2, pp. 58-67.
- Li, L., Su, Q. and Chen, X. (2011), "Ensuring supply chain quality performance through applying the SCOR model", *International Journal of Production Research*, Vol. 49 No. 1, pp. 33-57.
- Lian, Y. (2014), "The third-party virtual supply chain alliance in industry cluster under electronic business environment", *Contemporary Logistics*, Vol. 14, pp. 63-66.
- Lin, H.M., Huang, C.H., Lin, C.P. and Hsu, W.C. (2012), "How to manage strategic alliances in OEM-based industrial clusters: Network embeddedness and formal governance mechanisms", *Industrial Marketing Management*, Vol. 41 No. 3, pp. 449-459.
- Łupicka, A. (2016), "Dominacja w łańcuchu dostaw", *Zeszyty Naukowe „Ekonomika Transportu i Logistyka Uniwersytetu Gdańskiego*, 58, *Modelowanie Procesów i Systemów Logistycznych*, Vol. 58 No. 15, pp. 53-61.
- Malina, A. (2004), *Wielowymiarowa Analiza Przestrzennego Zróżnicowania Struktury Gospodarki Polski Według Województw*, Wydawnictwo AE w Krakowie, Kraków.
- Marco-Lajara, B. and Garcia-Lillo, F. (2004), "SMEs and supplier alliance use. An empirical analysis. Supply chain management", *An International Review*, Vol. 9 No. 1, pp. 71-85.
- Markusen, A.R. (1996), "Sticky places in slippery space: a typology of industrial districts", *Economic Geography*, Vol. 72 No. 3, pp. 293-313, doi: [10.2307/144402](https://doi.org/10.2307/144402). Taylor and Francis.
- Melnyk, S.A., Stewart, D.M. and Swink, M. (2004), "Metrics and performance measurement in operations management: dealing with the metrics maze", *Journal of Operations Management*, Vol. 22 No. 3, pp. 209-218.
- Mentzer, J.T., Foggin, J.H. and Golicic, S.L. (2000a), "Collaboration: the enablers, impediments, and benefits", *Supply Chain Management Review*, Vol. 4, pp. 52-58.
- Mentzer, J.T., Min, S. and Zacharia, Z.G. (2000b), "The nature of interfirm partnering in supply chain management", *Journal of Retailing*, Vol. 76 No. 4, pp. 549-568.
- Mohaghar, A. and Ghasemi, R. (2011), "A conceptual model for supply chain relations quality and supply chain performance by structural equation modeling: a case study in the iranian automotive industry", *European Journal of Social Sciences*, Vol. 21 No. 3, pp. 456-470.
- Molina-Morales, F.X., Capovicedo, J. and Martínez-Fernández, M.T. (2012), "Social Capital in industrial districts: Influence of the strength of ties and density of the network on the sense of belonging to the district", *Papers in Regional Science*, Vol. 92 No. 4, pp. 773-790.



- Moody, J. and White, D.R. (2003), "Structural cohesion and embeddedness: a hierarchical concept of social groups", *American Sociological Review*, Vol. 68 No. 1, pp. 103-127.
- Morgan, R.M. and Hunt, S.D. (1994), "The Commitment-Trust theory of relationship marketing", *Journal of Marketing*, Vol. 58 No. 3, pp. 20-38.
- Nyholm, M. (2011), *Activation of Supply Relationships. A Study of Main Providers in the Turku Logistics Cluster*, Åbo Akademi University Press, Åbo.
- Obstfeld, D. (2005), "Social networks, the tertius iungens orientation, and involvement in innovation", *Administrative Science Quarterly*, Vol. 50 No. 1, pp. 100-130.
- Olson, M. (1965), *The Logic of Collective Action*, Harvard University Press, Cambridge, MA.
- Payan, J.M., Svensson, G. and Hair, J. (2010), "A Cross-Cultural RELQUAL-Scale in Supplier-Distributor relationships of Sweden and the USA", *International Marketing Review*, Vol. 27 No. 5, pp. 541-561.
- Pelletier, C., Vieru, D. and Croteau, A.M. (2017), "The interorganizational relationships process: an asset orchestration mechanisms perspective in an SME context", *Conference: 50<sup>th</sup> Americas Conference on Information Systems (HICSS), Big Island, HI*, pp. 5531-5540.
- Porter, M.E. (2003), "The economic performance of regions", *Regional Studies*, Vol. 37 No. 6-7, pp. 549-578.
- Rauyruen, P. and Miller, K.E. (2007), "Relationship quality as a predictor of B2B customer loyalty", *Journal of Business Research*, Vol. 60 No. 1, pp. 21-31.
- Sako, M. (1992), *Prices, Quality and Trust: Inter-firm Relations in Britain and Japan*, Cambridge, pp. 30-49.
- Simangunsong, E., Hendry, L.C. and Stevenson, M. (2012), "Supply-chain uncertainty: a review and theoretical foundation for future research", *International Journal of Production Research*, Vol. 50 No. 16, pp. 4493-4523.
- Skarmeas, D., Katsikeas, C.S., Spyropoulou, S. and Salehi-Sangari, E. (2008), "Market and supplier characteristics driving distributor relationship quality in international marketing channels of industrial products", *Industrial Marketing Management*, Vol. 37 No. 1, pp. 23-36.
- Stanimir, A. (2005), *Analiza Korespondencji Jako Narzędzie Do Badania Zjawisk Ekonomicznych*, AE we Wrocławiu, Wrocław, Wydaw.
- Su, Q., Song, Y., Li, Z. and Dang, J. (2008), "The impact of supply chain relationship quality on cooperative strategy", *Journal of Purchasing and Supply Management*, Vol. 14, pp. 263-272.
- Svensson, G. and Mysen, T. (2011), "A construct of RELQUAL: Measurement model and theory testing", *Baltic Journal of Management*, Vol. 6 No. 2, pp. 227-244.
- Sztompka, P. (2007), *Zaufanie. Fundament Społeczeństwa*, Wydawnictwo Znak, Kraków.
- Tarifa-Fernandez, J. and de Burgos-Jiménez, J. (2017), "Supply chain integration and performance relationship: a moderating effects review", *The International Journal of Logistics Management*, Vol. 28 No. 4, pp. 1243-1271.
- Tolossa, N.J., Beshah, B., Kitaw, D., Mangano, G. and De Marco, A. (2013), "A review on the integration of supply chain management and industrial cluster", *International Journal of Marketing Studies*, Vol. 5 No. 6, pp. 164-174.
- Tsanos, C.S., Zografos, K.G. and Harrison, A. (2014), "Developing a conceptual model for examining the supply chain relationships between behavioural antecedents of collaboration, integration and performance", *The International Journal of Logistics Management*, Vol. 25 No. 3, pp. 418-462.
- Walter, A., Muller, T.A., Helfert, G. and Ritter, T. (2003), "Functions of industrial supplier relationships and their impact on relationship quality", *Industrial Marketing Management*, Vol. 32 No. 2, pp. 159-169.
- Westlund, H. and Bolton, R. (2003), "Local social Capital and entrepreneurship", *Small Business Economics*, Vol. 21 No. 2, pp. 77-123.
- White, W.J. O'Connor, A.C. and Rowe, B.R. (2004), "Economic impact of inadequate infrastructure for supply chain integration", Final report, NIST.

- 
- Williamson, O.E. (1991), "Comparative economic organization: the analysis of discrete structural alternatives", *Administrative Science Quarterly*, Vol. 36 No. 2, pp. 2, 269-296.
- Witkowski, J. (2003), *Zarządzanie Łańcuchem Dostaw*, PWE, Warszawa.
- Xue, X., Wei, Z. and Zeng, Z. (2011), "The design of service system for SMEs collaborative alliance: Cluster supply chain", *Journal of Software*, Vol. 6 No. 11, pp. 2146-2153.
- Yu, C. (2012), "Research on enterprise innovation network based on cluster supply chain", *Contemporary Logistics*, Vol. 9, pp. 33-36.
- Yu, Y. and Huo, B. (2019), "The impact of relational Capital on supplier quality integration and operational performance", *Total Quality Management and Business Excellence*, Vol. 30 Nos 11/12, pp. 1282-1301.
- Zacharia, Z.G. (2009), "An analysis of supply chain collaborations and their effect on performance outcomes", *Journal of Business Logistics*, Vol. 30 No. 2, pp. 101-123.
- Zhao, R., Mashruwala, R., Pandit, S. and Balakrishnan, J. (2019), "Supply chain relational Capital and the bullwhip effect", *International Journal of Operations and Production Management*, Vol. 39 No. 5, pp. 658-689.

### Further reading

- Bąk, I. (2013), *Statystyczna Analiza Aktywności Turystycznej Seniorów w Polsce*, Wydawnictwo Uczelniane Zachodniopomorskiego Uniwersytetu Technologicznego w Szczecinie, Szczecin.
- Becattini, G. (1990), "The marshallian industrial district as a socioeconomic notion", in Pyke, F., Becattini, G. and Sengenberger, W. (Eds), *Industrial Districts and Inter-Firm co-Operation in Italy*, International Institute for Labour Studies, Geneva, pp. 37-51.
- Łupicka, A. (2009), "Analiza strategiczna w łańcuchu dostaw", in Ciesielski, M. (Ed.), *Instrumenty Zarządzania Łańcuchami Dostaw*, PWE, Warszawa.
- Otto, J. (2020), "Marketing relacji", *Koncepcja i Stosowanie*, Wydawnictwo C.H. Beck, Warszawa.
- Woo, K. and Ennew, C.T. (2004), "Business-to-Business relationship quality: an IMP Interaction-Based conceptualization and measurement", *European Journal of Marketing*, Vol. 38 Nos 9/10, pp. 1252-1271.

### Corresponding author

Marzena Frankowska can be contacted at: [marzena.frankowska@usz.edu.pl](mailto:marzena.frankowska@usz.edu.pl)