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Lenka Veselovská ACHIEVING FLEXIBILITY: A NEW TREND IN SUPPLY CHAIN MANAGEMENT



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UNIVERZITA  
MATEJA BELA  
V BANSKEJ BYSTRICI

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# ACHIEVING FLEXIBILITY: A NEW TREND IN SUPPLY CHAIN MANAGEMENT

ELIANUM

**Ekonomická fakulta  
Univerzity Mateja Bela v Banskej Bystrici**



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## **LIST OF ACRONYMS**

CFL	contract flexibility
VFL	volume flexibility
PFL	product mix flexibility
DFL	delivery flexibility
MFL	manufacturing flexibility
FXP	flexible promotion
FXT	multiple modes and types of transport of raw materials and products
PRT	pressure to reduce production time of product or service
SFP	creation of stocks of finished products for special orders
INR	insurance against the risk of adverse events
FPI	frequent product innovations
PFC	penalizations for failures to comply with the terms of supply of raw materials
GTM	application of game theory methods in parameters settings of production factors
ELO	external logistics organization
FSC	flexible supply contracts
BUP	preparation of back-up plans and crisis management teams
MPU	mathematical programming utilization in supply chain management
RDP	creating possibilities for rapid redeployment of human and material resources between process and / or facilities
RLU	reverse logistics utilization
LCP	long-term capacity planning
CEF	expectations forecasts
SSC	selection of suppliers based on predefined criteria
CCC	corporate culture focused on change
IRD	investments in research and development
IRA	implementation of risk analyses

- ROQ raising order amounts for raw materials reserves
- FPS utilization of flexible planning systems
- MPL periodical analysis of market conditions and product life cycle
- CPS creating partnerships
- COC customer orientation as a main strategic concept of enterprise
- CLO continuous improvement, learning organization
- ESI economic supply incentives
- PSP product standardization and postponement
- CPC creating plants closer to key customers
- ISP effective flow of information in whole supply chain and sharing of information with partners
- APP frequent adjustments in pricing policies
- IQS implementation of quality systems such as ISO, TQM, etc.

## **INTRODUCTION**

Nowadays companies face severe competition which puts significantly increased pressure not only on their quality requirements, but also on effectiveness of their production processes. It is the goal of company's operations management to ensure the best possible outcome and gain the competitive advantage which enables company to establish a desirable market position. However, it is not a single set of managerial decisions which makes it possible. A strive for excellence is a continuous process which does not only involve establishing a good market position, but it also focuses on implementing measures necessary to maintain it. Cost minimization is one of the original goals of all companies, which is nowadays viewed more as an essential part of companies' financial management. One of the newer ways companies can achieve excellence is through implementing specific measures in order to achieve flexibility of their processes.

The main objective of this monograph is to explore the extent of utilization of various measures to increase supply chain flexibility in Slovak enterprises operating in manufacturing industry and to create a framework for modelling metrics of supply chain flexibility. This publication is divided into three main parts. Firstly, we provide the motivation for this study which also includes a brief literature review of researched topics such as supply chain definition, various flexibility characterizations and we also briefly focus on methods designed to increase supply chain flexibility. Secondly, we provide findings of empirical research conducted on a sample file of Slovak manufacturing enterprises. Research methodology is also explained in detail since this empirical study was conducted on a representative sample of Slovak enterprises. The last section of this publication describes the proposed models and frameworks created on the grounds of both literature research

and findings from the empirical research. We also include model assessment in terms of its practical applications and the discussion including possibilities for further research.

Lenka Veselovská  
Poprad, 10<sup>th</sup> March 2019

# **1. THEORETICAL BASIS OF FLEXIBILITY IN SUPPLY CHAIN MANAGEMENT RESEARCH**

Nowadays, the ever changing global economic conditions deteriorate the business environment and make it more difficult for companies to manage. Therefore, all companies must learn to adapt and make an effort to secure an effective and promising development in these fluid conditions. As a consequence, managers should pay more attention to improving and optimizing methods, which would help their company not only to survive but also to gain excellence in terms of defined goals. Integration of flexible measures throughout the supply chain, partnership development and information sharing are just three of these possibilities. However, the optimal solution would be the integration of all three concepts in order to achieve synergy.

## **1.1. Supply chain management definition**

Global competition has imposed tremendous pressure on product and service providers to transform and improve their operations and practices. To remain competitive in business, all companies are required to manufacture products of a quality acceptable to customers and to deliver those products at competitive cost with highly reliable delivery times (Angkiriwang et al., 2014; Talluri and Baker, 2002). New model of competition was introduced in 21<sup>st</sup> century, where competition is among supply chain networks rather than individual companies (Patnayakuni et al., 2014). Traditionally, the supplier has been more powerful, and, hence, the existing literature in the area emphasizes supplier-driven contracts. However, in some current markets the power has shifted to the buyer (Liu and Çetinkaya, 2009). In order to offer competitive advantage, supply chains have to be tightly aligned with a company's business context. This is true even more so today as

both global business parameters and companies' product portfolios quickly evolve over time. Companies strive to improve their weaknesses through partner relationship management to maximize their supply chain performance (Wu et al., 2013; Seifert and Langenberg, 2011). Success of supply chain depends on effective strategy for improving coordination among the members to make it more responsive for market needs by optimizing available resources. In this context, supply chains need to be flexible (Singh and Sharma, 2013).

Recently, the concept of supply chain has received considerable attention from both practitioners and researchers. Therefore, there can be found various other characterizations of supply chain in literature since the authors' points of view are different. In a work of Agarwal et al. (2006) supply chain is described as a chain linking each element from customer and supplier through manufacturing and services so that flow of material, money and information can be effectively managed to meet the business requirements. Cardoso et al. (2013) provide more traditional view. They describe supply chains as logistics systems that start at the supply of raw-materials and end with the sales and distribution of goods to final consumers. Tallari and Baker (2002) consider supply chain as an alliance of independent business processes, such as supplier, manufacturing, and distribution processes that perform the critical functions in the order fulfilment process. According to Mula et al. (2010) a supply chain may be considered an integrated process in which a group of several organizations, such as suppliers, producers, distributors and retailers, work together to acquire raw materials with a view to convert them into end products which they distribute to retailers. It is obvious that these authors view supply chain through the lens of process management. Chuu (2011) offers a different characterization. According to this author, supply chain is a network of suppliers, manufacturers, distributors and retailers, through which raw

materials are required, transformed, produced, and delivered to end consumers. Thus, a supply chain involves the complex flow of materials, products, services, information, and money across multiple functional areas within and among the complex hierarchies of the participating enterprises. These definitions offer a wide spectrum of aspects involved in creation, design and managing of supply chains. As competition intensifies and markets become global, organizations have begun to realize that improving efficiency within an organization is insufficient, and their whole supply chain must be made competitive.

Supply chain management provides framework and foundations necessary for operations to run smoothly. One of its roles is to develop partnerships among key suppliers and customers with the supply chain (Kopczak, 1997, Sukwadi et al., 2013, Brinkhoff et al., 2014, Voss and Williams, 2013, Glasbergen, 2010, Cheung et al., 2009). Sharing of information among these partners is the next necessary step in partnership development. The nature, motivation and implementation of the supply chain partnership have been examined by various authors (Liu et al., 2007, Rezaei et al., 2015, Wang and Shu, 2007, Singh and Garg, 2015). Recently, these partnerships started to play even more significant roles, therefore issues such trust, reliability, honesty and commitment became deciding factors influencing success or failure of joint operations within supply chains (Brinkhoff et al., 2014, Gosain et al., 2014, Chang and Shaw, 2014, Toften and Hammervoll, 2013). Information itself became used as a tool for organization to an unprecedented capability to communicate with, coordinate with, and even to control its suppliers (Ye and Farley, 2015). The type of information shared depends upon the supply chain problem to be solved (Chandra et al., 2007). Information sharing can be exploited to obtain a distinct supply chain advantage and especially to reduce bullwhip effect within supply chains (Huang et al., 2010; Zhu et al., 2015). Moreover, information

sharing has been cited as one of the major means to enhance supply chain performance (Baihaqi and Sohal, 2013, Hung et al., 2011, Yee, 2007, Vanichchinchai and Igel, 2010). The relationship between the degree of information sharing and organizational performance was then tested by various authors (Baihaqi and Sohal, 2013, Shi et al., 2014, Wakolbinger and Cruz, 2010).

The recent years have brought significant and major changes in supply chains due to ever-increasing level of globalization and more detailed focus on its innovations. The growing role of global supply chains is associated with increased interconnectedness among members of supply chain regardless of its size and structure, which results in higher rates of dependency among organizations within their respective supply chains and a higher level of supply chain complexity. All changes mentioned above resulted in a whole new set of emerging uncertainties and hazards specifically related to supply chain operations. In order to minimize the impact of such disruptions on supply chain performance, several attempts have been made to model and optimize supply chain design, mostly utilizing a deterministic approach to supply chain modelling and analysis (Juttner, 2005; Cantor et al., 2014; Gong, 2008; Esfahbodi et al., 2016). Building on the facts mentioned above, one of the underlying foundations of supply chain management is that it implies that the concept of supply chain that can be efficient while responsive to disruptions is a significantly complex and challenging task. To address these issues, the concept of introducing flexibility measures to supply chain management has received significant attention in recent years (Kamalahmadi and Parast, 2016; Kauppia et al., 2016; He, 2017; Sun and Fang, 2015; Giannakis and Papadopoulos, 2016; Wadhwa and Saxena 2007).

## **1.2. Flexibility in supply chains as an object of research**

Vanichchinchai, Igel (2011) and Baghalian et al. (2013) state that nowadays competition between companies is not as significant as competitions between their supply chains. Therefore, implementing flexibility measures is getting more important than ever. According to Peidro et al. (2010) companies have to face many uncertainties as a result of changes in their inner and outer environment. Adaptation to these changes is crucial for company's survival and key to discovering possible paths to success.

Building supply chains as flexible systems represents one of the most exciting opportunities to create value and one of the most challenging tasks for the policy makers. It requires integrated decision making amongst autonomous chain partners with effective decision knowledge sharing between them. Supply chain management is a relatively newly developed field of study. It is however highly necessary to focus on development of supply chains in current conditions. Given the ever-changing business environment, resources that have historically sustained an organization's competitive advantage in business may no longer be viable. In today's globalized world, competition has gone beyond the boundaries of single company and extended across the full supply chain spectrum. According to Moon et al. (2012) it is therefore essential that supply chain members adjust and reconfigure themselves to achieve a balance between the responsiveness of their organizations and changes in the marketplace by increasing their flexibility in all operational activities. Supply chain flexibility involves the application of supply chain resources according to marketing dynamics, and requires firms to develop cross-functional and cross-company strategies that eliminate bottlenecks and create a level of performance that allows firms to strengthen their competitive advantage in an uncertain market.

Modern supply chains are very complex, and recent lean practices have resulted in these networks becoming more vulnerable (Datta and Christopher, 2010). Various methods have been created to make supply chains more resilient and consequently more adaptable to changing environment (Lummus et al., 2005; Lee; 2004). Therefore, flexibility should be considered as the ability of the whole supply chain system to cope with internal and external variations with high competitive competency and high economic profitability Flexibility is the willingness to alter conditions to meet an unanticipated situation (Chu et al., 2011).

The ability to deal with external and internal uncertainties often decides an enterprise's development and fate. Flexibility is now one of the strategic goals of many enterprises. Gong (2008) found out that flexibility, cost, quality, and technology are considered as the strategic core areas of the enterprise and therefore are a significant focus of research. Moon et al. (2012) came up with a performance-based definition of supply chain flexibility as the agility of a supply chain in responding to marketplace changes to gain or maintain competitive advantage.

Nowadays, it is not suitable to limit supply chain flexibility to product flexibility and distribution flexibility. Garavelli (2003) and Sánchez and Pérez (2005) examined two main aspects of supply chain flexibility: process flexibility and logistics flexibility. Process flexibility concerns the number of product types that can be manufactured at each production site, regardless of where they are located. Logistics flexibility refers to the different logistics strategies that can be adopted to release a product into a marketplace or to procure a component from a supplier. Similarly, Swafford et al. (2006) proposed a three-dimensional supply chain flexibility that includes procurement/sourcing flexibility, manufacturing flexibility, and distribution/logistics flexibility. This approach can be utilized to describe supply chain flexibility in other types of enterprises.

Lummus et al. (2005) conducted a Delphi study with an aim to characterize the supply chain flexibility based on opinions of managers in practice. One of the main results of this study was that performance of a supply chain can improve if the entire chain is flexible, not just the manufacturing or delivery dimension. Therefore, current research needs to focus not only on these measures, but also on other methods to increase the flexibility of the whole supply chain.

Gong (2008) defines flexibility at the internal production level as the ability of the manufacturing system to cope with changes such as product, process, load, and machine breakdown. A more comprehensive definition might be the ability of the enterprise to respond to variations more quickly, with lower costs, and less effect on system effectiveness. Even though this approach is valuable in terms of effectiveness, it lacks the view of other flexibility dimensions provided by the entire supply chain, and therefore omits various possibilities for improvement that can only be discovered by studying supply chain in its full complexity.

Although awareness is increasing among managers in practice, the concepts of supply chain adaptability and its managerial counterpart - supply chain management are still in their infancy. Many companies have recognized the need to conduct formal supply chain analyses and to seek ways to manage flexibility, but the definition of flexibility is usually fairly limited. At an academic level there has emerged a growing body of research into supply chain flexibility from a number of different perspectives (Mavi et al., 2016; Li et al., 2015; Wang et al., 2015; Heckmann et al., 2015; Mangla et al., 2015). However, much like other issues, there is a lack of consensus on what the key characteristics can completely represent and their practical implications.

From the view of supply chain management, a number of strategic measures can be utilized to increase flexibility of

supply chain. Although research on flexibility is considerable and its importance has been recognized for some time, much of the research has concentrated on intra organizational flexibility and has focused largely on manufacturing systems. Current literature in the field is vast; however, it mainly focuses on modelling approaches. Flexibility studies from the supply chain perspective, however, have thus far been limited. The lack of a theoretical base and the wide array of measures used by individual researchers have been identified as major causes of the incomplete state of knowledge of supply chain flexibility (Beach et al., 2000; Stevenson and Spring, 2007; De Toni and Tonchia, 1998). An extensive review of applied measures in supply chain development is a natural extension of these studies.

Based on the existing research (Chopra and Sodhi, 2004; Sodhi and Tang, 2012), it is evident that creating flexibility within a supply chain potentially addresses uncertainty in addition to improving other business performances. Since most supply chain risks are rooted in uncertainty, flexibility creation would also contribute to the mitigation of such risks (Das, 2011; Baghalian et al., 2013; Sodhi and Lee, 2007; Jain et al., 2009).

Considering the fact that flexibility in supply chain is not a new practice, the intense competition in present marketplaces, combined with an increase in globalization of business processes, have made these processes so complex that flexibility consideration has become an integral part of management planning for each and every company. Supply-related flexibility has been addressed in several interesting research projects with impacting findings for both practice and academia. Tomlin and Tang (2008) and Das (2011) recommended using supply chain flexibility to provide supply flexibility through several suppliers, to provide flexible supply via flexible contracts, to include a flexible process strategy through flexible manufacturing, to produce a flexible product strategy by postponement and to present a flexible pricing strategy to avert supply chain

disruption risks. Based on the work of various authors (Nakandala et al., 2013; Baboli et al., 2013; Georgiadis and Athanasiou, 2013; Schönlein et al., 2013) we can derive several types of flexibility: contract flexibility, volume flexibility, product mix flexibility, delivery flexibility and manufacturing flexibility. In our current market conditions, each flexibility type should be considered as the ability of a specific system of enterprise to cope with internal and external variation with high competitive competence and high economic profitability in a form of cost minimization in its designated dimension.

It is an established fact that the inclusion of effective flexibility measures can make a business more responsive and consequently resolving most production process uncertainty issues. Companies must include flexibility planning at the strategic level, based on overall business perspectives, if they intend to be successful within this type of complex, predominantly global business environment. Overall integrating flexibility measures into all company's production processes can provide an opportunity for increase of its economic effectiveness and securing of its market position.

However, it is not enough to limit the scope of flexibility orientation only to company's own processes. In order to achieve desirable results, it is necessary to consider supply chain as a whole and to apply flexibility measures accordingly. Also, greater flexibility in terms of flows tends to create a more profitable network. The two most crucial decision making areas in present competitive business environments are addressing supply chain uncertainties and improving market responsiveness. Developing appropriate strategies in these areas will allow supply chains to avoid most of the common business disruptions. Over the years researchers have imparted enormous importance to supply chain flexibility, developing various types of flexibility measures. The most complex lists of measures can be found in works of Agarwal et al. (2006), Akyuz and Erkan

(2009), Gualandris (2015), Baboli et al. (2013), Závadský and Závadská (2018), Sodhi and Tang (2012), Lummus et al. (2005), Chopra and Mohan (2004), Gong (2008), Georgiadis and Athanasiou (2013), Veselovská (2015) and Veselovská (2017). Based on findings from these research studies we can conclude that there are 32 measures designed to increase supply chain flexibility that are currently applied in practice. It has been proven that they can contribute to increase of supply chain flexibility.

In terms of marketing promotion it is crucial to spread the awareness of company's products and services. If company changes its promotion rapidly, based on market changes, it can result in flexible promotion (FXP). This type of promotion differs from a common promotion since the flexible promotion enables making rapid changes in company's promotion activities based on market changes and company's plans. It represents the set of promotion activities which are already created and available in the moment of need, often in cooperation with supply chain partners.

In practice many companies decide on the use of multiple modes and types of transport of raw materials and products (FXT). Increased flexibility of transportation has proved to have significant effects on costs and time which are the two main indicators of supply chain performance. However, the challenge in application of this measure lies in the increased pressure on coordination of activities. Some companies therefore opt to use external logistics organization (ELO) as a type of outsourcing. If this measure is applied, all supply chain activities are not managed by an internal employee but by an external company. The greatest advantage is that such logistics organization has both the background and experience enough to provide effectiveness. This often provides a much greater benefit than the increase in costs that the company has to pay such organization.

Joining supply chain management with risk management is a relatively new concept. However, such union has already proven fruitful in terms of introduction of risk management measures to increase supply chain flexibility. Insurance against the risk of adverse events (INR) such as natural disasters, changes in political situation, changes on financial markets, etc. is a well known method to deal with external problems. The majority of companies use this method frequently; however, some companies and researchers explored other possibility to apply this method. It can be used to target specific risks related to supply chain activities and thus contribute to the increase of supply chain flexibility. It is similar with the implementation of risk analyses (IRA) and preparation of back-up plans and crisis management teams (BUP). According to current research studies (Kumar et al., 2018; Shafiq and Savino, 2019; Del Castillo and Dimitrakopoulos, 2019) only few companies apply this method to target specifically their supply chain processes and activities successfully.

On the other hand there are several measures of supply chain management that have been widely used since their introduction. These methods are utilization of flexible planning systems (FPS), long-term capacity planning (LCP), selection of suppliers based on predefined criteria (SSC), flexible supply contracts (FSC), creation of stocks of finished products for special orders (SFP), penalizations for failures to comply with the terms of supply of raw materials (PFC), creating plants closer to key customers (CPC) and raising order amounts for raw materials reserves (ROQ). These methods represent the connection of two scientific fields of study – supply chain management and logistics. Other measures are currently emerging from this innovative way of thinking which can also provide a useful tool to increase supply chain flexibility. They are reverse logistics utilization (RLU) and creating possibilities

for rapid redeployment of human and material resources between process and / or facilities (RDP).

Supply chain management has always had a very close relationship with operations management. In a way the latter manages the activities inside the company that directly relate to supply chain performance. Therefore, some operations management measures can be used to directly or indirectly increase supply chain flexibility. These methods include mathematical programming utilization in supply chain management (MPU), pressure to reduce production time of product or service (PRT), application of game theory methods in parameters settings of production factors (GTM), continuous improvement, learning organization (CLO).

There is also a significant connection between supply chain management and marketing which has produced various useful measures to increase supply chain flexibility. These methods include frequent adjustments in pricing policies (APP), product standardization and postponement (PSP), economic supply incentives (ESI), expectations forecasts (CEF), frequent product innovations (FPI), periodical analysis of market conditions and product life cycle (MPL), investments in research and development (IRD), customer orientation as a main strategic concept of enterprise (COC) and corporate culture focused on change (CCC).

There are other supply chain management methods to increase supply chain performance and its flexibility. One of the most advantageous methods is creating partnerships (CPS). Company carefully selects partners from the pool of its suppliers and customers and chooses to strengthen the relationship between them. Such relationship can provide a unique way to tackle problems that influence both partners. The quality of communication is on a different level in comparison to other members of a supply chain. Creating a partnership is, however, a long-term process which has to be based on trust, commitment

and honesty. Both potential partners have to be perceived as reliable from the point of view of the other company (Lin et al., 2016; Yan and Azadegan, 2017).

Partnership can become a foundation for effective flow of information in the whole supply chain and for sharing of information with partners (ISP). However, this measure can be applied even without creation of partnership if all members involved are committed to the same goal. Therefore, we consider information sharing an independent measure which can significantly contribute to the increase of supply chain flexibility.

Implementation of quality systems such as ISO, TQM, etc. (IQS) can also strengthen the supply chain resilience. On the other hand introduction of any system automatically increases the level of its transparency. The way information is handled also provides foundation for increased effectiveness of processes, their speed and, consequently, also the quickness of response in the case of change, especially if members of a supply chain use a similar standardized system (Závadský and Závadská, 2018). Therefore, implementation of quality systems increases supply chain flexibility.

Furthermore, these measures can help strengthen company's position in a supply chain and provide support for the entire supply chain to gain other abilities that make it more competitive. Agility is one of these possible targets. It provides the ability of a supply chain to respond quickly to sudden changes in both supply and demand. Agility also improves the ability of a supply chain to handle unexpected external disruptions smoothly and cost-efficiently and to promptly recover from shocks. The main challenge in terms of agility is to apply such flexibility measures that enable company to gain the ability to respond to short term changes in demand and supply quickly. Another effect of making supply chains more flexible can be the ability to evolve over time as economic progress,

political shifts, demographic trends and technological advances reshape markets. This is commonly referred to as supply chain adaptability. It can also be achieved by adjusting the supply chain design to accommodate market changes. The highest level of cooperation in supply chain can lead to its alignment. This stands for the ability of supply chain to align the interests of all participating companies. As a result, as each company maximizes its own interests, it optimizes the chain's performance as well. The main challenge in terms of alignment is to establish incentives for supply chain partners to improve performance of the entire chain, not just those of an individual company (Lee, 2004).

Faster the parts, information and decisions flow through supply chains, the faster they can respond to customer needs and to the demands of the market. Effective management and coordination of supply chains requires the sharing of a wide range of data. Information sharing is a key enabler for supply chain management and has widely been regarded as an essential tool to coordinate supply chains activities in order to overcome supply chains dynamics (Chandra et al., 2007, Chan and Chan, 2009; Jain et al., 2009; Shore, 2014). It is one of the most important topics in supply chain management, but it is not an easy task due to the numerous challenges (Hung et al., 2013). The results indicate that information sharing has positive influence on partner relationship management and supply chain performance (Wu et al., 2013). The operational characteristics of supply-chain partnerships and identification of the relational attributes that cultivate knowledge transfer in such partnerships may contain trust, commitment, interdependence, shared meaning, balanced power and thus facilitate knowledge transfer in supply-chain partnerships. That knowledge transfer should be treated as a dynamic multistage process (He et al., 2011). There is a positive relationship between the level of information sharing, quality and availability, and the level of trust. Moreover,

various studies indicate that there is a positive relationship between levels of trust and commitment in supply chain relationships (Chen et al., 2014; Hung et al., 2011; Ruel et al., 2015). Consequently, trust has a direct impact on supplier's volume flexibility and flexibility. These findings indicate that a shared vision has direct impact on supplier's mix, new product, and flexibility. Shared vision plays a mediating role among trust and mix, new product, and delivery flexibility (Chu et al., 2011). Both information sharing and flexibility have been an important research issue in supply chain management. Although they have been studied frequently, our understanding of sharing information strategically and appropriately in order to increase flexibility of supply chains remains limited.

Missing from the literature is the knowledge of how these two strategic components, partnership development and flexibility, can be integrated. Datta and Christopher (2010) discovered that centralized information structure without widespread distribution of information and coordination is not effective in managing uncertainty of supply chain networks, even with increased frequency of information flow. The lack of effective information sharing to increase supply chain flexibility can be a major impediment to the implementation of effective integrated supply chain management in today's highly competitive business environment.

Another issue with flexible supply chain is its sustainability. Since flexibility is often based on rapid changes, it pressures its activities to perform perfectly which may not be possible in a long term. The pursuit of sustainability is increasingly recognised as an effective strategy to deal with some of the contemporary challenges facing global supply chains. It leads to enhanced competitiveness and improved financial performance without losing its supply chain flexibility. The focus of business strategies has moved from local optimization of sustainability factors, to consideration of the interface of the operation with its

suppliers. Supply chain sustainability is increasingly perceived as an important source of cost reduction and an essential tool for the long-term profitability of a company (Giannakis and Papadopoulos, 2016).

It is important to consider supply chain flexibility in the context of supply chain dimensions contributing to performance of all companies involved in supply chain. Supply chain flexibility is one of the main components of its performance. In the current economic environment the struggle is shifting from performance of an individual company to supply chain performance. It refers to the extended supply chain's activities conducted in order to meet end-customer requirements, including product availability, on-time delivery, and all the necessary inventory and capacity in the supply chain to deliver that performance in a responsive manner. Therefore, supply chain performance crosses company boundaries since it includes basic materials, components, subassemblies and finished products, and distribution through various channels to the end customer. It also crosses traditional functional organization lines such as procurement, manufacturing, distribution, marketing & sales, and research & development (Hausman, 2004).

Relevant information on supply chain flexibility components, effects and prerequisites can be summarized by creating a model of assumptions (Figure 1) based on literature review. This theoretical framework of supply chain flexibility achievement and effects can serve as foundation for our empirical research in practice.

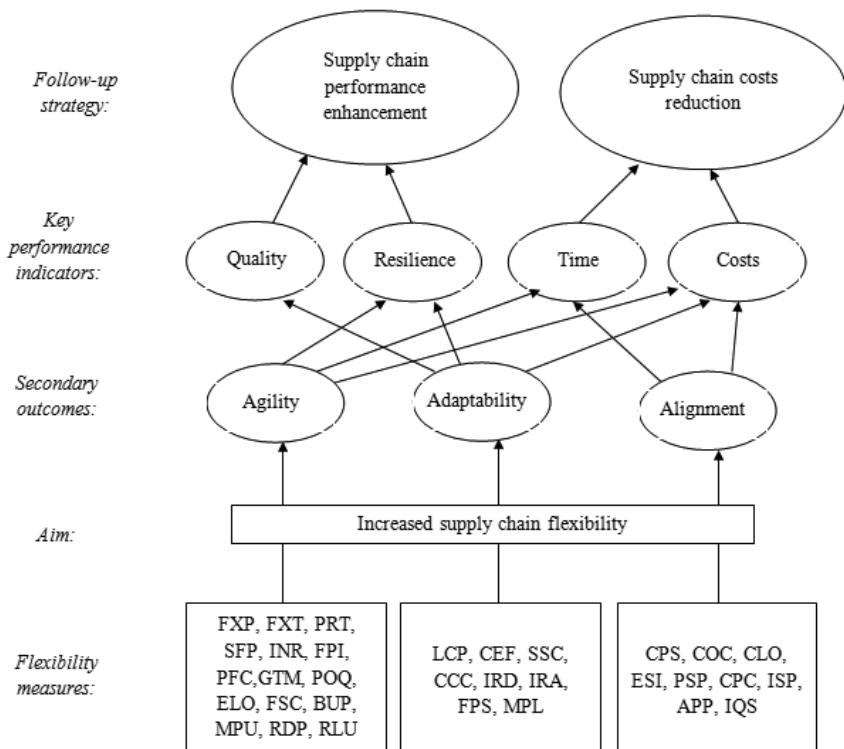


Figure 1 Theoretical framework of supply chain flexibility achievement and effects

Source: Own elaboration, 2017.

The first part of the model consists of the described flexibility measures divided into three groups according to which secondary effect of supply chain flexibility they may cause. Goal of application of these measures is increase in overall supply chain flexibility. Both literature and practice provide us with indicators designed to measure the increase in supply chain flexibility and/or its secondary effects. These indicators can measure quality of product manufactured and moved throughout supply chain, resilience of supply chain as a whole against adverse events of unexpected fluctuations, time

which measures the speed of supply chain activities and costs of such activities. When managers have sufficient information about their supply chain they can evaluate the results and make decisions. If the desired increase measured by key indicators is not high enough it is necessary to decide on application of measures in terms of what methods should be applied, what resources should be used, to what activities and to what extent. Such decisions are part of greater strategic decisions related to supply chain performance and/or supply chain cost reduction.

## **Summary**

Supply chain flexibility is not a new subject of study. It has been a focus of many research studies. However, there are still many areas in this field of study that have not been properly explored. This monograph strives to cover this existing gap. Our focus is not to examine supply chain flexibility from the point of view of one selected company, but it is to explore its main aspects on the representative sample of companies in a selected sector of economy and therefore observe the experiences of many managers in order to discover interesting findings.

Supply chain flexibility represents the ability of supply chain as a whole to respond rapidly and effectively to any expected or unexpected change in both the internal and the external environment. Various measures exist in practice, which can positively stimulate the increase of supply chain flexibility, even if that is not the primary objective of their application. Based on many research studies, 32 measures were selected and briefly described in terms of their relationship with supply chain flexibility. Naturally, it is necessary to explore how these methods are applied in practice. The most significant existing information about supply chain flexibility was integrated and incorporated into the theoretical framework of supply chain flexibility achievement and effects (Figure 1), which covers the

main aspects of the researched topic and serves as foundation for empirical research.

## **2. ANALYSIS OF FLEXIBILITY IN SUPPLY CHAIN MANAGEMENT**

This research contributes to the existing resource-based view literature by linking supply chain flexibility to the applications of various measures in different organizational contexts. It also sheds a light on the association between supply chain flexibility and different performance dimensions such as alignment and adaptability and adds value to the current debate on the association between information sharing and partnership quality.

This supply chain flexibility study makes an original empirical contribution to the supply chain management literature by using a direct approach to investigate various aspects of flexibility. The influences of individual measures designed to increase supply chain performance examined in this monograph have not been explored thus far in terms of their effect on supply chain flexibility. This study also makes an original empirical contribution by investigating this topic in the production enterprises, which has not recently received enough attention.

The premise of this study is that both partner collaboration and flexibility are multidimensional concepts; managers must understand how various partner activities correspond to different dimensions of flexibility. An extensive review of applied measures in supply chain development is a natural extension of these research questions.

Given these problems, we undertook an empirical study among manufacturing enterprises in Slovakia to determine which measures are most commonly used in practice. Research results are presented in an attempt to gain better understanding of the various methods used in order to achieve flexibility of supply chains and to provide a current image of Slovak business reality in its selected sector of economy.

Furthermore, in order to fill the gap, this research aims to understand the content of partnership development strategy in supply chains and, specifically, how it influences the flexibility of supply chains.

## **2.1. Research methodology**

Prior to the research it is important to define its aims and research hypotheses. Since this research is focused on the topic of supply chain flexibility, its main objective and partial objectives are defined in accordance with desired overview of the problem in terms of studies conducted on the topic, as well as an overview of the current state of Slovak business reality.

We have set one main and four partial objectives. The main aim of this research is to explore the extent of utilization of various measures to increase supply chain flexibility in Slovak enterprises operating in manufacturing industry and to create a framework for modelling metrics of supply chain flexibility. Manufacturing industry was selected as a target sample of this research mainly because of its relevance to Slovak economy. The others reasons are related to the nature of business activities performed in this sector of economy, to the importance of optimization of such activities and to the variability of supply chains with various nodes - structures that provide an internally heterogeneous subject for supply chain research.

The partial objectives of the research are defined on the basis of the main scientific aim:

- to summarize significant knowledge on the topic of supply chain flexibility based on current literature review;
- to analyze methods used to increase supply chain flexibility;
- to explore relationships between supply chain flexibility and various characteristics of selected company;

- to create the framework for modelling metrics of supply chain flexibility.

We combine the meeting the aims of this research with the verification of one main and three partial hypotheses.

Hypothesis H<sub>0</sub>: We assume that the most commonly used method to increase supply chain flexibility in Slovak manufacturing industry is flexible promotion.

This hypothesis directly relates to the main scientific aim of this research study. The assumption is that the majority of Slovak manufacturing companies utilize such measure to increase flexibility which is easily accessible to them and therefore, also the simplest to apply. Furthermore, the results achieved by applying this method can be visible directly and relatively quickly, which further strengthens the advantages of its application. Flexible promotion has also been studied extensively and there are many practical examples of its successful applications. Even though we decided to focus this hypothesis on one selected method, other methods will not be excluded from the research.

Hypothesis H<sub>1</sub>: We assume that the size of company has direct dependence with level of supply chain flexibility.

Hypothesis H<sub>2</sub>: We assume that the number of company's suppliers has direct dependence with level of supply chain flexibility.

Hypothesis H<sub>3</sub>: We assume that the number of company's customers has direct dependence with level of supply chain flexibility.

Hypotheses H<sub>1</sub>, H<sub>2</sub> and H<sub>3</sub> focus on the assumptions related to the second partial aim. These three company characteristics were chosen for exploration in terms of their relationships with levels of supply chain flexibility. However, other company and supply chain characteristics are not omitted in research.

The base file consists of Slovak enterprises classified according to the Classification of Economic Activities (SK NACE) as manufacturing enterprises. On the basis of the pre-selected criteria, we created a sample file, which is a sufficiently representative sample of enterprises with respect to the base file. We selected the enterprises randomly from all the companies in the base file. Therefore, in order to fulfil the set aims, we use data provided by Slovak companies via the survey, which was conducted in the period between April 2017 and March 2018. The research sample file was created as a representative sample of the base file (Table 1). We took the criterion of the company size into account and also structured our sample file accordingly. The decisive criterion was set according to the European Standard No. 2003/361/EC.

Table 1 Base file structure based on the company size in 2017

<b>Number of employees</b>	<b>Number of companies</b>	<b>Percentage</b>
0 - 49	11976	89.79%
50 - 249	1054	7.90%
over 250	308	2.31%
<b>Total</b>	<b>13338</b>	<b>100.00%</b>

Source: Own elaboration based on data from the Statistic Office of the Slovak republic, 2019.

During the research period, 326 questionnaires were returned, 12 were discarded due to inconsistent data. The final sample file used in this study consisted of 322 enterprises. Our sample file consists of 279 micro and small sized enterprises (86.64 %), 31 medium sized enterprises (9.36 %) and 12 large sized enterprises (3.73 %).

To verify the representativeness of the sample we used Chi-square test. We set the null hypothesis which assumes that the sample is representative. The alternative hypothesis is an

assumption of non-representativeness of the sample. From the mathematic point of view, the hypotheses are formulated as:

$$H_0 = F(x) = G(x); H_1 = F(x) \neq G(x)$$

Statistical testing in SPSS software is based on the following formula (1):

$$X^2 = \sum_{j=1}^r \frac{(n_j - m_j)^2}{m_j} \approx X^2_{(r-1)} \quad (1)$$

where:

$X^2$  - is Pearson statistics,

r - is line,

n - is overall frequency in the base file,

m - is measured frequency.

Consequently we find the critical value of  $X^2$  distribution for  $(r-1)$  degrees of freedom and selected level of significance  $\alpha$  from tables of critical values of chi square. However, Chi square test requires the fulfilment of two conditions:

- No interval should have zero frequency;
- A maximum of 20 % confidence intervals should have frequency less than 5 (Maloney, Byard, 2013).

We have performed the test at a significance level of 95 %. If the critical value is lower than the value of tested statistics, null hypothesis is rejected and an alternative hypothesis  $H_1$  is accepted. Our calculated chi square value was 0.883; it means that the null hypothesis can be accepted. Our sample is representative in terms of enterprise's size.

Another important criteria designed to differentiate the respondents was their position in supply chain. Table 2 shows how companies in our sample file are positioned in their supply chains based on the type of business activities they run.

Table 2 Structure of sample file based on the company's position in supply chain

<b>Position of company in SC</b>	<b>Number of companies</b>	<b>Percentage</b>
supplier of raw material	17	5.28%
supplier of components	62	19.25%
main supplier	154	47.83%
producer	89	27.64%
<b>Total</b>	<b>322</b>	<b>100.00%</b>

Source: Own elaboration, 2018.

Other statistical methods were used to evaluate data and discover relevant information. Individual correlation coefficients were calculated according to this formula 2 (Maloney, Byard, 2013):

$$r = r_{xy} = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2} \sqrt{\sum_{i=1}^n (y_i - \bar{y})^2}} \quad (2)$$

where:

$x_i, y_i$  – are defined as a value of i-element belonging to dataset  $\{x_1, \dots, x_n\}$ ,

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i \quad \text{- the sample mean and analogously for } \bar{y}.$$

Correlation is an analysis that measures the strength of association between two variables and the direction of the relationship. In terms of the strength of relationship, the value of the correlation coefficient varies between +1 and -1. A value of  $\pm 1$  indicates a perfect degree of association between the two variables. As the correlation coefficient value goes towards 0, the relationship between the two variables will be weaker. The direction of the relationship is indicated by the sign of the

coefficient; a + sign indicates a positive relationship and a – sign indicates a negative relationship (Maloney, Byard, 2013).

In order to further explore correlation relationships between flexibility parameters in supply chain management, for hypotheses verification and to provide more detailed image of the situation in Slovak manufacturing industry we used statistical tests such as binomial test and Pearson correlation test.

## **2.2. Analysis of selected methods and their applications to increase flexibility of supply chain**

In this part of the monograph, we present the results of a survey conducted in order to evaluate the current state of use of measures to increase supply chain flexibility.

In the first part of the questionnaire we obtained information about the types of supply chains that exist in Slovak manufacturing industry. Table 3 provides the information about structure of these supply chains. The most common structure that can be found in examined environment is divergent since nearly 40 % of the companies operate within such type of supply chain. Other significant structure types are convergent (24.84 %) and serial (15.84 %). The least commonly found structure of supply chain is network (7.76 %).

Relationship between the position in a supply chain and the level of supply chain flexibility was also explored. Data provided in Table 4 indicates that with the exception of suppliers of raw materials and main suppliers, all companies in the sample file have significantly higher levels of supply chain flexibility. More than a half of companies that operate in their supply chain as main producers perceive their level of supply chain flexibility as medium (56.49 %). In this group of companies we also marked the highest rate of low supply chain flexibility (14.29 %). Over one third of suppliers of raw material have high flexibility and 58.82 % of these companies perceive their supply

chain flexibility level as medium. On the other hand, only 5.88 % of them have low level of supply chain flexibility.

Table 3 Structure of supply chains in Slovak manufacturing industry

<b>Structure of SC</b>	<b>Number of companies</b>	<b>Percentage</b>
dyadic	42	13.04%
serial	51	15.84%
divergent	124	38.51%
convergent	80	24.84%
network	25	7.76%
<b>Total</b>	<b>322</b>	<b>100,00%</b>

Source: Own elaboration, 2018.

Table 4 Levels of supply chain flexibility structured by company's position in supply chain

<b>Position in supply chain</b>	<b>Level of SC flexibility</b>		
	<b>high</b>	<b>medium</b>	<b>low</b>
supplier of raw material	35.29%	58.82%	5.88%
supplier of components	50.00%	38.71%	11.29%
main supplier	29.22%	56.49%	14.29%
producer	55.06%	32.58%	12.36%

Source: Own elaboration, 2018.

Furthermore, we also explored the relationship between the structure of supply chain and the level of supply chain flexibility (Table 5). Several interesting findings can be observed if companies in sample file are structured by these two factors. For instance, 96 % of companies operating in network supply chain have high levels of supply chain flexibility and 4 % of them perceive their flexibility levels as medium. There are no

companies with low levels of supply chain flexibility. The majority of companies with divergent and convergent supply chains perceive their flexibility levels as medium. On the other hand, it is interesting that only 7.14 % of companies with dyadic supply chains perceive their supply chain flexibility as low.

Table 5 Levels of supply chain flexibility structured by company's supply chain structure

Structure of SC	Level of SC flexibility		
	high	medium	low
dyadic	50,00%	42,86%	7,14%
serial	45,10%	41,18%	13,73%
divergent	28.23%	58.06%	13.71%
convergent	35.00%	47.50%	17.50%
network	96.00%	4.00%	0.00%

Source: Own elaboration, 2018.

In hypothesis H<sub>1</sub> we assumed that the size of a company has direct dependence with the level of supply chain flexibility. Table 6 provides information on how these two examined factors relate in terms of percentage of companies in our sample file. According to the data it is obvious that all companies with more than 250 employees have high levels of supply chain flexibility. This percentage decreases with the company size and less than a third of small-sized enterprises have high levels of flexibility in their corresponding supply chains. Furthermore, we used Pearson correlation test to test the hypothesis. We discovered that even though there is a dependence between these two factors (0.369), it is not statistically significant enough to confirm the hypothesis H<sub>1</sub> on our sample file.

Table 6 Levels of supply chain flexibility structured by company size

Number of employees	Level of SC flexibility		
	high	medium	low
less than 50	32,62%	53,05%	14,34%
50 - 249	90,32%	6,45%	3,23%
250 and more	100,00%	0,00%	0,00%

Source: Own elaboration, 2018.

We asked enterprises to select measures they use to achieve flexibility. We presented them with 32 options. The list of these methods was created based on literature review. In order to properly evaluate these selections, we correlated these results with information provided about the number of their supplier and number of their customers. Our goal was to provide a detailed analysis of integration of flexibility measures into supply chain management. Ten most commonly used measures are displayed in Table 7 and Table 9.

The most commonly used measure is flexible promotion. Over 58.28 % of all enterprises (183 enterprises) apply this tool in their supply chain management. The second most commonly used measure is selection of suppliers based on predefined criteria (42.24 % of all enterprises). Table 7 also provides information about the number of suppliers of these enterprises. We can observe downward trend in these numbers. Therefore, we can state that majority of enterprises in our sample file have less than 20 suppliers.

Moreover, we used binomial test to verify hypothesis  $H_0$  which relates to position of flexible promotion as the most commonly used method to increase supply chain flexibility. This hypothesis was confirmed.

Table 7 The most commonly used methods structured by the number of suppliers

No. of suppliers	1 - 20	21 - 50	51 - 75	76 - 100	101 - 200	201 - 500	over 501	Total
Measures								
FXP	81	36	14	16	16	10	10	<b>183</b>
SSC	43	14	8	32	12	15	12	<b>136</b>
SFP	18	26	9	15	4	3	3	<b>78</b>
RDP	51	17	15	9	18	6	7	<b>123</b>
IQS	42	27	13	10	9	14	6	<b>121</b>
INR	54	16	16	11	9	4	10	<b>120</b>
COC	31	32	26	4	7	6	7	<b>113</b>
CLO	32	18	19	9	6	1	9	<b>94</b>
APP	24	17	6	0	7	4	5	<b>63</b>
IRA	23	17	9	2	5	2	2	<b>60</b>

Source: Own elaboration, 2018.

Furthermore, the relationship between company's number of suppliers and the level of flexibility was examined (Table 8).

Table 8 Levels of supply chain flexibility structured by company's number of suppliers

No. of suppliers	Level of SC flexibility		
	high	medium	low
1 - 20	9.84%	73.77%	16.39%
21 - 50	51.92%	37.50%	10.58%
51 - 75	55.81%	27.91%	16.28%
76 - 100	74.19%	19.35%	6.45%
101 - 200	88.89%	11.11%	0.00%
201 - 500	75.00%	16.67%	8.33%
over 501	100.00%	0.00%	0.00%

Source: Own elaboration, 2018.

At the first glance the data provided in Table 8 seems to support the assumption that if company has more suppliers, it also has higher levels of flexibility. These results indicate that higher levels of flexibility can be assumed in all groups of companies with the exception of the group with 20 and less suppliers. However, the margin between the high level of flexibility and medium and low levels increases along with the number of company's suppliers. Companies with over 501 suppliers all have high levels of supply chain flexibility. Three quarters of Slovak manufacturing companies with number of suppliers between 201 – 500 have high levels of flexibility, and only 8.33 % of these companies have low levels of supply chain flexibility. Hypothesis H<sub>2</sub> examines the assumption that the number of company's suppliers has direct dependence with level of supply chain flexibility. Pearson correlation test was used to verify this supposition and confirmed it. Therefore, we can conclude that there is a significant relationship between these two factors.

According to the data provided in Table 9 the majority of enterprises in our sample file has between 76 to 100 customers. An interesting finding is that over 19.13 % enterprises (35 enterprises) that use flexible promotion have between 6 to 10 customers, which is the highest number of enterprises using the same measure within the same interval of the number of customers. Another interesting finding is that the second most commonly used measure by enterprises with over 501 customers is the application of concepts of continuous improvement and learning organization (25.53 %). The most commonly used measure by enterprises with 5 and less customers is the redeployment of resources (13 %).

Table 9 The most commonly used methods structured by the number of customers

No. of suppliers	1 - 5	6 - 10	11 - 20	21 - 50	51 - 75	76 - 100	101 - 200	201 - 500	over 501
Measures									
Flexible promotion	35	35	35	35	35	35	35	35	35
Application of concepts of continuous improvement and learning organization	35	35	35	35	35	35	35	35	35
Redeployment of resources	35	35	35	35	35	35	35	35	35

FXP	10	35	13	13	20	30	11	25	26
SSC	12	18	9	11	10	22	7	32	15
SFP	7	14	5	6	5	27	6	4	4
RDP	16	13	9	15	21	17	9	6	17
IQS	10	15	10	9	5	29	7	18	18
INR	9	12	11	10	15	8	17	18	20
COC	7	14	5	8	13	24	10	14	18
CLO	7	11	4	12	9	6	11	10	24
APP	10	4	6	4	4	25	4	3	3
IRA	3	6	2	6	7	12	5	9	10

Source: Own elaboration, 2018.

There was an assumption that the number of customers directly correlates with the level of flexibility in company's supply chain (Hypothesis H<sub>3</sub>). Table 10 provides data necessary to examine this assumption.

Table 10 Levels of supply chain flexibility structured by company's number of customers

No. of customers	Level of SC flexibility		
	high	medium	low
1 – 5	0.00%	10.53%	89.47%
6 – 10	0.00%	73.81%	26.19%
11 – 20	8.33%	75.00%	16.67%
21 – 50	10.53%	78.95%	10.53%
51 – 75	26.92%	53.85%	19.23%
76 – 100	40.54%	56.76%	2.70%
101 – 200	62.07%	34.48%	3.45%
201 – 500	34.62%	65.38%	0.00%
over 501	93.24%	6.76%	0.00%

Source: Own elaboration, 2018.

In the case of relationship between company's number of customers and its supply chain flexibility level, the assumption is similar to the number of suppliers. Therefore, we assume that the more customers company has, the more flexible its supply chain is. The data in Table 10 indicates that this assumption might be correct. Almost all companies with 501 and more customers have a high level of supply chain flexibility (93.24%). Moreover, there are no companies with more than 200 customers with low level of flexibility. On the other hand, there are no manufacturing companies with 10 or less customers with high levels of supply chain flexibility. The majority of companies with less than 6 customers have low level of supply chain flexibility (89.47 %). In order to further explore possible relationship between these two factors Hypothesis H<sub>3</sub> was verified. Pearson correlation test was performed with the conclusion that this hypothesis cannot be confirmed. Therefore, we can state that number of customers and level of flexibility in company's supply chain are independent.

Table 11 provides information about the extent of the methods' use in practice. According to data provided by enterprises in the sample file, we divide analyzed methods into three categories. The first category consists of the most commonly used methods. These are the methods which are used by more than 20 % of enterprises in our file. The next category consists of the methods used by at least one of the enterprises. We named this category "used methods". Lastly, we also provided information about the methods which are not used in Slovak business environment.

Table 11 Levels of methods utilization

<b>Most commonly used methods</b>	<b>Used methods</b>	<b>Unused methods</b>
FXP	FPI	CEF
SSC	APP	FSC
SFP	PFC	MPU
RDP	PRT	GTM
IQS	CPS	ESI
INR	ROQ	
COC	PSP	
CLO	CPC	
	FXT	
	IRD	
	IRA	
	RLU	
	FPS	
	CCC	
	ELO	
	MPL	
	BUP	
	LCP	

Source: Own elaboration, 2018.

Furthermore, we explored the relationships between the most commonly applied measures and various factors. Correlation coefficient was used to evaluate these relations and to discover significant dependences between factors (Table 12).

Table 12 Dependences between measures applications and various factors

Applied measures	No. of suppliers	No. of customers	Enterprise size	Business sector
<b>FXP</b>	0.091	0.137	0.128	0.107
<b>SSC</b>	0.741	0.186	0.322	- 0.151
<b>RDP</b>	- 0.205	- 0.091	- 0.440	0.018
<b>IQS</b>	0.228	0.153	0.177	- 0.196
<b>INR</b>	0.703	0.168	0.055	0.164
<b>COC</b>	0.348	0.696	0.206	- 0.102
<b>CLO</b>	0.001	0.221	0.098	- 0.024

Source: Own elaboration, 2018.

These results indicate there is no significant dependence between any of the examined measures and business sector in which enterprise operates. However, the size of enterprise proves to be different. There is a medium-strong direct dependence between size and application of measure concerning the selection of suppliers based on predefined criteria. This result indicates that larger Slovak enterprises are more likely to use this approach when selecting a new supply chain partner. Furthermore, according to the data provided there is a significant indirect dependence between the enterprise's size and the redeployment of human and material resources between the process and/or facilities. This means that smaller enterprises are more likely to adopt this approach. An interesting finding is the fact that the implementation of quality system standards is not dependable neither with the size of enterprise nor with its business sector.

We even noticed a few strong dependences. One of them was between the number of suppliers and their selection based on predefined criteria (0.741). This result is not surprising since

there clearly is a link between these observed factors. Similar dependence is between customer orientation as the main strategic concept of enterprise and the number of customers.

What can also be considered interesting is the finding that there is a strong positive correlation between using insurance against the risk of adverse events and number of enterprise's suppliers. However, application of this measure is not significantly correlated with the number of enterprise's customers.

Based on these findings we can conclude that neither the size of enterprise nor its business orientation have any correlation affects on applied measures to increase supply chain flexibility.

The most commonly used measures were also examined in relation to the types of supply chain flexibility they affect. The first set of indicators consists of five types of flexibility as drafted by literature review. We examine the following flexibility types: contract flexibility (CFL), volume flexibility (VFL), product mix flexibility (PFL), delivery flexibility (DFL) and manufacturing flexibility (MFL). These possible relationships were described by correlation coefficients (Table 13).

Table 13 Dependences between flexibility types and applied measures

Most commonly applied measures	Flexibility types				
	CFL	VFL	PFL	DFL	MFL
<b>FXP</b>	0.371	0.402	0.218	0.137	0.236
<b>SSC</b>	0.674	0.261	0.311	0.799	0.385
<b>RDP</b>	0.183	0.507	0.476	0.137	0.802
<b>IQS</b>	0.497	0.285	0.159	0.573	0.649
<b>INR</b>	0.542	0.426	0.329	0.509	0.452
<b>COC</b>	0.627	0.856	0.273	0.510	0.539
<b>CLO</b>	0.285	0.153	0.174	0.359	0.733

Source: Own elaboration, 2018.

According to the data provided in Table 13 it is possible to describe several significant dependences. Although it is important to focus on relationships which provide evidence of the influence that one factor has on the other and vice versa, similarly the lack of relationship can also prove interesting. Such is the case of flexible promotion. Despite the fact that it was discovered to be the most commonly used method to increase supply chain flexibility by Slovak manufacturing enterprises, its effects are questionable at best. When its application is correlated with achieved flexibility types, it becomes obvious that there is no strong dependence between these two factors. The best results are the medium strong relationships the flexible promotion has with contract and volume flexibility. On the other hand, we identified two significant relationships that selection of suppliers has. They are with contract flexibility (0.674) and even stronger with delivery flexibility (0.799). Redeployment of resources influences just the manufacturing flexibility, as was expected. Quality management and continuous improvement in terms of learning organization both also have significant relationships with manufacturing flexibility. Insurance against adverse events is also quite commonly used by companies in practice to achieve higher levels of supply chain flexibility. However, we discovered that this method has no strong dependence with any flexibility type and therefore, it could be said that is useless. Moreover, insurance is usually connected with additional costs which are almost never returned in form of any revenues. Even current risk management recognizes that insurance should be considered only if all other methods to deal with risks fail or are unavailable to the company. Customer orientation as a main strategic concept of enterprise is another commonly used method to increase supply chain flexibility. This method has significant relationships with two flexibility types – contract flexibility (0.627) and volume flexibility (0.856). The

latter is also the strongest discovered relationship between applied measure and flexibility type.

### **2.3. Analysis of secondary outcomes of increased supply chain flexibility**

Secondary effects in terms of agility, adaptability and alignment were also examined. Firstly, we took a closer look into levels of these three supply chain characteristics in relation with levels of supply chain flexibility. Table 14 provides data about percentage of enterprises with certain levels of supply chain agility structured by levels of supply chain flexibility.

Table 14 Levels of supply chain agility

Level of SC agility	Level of SC flexibility		
	high	medium	low
<b>high</b>	8.70%	4.66%	0.31%
<b>medium</b>	26.09%	24.53%	6.52%
<b>low</b>	5.90%	17.39%	5.90%

Source: Own elaboration, 2018.

The data indicates that 13.66 % of all manufacturing enterprises consider their level of supply chain agility as high. Furthermore, only 8.70 % of all enterprises in the sample file consider both their level of supply chain flexibility and the level of supply chain agility as high. On the other hand, only even less enterprises (5.90 %) perceive both their level of supply chain flexibility and supply chain agility as low. Almost one third of all enterprises (29.19 %) consider their supply chain agility to be low.

Table 15 Levels of supply chain adaptability

Level of SC adaptability	Level of SC flexibility		
	high	medium	low
<b>high</b>	4.35%	4.97%	0.31%
<b>medium</b>	17.70%	25.47%	4.66%
<b>low</b>	18.63%	16.15%	7.76%

Source: Own elaboration, 2018.

Table 15 provides information about the levels of supply chain adaptability in relation with the levels of supply chain flexibility. According to the data, overall levels of supply chain adaptability are considerably lower than levels of supply chain agility. This finding is especially obvious in the group of enterprises with high level of supply chain flexibility. In total, less than 10 % of all manufacturing enterprises consider their level of supply chain adaptability high. On the other hand, 42.55 % of enterprises have low level of supply chain adaptability.

Furthermore, levels of supply chain alignment were examined. According to the data provided in Table 16, it is obvious that this secondary effect of supply chain flexibility is achieved by very few enterprises. Only 18.01 % of Slovak manufacturing enterprises have medium or high levels of supply chain alignment. Moreover, less than 1 % of enterprises with high levels of supply chain flexibility are able to also achieve high levels of supply chain alignment. Even more concerning is the finding that 35.71 % of Slovak manufacturing enterprises have high supply chain flexibility, but only low levels of supply chain alignment.

Table 16 Levels of supply chain alignment

Level of SC alignment	Level of SC flexibility		
	high	medium	low
<b>high</b>	0.62%	2.17%	0.00%
<b>medium</b>	4.35%	6.52%	4.35%
<b>low</b>	35.71%	37.89%	8.39%

Source: Own elaboration, 2018.

Since it was discovered that different flexibility types can have different effects on overall supply chain performance, a more detailed examination of the relationship between flexibility types and levels of agility, adaptability and alignment was conducted. Table 17 provides data about such relationships expressed by calculated correlation coefficients. It is important to explore which flexibility type or types have significant impact on achievement of secondary effects such as supply chain agility, adaptability and alignment. According to the data, the majority of significant relationships with secondary outcomes can be found in correlations with delivery flexibility. Volume and manufacturing flexibility also show some significant correlations with the levels of supply chain agility, adaptability and alignment. It was discovered that the weakest relationship is between product flexibility and the levels of both supply chain adaptability and alignment.

Table 17 Dependences between flexibility types and levels of supply chain agility, adaptability and alignment

Flexibility types	Level of SC		
	agility	adaptability	alignment
<b>CFL</b>	0.473	0.469	0.365
<b>VFL</b>	0.801	0.681	0.701
<b>PFL</b>	0.497	0.318	0.295
<b>DFL</b>	0.839	0.791	0.764
<b>MFL</b>	0.740	0.637	0.611

Source: Own elaboration, 2018.

Levels of Slovak manufacturing supply chain agility, adaptability and alignment were also explored in terms of their relationships with various other supply chain characteristics (Table 18). According to the data, there are significant dependences among various pairs of examined factors. Level of supply chain agility has strong relationship with both enterprise's number of customers (0.695) and number of suppliers (0.742), however, it has no significant relationship with supply chain structure or enterprise's position in its corresponding supply chain. On the other hand, level of supply chain adaptability has no significant relationship with either number of customers or number of suppliers. Enterprise's size and position in supply chain strongly affect its adaptability. Level of alignment is the only one of the three that has a significant relationship with supply chain structure (0.814). Furthermore, it is the strongest relationship discovered. As anticipated, alignment has a significant negative relationship with both enterprise's number of customers (-0.581) and number of suppliers (-0.620), since more members of supply chain make achievement of alignment more challenging. There is also a relationship between level of alignment and enterprise's position in supply chain, which indicates that enterprises located closer to the customer are more likely to gain the ability to align their aims with other members of their supply chain.

Table 18 Dependences between levels of supply chain agility, adaptability, alignment and various factors

<b>Level of SC</b>	<b>No. of suppliers</b>	<b>No. of customers</b>	<b>Size of enterprise</b>	<b>Supply chain structure</b>	<b>Position in supply chain</b>
<b>agility</b>	0.742	0.695	-0.153	0.042	0.193
<b>adaptability</b>	-0.271	0.183	0.706	-0.174	0.683
<b>alignment</b>	-0.620	-0.581	0.329	0.814	0.696

Source: Own elaboration, 2018.

## **2.4. Analysis of selected aspects of flexibility and partnerships in supply chains**

The topic of flexibility was further studied in relation to various aspects identified as essential for successful partnerships as a premise of information sharing (Veselovská, Kožárová and Závadský, 2018; Veselovská, Závadský, 2017).

Table 19 provides the values of correlation coefficients between the types of flexibility and the key partnership prerequisites. We examined whether there is dependence between flexibility and some of the key aspects of partnership such as trust (TRS), honesty (HNS), reliability (RLB) and commitment (CMT).

The data provided indicates that contact flexibility is directly dependant on both trust and reliability. However, manufacturing, volume and product mix flexibilities are not significantly influenced by any partnership aspects. Delivery flexibility shows a strong direct dependence on reliability of a partner. The relationship between this flexibility type and trust is also significant. The potential for the future development is clearly based on these results, however nowadays these results indicate that the key partnership prerequisites have no impact on flexibility in Slovak manufacturing supply chains.

Table 19 Dependences among significant partnership issues and flexibility types

correlation coefficient	CFL	VFL	PFL	DFL	MFL
<b>TRS</b>	0.311	0.054	-0.032	0.402	-0.168
<b>HNS</b>	0.226	-0.085	-0.125	0.173	0.067
<b>RLB</b>	0.690	0.105	0.095	0.712	-0.075
<b>CMT</b>	0.133	0.080	0.007	0.125	0.034

Source: Own elaboration, 2018.

## **Summary**

The main aim of this research was to analyse the utilization of various measures and approaches designed to increase flexibility in supply chains. Our main focus was on assessing the extent of such applications in enterprises of all sizes located in the Slovak Republic. The data was gathered by questionnaire. We provided 32 possible measures used in practice in order to increase flexibility of supply chains. We discovered that the most commonly used measures are flexible promotion (56.83 %), selection of suppliers based on predefined criteria (42.24 %) and redeployment of resources (38.2 %). Our findings also describe how these measures are utilized in Slovak practice. This research also uncovered the measures which are currently not being used. The potential for improvement lies mainly in the area of measures evaluated as “unused measures”. In total, 5 measures belong to this category according to the level of their application in enterprises.

Furthermore, we used one main and three partial hypotheses to explore our assumptions concerning the supply chain flexibility. The main hypothesis  $H_0$  assumes that the most commonly used method to increase supply chain flexibility in Slovak manufacturing industry is flexible promotion. This hypothesis was confirmed. Hypothesis  $H_1$  focused on the assumption that the size of company has direct dependence with level of supply chain flexibility. This assumption was also confirmed. On the other hand, hypothesis  $H_2$  was confirmed. We discovered that the number of company's suppliers has direct dependence with level of supply chain flexibility. The last hypothesis  $H_3$  was also not confirmed, therefore we can conclude the number of company's customers has no relation to the level of supply chain flexibility.

The findings contribute to the understanding of the supply chain flexibility considering the application of selected measures and, briefly, also their outcomes. This study also contributes to the concept of supply chain partnership by

identifying information sharing as one of the main prerequisites of successful and effective partnership.

### **3. POSSIBILITIES FOR FLEXIBILITY IMPROVEMENT IN SUPPLY CHAIN MANAGEMENT**

Based on the achieved results, it is clear that delivery and manufacturing flexibility are the most targeted flexibility types by application of measures. However, such view is strictly limited for many significant reasons which cannot be omitted. Firstly, supply chain flexibility is at its most beneficial if all its elements are targeted. In this case it means that all flexibility types should be considered so that they can work in synergy. Secondly, supply chain flexibility significantly limits the possibilities for selection of methods. The question remains whether the targeting of solely these flexibility types is a sentient choice, or it is merely the result of managers having insufficient information on how methods truly react in terms of their companies or supply chains and what affects they have. And last but not least the achievements of secondary effects are also limited since even delivery flexibility strongly affects agility, adaptability and alignment, manufacturing flexibility has strong relationship only with agility. Lummus et al. (2005) also discovered that many managers abroad believe that improving just manufacturing and delivery flexibility is not sufficient to increase the performance of the entire supply chain and to achieve its desired outcomes. Therefore, Slovak enterprises still have potential for improvement in this area.

Nature of Slovak manufacturing supply chains has evolved and nowadays the divergent structure is dominant which is a significant shift towards having more options for selling final goods or services. However, many companies still operate in serial (15.84 %) or even dyadic supply chains (13.04 %), which are highly open to risks of disruptions, much more than any other supply chain structures. Consequently, these companies abandon possibilities of flexibility for some other advantages. It

is not an entirely incorrect strategy, if the relationships between partners are close and reliable. On the other hand, such close relationships can also be built within another, more flexible supply chain structure if all companies involved are perceived as reliable, since this factor has the strongest impact on supply chain flexibility according to our research.

The unutilized potential for improvement, or even excellence, lies in the network structure of supply chains, which is used by very few companies (7.76 %). Current literature indicates that this supply chain structure can be most advantageous to all its members (Chan et al., 2019; Li et al., 2019). Even our findings show that 96 % of companies in network supply chains have high levels of supply chain flexibility. Moreover, the structure of supply chain has an extremely strong impact on the level of supply chain alignment.

It is a well-known fact that when supply chain flexibility is the goal, methods to achieve it have to be considered. This was also the main focus of this research. Examples and definitions from many studies were provided to describe various measures to increase supply chain flexibility. Based on this information we set out to explore Slovak business reality on the example of its manufacturing industry. The findings are as interesting as they are contradictory. For instance, we discovered that flexible promotion is the most commonly used method to increase supply chain flexibility (56.83 %). However, when we took a closer look at the effects of application of this method, we discovered that it has absolutely no strong correlation with any flexibility type. It means that even though Slovak manufacturing companies use the flexible promotion, its application does not directly contribute to increase of supply chain flexibility. Therefore, it would be more advantageous for managers of such companies to consider application of other methods.

The second most commonly applied method by Slovak manufacturing companies is the selection of suppliers based on predefined criteria. This method has strong direct relationships

with contract and delivery flexibility types. The third and the fourth most commonly applied methods, which are creating possibilities for rapid redeployment of human and material resources between process and/or facilities and implementation of quality systems such as ISO, TQM, etc., both have only one strong influence and that is on manufacturing flexibility. Even insurance against the risk of adverse events as the fifth most commonly applies measure has only one significant influence (0.542 with contract flexibility). Therefore, we can conclude that the five most commonly used methods to increase supply chain flexibility are insufficient to achieve this goal. It is different for the sixth measure (customer orientation as a main strategic concept of enterprise) which has significant relationships with all flexibility types with the exception of product mix flexibility. Measures such as this provide a much wider range of influence which may result in increase of majority of flexibility types.

These findings concerning the influences various methods have on flexibility types do not necessarily mean that it is the same for every manufacturing company. Since the sample file is quite vast, individual differences can exist. However, overall this information can provide some guidance for managers in terms of future selection of methods used with the goal of supply chain flexibility increase.

Moreover, our research discovered that there are methods to increase supply chain flexibility which are not yet used by Slovak businesses. These methods include expectations forecasts, mathematical programming utilization, application of game theory methods, economic supply incentives and flexible supply contracts. This means that even though managers of some companies use these methods they do not apply them with the intent to increase supply chain flexibility but with other goal in mind. Therefore, they are not utilized to their full potential. Possible outcomes resulting from application of these five methods are provided in Figure 1; however, this information is

based solely on research studies from other countries since there is no information on Slovak businesses due to the managers' lack of experience with these methods.

Research findings provide an interesting source of information for both researchers and managers in practice. In order to create a clear image of how these findings can help improve current business reality, it is beneficial to further explore them by creating relationships models and frameworks.

### **3.1. Framework for modelling metrics of supply chain flexibility**

It has been established that application of selected measures leads to increased supply chain flexibility. Based on the criteria of which measures were applied and how successful they were, supply chain can gain agility, adaptability, alignment or combination of some of those three as a secondary effect. Such effects can be utilized in elaboration of a new supply chain management strategy built on its newly gained abilities. This is in accordance with requirement of continuous improvement and optimization. The proposed framework for modelling metrics of supply chain flexibility is illustrated in Figure 2.

This model demonstrates all the major relationships between measures, flexibility types and effects. This model describes the continuous process of supply chain flexibility. We discovered that application of various individual measures may lead to the increase of corresponding flexibility type (Table 13). Furthermore, such increase in flexibility may lead to some secondary outcomes such as agility, adaptability or alignment (Table 17). There are however also dependences between the applied measures and increase in supply chain agility, adaptability and/or alignment proved by various research studies (Figure 1).

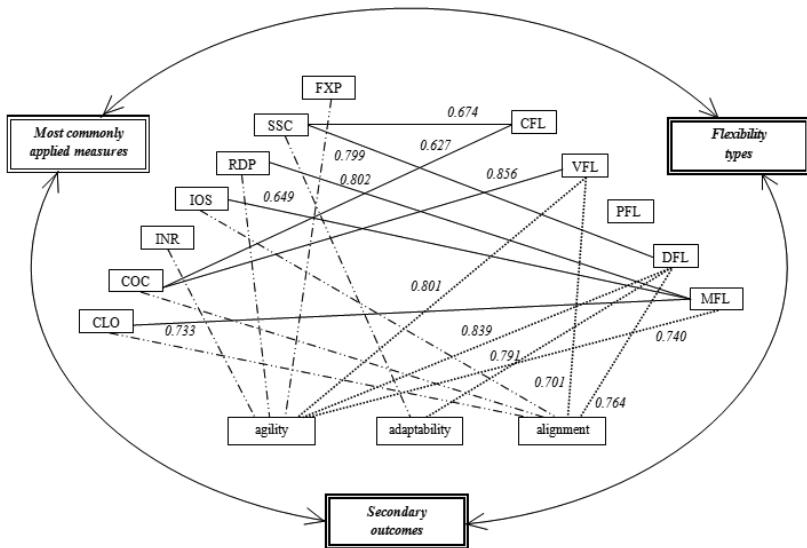


Figure 2 Framework for modelling metrics of supply chain flexibility

Source: Own elaboration, 2019.

The three main components of this model are supply chain flexibility types, most commonly applied methods to increase supply chain flexibility and secondary effects. Based on literature review we can pair up each of the measures with secondary effect it can provide for supply chain. However, since this part of the model is not based on our own empirical study we are unable to determinate the exact nature of such relationships by providing their corresponding correlation coefficients. The basis for creating model relationships comes from the following literarure sources: Agarwal et al., 2006; Angkiriwang et al., 2014; Baihaqi And Sohal, 2013; Beach et al., 2000; Chen et al., 2014; Chopra and Mohan, 2004; Gualandris et al., 2015; Heckmann et al., 2015; Lee, 2004; Patnayakuni et al., 2014; Lummus et al., 2005; Sánchez and Pérez, 2005; Sodhi and Lee, 2007. Our contribution lies in

linking this knowledge to the current situation in the Slovak manufacturing industry and evaluating it by incorporating the findings into the model in relation to its other components since these studies were not primarily oriented on examining secondary affects.

What we are able to do is to select which measures are most commonly used in practice of Slovak manufacturing companies (Table 11) and consequently not to focus on measures that may have some effects, but are not applied often enough to achieve this effect. On the other hand, we can determinate with precision the relationships between the most commonly applied methods and types of flexibility they affect and therefore, describe how these measures contribute to the increase of supply chain flexibility by increasing one or more of its components.

For instance, flexible promotion is the most commonly applied method to increase supply chain flexibility in the Slovak manufacturing companies. Even though literature clearly explains its relationship with supply chain agility, it was discovered that in terms of Slovak business reality this measure has no strong relationship with any of the flexibility types. Therefore, based on experience of managers in practice we can state that utilization of this measure is not likely to have a significant impact on supply chain flexibility.

### **3.2. Possibilities for improvement through the application of unused methods**

Since the empirical research was conducted on a representative sample file of Slovak manufacturing enterprises, it enables us to apply the most significant findings to create guideline managers of such companies in practice. We discovered that the most commonly used measures are flexible promotion (56.83 %), selection of suppliers based on predefined criteria (42.24 %) and redeployment of resources (38.2 %). The potential for improvement lies mainly in the area of measures evaluated as

“unused measures”. In total, 5 measures belong to this category according to the level of their application in enterprises.

Since these measures are not applied by Slovak manufacturing companies it is not possible to define their benefits and outcomes based on managers’ experiences. The file of unused methods contains expectations forecasts, flexible supply contracts, economic supply incentives, application of game theory methods in parameters settings of production factors, and mathematical programming utilization in supply chain management. It could be beneficial for managers in practice to understand these methods and possibly include them in their design plans in supply chain management. Therefore, we provide a brief overview of how these methods can be applied and what potential benefits their introduction in a manufacturing company can have.

Expectations forecasts were primarily a marketing tool to measure potential variations in customers’ demand, especially in terms of product life cycle. However, since then this tool has evolved significantly. Nowadays, these forecasts provide an early warning system for any internal or external changes based on models of future trends in selected parameters. Such warning can make a significant difference in terms of compliance of companies’ responsibilities. Therefore, they can also contribute to the increase of flexibility not just in company, but also in its external environment such as other members of supply chain. It might also be interesting to examine what outcomes the application of this method along with other measures would have on overall supply chain flexibility especially if they shared information throughout a supply chain.

Flexible supply contracts can be highly beneficial for the companies since such contracts enable managers to make changes in their demands from suppliers without being forced to renegotiate an existing or to create a new contract. On the other hand, they put that much pressure on suppliers who have to comply with demands for their products in quantities or qualities

swiftly and without prior notice, in a form of agreed terms and requirements in contract. It is obvious that few suppliers are able to meet this requirement and therefore it would be highly advantageous for companies to actively seek such suppliers and try to start a partnership with them. The overall increase in supply chain flexibility due to the introduction of such flexible contracts in supply chain can be tremendous.

The challenges and benefits are similar with economic supply incentives. This tool provides opportunities for companies to reward special behaviour, to provide special allowances etc. Such incentives are meant to motivate suppliers to comply with demands that go beyond those defined in terms of contract. Furthermore, they can motivate suppliers to put more importance on the company's demands even if it is not their only customer. Basically, this method means that company is buying a sort of special treatment. Depending on the strength of the relationship between company and its supplier, this method can also be used to ensure the supplier's compliance with the agreed terms. This could be the case if the relationship is either not strong enough or the supplier has a dominant position. Application of this method is a classic example of how increase in supply chain flexibility is achieved by increase in costs. However, the long term benefits are undeniably higher. Moreover, other research studies have already proven that utilization of economic supply incentives in supply chain management may have an impact on supply chain alignment (Figure 1).

Mathematical programming has been a tool to resolve all kinds of operational problems. Its applications are numerous and well documented. Moreover, a lot of software exists to support its utilizations. Despite of such overwhelming evidence of successes in company's operations managements, its utilization in supply chain management is not yet common. According to our findings, it is the same in Slovak manufacturing enterprises.

Arguably, the most unutilized method in terms of its potential to increase supply chain flexibility is the application of game theory methods. In essence, game theory focuses on calculating the best strategies how to reach the best possible outcome for every subject involved in decision or with an influence on its results. Game theory can therefore, serve as suitable instruments to align interests of all key supply chain members through cooperation, and to design flexible and sustainable solutions in accordance with specific needs of all companies whose involvement has direct impact on the outcomes for everyone. The prerequisite of maximizing the benefits offered by game theory methods application is the cooperation of partners.

### **3.3. Supply chain flexibility assessment from enterprise's perspective**

Based on research findings it is possible to draw even more recommendations for manufacturing enterprises. Since not all enterprises are even aware of all options that are available to them we propose a checklist that provides an opportunity to conduct a periodical assessment of supply chain flexibility. This checklist does not measure the level of supply chain flexibility, it simply examines the development of this factor and its individual elements. The performance of assessment according to the proposed checklist is based on the premise of continuous improvement. Managers can ascertain what progress has been done during the analyzed period and whether the application of measures provided desirable results.

The proposed checklist for the first assessment is provided in Table 20.

**Table 20 Supply chain flexibility assessment – 1<sup>st</sup> year**

Assessment of supply chain flexibility			
Date of assessment:			
Question			
Describe the rate of application of the following supply chain flexibility measure:	Currently used	Planned to be used	Not used
flexible promotion			
the use of multiple modes and types of transport of raw materials and products			
the use of external logistics organization			
insurance against the risk of adverse events			
implementation of risk analyses			
preparation of back-up plans and teams of crisis management			
utilization of flexible planning systems			
long-term capacity planning			
selection of suppliers based on predefined criteria			
flexible supply contracts			
creation of stocks of finished products for special orders			
penalizations for failures to comply with the terms of supply of raw materials			
creating plants closer to key customers			
raising orders amounts for raw materials reserves			
reverse logistics utilization			
creating possibilities for rapid redeployment of human and material resources between process and/or facilities			
mathematical programming utilization in supply chain management			
pressure to reduce production time of product or service			
application of game theory methods in parameters settings of production factors			
continuous improvement, learning organization			
frequent adjustments in pricing policies			
product standardization and postponement			
economic supply incentives			
expectations forecasts			

frequent product innovations			
periodical analysis of market conditions and product life cycle			
investments in research and development			
customer orientation as a main strategic concept of enterprise			
corporate culture focused on change			
creating partnerships			
implementation of quality systems such as ISO, TQM, etc.			
Describe the rate of application of following supply chain flexibility measure by any of your customers or suppliers:	Currently used	Planned to be used	Not used
flexible promotion			
the use of multiple modes and types of transport of raw materials and products			
the use of external logistics organization			
insurance against the risk of adverse events			
implementation of risk analyses			
preparation of back-up plans and teams of crisis management			
utilization of flexible planning systems			
long-term capacity planning			
selection of suppliers based on predefined criteria			
flexible supply contracts			
creation of stocks of finished products for special orders			
penalizations for failures to comply with the terms of supply of raw materials			
creating plants closer to key customers			
raising orders amounts for raw materials reserves			
reverse logistics utilization			
creating possibilities for rapid redeployment of human and material resources between process and / or facilities			
mathematical programming utilization in supply chain management			
pressure to reduce production time of product or service			
application of game theory methods in parameters settings of production factors			
continuous improvement, learning organization			
frequent adjustments in pricing policies			
product standardization and postponement			

economic supply incentives			
expectations forecasts			
frequent product innovations			
periodical analysis of market conditions and product life cycle			
investments in research and development			
customer orientation as a main strategic concept of enterprise			
corporate culture focused on change			
creating partnerships			
implementation of quality systems such as ISO, TQM, etc.			
There is a flexibility-oriented culture within the supply chain and measures are implemented to increase its flexibility	Yes	No	Partially
Supply chain management resources for top management have been identified and validated	Yes	No	Partially
There are measures in place to identify potential partners and build partnerships in supply chain.	Yes	No	Partially
Relationships crucial to success are identified, along with issues to be avoided	Yes	No	Partially
Supply chain goals are validated and circumstances that jeopardize the achievement of these goals are being tested	Yes	No	Partially
The necessary resources are identified and provided to support supply chain management activities	Yes	No	Partially
Incident reporting procedures are in place to help identify negative trends along with problem escalation procedures in accordance with supply chain partners.	Yes	No	Partially
Business continuity plans and Supply chain recovery plans have been implemented and are regularly tested.	Yes	No	Partially
Measures are in place to control the effectiveness and efficiency of the controls in place for all applied supply chain flexibility measures.	Yes	No	Partially
Measures for mandatory reporting in supply chain management are implemented in the required structure	Yes	No	Partially

Source: Own elaboration, 2019.

Since it is used for the first time, the progress towards supply chain flexibility cannot yet be measured. Any following assessment is, however, able to monitor the development and the effectiveness of applied measures. The proposed checklist for the following assessments is provided in Table 21. This checklist is supplemented by additional questions to monitor progress.

**Table 21 Supply chain flexibility assessment – following years**

Assessment of supply chain flexibility							
Date of assessment:							
Question						Effectiveness of measure application	
Describe the rate of application of the following supply chain flexibility measure:	Used continuously	Used ad hoc based on needs, but more than 10 times a year	Used ad hoc based on needs, but more between 9 to 2 times a year	Used only once	Not used last year	Yes	No
flexible promotion							
the use of multiple modes and types of transport of raw materials and products							
the use of external logistics organization							
insurance against the risk of adverse events							
implementation of risk analyses							

preparation of back-up plans and teams of crisis management						
utilization of flexible planning systems						
long-term capacity planning						
selection of suppliers based on predefined criteria						
flexible supply contracts						
creation of stocks of finished products for special orders						
penalizations for failures to comply with the terms of supply of raw materials						
creating plants closer to key customers						
raising orders amounts for raw materials reserves						
reverse logistics utilization						
creating possibilities for rapid redeployment of human and material resources between process and / or facilities						

mathematical programming utilization in supply chain management						
pressure to reduce production time of product or service						
application of game theory methods in parameters settings of production factors						
continuous improvement, learning organization						
frequent adjustments in pricing policies						
product standardization and postponement						
economic supply incentives						
expectations forecasts						
frequent product innovations						
periodical analysis of market conditions and product life cycle						
investments in research and development						
customer orientation as a main strategic concept of enterprise						

corporate culture focused on change						
creating partnerships						
implementation of quality systems such as ISO, TQM, etc.						
Describe the rate of application of the following supply chain flexibility measure by any of your customers or suppliers:	Used by customer(s) only	Used by supplier(s) only	Used by both customer(s) and supplier(s)	Not used by neither customer(s) or supplier(s)		
flexible promotion						
the use of multiple modes and types of transport of raw materials and products						
the use of external logistics organization						
insurance against the risk of adverse events						
implementation of risk analyses						
preparation of back-up plans and teams of crisis management						
utilization of flexible planning systems						
long-term capacity planning						

selection of suppliers based on predefined criteria			
flexible supply contracts			
creation of stocks of finished products for special orders			
penalizations for failures to comply with the terms of supply of raw materials			
creating plants closer to key customers			
raising orders amounts for raw materials reserves			
reverse logistics utilization			
creating possibilities for rapid redeployment of human and material resources between process and / or facilities			
mathematical programming utilization in supply chain management			
pressure to reduce production time of product or service			
application of game theory methods in parameters			

settings of production factors				
continuous improvement, learning organization				
frequent adjustments in pricing policies				
product standardization and postponement				
economic supply incentives				
expectations forecasts				
frequent product innovations				
periodical analysis of market conditions and product life cycle				
investments in research and development				
customer orientation as a main strategic concept of enterprise				
corporate culture focused on change				
creating partnerships				
implementation of quality systems such as ISO, TQM, etc.				
How many customers did the company	None	1 -3	4 - 10	over 10

create a new partnership with in the last year?				
How many suppliers did the company create a new partnership with in the last year?	None	1 -3	4 - 10	over 10
How many customers (with whom partnerships had previously been established) company stopped conducted business with in the last year?	None	1 -3	4 - 10	over 10
How many suppliers (with whom partnerships had previously been established) company stopped conducted business with in the last year?	None	1 -3	4 - 10	over 10
What is the rate of information sharing with supply chain partners?	0 - 50 %	51 - 80 %	81 - 100 %	Trend in comparison to previous assessment  Increase      Decrease
What additional outcomes were achieved in the last year?	Increase in supply chain agility	Increase in supply chain adaptability	Increase in supply chain alignment	No additional outcomes have been achieved

There is a flexibility-oriented culture within the supply chain and measures are implemented to increase its flexibility	Yes	No	Partially
Supply chain management resources for top management have been identified and validated	Yes	No	Partially
There are measures in place to identify potential partners and build partnerships in supply chain.	Yes	No	Partially
Relationships crucial to success are identified, along with issues to be avoided	Yes	No	Partially
Supply chain goals are validated and circumstances that jeopardize the achievement of these goals are being tested	Yes	No	Partially
The necessary resources are identified and provided to support supply chain management activities	Yes	No	Partially

Incident reporting procedures are in place to help identify negative trends along with problem escalation procedures in accordance with supply chain partners.	Yes	No	Partially
Business continuity plans and Supply chain recovery plans have been implemented and are regularly tested.	Yes	No	Partially
Measures are in place to control the effectiveness and efficiency of the controls in place for all applied supply chain flexibility measures.	Yes	No	Partially
Measures for mandatory reporting in supply chain management are implemented in the required structure	Yes	No	Partially

Source: Own elaboration, 2019.

This checklists proposal does not mean that they have to be applied in an exact form as provided in Table 20 and Table 21. These checklists consider possible application of all supply chain flexibility measures. However, in practice not all measures

can actually be used by particular enterprise. It is up to managers to carefully consider the specific conditions of their enterprise and to make decisions regarding the elements used in the checklist and periodicity of assessment. Such factors as business orientation, size, number of produced products, number of different production processes, and number of partners in a supply chain and so on, have to be considered. Therefore, this provided checklist may be in a need of modifications. Furthermore, the proposed checklist can be supplemented by additional questions regarding supply chain management can therefore be used as an assessment tool for the state of supply chain management as a whole.

The evaluation through this proposed checklist can also include quantification based on current needs of an enterprise or a supply chain. Such quantification can include variations in points assigned to each method applied and vary due to extend of its application. Utilization of unified checklist and its quantification by key members of supply chain can also provide a clear image of supply chain flexibility as a whole and, even more importantly, also its weaknesses as viewed by each member.

### **3.4 Possibilities for further research in supply chain flexibility**

This study provides a foundation for further research into this topic and may provide a source of information for other authors looking for enrichment of discussion concerning supply chain flexibility. Particular set of measures used in this research is not a complex one. However, it provides a suitable foundation for exploring this topic in terms of Slovak business environment as a whole.

This monograph contributes to current research in the field of business enterprises and management science by providing an overview of how managers in practice can locate an interesting

source of competitive opportunity by analyzing their supply chains and consequently increase not only their flexibility, but also other significant supply chain performance aspects. The relationship between partners is the key factor of success of whole supply chain and, consequently, the quality of information they share among each other is the foundation for achieving an agile and responsive supply chain especially in a highly competitive industry such as the manufacturing industry. Furthermore, the results presented in this research study serve as an interesting starting point for researchers interested in supply chain flexibility and information sharing within supply chain. This monograph can assist in future development of this research topic and provide foundation for further research into connections of these two significant issues in supply chain management. Therefore, this topic is an appropriate area to research as companies nowadays strive to improve supply chain performance by revising existing industry practices. However, the main limitation of this research was the complexity of this issue. Many ideas for further research studies can be found in focusing on some of the particular problems stated above, which can be further examined in more detailed in order to provide more accurate guidelines for managers in practice in terms of forms and types of information sharing throughout the supply chain. The study of particular measures applied to achieve flexibility was not omitted, since the examination of how some measures, other than information sharing, can affect supply chain flexibility provided interesting findings. This monograph provides a complex view of this issue within Slovak manufacturing sector of economy while using a representative sample of companies.

Another natural possibility to expand this research was already discovered in the first chapter. In order to provide a thorough and complex image of supply chain flexibility, it is essential to determinate the exact nature of relationships

between most commonly applied measures to increase supply chain flexibility and secondary outcomes. Very few authors provide their opinions on the topics which served as an essential part of our proposed framework for modelling metrics of supply chain flexibility, however, there are no reliable data from Slovak business environment. So there lies the natural extension of our research and possible verification of proposed framework.

Applying the measures targeting the volume and contract flexibility can also help in increasing company's ability to meet customers' requirements. Nowadays, reliability is the most important characteristic of a desirable supply chain partner. It is even more important and has more impact on joint flexibility than other characteristics such as honesty, trust and commitment. Learning from the best possible benchmarks can assist managers to gain competitive advantage in current rapidly changing conditions on global markets which is nowadays proving essential for survival of all Slovak manufacturing companies, especially under the pressure of Asian manufacturing companies.

## **Summary**

The main aim of this research was to analyze the utilization of various measures and approaches designed to increase flexibility in supply chains. Our main focus was on assessment of the extent of such applications in manufacturing enterprises located in the Slovak Republic regardless of their size. The data was gathered by questionnaire. We provided 32 possible measures used in practice in order to increase flexibility of supply chains. Our findings describe how these measures are utilized in Slovak practice. Our research also uncovered the measures which are currently not used. The potential for improvement lies mainly in the area of measures evaluated as "unused measures". In total, 5 measures belong to this category

according to the level of their application in enterprises. We provided a brief overview of how these methods can be applied and what potential benefits their application can bring to the company.

Furthermore, it is essential for supply chain managers to understand how application of certain methods influences one or more supply chain flexibility elements and its secondary outcomes. Our proposal for framework provides a visually enticing and simplistic view of these relationships or the lack of relationships which are equally important to know in detail. Therefore, this proposed model provides managers with a useful tool to learn from experience of their colleagues in Slovak manufacturing industry and to get better understanding of the main aspects of supply chain flexibility which are essential to design optimizing plans for strengthening the performance of a whole supply chain and therefore, bring benefits not only to their company, but also to other companies involved in business activities of their supply chain. Together, these companies may achieve synergy and consequently other improvements.

## **CONCLUSION**

Supply chain flexibility has already been proven to be a relevant issue with great importance for supply chain management. As many academic and practical examples prove, integrating flexibility measures into all company's processes can provide an opportunity for increasing its economical effectiveness and securing company's market position. Furthermore, flexibility measures as any system measures provide an increase in transparency of processes and often also lead to a slight decrease in bureaucracy throughout the supply chain.

The main aim of this monograph was to explore the extent of utilization of various measures to increase supply chain flexibility in Slovak enterprises operating in manufacturing industry and to create a framework for modelling metrics of supply chain flexibility. This aim was achieved by conducted empirical research on a representative sample of Slovak manufacturing companies. Findings from this research study then served as a foundation for creating a model of influences between various significant factors in supply chain management.

Firstly, we set out to analyze and classify various options to increase supply chain flexibility. We described 32 methods that many authors and practitioners perceive as possibilities to increase supply chain flexibility. These methods were listed and analyzed according to previous examples of their achievements. Thus we achieved the first partial aim of this research.

Selected flexibility types were analyzed based on their existence throughout supply chains, especially those in manufacturing industries since they also have various specifications which differentiate them from supply chains of other business oriented industries. Our monograph provides an overview of how various types of flexibility correlate with measures applied by enterprise. The parameters we examined in order to describe not only the current state in Slovak manufacturing industry, but also define areas where

improvement can be essential in order to achieve desirable results by companies involved and obtain competitive advantage.

Our third partial goal was related to possible relationships between supply chain flexibility and various selected company characteristics. We were able to discover some interesting dependences and, on the other hand, the lack of mutual influence which can also provide significant information for managers in practice in terms of method selection and its outcomes. Moreover, this monograph contributes to current research field of manufacturing business enterprises by providing an overview of how they can locate an interesting source of competitive opportunity by analyzing their supply chains.

The relationship between partners is the key factor of success of the whole supply chain and consequently the quality of information they share among each other is the foundation for achieving an agile and responsive supply chain especially in highly competitive industry such as the manufacturing industry. Therefore, a framework for modelling metrics of supply chain flexibility was created. This framework provides an innovative approach to supply chain flexibility by looking into its components and their relationship. The application of system approach provided us with an opportunity to analyze these elements using the results of our own empirical study, and findings from the pool of existing literature sources.

Furthermore, the results presented in this research study serve as an interesting starting point for researchers interested in the supply chain flexibility and partnership development within a supply chain. This monograph can assist in future development of this research topic and provide foundation for further research into connections of these two significant issues in supply chain management. Therefore, this topic is an appropriate area to research as companies nowadays strive to improve supply chain performance by revising the existing industry practices. Our

findings and proposed models provide a complex view of this issue within Slovak manufacturing industry using a representative sample of companies.

## SUMMARY

Publikácia „Dosahovanie flexibility: nový trend v manažmente dodávateľsko-odberateľských reťazcov“ sa zaobrá mnohými aspektmi zvyšovania flexibility, a to nielen na podnikovej úrovni, ale aj na úrovni celého dodávateľsko-odberateľského reťazca.

Flexibilita dodávateľsko-odberateľského reťazca sa ukázala ako relevantná problematika s veľkým významom pre manažment týchto reťazcov. Hlavným cieľom tejto monografie bolo preskúmať rozsah využitia rôznych opatrení na zvýšenie flexibility dodávateľsko-odberateľského reťazca v slovenských podnikoch, pôsobiacich vo výrobnej sfére a vytvoriť rámec pre modelovanie metrík flexibility dodávateľsko-odberateľského reťazca. Tento cieľ bol dosiahnutý realizovaným empirickým výskumom na reprezentatívnej vzorke slovenských výrobných spoločností. Zistenia z tejto výskumnej štúdie následne slúžili ako základ pre vytvorenie modelu závislostí a vplyvov medzi rôznymi významnými faktormi v manažmente dodávateľsko-odberateľského reťazca.

Najprv sme sa rozhodli analyzovať a klasifikovať rôzne možnosti na zvýšenie flexibility celého dodávateľsko-odberateľského reťazca. Charakterizovali sme 32 metód, ktoré mnohí autori a praktici vnímajú ako možnosti na zvýšenie flexibility reťazca. Dosiahli sme tak prvý čiastočný cieľ tohto výskumu.

Táto monografia poskytuje prehľad o tom, ako rôzne typy flexibility korelujú s opatreniami uplatňovanými podnikmi. Parametre, ktoré sme skúmali, opisujú nielen súčasný stav v slovenskom výrobnom priemysle, ale poskytujú aj oblasti, kde môže byť nevyhnutné zlepšenie, aby sa dosiahli žiaduce výsledky zainteresovaných spoločností.

Tretí čiastkový cieľ súvisel s možnými vzťahmi medzi flexibilitou dodávateľsko-odberateľského reťazca a rôznymi charakteristikami podnikov. Podarilo sa nám identifikovať

niektoré zaujímavé závislosti a na druhej strane nedostatok vzájomného vplyvu, ktoré môžu poskytnúť významné informácie pre manažérov v praxi z hľadiska výberu metódy a jej výsledkov. Okrem toho táto monografia prispieva k súčasnej oblasti výskumu podnikateľských podnikov tým, že poskytuje prehľad o tom, ako môžu nájsť zaujímavý zdroj konkurenčných príležitostí analýzou ich dodávateľsko-odberateľských reťazcov.

Vzťah medzi partnermi je klúčovým faktorom úspechu celého reťazca a následne aj kvalita informácií, ktoré medzi sebou zdieľajú, je základom pre dosiahnutie agilného a dodávateľsko-odberateľského reťazca s rýchlymi možnosťami pre zmeny, najmä vo vysoko konkurenčnom prostredí, akým je aj výrobný priemysel. Na základe uvedeného bol vytvorený rámec pre modelovanie metrík flexibility dodávateľského reťazca. Tento rámec poskytuje inovatívny prístup k skúmaniu flexibility dodávateľsko-odberateľského reťazca prostredníctvom skúmania jeho zložiek a ich vzájomných vzťahov. Aplikácia systémového prístupu nám umožnila analyzovať tieto prvky prostredníctvom výsledkov vlastnej empirickej štúdie a zistení zo súboru existujúcich literárnych zdrojov.

Okrem toho výsledky prezentované v tejto výskumnej štúdii slúžia ako zaujímavý východiskový bod pre výskumných pracovníkov, ktorí sa zaujímajú o flexibilitu dodávateľsko-odberateľského reťazca a rozvoj partnerstva v rámci týchto reťazcov. Táto monografia môže pomôcť pri budúcom rozvoji tejto výskumnej témy a poskytnúť základ pre ďalší výskum v spojení týchto dvoch významných problematík manažmentu dodávateľsko-odberateľského reťazca. Keďže podniky sa v súčasnosti usilujú o zlepšenie výkonnosti celého reťazca prostredníctvom revízie existujúcich postupov v odvetví, táto téma je preto vhodnou oblasťou výskumu. Naše zistenia a navrhované modely poskytujú komplexný pohľad na túto

problematiku v rámci slovenského výrobného priemyslu s použitím reprezentatívnej vzorky spoločnosti.

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Studia oeconomica má za cieľ publikovanie výsledkov vedeckého výskumu pedagogických a výskumných zamestnancov Ekonomickej fakulty UMB a ich sprístupnenie odbornej verejnosti. Kritériom výberu je originalita, vedecká kvalita a praktické zameranie navrhovaných prác.

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