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ORIGINAL PAPER

FACTORS AFFECTING THE LEVEL OF SUPPLY CHAIN PERFORMANCE AND ITS DIMENSIONS IN THE CONTEXT OF SUPPLY CHAIN ADAPTABILITY

Dorota Leończuk

Bialystok University of Technology, Bialystok, **Poland**

ABSTRACT. **Background:** A vital determinant of supply chain performance is its adaptability. It is one of essential features that affect the results of the functioning of a supply chain. Many researchers indicate adaptability as a significant source of acquiring and maintaining a long-term competitive advantage, one of major factors that guarantee the success of a supply chain, or a major development megatrend of supply chains. The main objective of the article is to analyse the impact of such factors as industry and applied competitive strategy (cost leadership, differentiation, or focus) on the level of supply chain performance and results achieved by the supply chain with regard to the key aspects of performance in the context of adaptability.

Methods: In the article the author analyses results of studies conducted with CATI method at a sample of 200 enterprises representing four industries: automotive, food, furniture as well as consumer electronics and household appliances, which are among most advanced sectors in the Polish economy (leaders of Polish export). The analysis of data gathered was carried out at a few stages. Firstly, a hierarchical confirmatory factor analysis was applied. The developed model was used for measuring and assessing the performance of supply chains and its dimensions by means of designating factor scores. The last stage involved studying the impact of such factors as type of industry or applied competitive strategy on the level of performance and its four dimensions: visibility, velocity, versatility, and responsiveness. At this stage the non-parametric Kruskal-Wallis test was used.

Results: The results of the conducted studies provided evidence that the level of supply chain performance as well as its four dimensions is not affected by the type of industry, but vary in accordance to the applied competitive strategy.

Conclusions: The model, developed and positively verified in terms of quality, may constitute a useful tool for management practitioners to measure and assesses the performance of specific supply chains, as well as make comparisons between them. Thanks to determining factors that affect the level of performance and its four dimensions, managers may as well consciously indicate directions in improving supply chains.

Key words: supply chain performance, supply chain adaptability, 3V formula, hierarchical confirmatory factor analysis.

INTRODUCTION

According to the paradigm of the supply chain management, enterprises no longer compete as individual units but as a part of a larger, complex network. Growing market competition makes it possible that tightened cooperation within supply chains gives a better opportunity for achieving success [Espinoza, Bond, Kline 2010].

Supply chain management requires interpreting the supply chain as a whole, accounting for all links that must coordinate and synchronise their operations. R. Kaplan and D. Norton [1996] highlight that "it is not possible to effectively manage things that cannot be measured". Hence, the measurement and evaluation the functioning of supply chains has particular significance in the context of their management [Carvalho, Azevedo, Cruz-Machado 2012]. As D. Estampe claims [2014],

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there is no single, commonly accepted mechanism of identifying whether the supply chain functions properly. Literature describes many methods and models of measuring and evaluating the functioning of supply chains that account for many measures ascribed to various categories.

The selection of proper measurer and indicator categories used in measuring and evaluating supply chain performance depends on many factors, e.g. industry, organisational structure, conditions for the functioning of supply chains, output effects (product/service) [Cho et al. 2012; Elrod, Murray, Bande 2013]. Many authors (D. Chimhamhiwa, P. van der Molen, O. Mutanga & D. Rugege [2009], P. Folan & J. Browne [2005]) highlight the need for a multidimensional, balanced approach that incorporates the measurement context (objective and destination). Moreover, researchers emphasise the need to take into account the demanding number of dimensions [Chimhamhiwa et al. 2009; Espinoza at al. 2010]. The proper structure of the system of performance measurement also differs with regard to the desired features of the supply chain (e.g. agility, adaptability etc.) [Gopal, Thakkar 2012].

Literature, apart from the methods and models characterised by universality (e.g. Balanced Scorecard, SCOR model, GSCF model, APQC model, performance prism etc.), also offers solutions that account for the context of measurement and are dedicated to the evaluation of: green supply chains [Shaw, Grant, Mangan 2010], sustainable supply chains [Piotrowicz, Cuthbertson 2015; Zailani et al. 2012], lean supply chains [Arif-Uz-Zaman, Ahsan 2014] etc. While reviewing scientific publications, the author did not identify papers that deal with the subject of the measurement and evaluation of supply chain performance in the context of adaptability as one of the most significant features of the supply chain that affect the results of its functioning. Many researchers associate adaptability as an important source of acquiring and maintaining long-term competitive advantage and one of the major features that guarantee the success of the supply chain [Ahimbisibwe et al., 2016]. Adaptive capacity is also called the major developmental megatrend of supply chains [Szymczak 2015a].

With reference to the identified research gap, the article undertakes the issue of measuring and assessing the performance of a supply chain in the context of its adaptability. The basic objective of the paper is analysing major dimensions of performance as well as a studying the impact of such factors as industry and the applied competitive strategy on the performance of a supply chain and results achieved by this supply chain within key aspects of performance.

The article is organized as follows. In the first part of the article the author outlines a review of literature in the scope of assessing supply chain performance, supply chain adaptability and dimensions of supply chain performance with regard to the adaptability feature. The analysis of literary sources leads to the formulation of hypotheses, being the subject of theoretical and empirical verification. The article continues to describe the methodology of conducted research and next – the results of analyses. The author as well elaborates on the achieved findings and summarises the article, indicating basic limitations of the presented approach as well as future directions of studies.

THEORY AND HYPOTHESES

Supply chain performance measurement

As P. Brewer and T. Speh [2000] emphasise, a successful supply chain involves, apart from effective coordination of processes, concentration of measures on providing customers values and elimination of unnecessary costs in key areas of functioning, the implementation of a measurement system that provides information whether the supply chain properly satisfies basic expectations. H. Carvalho, S. Azevedo and V. Cruz-Machado [2012] also point out that the measurement and assessment of the functioning of a supply chain are of particular significance in the context of its effective management.

The notion of performance is most frequently understood as a process of quantifying the efficiency and effectiveness of actions. Efficiency measures the application of resources aimed at satisfying a specific level of customer satisfaction in an economic aspect. Effectiveness, in turn, measures the level of satisfying customer expectations [Neely, Gregory, Platts 1995].

What distinguishes the measurement of supply chain performance is the fact that it should primarily account for measurers that entail the entire supply chain, allowing for an analysis of interdependencies that go beyond the limits of an organization [Ganga, Carpinetti 2011; Schmidt, Foerstl, Schalten-brand 2017]. Among basic elements of cooperation between entities in a supply chain, S. Min et al. [2005] enumerate a common assessment of achievements apart from information sharing, joint planning and problem solving and an ability to exert effective impact on partners. The assessment of effects that are the result of collaboration allows for drawing conclusions for further cooperation. Therefore, it is vital that the measurement and assessment are both of a horizontal character, which concentrates on the entire supply chain, and vertical – dedicated to analysing organisational processes in specific enterprises [Lin, Li 2010]. J. Ying and Z. Li-jun [2011] as well claim that the scope of measurement that refers to a supply chain should cover not only operational performance of enterprises, but also their impact on the entire supply chain, cooperation between these enterprises and their partners. The second aspect should even be the subject of greater attention. As D. Estampe et al. [2013] emphasise, the assessment of supply chain performance is a complex undertaking, being a transversal process that engages many actors cooperating one with another in order to achieve assumed logistics and strategic objectives.

Supply chain adaptability

Adaptiveness is one of the most significant features of the supply chain that affects the results of its functioning. Supply chain adaptability can be defined as its capacity for changes that lead to preventing from the occurrence of undesired events, improving the functioning or acquiring new skills in order to achieve the objective of the supply chain in specific environmental conditions (that are changeable) and in the light of incomplete information on their dynamics [Ivanov, Sokolov 2010]. Participants in the adaptive supply chain get the ability to recognise the changing operational conditions in a period that allows them to evaluate alternative corrective measures as well as react in order to alleviate their impact on the company's operation. This is particularly significant in the light of uncertainty currently faced by the enterprises (associated with such events as terrorist attacks, employee protests, force majeure etc.) [Davidrajuh 2006]. Adaptability allows partners in the supply chain to work in a dynamic environment so as to foster the achievement of greater effectiveness of operations [Whitten, Green, Zelbst 2012].

D. Ivanov, B. Sokolov and J. Kaeschel [2010] claim that a supply chain can be called adaptive if it is capable of adapting to:

- changes in the market environment and the functioning in conditions of uncertainty,
- changes in the executive environment of specific measures,
- internal changes in the supply chain itself

by means of using structural and functional reserves as well as better coordination that results from the application of information and computer technologies, in particular the Internet. Under the influence of long-term and strong changes in the environment, this type of supply chain is able to reduce, suppress or eliminate disruptions and maintain, or even improve the operational efficiency through reconfiguring its elements (transition to a new state). Adaptability is crucial in the context of adjusting to global markets as a response to changes in the life cycle of a product and technology as well as in reaction to the customer's needs.

Performance dimensions

Adaptability capacity is an effect of developing a certain set of features in the supply chain. The most significant ones are: visibility, velocity and versatility. R. Kalakota,

M. Robinson and P. Gundepudi [2003] consider inventory visibility, fulfillment velocity and coordination versatility as three fundamental pillars of adaptive supply chains, also termed as 3V in the literature [Ruhi, Turel 2005; Szymczak 2015b]. Moreover, analyses conducted by D. Leończuk, U. Ryciuk, M. Szymczak & J. Nazarko [2019] reveal that 3V formula need to be supplemented by yet another factor called responsiveness that relates to reaction to customer needs (expanded to 3V + R formula).

Visibility is associated with ensuring access to information to all participants in the supply chain, including customers [Barrat, Oke 2007; Johansson, Melin 2008; Jűttner, Maklan 2011; Swaminathan, Tayur 2003]. Its scope may also include the application of innovative technologies that support cooperation in the supply chain, coordination of material and non-material resources [Caridi et al., 2014; Holcomb, Ponomarov, Manrodt 2011; Johansson, Melin 2008; Kalakota, Robinson, Gundepudi 2003; Ross, Holcomb, Fugate 2004], as well as substitution of resources with information share [Clark 2007; Hines 2013]. A supply chain reaching high values in the framework of this dimension is characterised by transparency necessary for early detection and proper reaction to all sorts of disruptions, in particular associated with order execution [Scholten, Schilder 2015]. Ensuring visibility of all processes provides necessary information in order to make decisions and corrections in plans. This allows partners in the supply chain to identify bottlenecks, which in turn fosters immediate reaction in order to eliminate them [Iyer, Seshadri, Vasher 2009]. Supply chain visibility is also connected with the ability to track the flow of resources, in particular inventories, as well as the current update of the order fulfillment status [Szymczak 2015b].

Velocity, in turn, is associated with the capacity of the supply chain to execute various processes and measures aimed at achieving the desired goals in a fast manner [Tsironis, Matthopoulos 2015]. On the one hand, such velocity refers to implementing changes: the development of the currently offered products and launching new products [Hines 2013], on the other – it is associated with the ability to react to diverse events and changes on the market [Jűttner, Maklan 2011].

The third element that joins the described approaches is a widely understood versatility of operation. It primarily concerns balancing the operational efficiency of the supply chain with market needs, in particular providing proper products and services at the required quality and in the right volume. It is also crucial to adjust the offer to the individual needs of customers. [Momeni et al., 2014; Olugu, Wong 2009]. Versatility involves as well undertaking cooperation with suppliers and recipients in the light of various conditions of order processing, which is connected with the need to ensure high flexibility of the operation within the supply chain so that it can handle changeability [Szymczak 2015b]. Many authors also perceive variety as an important feature, which, however, can be treated as one of the elements of supply chain versatility [Kohlberger, Gerschberger, Engelhardt-Nowitzki 2011; Nielsen & Holmström 1995]. The supply chain reaching high values in the scope of this dimension is characterised by a high level of flexibility and changeability of the undertaken arrangements [Nutt 2004].

Responsiveness refers to the aspects of the supply chain responsiveness connected with getting familiarized with customer needs as well as reaction to them (delivering products fast and in a timely manner). H. Lee [2004] and G. Whitten, K. Green and P. Zelbst [2012] wrote about creating adaptive supply chains by means of analysing the needs of both direct and final customers. This dimension also referred to the time of order execution as well as their timely delivery, as e.g. R. Basu and J. Wright argued [2008].

Research hypotheses

C Bozarth and R. Handfield [2007] claim that “on a competitive market no enterprise can indefinitely maintain advantage in all dimensions of performance. Perfection in certain dimensions may contradict the perfection in other aspects; therefore there is no single company that can be best at everything. In such cases one has to make difficult choices and decisions as a result of which the significance of certain dimensions

increases at the cost of other ones". Understanding the importance of specific measurers of supply chain performance and its dimensions translates into achieving a high level of measurement in areas perceived as essential.

In a competitive environment, the results of the functioning of an enterprise are closely related to its ability to manage complex relations with business partners. The so-called focal enterprise, namely the one that is seen by customers as being responsible for a product or service as well as coordinating material and information flow, plays a particularly significant role. By means of taking specific (e.g. improved visibility), such a company may influence the performance of the entire supply chain [Caridi et al. 2014; Elking et al., 2017; Kot, Onyusheva, Grondys 2018].

The significance of specific dimensions as well as specific measurers and indicators of assessing supply chain performance may as well differ, depending on the industry in which a given enterprise operates. Research on the significance of measurers of performance was conducted e.g. by F. Chan [2003], who suggested using the AHP method in indicating priorities of performance measures, as exemplified by various branches of industry. C. Elrod et al. [2013], in turn, analysed the issue of applying various measurers of supply chain performance in selected industries. On the basis of interviews conducted with representatives of enterprises from three industries (arms industry, chemical industry as well as food and beverage production and distribution industry), the authors state that the significance of measurers of supply chain performance depends on the type of industry, organisational structure and conditions of the functioning of an enterprise. In case of a company operating in food and beverage production and distribution, the most significant measurers are time (in particular time spent by the stocks in a warehouse in order to avoid being expired), elimination of delays and quality (assessed as per value perceived by a customer). Conducting business activity in the chemical industry requires focusing on ensuring flexibility of actions taken, using production capacity, adjusting plurality of production to current needs and limiting costs. In the arms sector, in turn, priority was given to: costs (also with regard to information processing), quality (expressed in the value perceived by the customer), time of order processing and flexibility within launching new products and services as a reaction to the development of technologies.

Thus, it can be assumed that the level of supply chain performance as well as the results achieved within specific dimensions of performance distinguished in the context of adaptability, will be diversified with respect to the industry in which a given supply chain functions, as well as the applied competitive strategy. Based on the above deliberations the following research hypotheses were formulated:

H1: The type of industry a given supply chain belongs to, affects the level of its performance and results achieved by the supply chain within performance dimensions assessed in the context of its adaptability.

H2: The competitive strategy applied in a supply chain (by a focal company) affects the level of supply chain performance and results achieved by the supply chain within performance dimensions assessed in the context of its adaptability.

METHODOLOGY

Survey development and measures

The construction of the measuring tool was initiated with drawing up a list of measures of supply chain performance that were cited in the literature and also applied in the business practice. Next, the author selected only those that were most frequently mentioned and that encompassed the perspective of the entire supply chain. The following step involved selecting potential indicators for each assumed dimensions of the supply chain performance, described with the use of the 3V formula, based on literature review. The list of indicators was limited on the basis of the principle "less is better" [Chae 2009;

Gunasekaran, Kobu 2007], according to which the system of performance measurement should be based on the minimal number of metrics and indicators.

In effect, the scale for measuring the performance of the adaptive supply chain included 23 indicators (Appendix A). The list of indicators has been prepared based on the definition of three assumed dimensions of the supply chain performance. Questions were listed without grouping into categories. Likert's seven-level scale was used in the questionnaire to evaluate each indicator: from "strongly disagree" to "strongly agree".

Data collection and sample

The research was conducted with the use of CATI technique. Interviews involved a sample of 200 enterprises operating in four industries: automotive, food, furniture as well as consumer electronics and household appliances (Table 1), which are among most advanced sectors in the Polish economy (leaders of Polish export). In case of all enumerated sectors, interviews were conducted with representatives of 50 randomly selected enterprises, mainly employing 50 or more employees. The research sample was selected in a quota random way. The percentage of denials or unsuccessful contact attempt is 81%.

Table 1. Sample characteristics

		N	%
Sector	Automotive	50	25
	Food	50	25
	Furniture	50	25
	Consumer electronics and household appliances	50	25
Employment	10-49 employees	6	3
	50-249 employees	118	59
	250 and more employees	70	35
	n/a	6	3
Source of the entity's capital	Entity with solely Polish capital	132	66
	Entity with solely foreign capital	23	11.5
	Entity with dominating Polish capital	16	8
	Entity with dominating foreign capital	17	8.5
	n/a	12	6

Research sample consisted of Polish companies (from all Polish voivodeships) mainly employing 50 or more employees of which 59% were medium-sized enterprises employing less than 250 employees and 35% of large enterprises employing more than 250 employees. The major part of the sample (74% in total) constituted enterprises with solely Polish capital or with dominating Polish capital.

Interviews involved persons experienced in logistics and supply chain management. Most respondents (72%) declared that they have more than five years of experience (in case of 62.5% of interviewees, their experience is more than ten years). The representatives of enterprises that took part in interviews knew the specifics of the companies under study, since 71.5% of them worked there for more than five years. Only 8.5% of respondents worked for less than two years in the analysed enterprise. A large percentage of interviewees (approximately 35.5%) constituted persons who worked in logistics departments. This group was comprised of managers and specialists in the following areas: logistics, transport, forwarding, storage as well as combining tasks related to purchasing and logistics, production planning and logistics, or transport and logistics. The same percentage of respondents constituted procurement specialists.

The interviews were conducted with the use of a structured questionnaire, which included statements comprising a developed scale for measuring supply chain performance, closed questions on the enterprise's strategy and characteristics of a supply chain, as well as open questions allowing for raising potential

remarks and comments. The questionnaire was capped with demographics questions.

Analysis

The analysis of the gathered data was carried out at several stages. Firstly, the authors conducted an exploratory factor analysis of a set of indicator variables selected for measuring supply chain performance. The next stage involved a confirmatory factor analysis, where again, on the basis of obtained results, the authors modified a set of indicator variables by means of eliminating those which proved statistically insignificant or irrelevant (the signs of factor loadings did not meet expectations). The findings resulting from these two stages were published in a publication of Leończuk at al. [2019].

Another phase involved conducting a hierarchical confirmatory factor analysis, aimed at verifying the possible existence of a higher-order factor structure. The models of higher-order factors constitute an elaboration of a concept that characterises factor analysis, which assumes that a common variance of observable variables can be explained by means of underlying latent variable or variables (factors). In hierarchical models, the analysis of correlation-covariance existing between observable variables is replaced with a correlation between latent variables. The existence of correlations between latent variables means that there is a common between variance. In such a situation, similar to observable indicators, it is possible to distinguish one factor (or several factors) of higher order. Then correlations between primary factors (based on correlations between observable variables) become an input matrix for higher-order analyses [Brown, 2015].

The developed model was used for measuring and assessing supply chain performance as well as obtaining a detailed picture of their situation within major performance dimensions, crucial in the context of supply chain adaptability. On the basis of conducted factor analysis, according to the obtained factor structure, indicators of latent variables, the so-called factor scores, were created [O'Rourke, Hatcher 2013]. Factor scores are most frequently calculated with the use of the results of an exploratory factor analysis; however, they can also be designated on the basis of results of a confirmatory factor analysis. As Ch. DiStefano, M. Zhu and D. Mîndrilă [2009] indicate, factor scores created on the basis of CFA are of similar significance to those created with EFA results. Hence, they can also be used for determining the value of a latent variable and conducting further analyses.

Factor scores based on CFA outcomes are usually designated with the use of non-refined methods, e.g. sum (average) of variable values within a given factor, sums of standardized variable values, weighted sum of variable values. In ordinary indicator summing or averaging it is assumed that each statement is of the same significance for the measurement of a latent variable which is to be measured by the scale. Nonetheless, factor analysis proved the contrary since specific questions have different factor loadings. Many authors, e.g. M. Uluman and C. Doğan [2016], indicate that a more precise solution is creating indicators by means of averaging results of respondents in specific survey questions, after multiplying them by the values of standardized factor loadings. Thanks to this, statements of strong factor load make a greater contribution to the indicator and those with smaller factor load make a smaller contribution. Factor scores were determined for each enterprise under study within four constructs and a higher-order latent variable, based on confirmatory factor analysis. Factor scores for supply chain performance were designated on the basis of the results of a hierarchical factor analysis as a weighted average of factor scores for four performance dimensions: responsiveness, velocity, visibility and versatility, with weights in a form of factor loadings that define relations between a higher-order factor and specific performance dimensions.

The last stage of conducted analyses focused on the impact of such factors as type of industry and applied competitive strategy on the level of supply chain performance as well as results achieved by supply chains within indicated performance dimensions.

RESULTS

Conducting an exploratory, and subsequently confirmatory, factor analysis, the results of which were described in a publication of D. Leończuk et al. [2019], allowed for distinguishing four factors that create a scale for measuring supply chain performance: responsiveness (RES), versatility (VER), visibility (VIS) and velocity (VEL). Each of these factors portrays a different aspect of the performance of an adaptive supply chain, and variables connected with a given factor allow for measuring the level of a specific feature of a supply chain.

Table 2. Factor correlation matrix

Factor	RES	VER	VIS	VEL
RES	1.000	0.561	0.625	0.623
VER	0.561	1.000	0.518	0.580
VIS	0.625	0.518	1.000	0.597
VEL	0.623	0.580	0.597	1.000

All correlations significant at p <0.001

With regard to the existence of correlations between distinguished factors (Table 2), a model of hierarchical factor analysis was constructed in order to capture a superior common factor, introducing an additional latent variable that represents the total outcome on a measurement scale of supply chain performance. Figure 1 presents the results of the conducted analysis.

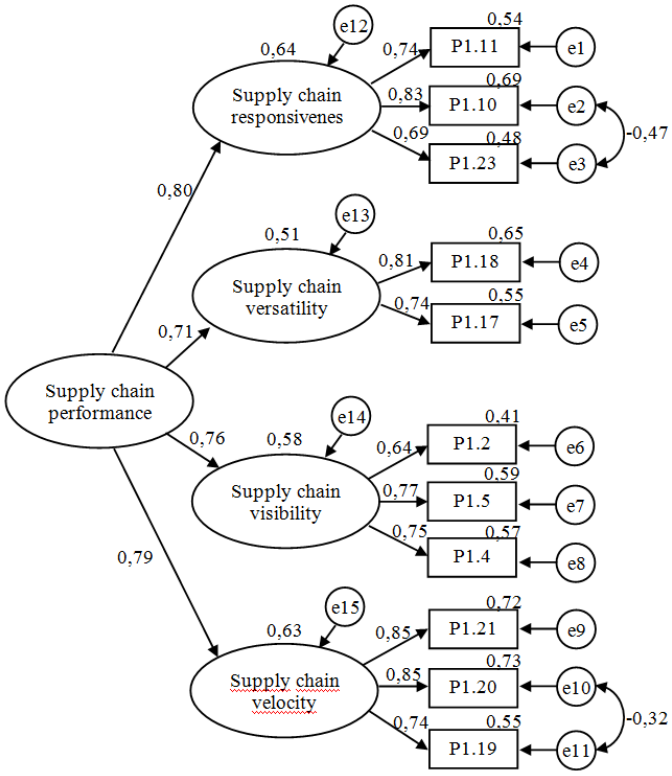

Fig. 1. Confirmatory factor analysis-hierarchical model

The quality assessment of the model engaged a series of goodness-of-fit. The author made an initial assessment of the model with the use of chi-squared statistics with reference to the number of degrees of freedom. It is often argued that the model is very good when this value is smaller than 2 [Fischer 2013]. In the assessed model the value $\chi 2/df$ equals 1.205. The good fit of the model is also confirmed by the RMSEA equals 0.032. It is assumed that the model is good if the approximation error does not exceed 0.05 [Fischer 2013]. Good model fit is also confirmed by such measures as GFI=0.958, AGFI=0.927, CFI=0,957, which exceed required value of 0.9 [Brown 2015]. Only the NFI=0.806 reached the value below 0.9. The main drawback of the NFI is its sensitivity to the sample size (it is frequently

underestimated for samples below 200) and the model's complexity (higher values are obtained for more complex models). This problem was solved by the application of the TLI, which prefers simpler models [Hooper, Coughlan & Mullen 2008]. For the assessed model, the TLI exceeded the acceptance threshold and equals 0.938.

Analyses show that all questionnaire items obtain respectively high factor loadings (above 0.7 or slightly below this value) and are of statistically significant. It should be noted that a superior factor of supply chain performance is best represented by factor 1 – supply chain responsiveness (0.8) and factor 4 – supply chain velocity (0.79), and in lesser extent by factor 3 – supply chain visibility (0.76) and factor 2 – supply chain versatility (0.71).

The developed model was used for measuring and assessing the level of supply chain performance and its four distinguished dimensions in Polish enterprises, calculating indicators of latent variables, according to the obtained factor structure. The level of indicators may assume values from 1 to 7. In case of companies under analysis, an average level of supply chain performance was $\bar{x}$ =5.28 (with standard deviation SD=0.92). With its value of Me=5.33, the median as well obtained an approximate value. The values of the average and the median in case of three performance dimensions were also similar: responsiveness ($\bar{x}$ =5.41; SD=1.12; Me=5.61), visibility ($\bar{x}$ =5.48; SD=1.16; Me=5.7) and versatility ($\bar{x}$ =5.28; SD=1.3; Me=5.47). In measuring the fourth dimension – velocity, slightly lower values were obtained ($\bar{x}$ =4.95; SD=1.2; Me=5).

In order to compare the level of supply chain performance and its dimensions in enterprises operating in four analysed industries, the non-parametric Kruskal-Wallis test was used. The selection of the test was caused by the non-performance of assumptions required by parametric tests, primarily lack of compliance of the distribution of dependent variables with normal distribution. Table 3 illustrates outcomes of conducted tests.

Table 3. Results of the analysis of differences at the level of supply chain performance and performance dimensions in selected industries with the use of the Kruskal-Wallis test

	Food sector N=50	Furniture sector N=50	Automotive sector N=50	Consumer electronics and household appliances sector N=50	Results of Kruskal-Wallis test
Supply chain performance	M=5.29 SD=0.91	M=5.19 SD=1.07	M=5.26 SD=0.78	M=5.38 SD=0.91	chi=0.938, df=3, p=0.816
Supply chain responsiveness	M=5.47 SD=1.10	M=5.24 SD=1.23	M=5.42 SD=1.08	M=5.52 SD=1.09	chi=1.216, df=3, p=0.749
Supply chain velocity	M=5.02 SD=1.25	M=5.04 SD=1.19	M=4.72 SD=1.12	M=5.02 SD=1.24	chi=2.928, df=3, p=0.403
Supply chain visibility	M=5.57 SD=1.13	M=5.30 SD=1.29	M=5.50 SD=1.00	M=5.56 SD=1.24	chi=1.688, df=3, p=0.640
Supply chain versatility	M=5.08 SD=1.26	M=5.20 SD=1.52	M=5.42 SD=1.15	M=5.44 SD=1.25	chi=2.903, df=3, p=0.407

The results of the Kruskal-Wallis test (level of test probability for all dependable variables exceeding the value of 0.05) indicate that the level of supply chain performance as well as its four dimensions does not depend on the type of industry a given enterprise operates.

The level of variables was also compared among groups of enterprises with regard to the applied strategic approach (Table 4). For this reason, the author divided competitive strategies into three types, as proposed by M. Porter [1985]:

I. Cost leadership – involves obtaining a leading position in a given industry in terms of total costs; the leading motive of this strategy is a low manufacturing cost as compared to competitors, also with regard to quality, level of customer care etc.

II. Differentiation – involves differentiating the product or service offered by the enterprise, creating something which is considered unique in the entire sector.

III. Focus – involves concentrating on a specific group of purchasers, a specific range of product assortment or a geographical market.

Table 4. Results of the analysis of differences at the level of supply chain performance and performance dimensions with regard to a competitive strategy used by enterprises with the use of the Kruskal-Wallis test

	I. Cost leadership N=19	II. Differentiation N=67	III. Focus N=103	Results of Kruskal-Wallis test
Supply chain performance	M=4.48 SD=0.91	M=5.29 SD=0.85	M=5.39 SD=0.90	chi=14.8, df=3, p=0.002
Supply chain responsiveness	M=4.83 SD=1.22	M=5.32 SD=1.12	M=5.55 SD=1.06	chi=9.051, df=3, p=0.029
Supply chain velocity	M=4.31 SD=0.88	M=4.92 SD=1.23	M=5.06 SD=1.20	chi=8.526, df=3, p=0.036
Supply chain visibility	M=4.64 SD=1.23	M=5.59 SD=0.91	M=5.54 SD=1.23	chi=11.773, df=3, p=0.008
Supply chain versatility	M=4.08 SD=1.53	M=5.34 SD=1.22	M=5.43 SD=1.24	chi=13.787, df=3, p=0.003

The results of the conducted tests (the level of test probability for all dependable variables is below 0.05) indicate that the type of applied competitive strategy makes a significant statistical impact on the level of supply chain performance and its four dimensions. In order to identify which groups of enterprises vary among each other in terms of the level of supply chain performance, their responsiveness, velocity, visibility and versatility, the author conducted multiple comparisons tests for each analysed variable.

The test results showed that the level of supply chain performance, as well as their visibility and versatility, significantly vary for enterprises that apply a strategy of cost leadership and enterprises applying the other two strategies. However, there were no differences in the level of variables among enterprises that apply differentiation and focus strategies. It should also be noted that the application of the strategy of cost leadership entails a lower level of described variables.

Still, the multiple comparisons tests, conducted for responsiveness and velocity variables, point to the fact that the difference between the first and third strategy is significant. Other differences proved insignificant. Hence, it can be claimed that supply chains of enterprises applying the strategy of cost leadership are characterised by lower responsiveness and velocity than those that aim at concentration.

DISCUSSION

The conducted hierarchical factor analysis allowed for expanding the model described in a publication by D. Leończuk et al. [2019], which indicates visibility, velocity, versatility and responsiveness as four major factors in assessing supply chain performance in the context of its adaptability, by an additional, second-order factor. Introducing an additional, latent variable, defined as performance, allows for making a measurement and assessment of four major aspects of adaptability as well as assessing a general level of supply chain performance (Figure 2).

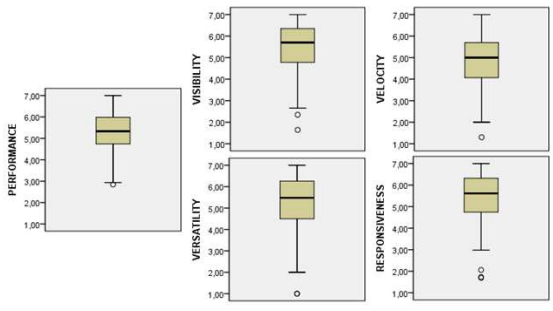

Fig. 2. The level of supply chain performance and its dimensions in Poland

The level of performance within the range <1.0-3.0> was considered as low, in the range <3.0-5.0> as medium, and within <5.0-7.0> as high [Ryciuk 2016]. According to the assumed assumptions, it can be stated that the level of supply chain performance in Poland is high (5.28). Also, the level of three dimensions of performance, i.e. responsiveness (5.41), visibility (5.48) and versatility (5.28) was high, whereas velocity ranks as medium (4.95).

A vital element of the research was also determining factors that affect the level of supply chain performance and its four dimensions. The results of the conducted statistical analysis suggest that the first hypothesis on the impact of the industry on the level of supply chain performance and the results achieved by the supply chain in its major dimensions: visibility, velocity, versatility, and responsiveness; should be rejected. Still, the conducted research provided evidence that the second hypothesis should be assumed. The factor which significantly affects the level of analysed variables is hence a competitive strategy applied in a supply chain by a focal enterprise. The most vital differences can be observed in case of applying the strategy of cost leadership and two other strategies. Supply chains in which this strategy is conducted, are characterised by a clearly lower level of performance as well as visibility, velocity, versatility and responsiveness. These results confirm that actions taken by an enterprise perceived by customers as the one that is in charge of a product or service, affects the results achieved by the supply chain [Caridi et al. 2014; Kot, Onyusheva & Grondys 2018].

Contribution and Implications

This article focuses on the issues of supply chain performance in terms of its adaptability. The author develops the model described by D. Leończuk et al. [2019]. The construction of an additional, hierarchical factor analysis model allowed for indicating an additional latent variable which represents a total outcome on the measurement scale of supply chain performance. Thanks to this, it is possible to make a measurement and assessment of the performance level of specific supply chains in the context of their adaptability, as well as a diagnosis of their situation within four major dimensions of performance: visibility, velocity, versatility, and responsiveness. The conducted statistical analyses also allowed for indicating factors that affect the level of analysed variables.

The model, developed and positively verified in terms of quality, may constitute a useful tool for management practitioners to measure and assesses the performance of specific supply chains, as well as make comparisons between them. Thanks to determining factors that affect the level of performance and its four dimensions, managers may as well consciously indicate directions in improving supply chains.

Limitations and future research

In addition to its contributions, this study has limitations. Firstly, limitations concern the selection of a research sample, in particular its volume. The research was conducted with a sample of 200 enterprises. Some researchers, e.g. J. Guilford [1954] claim that such a volume allows for conducting a factor analysis and generalizing results of the research. However, others suggest that the sample should be larger and entail 300, or even 500 respondents [MacCallum, Widaman, Zhang & Hong 1999]. The consequence of such a small research sample was an uneven number of groups of enterprises analysed with the Kruskal-Wallis test, as well as their small size (division according to the applied strategy into three groups with the size of 19-67-103). This dictates certain caution in interpreting results. Another limitation is connected with conducting research on a sample composed solely of Polish entrepreneurs (the major part of the sample constituted enterprises with solely Polish capital or with dominating Polish capital). Moreover, the research involved enterprises solely operating in four industries (automotive, food, furniture as well as consumer electronics and household appliances). It is recommended to analyse the existence of the observed dependencies also in other sectors.

The analyses and deliberations put forward in the article may constitute the basis and inspiration for further research in this field.

Due to the limitations resulting from the selection of such a research sample and the assumed research methodology, it is necessary to confirm the obtained results of studies in future research and expand them by other European countries. It is recommended to verify the model on a larger research samples. Further research directions may be also associated with the use of the developed model for measuring and evaluating supply chain performance from other than the sectors researched within the article, as well as in-depth analyses of dependencies between the distinguished performance dimensions. Moreover, the author identifies developing measurement tools that allow for improving the evaluation of the functioning of supply chains other than the adaptive ones (agile, lean etc.) as further research challenges.

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Appendix 1. Questionnaire statements

Statement	Source
SCP1: The supply chain is able to limit stocks	Based on Whitten, Green & Zelbst 2012
SCP2: The supply chain is characterised by considerable planning accuracy	Based on Tarasewicz 2014
SCP3: The supply chain is capable of limiting wastefulness	Based on Whitten, Green & Zelbst 2012
SCP4: In the supply chain, it is possible to track and monitor order fulfillment and related resource flows	Own
SCP5: The supply chain can detect the appearing problem connected with order execution and deal with them	Based on Jűttner & Maklan 2011
SCP6: The demand forecasts developed in the supply chain are accurate	Based on Arif-Uz-Zaman & Ahsan 2014
SCP7: The supply chain is characterised by a large volume of mutual contacts with partners	Based on Qrunfleh & Tarafdar 2014
SCP8: The supply chain is able to foresee abrupt changes	Based on Szymczak 2015b
SCP9: The supply chain can minimise total costs of delivering the product to the final customer	Based on Beamon 1999
SCP10: The supply chain guarantees a short time from the moment of order placement to the execution of the delivery	Based on Jűttner & Maklan 2011
SCP11: The supply chain has the capacity to deliver products to the final customer exactly on time	Based on Beamon 1999
SCP12: The supply chain contains a mechanism for eliminating the execution of delayed, incomplete and damaged deliveries	Based on Whitten, Green & Zelbst 2012
SCP13: The supply chain is capable of quick reactions and solving problems raised by the final customer	Based on Tarasewicz 2014
SCP14: The supply chain is characterised by a high level of orders that can be executed immediately from the current stocks	Based on Chae 2009
SCP15: In the supply chain receivables are swiftly paid	Based on Chae 2009
SCP16: The supply chain ensures a short reaction time in terms of customer enquiry	Based on Beamon 1999
SCP17: The supply chain can handle non-standard orders and satisfy special customer requirements	Based on Qrunfleh & Tarafdar 2014
SCP18: The supply chain is capable of providing products in different variants	Based on Qrunfleh & Tarafdar 2014
SCP19: The supply chain can quickly adapt its production capacity so as to accelerate or slow down production in its reaction to decreasing demand	Based on Qrunfleh & Tarafdar 2014
SCP20: The supply chain can swiftly launch a new product on the market	Based on Qrunfleh & Tarafdar 2014
SCP21: The supply chain can swiftly implement product improvements	Based on Qrunfleh & Tarafdar 2014
SCP22: The supply chain offers a wide range of post-sales services	Based on Golrizgashti 2014
SCP23: In the supply chain the level of customer satisfaction is analysed	Based on Beamon 1999

CZYNNIKI WPŁYWAJĄCE NA POZIOM WYDAJNOŚCI ŁAŃCUCHA DOSTAW ORAZ JEJ WYMIARÓW W KONTEKŚCIE ADAPTACYJNOŚCI ŁAŃCUCHA DOSTAW

STRESZCZENIE. **Wstęp:** Ważną determinantą wydajności łańcucha dostaw jest jego adaptacyjność. Jest to jedna z istotnych cech, które przekładają się na wyniki funkcjonowania łańcucha dostaw. Adaptacyjność jest przez wielu badaczy wskazywana jako ważne źródło zdobycia i utrzymania długoterminowej przewagi konkurencyjnej, jeden z głównych czynników gwarantujących sukces łańcucha dostaw, czy też główny megatrend rozwojowy łańcuchów dostaw. Głównym celem artykułu jest zbadanie wpływu czynników, takich jak branża i stosowana strategia konkurencyjna na poziom wydajności łańcucha dostaw oraz wyniki osiągane przez łańcuch dostaw w ramach kluczowych aspektów wydajności z uwzględnieniem kontekstu adaptacyjności.

Metody: W artykule przeanalizowano wyniki badań przeprowadzonych techniką CATI na próbie 200 przedsiębiorstw z czterech branż: spożywczej, RTV/AGD i elektroniki, motoryzacyjnej oraz meblarskiej. Analiza zgromadzonych danych została przeprowadzona w kilku etapach. W pierwszej kolejności wykonano hierarchiczną konfirmacyjną analizę czynnikową. Opracowany model wykorzystano do pomiaru i oceny wydajności łańcuchów dostaw oraz jej wymiarów, poprzez wyznaczenie ocen czynnikowych. W ostatnim etapie zbadano wpływ takich czynników jak przynależność do branży oraz stosowana strategia konkurencyjna na poziom wydajności oraz jej czterech wymiarów. W tym etapie wykorzystano nieparametryczny test Kruskala-Wallisa.
Wyniki: Wyniki przeprowadzonych badań wykazały, że poziom wydajności łańcuchów dostaw, a także jej czterech wymiarów nie jest zależny od przynależności do branży, natomiast różni się w zależności od stosowanej strategii konkurencyjnej.
Wnioski: Opracowany oraz pozytywnie zweryfikowany pod względem jakości model może stanowić narzędzie użyteczne dla praktyków zarządzania do pomiaru i oceny wydajności poszczególnych łańcuchów dostaw, a także dokonywania ich porównań. Dzięki wskazaniu czynników wpływających na poziom wydajności oraz jej czterech wymiarów menedżerowie mogą także w świadomy sposób wskazywać kierunki doskonalenia łańcuchów dostaw.

Słowa kluczowe: dokonania łańcucha dostaw, adaptacyjność, formuła 3V, hierarchiczna konfirmacyjna analiza czynnikowa

Dorota Leończuk ORCID ID: https://orcid.org/0000-0002-0424-0226
Bialystok University of Technology,
Faculty of Engineering Management,
45A, Wiejska Street, 15-351 Bialystok, **Poland**
e-mail: d.leonczuk@pb.edu.pl