Measuring Performance of Adaptive Supply Chains

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Abstract In the wake of the intensification of competitive struggle that we can call hyper-competition and in the face of temporary, transient and often unsustainable competitive advantage supply chains have to master their processes in many dimensions at the same time. Excellence is achieved through a shared vision of development and cooperation with up and down-tier supply chain members especially by continuous assessment and improvement the effectiveness and efficiency of the supply chain processes. Typical determinants of the supply chain performance is the triad: level of customer service—time—costs. However, intensive changes taking place in the supply chains surroundings enforce the inclusion of new criteria in supply chain performance measurement. In the chapter the problem of supply chain performance measurement with reference to the concept of adaptive supply chains was considered. The study was based on quantitative research conducted among Polish companies employing 50 or more employees from four sectors of economy: automotive, food, furniture as well as consumer electronics and household appliances. 200 computer assisted telephone interviews (CATI) were held. According to the conducted research the scale for measuring the supply chain performance should take into account four factors, namely responsiveness, versatility, velocity, and visibility (3V + R formula).

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1 Introduction

Nowadays supply chains need to keep pace with competition to more extent than ever before. In the wake of the intensification of competitive struggle that we can call hyper-competition [15] and in the face of temporary, transient [45] and often unsustainable competitive advantage [44] supply chains have to master their processes in many dimensions at the same time. It is said that they have to raise their level of excellence, they have to be managed towards maturity. Maturity itself is the term that has already been well received in the context of increasing supply chain performance. Achieving supply chain maturity is a strategic task that requires co-operation of all entities involved. Only then it is possible to increase process capability, effectiveness and productivity. Supply chain maturity models assume the existence of different levels on which supply chains can be placed. Supply chain maturity can be determined by control (the difference between targets and actual results), predictability (the variability in achieving objectives) and effectiveness (the achievement of targeted results and the ability to raise targets) [43]. The most widespread supply chain maturity models are:

- the "compass" model [60],
- PRTM/PMG model [3],
- and Poirier's model [53].

The order in which the three models are mentioned here corresponds to the chronology of their development. All of them were published at the beginning of the 21st century not counting the very first preliminary version of the Poirier's model. Each of them shows the achievement of supply chain maturity in a very similar way. They exhibit only a certain shift of focus. Maturity (excellence) is achieved through a shared vision of development and cooperation with up and down-tier supply chain members especially by continuous assessment and improvement the effectiveness and efficiency of the supply chain processes.

Typical determinants of the supply chain performance is the triad: level of customer service-time-costs. However, intensive changes taking place in the supply chains surroundings enforce the inclusion of new criteria in performance measurement and improvement, for example the ability to react quickly or to operate flexibly. Main factors influencing supply chains evolution are related to globalisation, increased customer expectations as well as technologisation and technicisation of life [62].

Today's supply chains should be characterised mainly by visibility, velocity and versatility. It is so-called "3V rule" [56]. Supply chains outstanding in the characteristics that could be described by the 3V formula parameters are adaptive supply chains (having the features of flexible, responsive and resilient). The new concept are also smart supply chains. Smart "is the coming together of software, hardware, cloud and sensing technologies so as to be able to capture and communicate real time sensor data of the physical world, which can be used for advanced analytics and intelligent decision making" [47]. However, smart supply chains are also integrated, intelligent and innovative [74]. Smart supply chains with main distinction of adapting to technological changes and its consequences could be also called adaptive.

Managing an adaptive supply chain, maintaining and developing all its capabilities requires a system that will show which way to follow. Performance measurement systems fulfil this role. Performance measurement includes a usage of set of diagnostic tools used to measure, monitor and assess the processes in supply chain. That's why they are currently so popular and why hereby, in the chapter the problem of supply chain performance measurement (SCPM) with reference to the concept of adaptive supply chains was considered. The purpose of the study was to indicate the factors that should be taken into account when measuring supply chain performance in order for the supply chain to gain the feature of adaptability and show its excellence in this regard as it develops in time. The rationale for doing such research was to verify and confront with the approach referred to as the 3V formula.

The study was based on quantitative research conducted among Polish companies employing 50 or more employees from four sectors of economy: automotive, food, furniture as well as consumer electronics and household appliances—sectors that are indisputable leaders of Polish export. 200 computer assisted telephone interviews (CATI) were held. Interviews were conducted with the management staff on the basis of a structured questionnaire. The research was preceded by a comprehensive literature review that allowed for identification and selection of indicators of supply chain performance.

2 Smart and Adaptive Supply Chains

Adaptability is one of the most significant features of a supply chain that has an impact on the results of its functioning. The aptitude of a supply chain in terms of adjusting to all the more challenging operational conditions is one of the paramount factors that guarantee long-term competitiveness and success. Ivanov et al. [30] 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).

The adaptive capacity is an effect of developing a certain set of features in the supply chain. Among the major features in the supply chain many authors indicate visibility, velocity and variability, known as the 3V's [31, 56]. Kalakota et al. [37] consider inventory visibility, fulfillment velocity and coordination versatility the three fundamental pillars of adaptive supply chains.

Mastering many supply chain processes at the same time means that the supply chain can stand out in a variety of areas simultaneously, can exhibit many different characteristics, can have many abilities and maintain a competitive edge in many different areas. One may call such a supply chain a smart one. Butner [11] states that supply chains must become a lot smarter to deal effectively with risk and meet business objectives. She argues that we can expect a different kind of supply chain to emerge that is instrumented ("full of sensors, RFID tags, meters, GPSs, and other devices and systems"), interconnected (characterised by "unprecedented levels of interaction with customers, suppliers, and IT systems in general, but also among objects that are monitoring or even flowing through the supply chain") and intelligent (capable of learning and making some decisions by itself, without human involvement as well as to predict future scenarios) [11]. Other researchers go even further. For example, according to Wu et al. [74] a smart supply chain possesses as many as six distinctive characteristics—it is instrumented, interconnected, intelligent, automated, integrated, and innovative.

The concept of smart supply chain derives from customers' expectations of high quality service adjusted to fast-changing needs. Now it is oriented to adding value to customer. To imagine this phenomenon a term 'smart convenience" has been coined. How to be smart convenient in supplying goods is particularly visible when selling foodstuffs. Convenient food shopping has progressed considerably from convenience stores through strip malls, leisure-oriented and personalised supermarket towards combining traditional shopping done in a traditional store with on-line shopping [63]. This concept is now the mainstream of smart convenience.

With the development of online sales, mixed shopping experience offering ordering online and the convenience of being able to pick up your order while you're out and about, and omnichannel sales, distribution channels will have to evolve as well as supply chains will have to operate under new schemes and business models [24]. Yet another incentive to develop smart supply chains is factory-on-demand model within dispersed manufacturing networks [49] which is strictly connected to the above mentioned customers' expectations but considered from the other side of distribution channels.

Smart supply chain is an integrated supply chain as the integration is the only solution providing high levels of flexibility, what enables the supply chain to respond immediately to demand signals with the ability to communicate and collaborate with each other and trading partners. Smart supply chains should be also featured by high level of trust between supply chain members as well as trust between information systems and information technologies. The most mature supply chains ensure real-time information and real collaboration between partners. Smart technologies introduced into supply chains could lead to real time transparency and higher levels of visibility. “The transparency within the value chain allows the manufacturer to identify changes in customer requirements and to reflect them in all of the production steps, from development to distribution” [66]. The visibility especially relates to inventories and possibility to monitor its levels anytime and from anywhere in the chain.

Smart supply chain is also resilient supply chain adapting strategies and operations to changes in the environment to reduce the risk of activity. It means actions are aimed at avoiding disturbances or reducing severity if they occur [8]. In the future, smart supply chains will evolve into self-adaptive supply chains where all things will be interconnected, exchanging information, recognizing and assessing situations. To collect/store/analyse the information in real time, IoT technologies, Radio Frequency Identification, sensors, GPS and BigData (including distributed databases and distributed parallel processing frameworks) are essential [38]. The supply chain of the future will fully rely on digital solutions and will be self-driving powered by artificial intelligence. An intelligent supply chain will automatically balance “supply with demand, with demand forecasting systems based on historical forecasts and predictive algorithms” [68].

3 Supply Chain Performance Measurement

Performance measurement includes a set of diagnostic tools used to measure, monitor and assess the effects of an organisation, which is an essential element of internal management control systems. It is a closed loop system that closely monitors the effects at the operational, tactical and strategic level of management, and thus operate in an efficient and effective manner [7]. Keeping up with the needs of consumer, more and more frequent changes in product range with the ever-increasing volumes of data, make changes in the field of business analytics. Analytical procedures need to be implemented at every stage of the supply chain and are focused on predicting future events so that the supply chain can be managed proactively. Today we’ve got a variety of data sources that have emerged in recent years. There should be mentioned various types of social networks operating in real time, which are not only a source of data about customers, but also serve as an internal organisational communication platform (e.g. Yammer, Chatter, Facebook at Work).

This requires the development of an information system that is able to process large amounts of raw data into valuable information that is then used in decision making and which contributes to the creation of knowledge within the organisation. The data source for such a system is the reporting of individual units under accounting activities. Therefore, many studies on performance measurement mainly focus on these issues. Both traditional cash measures and non-cash measures of supply chain operations are must-have in the assessment system.

In performance measurement systems various types of metrics are used, both quantitative and qualitative. The set has evolved over the years. The impact of unpredictable business environment and the increasing pressure from consumers have led to the transition from cost-oriented strategies to customisation and value-oriented strategies. Such strategies promote other measures [16]. Supply chains have changed and the role of individual entities within supply chains has changed as well. This has increased the need for changes in performance assessment [69]. The changes also took place in performance measurement systems [16].

A well-functioning performance measurement system positively influences the quality of managerial decisions. Especially in the supply chain environment, where many decisions are strongly interdependent (trade-offs) and are dispersed throughout a pattern of business entities. At the same time—as argued by Holmberg [27]—it is impossible to carry out measurement, monitoring and evaluation of performance in the supply chain in a completely uniform manner—as if it were one single company. According to him, it would harm supply chain integration. The author proposes that the foundation for supply chain performance measurement should not be one and only system, but independent systems in which metrics are used individually but which carry out assessment in a broader system aspect, with the recognition of relationships between entities and processes. This should be supported by the use of improvement models, such as SCOR, which reveal how supply chain really works [27].

From the perspective of supply chain management it is extremely important that the performance measurement system promotes the integration of many different business areas. The implementation of an integrated performance measurement system is in practice connected with many challenges the overcoming of which is critical to the success of the process. They result from [20]:

- the process of setting targets for each measure and assessing performance against these targets;
- if the targets are consistent with each other, they may not be useful for guiding managers in their day-to-day operations;
- inconsistencies and trade-offs among the targets provided managers with conflicting signals.

The selection of metrics to measure, monitor and assess supply chain performance is determined by many characteristics. Many studies in this regard adopt the SCOR optics and point to metrics associated with the main processes in the supply chain [12, 22]. Others link metrics to specific management levels [23] and still others—to specific characteristics of the supply chain [6]. Ahmed [1] in turn indicates the phase of product life cycle and the implemented market strategy. The pragmatic approach is very important. In this approach the performance measurement system is a comprehensive strategic management tool. Consistency with strategic goals, inclusiveness, universality and measurability are the four features of an effective performance measurement system [6].

Metrics can also be linked to stakeholder groups whose interests they reflect. In these approaches there are many similar metrics that one may call basic. They are of a universal nature, such as EBITDA (Earnings Before Interest, Taxes, Depreciation and Amortisation). Their use is justified regardless of the direction of improving supply chain performance. Nevertheless, they should be supplemented with a set of specific metrics related to the direction of supply chain development including adaptive supply chain.

4 The 3V's as the Main Features of Adaptive Supply Chains

4.1 Visibility

Supply chain visibility (SCV) is a complex issue that involves people, processes, technology and information flow [75]. However, there is no single, generally accepted definition of the SCV. Some authors, e.g. Swaminathan and Tayur [61] focus their attention mainly on information flow, defining visibility as the aptitude to ensure the access to information in the scope of a supply chain. Others, still, concentrate on the features of the exchanged information, arguing that the level of the SCV is determined by the scope in which this information is accurate, trusted, timely and in a readily usable format. Zhang et al. [75] define the notion of supply chain visibility from the IT perspective as an ability to gather and analyse dispersed data as well as generate specific recommendations that refer to strategy. But undoubtedly SCV is not only dependent on IT. There are many others enablers of visibility beyond technology-based ones [4].

One of the significant aspects of the SCV is transparency with regard to resources. It means the possibility to determine their current location in the supply chain, their volume, condition as well as the readiness of their handling. Such concept of transparency refers to all resources, but it particularly concerns stocks, determining the capability of monitoring their level in any link from any other link in the supply chain [62].

Another issue connected with the SCV is the visibility in terms of demand. Demand visibility is the capability of the system to possess undistorted information on the precise demand in time, that allow partners in the supply chain to react efficiently [26].

Supply chain visibility is created at three levels. The first one concerns gathering relevant information. The second refers to finding proper communication tools in order to disclose the collected information to other enterprises. The third level involves the skill to use information for continuous improvement of the functioning of the supply chain [33].

Scholten and Schilder [59] claim that apart from information sharing, transparency also requires mutual communication and shared creation of knowledge. All these elements provide supply chains with visibility required for early detection and proper reaction to all disruptions that appear in them. The SCV is determined by the scope in which the participants of the supply chain have access to the current information and may be treated as a condition for proper reaction to changes and disruptions, thanks to which it is termed as predecessor of resistance. Moreover, managers can expect increased visibility with extensive information processing capabilities from supply chain organization's internal integration [72].

Visibility is also interpreted as detecting potential problems before they appear. It supports anticipating the potential appearance of disruptions in the supply chain [59]. Visibility also fosters anticipating delays in supplies before they happen and applying proper methods of reaction. Wilhjelm [71] states that the SCV means "see around corners". Proper visibility that involves the entire supply chain plays a vital role in its management, making it more sensitive and susceptible to control [42].

4.2 Velocity

Literature defines supply chain velocity in many ways, taking into account various aspects. The velocity of the supply chain is understood by many authors as the time that lapses from the moment of placing an order until the execution of the delivery [56]. The lead-time is thus perceived as a key indicator of the supply chain velocity [36]. With regard to the B2C relations, velocity can be interpreted as the aptitude to satisfy the needs of the final customer in a short time, and in case of business customers (B2B relations) it means delivering the terms and conditions of the contract in a short time [62]. Still, Tsironis and Matthopoulos [67] define velocity as the capability of fast execution of various processes and measures.

Velocity may be assessed on the basis of e.g. [5]:

- time of order execution,
- time devoted to each process in the supply chain,
- share of deliveries executed on time,
- stock turnover ratio.

Some authors point to two major elements of velocity: speed of reaction and speed of implementing changes in order to deliver products exactly when they are needed [25]. Juttner and Maklan [36] describe velocity as the speed with which the supply chain is able to react to events and changes taking place on the market. Scholten and Schilder [59] apply a similar definition of this notion, extending it by an element connected with time required for restoring the continuity of the operation of the supply chain after disruptions appear.

Adequate management of supply chain velocity has a great impact on its efficiency and achieving a competitive advantage [25]. Therefore, it is crucial to aim for maximising the velocity of the supply chain, also by means of:

– while selecting suppliers—concentration on their flexibility, i.e. the capability of immediate reaction, where requirements concerning various parameters of the order may change (e.g. the volume of the order) [13];
– proper selection of suppliers of key materials and services, i.e. accounting for such factors as: the distance between the supplier and the recipient's location, agreed penalties for non-provision of obligations, extra charges for accelerated deliveries, service quality standards etc. [14];
– process facilitation by means of their re-designing in order to reduce the number of operations and simultaneous execution of operations [13];
– aiming at minimising the batch volume (order volume, production batch volume or consignment volume) in order to focus on flexibility towards the economies of scale [13];
– minimising the time devoted to operations that, according to the customers, add no value [13];
– planning synchronisation in the entire supply chain [29, 31];
– establishing trust among partners in the supply chain, joint problem solving as well as facilitating quick access to information and resources necessary for proper reaction to non-standard events [34];
– replacing stocks with information to avoid potential stock shortages that denote lost opportunities, as well as excessive volume of stocks that generate unnecessary costs [14];
– data transmission in real time, which allows supply chain to limit the time required for order execution [56];
– sharing current information in the entire supply chain with the application of technologies used for electronic exchange of data, handling orders, tracking stocks, supplies etc. [29, 37].

The problem with ensuring adequate velocity in the functioning of the supply chain stems from two major reasons: its structure and priorities determined by enterprises that operate within it. The first element primarily refers to situations, where large distances between the partners' locations cause lengthened time of order execution. The second reason, on the other hand, results from the concentration of specific enterprises on their business activity, regardless of the interests of all participants in the supply chain [29].

4.3 Versatility

In the light of changing market conditions and customer requirements, supply chains must be ready to ensure flexibility and changeability of the executed operations [51]. Therefore, another feature of supply chains that is crucial in terms of acquiring and maintaining competitive advantage is versatility [46, 52]. This feature mainly involves balancing the operational capability of the supply chain with the market needs, in particular providing adequate products and services of the required quality and volume. It is also vital to adapt the offer to the individual needs of customers.

Supply chain versatility is expressed in the aptitude to cooperate with suppliers and recipients in the context of various conditions of delivery execution. This feature means the ability to maintain the operational continuity of the supply chain in particularly unfavourable conditions of the environment (e.g. high level of inflation, changes in legal provisions, unstable political situations, natural disasters etc.). Versatility also involves flexibility in the field of operational conditions. On the one hand, it is the capability of adjusting to the requirements of various suppliers, on the other—the potential to satisfy the needs of various clients [62].

Aiming for satisfying individual, frequently specific customer requirements engages maximising the variety of products offered. This is also affected by the development of technologies and the products' shortened lifecycle. Adapting the product range to the requirements of various customers by means of applying such methods as: mass individualisation, customised designs, customised configuration and postponing assembly are also connected with managing variability in the supply chain [58].

Many authors treat the notion of versatility solely as the number of various products offered to customers, but they should be understood to a greater extent. This is due to the fact that it can be executed by means of e.g. introducing diverse product features, in particular packaging, diversification in the scope of distribution channels etc. [40]. As supply chains function in the international market, the need for versatility does not solely result from the will to satisfy specific customer requirements, but also the necessity to adjust products to the legal requirements of various countries, specific climates, languages etc. [48].

5 Research Methodology

5.1 Development of the Survey Instrument

The construction of the measuring tool was initiated with drawing up a list of indicators and metrics of supply chain performance that were cited in the literature and also applied in the business practice. Next, the authors 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. In effect, an initial set of statements in the questionnaire was drawn up. The list of indicators was limited on the basis of the principle “less is better” [12], 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 1). 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”.

5.2 Sample and Data Collection

The research was conducted using the CATI (computer assisted telephone interviews) technique. Interviews were conducted with the management staff on the basis of a structured questionnaire, the work is based on positivist paradigm. The research sample consisted of 200 Polish companies (from all Polish voivodeships) employing 50 or more employees of which 63% were medium-sized enterprises employing less than 250 employees and 37% of large enterprises employing more than 250 employees. Companies are representatives of four sectors of economy: 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 research sample was selected in a quota random way (Table 1). The percentage of denials or unsuccessful contact attempt is 81%.

The analysis of the gathered data was conducted at two stages. Firstly, the set of indicator variables selected for measuring supply chain performance was subject to the exploratory factor analysis (EFA). The aim of EFA is to obtain a minimum number of factors that contain the maximum possible amount of information contained in the original variables used in the model, and with the greatest possible reliability [55]. The use of exploratory factor analysis allows the identification of a small number of latent variables (factors) that cannot be measured directly but are presented by observable indicators [35]. Next, based on the obtained results, a confirmatory factor analysis (CFA) was conducted, which again involved the

Table 1 Information according research sample (n = 200)

Sector of economy	Number of companies (% n)	Number of denials or unsuccessful contact attempts (% n)
Automotive	50 (25%)	373 (44%)
Food	50 (25%)	140 (16%)
Furniture	50 (25%)	152 (18%)
Consumer electronics and household appliances	50 (25%)	192 (22%)
Total	200 (100%)	857 (100%)

Source own elaboration

modification of the set of indicator variables by means of deleting those that appeared statistically insignificant or inaccurate (factor load values did not meet expectations). Data were analysed using IBM SPSS Statistic version 23.0.

6 Analyses and Results

The analysis of the gathered data was initiated with an exploratory factor analysis. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.911, indicating a good sample size [73]. Bartlett's test of sphericity was significant ($\chi^2(253) = 1959.426$, $p < 0.000$) which indicating the variables are correlated enough for an EFA analysis—is bigger than the suggested minimum values of 0.5 [17] and 0.6 [64]. The number of factors to retain was decide using the Kaiser rule (retain factors with eigenvalues higher than 1) and scree plot analysis (Cattell's scree test). For a four-factor solution, a factor analysis was conducted with the use of a Principal Axis Factoring. The rotation of the obtained factor solution involved a method of oblique rotation Oblimin with the *Delta* parameter equalling 0. With the use of the factor loadings matrix, insignificant indicators were deleted, namely those that to no factor had a factor loading equalling the absolute value larger than 0.3 [9]: SCP14, and SCP15. Also ambiguous indicators were eliminated, namely those that had significant (though frequently relatively low) loadings for several factors: SCP16, SCP12, SCP22, SCP13, and SCP8. The final rotated factor matrix for the EFA is presented in Table 2. The use of EFA enabled the identification of four factors related to supply chain performance, namely: Responsiveness, Versatility, Visibility, and Velocity. These are three factors from the 3V formula supplemented by a brand new factor—Responsiveness.

The reliability analysis for each extracted factor (measurement scale) was made using Cronbach's alpha. In all cases Cronbach's alpha is higher than 0.60—Cronbach's alphas were 0.792, 0.718, 0.776 and 0.819 for Factors 1, 2, 3 and 4 respectively. Cronbach's alpha greater than 0.6, especially with a small number of questions, means that the set of observable variables (measured directly on Likert scale) is a reliable instrument for latent variable measurement. All the developed scales demonstrated reliabilities above the recommended threshold range of 0.6–0.7 [50].

The structure obtained in the EFA framework was verified with the use of a confirmatory factor analysis, which was aimed at evaluating a factor model that binds selected factors with constructs they are to measure. The values of the model parameters were assessed with the GLS method. In order to obtain a solution that is best suited to data, in the light of generally accepted matching criteria, the following variables with the lowest values of factor loadings (below 0.6) and with explained variances (below 0.4) were eliminated from specific factors: SCP1, SCP7, SCP6, SCP3, and SCP9.

The quality assessment of the model engaged a series of goodness-of-fit. The authors 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

Table 2 EFA of supply chain performance

	Factor 1 Responsiveness	Factor 2 Versatility	Factor 3 Visibility	Factor 4 Velocity
SCP11	**0.860**	−0.058	-0.079	0.033
SCP3	**0.597**	0.149	0.113	−0.004
SCP10	**0.595**	−0.154	−0.160	−0.227
SCP23	**0.511**	−0.035	0.081	−0.063
SCP9	**0.421**	−0.054	0.202	−0.073
SCP1	**0.348**	−0.083	0.175	−0.001
SCP18	0.006	**−0.887**	0.109	0.042
SCP17	0.070	**−0.504**	0.000	−0.185
SCP2	0.261	0.154	**0.637**	0.013
SCP5	0.074	−0.148	**0.611**	−0.002
SCP4	0.076	−0.149	**0.595**	−0.001
SCP6	−0.060	0.070	**0.567**	−0.144
SCP7	0.017	−0.163	**0.408**	−0.060
SCP21	−0.019	0.054	0.007	**−0.960**
SCP20	0.100	−0.074	−0.019	**−0.702**
SCP19	0.021	−0.047	0.179	**−0.517**
Variance explained (%)	34.229	6.439	4.707	4.424

Bold characters indicate highly significant correlations between the factors and corresponding variables.
Source own elaboration

the model is very good when this value is smaller than 2; if it oscillates between 2 and 5—the model is considered as acceptable [18]. In the assessed model the value χ^2/df equals 1.259. The good fit of the model is also confirmed by the RMSEA equals 0.036. It is assumed that the model is acceptable if the approximation error does not exceed 0.08 [39] and good (adequate) if the value is below 0.05 [18].

Good model fit is also confirmed by such measures as CFI = 0.948, GFI = 0.959, AGFI = 0.924, which exceed the required value of 0.9 [10, 39]. Only the NFI = 0.808 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 [28]. For the assessed model, the TLI exceeded the acceptance threshold and equals 0.921.

The next stage of model assessment was evaluating the theoretical validity, which involved determining the convergent validity and discriminant validity. The convergent validity is connected with the convergence of indicators measuring the same construct, and the discriminant validity helps to assess whether the indicators correlate too strongly with the measures of other constructs.

The convergent validity was evaluated on the basis of three criteria: (1) values of factor loadings (>0.7) and their significance; (2) reliability analysis: Cronbach's

Table 3 Assessment of reliability

Factor	Questionnaire statements	Standardised factor loadings	Cronbach's α	CR
Responsiveness	SCP11: The supply chain has the capacity to deliver products to the final customer exactly on time	0.740	0.729	0.801
	SCP10: The supply chain guarantees a short time from the moment of order placement to the execution of the delivery	0.831		
	SCP23: In the supply chain the level of customer satisfaction is analysed	0.696		
Versatility	SCP18: The supply chain is capable of providing products in different variants	0.807	0.718	0.750
	SCP17: The supply chain can handle non-standard orders and satisfy special customer requirements	0.742		
Visibility	SCP2: The supply chain is characterised by considerable planning accuracy	0.645	0.749	0.767
	SCP5: The supply chain can detect the appearing problem connected with order execution and deal with them	0.768		
	SCP4: In the supply chain, it is possible to track and monitor order fulfillment and related resource flow	0.753		
Velocity	SCP21: The supply chain can swiftly implement product improvements	0.850	0.819	0.856
	SCP20: The supply chain can swiftly launch a new product on the market	0.853		
	SCP19: The supply chain can quickly adapt its production capacity so as to accelerate or slow down production in its reaction to decreasing demand	0.739		

Source own elaboration

alpha and the CR reliability coefficient for specific constructs (>0.7); (3) the average variance extracted (AVE)(>0.5). Standardised factor loadings in the analysed model met the required criterion; merely two (with the SCP2 and SCP23) obtained values slightly below 0.7. All factor loadings are statistically significant (Table 3).

The results of the reliability analysis (on the basis of α-Cronbach and CR) indicate high coherence of items comprising the scales that measure four dimensions of the supply chain performance. Also the AVE was used to measure convergent reliability. Its value smaller than 0.5 means that on average there remains

Table 4 Fornell-Larcker criterion

	AVE	Responsiveness	Versatility	Visibility	Velocity
Responsiveness	0.574	(0.76)			
Versatility	0.601	0.561	(0.78)		
Visibility	0.524	0.625	0.518	(0.72)	
Velocity	0.665	0.623	0.580	0.597	(0.82)

The square root of the average variance extracted (AVE)—in brackets
Source own elaboration

more of error at the positions constituting the structure of the latent variable than the extracted variance [57]. The AVE for specific latent variables reached values from 0.524 to 0.665 (Table 4). The above results confirm that the convergent validity for all constructs is high.

The discriminant validity involved the Fornell-Larcker test, which focuses on verifying whether the AVE square root for each construct is higher than the correlations between the factors [19]. At the matrix diagonal (numbers in brackets) was filled with the AVE square root values for constructs, whereas the numbers outside the diagonal are the values of relevant correlation coefficients (Table 4). The criterion is satisfied if the number at the diagonal is highest in comparison with other numbers from own verse and column [32]. All latent variables met the described criterion.

Summarising the obtained results, it can be argued that the conditions for satisfying the model's theoretical validity are sufficient.

7 Discussion

The scale for measuring the supply chain performance that resulted from the conducted research includes four factors. Each of them portrays a different performance aspect of the adaptive supply chain, and variables that are connected with a given factor measure the level of a specific feature of a supply chain.

The first factor, called Supply Chain Responsiveness, is associated with such indicators as "The supply chain guarantees a short time from the moment of order placement to the execution of the delivery", "The supply chain has the capacity to deliver products to the final customer exactly on time", and "In the supply chain the level of customer satisfaction is analysed". This construct has no equivalent in a specific feature that complies with the 3V formula. This factor primarily refers to the aspects of the supply chain responsiveness connected with getting familiarised with customer needs as well as reaction to them (delivering products fast and in a timely manner). Lee [41] and Whitten et al. [70] wrote about creating adaptive supply chains by means of analysing the needs of both direct as well as final customers. Still, Szymczak [62] claimed that responsiveness to the needs of a customer is one of the three major directions in the evolution of supply chains (apart from flexibility and resistance to disruptions) that result from the adaptive capacity. The first factor also referred to the time of order execution as well as their timely delivery, as e.g. Basu and Wright argued [5].

The second factor, Supply Chain Versatility, includes such items as "The supply chain is capable of providing products in different variants", and "The supply chain can handle non-standard orders and satisfy special customer requirements". In its essence, this factor is close to the third element of the 3V formula—versatility. 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 [51]. It also has the capacity to adapt to the requirements of various suppliers and is capable of satisfying individual, specific customer requirements [62]. This factor is also associated with the variety of the offered products that may be executed by means of e.g. implementing various product features, special packaging, diversity in terms of distribution channels, etc. [40, 58].

Another factor, Supply Chain Visibility contains such items as "The supply chain can detect the appearing problem connected with order execution and deal with them", "In the supply chain, it is possible to track and monitor order fulfillment and related resource flow", and "The supply chain is characterised by considerable planning accuracy". 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 [59]. 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 [31]. 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 [62].

The fourth factor separated on the basis of the conducted factor analysis is Supply Chain Velocity. This construct includes such factors as "The supply chain can swiftly implement product improvements", "The supply chain can swiftly launch a new product on the market", and "The supply chain can quickly adapt its production capacity so as to accelerate or slow down production in its reaction to decreasing demand". In its content, this factor is approximate to the second element of the 3V formula—velocity. This construct 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 [67]. On the one hand, such velocity refers to implementing changes: the development of the currently offered products and launching new products [25]; on the other—it is associated with the ability to react to diverse events and changes on the market [36].

8 Conclusions

Adaptability as virtue enabling adjusting to all the more challenging operational conditions is one of the paramount factors that guarantee supply chains' long-term competitiveness and success. Adaptive supply chains are capable of adapting to: changes in environment, changes in the executive environment. They have the features of flexibility, responsiveness and resilience what could be considered/ reflected from a managerial perspective by the 3V formula relating to its visibility, velocity and versatility. Undoubtedly, this way of thinking can be seen as a shortcut and it really is one, but it shows in a simple way how pragmatic and utilitarian 3V formula supports management to achieve one of the most desired strategic goals for a supply chain, namely adaptability.

The goal of this paper was the elaboration of the set of metrics for supply chain performance measurement that could be used in case of adaptive supply chains. According to the conducted research the scale for measuring the supply chain performance should be expanded to four factors, namely responsiveness, versatility, velocity, and visibility (3V + R formula). Those findings support general view that adaptive supply chains are characterised by the transparency, high level of flexibility and capacity to adapt to the requirements of suppliers as well as the capacity to execute various processes and measures aimed at achieving the desired goals in a fast manner. Moreover, analyses reveal that 3 V formula need to be supplemented by yet another factor called responsiveness that relates to reaction to customer needs (delivering products fast and in a timely manner).

The scale could be used for the performance measurement of smart supply chains. It that case, however, smartness could be understood as the feature supporting supply chain adaptiveness and performance improvement. New emerging technologies, such as IoT and BigData, support information management and supply chain integration what in turn help to adjust to changing surrounding and consumer needs. Today's smart supply chain is able to capture and communicate real time data, can operate (almost) in real-time and can even anticipate customers behaviour. In the last stage smart supply chains will evolve into self-adaptive supply chains that fully rely on digital solutions and powered by artificial intelligence will be perceived as self-driving.

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Appendix 1

Questionnaire statements

Statement	Source
SCP1: The supply chain is able to limit stocks	Based on Whitten et al. [70]
SCP2: The supply chain is characterised by considerable planning accuracy	Based on Tarasewicz [65]
SCP3: The supply chain is capable of limiting wastefulness	Based on Whitten et al. [70]
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 Juttner and Maklan [36]
SCP6: The demand forecasts developed in the supply chain are accurate	Based on (Arif-Uz-Zaman and Ahsan [2]
SCP7: The supply chain is characterised by a large volume of mutual contacts with partners	Based on Qrunfleh and Tarafdar [54]
SCP8: The supply chain is able to foresee abrupt changes	Based on Szymczak [62]
SCP9: The supply chain can minimise total costs of delivering the product to the final customer	Based on Beamon [6]
SCP10: The supply chain guarantees a short time from the moment of order placement to the execution of the delivery	Based on Jűttner & Maklan [36]
SCP11: The supply chain has the capacity to deliver products to the final customer exactly on time	Based on Beamon [6]
SCP12: The supply chain contains a mechanism for eliminating the execution of delayed, incomplete and damaged deliveries	Based on Whitten et al. [70]
SCP13: The supply chain is capable of quick reactions and solving problems raised by the final customer	Based on Tarasewicz [65]
SCP14: The supply chain is characterised by a high level of orders that can be executed immediately from the current stocks	Based on Chae [12]
SCP15: In the supply chain receivables are swiftly paid	Based on Chae [12]
SCP16: The supply chain ensures a short reaction time in terms of customer enquiry	Based on Beamon [6]
SCP17: The supply chain can handle non-standard orders and satisfy special customer requirements	Based on Qrunfleh and Tarafdar [54]
SCP18: The supply chain is capable of providing products in different variants	Based on Qrunfleh and Tarafdar [54]
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 and Tarafdar [54]

(continued)

(continued)

Statement	Source
SCP20: The supply chain can swiftly launch a new product on the market	Based on Qrunfleh and Tarafdar [54]
SCP21: The supply chain can swiftly implement product improvements	Based on Qrunfleh and Tarafdar [54]
SCP22: The supply chain offers a wide range of post-sales services	Based on Golrizgashti [21]
SCP23: In the supply chain the level of customer satisfaction is analysed	Based on Beamon [6]

References

1. Ahmed, A. M. (2002). Virtual Integrated Performance Management. *International Journal of Quality and Reliability Management, 19*(4), 414–441.
2. Arif-Uz-Zaman, K., & Ahsan, A. M. M. N. (2014). Lean supply chain performance measurement. *International Journal of Productivity and Performance Management, 63*(5), 588–612.
3. Ayers, J. B. (2004). *Supply chain project management. A structured collaborative and measurable approach*. Boca Raton: St. Lucie Press.
4. Barratt, M., & Oke, A. (2007). Antecedents of supply chain visibility in retail supply chains: A resource-based theory perspective. *Journal of Operations Management, 25*(6), 1217–1233.
5. Basu, R., & Wright, J. N. (2008). *Total supply chain management*. United Kingdom: Elsevier.
6. Beamon, B. M. (1999). Measuring supply chain performance. *International Journal of Operations & Production Management, 19*(3), 275–292.
7. Bititci, U. S., Carrie, A. S., & McDevitt, L. (1997). Integrated performance measurement systems: A development guide. *International Journal of Operations and Production Management, 17*(5), 522–534.
8. Boin, A., Kelle, P., & Whybark, D. (2010). Resilient supply chains for extreme situations: Outlining a new field of study. *International Journal of Production Economics, 126*(1), 1–6.
9. Bradley, N. (2013). *Marketing research: Tools and techniques*. Oxford: Oxford University Press.
10. Brown, T.A. (2015). *Confirmatory factor analysis for applied research* (2nd ed.). New York: The Guilford Press.
11. Butner, K. (2010). The smarter supply chain of the future. *Strategy & Leadership, 38*(1), 22–31.
12. Chae, B. (2009). Developing key performance indicators for supply chain: An industry perspective. *Supply Chain Management: An International Journal, 14*(6), 422–428.
13. Christopher, M., & Peck, H. (2004). Building the resilient supply chain. *The International Journal of Logistics Management, 15*(2), 1–14.
14. Clark, C. (2007). Getting back to basics: Top five tips for accelerating supply chain velocity. *Supply & Demand Chain Executive, 8*(4), 26.
15. D'Aveni, R. (1995). *Hyper-competitive rivalries: Competing in highly dynamic environments*. New York: FreePress.
16. De Toni, A., & Tonchia, S. (2001). Performance measurement systems. Models, characteristics and measures. *International Journal of Operations and Production Management, 21*(1–2), 46–70.
17. Field, A. (2009). *Discovering statistics using SPSS*. London: SAGE Publications.

18. Fischer, C. (2013). Trust and communication in European agri-food chains. *Supply Chain Management: An International Journal, 18*(2), 208–218.
19. Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18*(1), 39–50.
20. Giovannoni, E., & Maraghini, M. P. (2013). The challenges of integrated performance measurement systems. Integrating mechanisms for integrated measures. *Accounting, Auditing and Accountability Journal, 26*(6), 978–1008.
21. Golrizgashti, S. (2014). Supply chain value creation methodology under BSC approach. *Journal of Industrial Engineering International, 10*(67), 1–15.
22. Gunasekaran, A., Patel, C., & McGaughey, R. E. (2004). A framework for supply chain performance measurement. *International Journal of Production Economics, 87*(3), 333–347.
23. Gunasekaran, A., Patel, C., & Tirtiroglu, E. (2001). Performance measures and metrics in a supply chain environment. *International Journal of Operations and Production Management, 21*(1–2), 71–87.
24. Heinemann, G. (2017). Online-Handel der Zukunft. *Der neue Online-Handel* (pp. 1–33). Wiesbaden: Springer Gabler.
25. Hines, T. (2013). *Supply chain strategies: Demand driven and customer focused*. New York: Routledge.
26. Holcomb, M. C., Ponomarov, S. Y., & Manrodt, K. B. (2011). The relationship of supply chain visibility to firm performance. *Supply Chain Forum: An International Journal, 12*(2), 32–45.
27. Holmberg, S. (2000). A systems perspective on supply chain measurements. *International Journal of Physical Distribution and Logistics Management, 30*(10), 847868.
28. Hooper, D., Coughlan, J., & Mullen, M. (2008). Structural equation modelling: guidelines for determining model fit. *Electronic Journal of Business Research Methods, 6*(1), 53–60.
29. Hudnurkar, M., & Rathod, U. (2012). Collaborative supply chain: insights from simulation. *International Journal of System Assurance Engineering and Management, 3*(2), 122–144.
30. Ivanov, D., Sokolov, B., & Kaeschel, J. (2010). A multi-structural framework for adaptive supply chain planning and operations control with structure dynamics considerations. *European Journal of Operational Research, 200*(2), 409–420.
31. Iyer, A., Seshadri, S., & Vasher, R. (2009). *Toyota supply chain management: A strategic approach to Toyota's renowned system*. New York: McGraw-Hill Education.
32. Janssen, S., Moeller, K., & Schlaefke, M. (2011). Using performance measures in innovation control. *Journal of Management Control, 22*(1), 107–128.
33. Johansson, S., & Melin, J. (2008). *Supply chain visibility. The value of information. A benchmark study of the Swedish industry*. Stockholm: KTH Royal Institute of Technology.
34. Johnson, N., Elliott, D., & Drake, P. (2013). Exploring the role of social capital in facilitating supply chain resilience. *Supply Chain Management: An International Journal, 18*(3), 324–336.
35. Jung, S. (2013). Exploratory factor analysis with small sample sizes: a comparison of three approaches. *Behavioural Processes, 97,* 90–95.
36. Jűttner, U., & Maklan, S. (2011). Supply chain resilience in the global financial crisis: An empirical study. *Supply Chain Management: An International Journal, 16*(4), 246–259.
37. Kalakota, R., Robinson, M., & Gundepudi, P. (2003). Mobile applications for adaptive supply chain: A landscape analysis. In E. Lim & K. Siau (Eds.), *Advances in mobile commerce technologies, Idea Group Inc* (pp. 298–312). USA: Hershey.
38. Kang, Y.-S., Park, I.-H., & Youm, S. (2016). Performance prediction of a MongoDB-based traceability system in smart factory supply chains. *Sensors, 16*(12).
39. Kersten, W., Blecker, T., & Meyer, M. (Eds.). (2009). *Supply chain performance management*. Berlin: Erich Schmidt Verlag.
40. Kohlberger, R., Gerschberger, M., & Engelhardt-Nowitzki, C. (2011). Variety in supply networks—Definitions and influencing parameters" In: Fang, C. H. (Ed.), *Proceedings of the 6th International Congress on Logistics and SCM systems, Kaohsiung, Taiwan* (pp. 191–203), March 07–09, 2011.

41. Lee, H. L. (2004). The triple-A supply chain. *Harvard Business Review, 82*(10), 102–112.
42. Lee, Y., & Rim, S-Ch. (2016). Quantitative model for supply chain visibility: process capability perspective. *Mathematical Problems in Engineering, 2016,* 1–11.
43. Lockamy, A., & McCormack, K. (2004). The development of a supply chain management process maturity model using the concepts of business process orientation. *Supply Chain Management: An International Journal, 9*(4), 272–278.
44. Markman, G. D., & Phan, P. H. (2011). *The competitive dynamics of entrepreneurial market entry*. Cheltenham: Edward Elgar Publishing Limited.
45. McGrath, R. M. (2013). Transient advantage. *Harvard Business Review* 64–70.
46. Momeni, E., Tavana, M., Mirzagoltabar, H., & Mirhedayatiane, S. M. (2014). A new fuzzy network slacks-based DEA model for evaluating performance of supply chains with reverse logistics. *Journal of Intelligent and Fuzzy Systems, 27*(2), 793–804.
47. Nam, T., & Pardo, T. A. (2011). Conceptualizing smart city with dimensions of technology, people, and institutions. In *Proceedings of the 12th Annual International Digital Government Research Conference on Digital Government Innovation in Challenging Times*.
48. Nielsen, N. P. H., & Holmström, J. (1995). Design for speed: A supply chain perspective on design for manufacturability. *Computer Integrated Manufacturing Systems, 8*(3), 223–228.
49. Noori, H., & Lee, W. B. (2002). Factory-on-demand and smart supply chains: The next challenge. *International Journal of Manufacturing Technology and Management, 4,* 372–383.
50. Nunnally, J. C., & Bernstein, I. H. (1994). *Psychometric theory*. New York: McGraw-Hill.
51. Nutt, B. (2004). Infrastructure resources: Forging alignments between supply and demand. *Facilities, 22*(13/14), 335–343.
52. Olugu, E. U., & Wong, K. Y. (2009). Supply chain performance evaluation: Trends and challenges. *American Journal of Engineering and Applied Sciences, 2*(1), 202–211.
53. Poirier, Ch C. (2002). Achieving supply chain connectivity. *Supply Chain Management Review, 6*(6), 16–22.
54. Qrunfleh, S., & Tarafdar, M. (2014). Supply chain information systems strategy: Impacts on supply chain performance and firm performance. *International Journal of Production Economics, 147,* 340–350.
55. Rossoni, L., Engelbert, R., & Bellegard, N. L. (2016). Normal science and its tools: Reviewing the effects of factor analysis in management. *Revista de Administração (RAUSP), 51*(2), 198–211.
56. Ruhi, U., & Turel, O. (2005). Driving visibility, velocity and versatility: The role of mobile technologies in supply chain management. *Journal of Internet Commerce, 4*(3), 95–117.
57. Ryciuk, U. (2016). *Zaufanie międzyorganizacyjne w łańcuchach dostaw w budownictwie*. Warszawa: Wydawnictwo Naukowe PWN.
58. SAP. (2002). *Adaptive supply chain networks*. http://www.carlosabrantes.com/4/upload/sapadaptivesc.pdf. Accessed January 18, 2018.
59. Scholten, K., & Schilder, S. (2015). The role of collaboration in supply chain resilience. *Supply Chain Management: An International Journal, 20*(4), 471–484.
60. Simchi-Levi, D., Kaminsky, P., & Simchi-Levi, E. (2000). *Designing and managing the supply chain. Concepts, strategies, and case studies*. Boston: McGraw-Hill/Irwin.
61. Swaminathan, J. M., & Tayur, S. R. (2003). Models for supply chains in e-business. *Management Science, 49*(10), 1387–1406.
62. Szymczak, M. (2015). *Ewolucja łańcuchów dostaw*. Poznań: Wydawnictwo Uniwersytetu Ekonomicznego w Poznaniu.
63. Szymczak, M. (2014). Smart convenience in food supply chains. In: *The International Forum on Agri-Food Logistics "Agri-Food Logistics as a Chance of Efficient Consumer Response in the Agri-Food Sector, Poznań* (pp. 178–180).
64. Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics*. Boston: Pearson.
65. Tarasewicz, R. (2014). *Jak mierzyć efektywność łańcuchów dostaw?* Szkoła Główna Handlowa – Oficyna Wydawnicza, Warszawa.
66. Tjahjono, B., Esplugues, C., Ares, E., & Pelazez, G. (2017). What does Industry 4.0 mean to supply chain? *Procedia Manufacturing, 13,* 1175–1182.

67. Tsironis, L. K., & Matthopoulos, P. P. (2015). Towards the identification of important strategic priorities of the supply chain network. *Business Process Management Journal, 21* (6), 1279–1298.
68. Upton, J. (2017). Setting sights on the smart supply chain. *Pharmaceutical Executive*, *37*(3).
69. van Hoek, R. I. (1998). Measuring the unmeasurable—Measuring and improving performance in the supply chain. *Supply Chain Management: An International Journal, 3*(4), 187–192.
70. Whitten, G. D., Green, K. W., & Zelbst, P. J. (2012). Triple-A supply chain performance. *International Journal of Operations & Production Management, 32*(1), 28–48.
71. Wilhjelm, R. (2013). *Revisiting the 3Vs of supply chain: Visibility, variation and velocity*. http://www.scdigest.com/experts/ComplianceNetworks_13–10-17.php?cid=7489. Accessed January 18, 2018.
72. Williams, B. D., Roh, J., Tokar, T., & Swink, M. (2013). Leveraging supply chain visibility for responsiveness: The moderating role of internal integration. *Journal of Operations Management, 31*(7–8), 543–554.
73. Wipulanusat, W., Panuwatwanich, K., & Stewart, R. A. (2017). Exploring leadership styles for innovation: An exploratory factor analysis. *Engineering Management in Production and Services, 9*(1), 7–17.
74. Wu, L., Yue, X., Jin, A., & Yen, D. C. (2016). Smart Supply Chain Management: A review and implications for future research. *The International Journal of Logistics Management, 27,* 395–417.
75. Zhang, A. N., Goh, M., & Meng, F. (2011). Conceptual modelling for supply chain inventory visibility. *International Journal of Production Economics, 133*(2), 578–585.