BUSINESS, MANAGEMENT AND EDUCATION
ISSN 2029-7491 / eISSN 2029-6169
2016, 14(1): 103–115
doi:10.3846/bme.2016.317

CATEGORIES OF SUPPLY CHAIN PERFORMANCE INDICATORS: AN OVERVIEW OF APPROACHES

Dorota LEOŃCZUK

Faculty of Management, Bialystok University of Technology,
Wiejska 45A, 15-351 Bialystok, Poland
E-mail: d.leonczuk@pb.edu.pl

Received 03 October 2015; accepted 16 May 2016

Abstract. The increasing complexity of supply chains, whose structure is changing from a linear to network form creates the need to track a growing amount of information allowing the evaluation of the functioning of the entire supply chain. Developing a system for measuring the performance of the supply chain requires the proper selection of indicators. Performance measurement should be done in a particular context, the analysed dimensions of indicators resulting from the purpose and focus of the survey should be determined. The article reviews Polish and foreign literature in terms of the proposed framework and methods for measuring the performance of the supply chain and the indicated categories (dimensions) of indicators. The authors approach the subject of evaluation of the performance of the supply chain in very different ways. Indicators are divided according to the level of the decision-making process: strategic, tactical, and operational. They are also divided into cost and non-cost or financial and non-financial ones. There are also approaches using the already well established methods and models. An example of this is the selection of perspectives according to the Balanced Scorecard (BSC) and the SCOR model.

Keywords: supply chain, performance measurement, indicators, categories, dimensions.

JEL Classification: L20.

1. Introduction

The increasing complexity of supply chains, whose structure is changing from a linear to a network form, creates the need to track a growing amount of information allowing the evaluation of the functioning of the entire supply chain. Achievement and maintenance of an adequate level of supply chain performance is becoming a major source of sustainable advantage in many industries, due to the increasing competition between supply chains. Supply chain performance is the ability of the supply chain to (Whitten *et al.* 2012):

– provide products and services of appropriate quality in specific quantities and at the appointed time, and;
– minimize the total cost of products and services to the final customer in the supply chain.

Creating and developing a system for measuring the performance of the supply chain requires the proper selection of indicators. Performance measurement should be done in a particular context, the analysed dimensions of indicators resulting from the purpose and focus of the survey should be determined. The article presents: (i) the concept of supply chain performance, (ii) a framework for measuring the performance of the supply chain and its role in supply chain management, (iii) review of the Polish and foreign literature in terms of the proposed framework and methods for measuring the performance of the supply chain and the indicated categories (dimensions) of indicators.

2. The concept of supply chain performance

Supply chain performance is defined as the ability of the supply chain to deliver the right product to the correct location at the appropriate time at the lowest cost of logistics (Zhang, Okoroafo 2015). This definition takes into account the time of delivery, cost, and value for the end consumer. The authors believe that this definition includes the most important aspects of the supply chain (Zhang, Okoroafo 2015). There are three basic criteria of performance evaluation (Estampe 2014):

- efficacy – the relationship between the achieved results and the pursued objectives; it is related to the level of customer satisfaction with respect to the resources committed for this purpose;
- efficiency – the relationship between efforts and resources involved in the operation and the actual utility value as a result of the action; it is linked to the achievement of objectives at a lower cost;
- effectiveness – is related to the satisfaction with the results.

Supply chain performance is the ability (of the entire supply chain) to meet end-customer needs, associated with ensuring the availability of product, deliver it on time in the right way and ensure appropriate inventory levels. It also exceeds the functional boundaries of organizations, i.e. production, distribution, marketing and sales, research and development. The functioning of the supply chains should be constantly improved. Therefore, measures to support the improvement of the performance of the global supply chain should be used, not only those that relate to the individual companies and their functions (Hausman 2004).

Performance measurement is defined as the process of quantifying the efficiency and effectiveness of the undertaken actions. Effectiveness is understood as the degree of fulfilment of customer expectations, while efficiency is a measure of the extent to which business assets are used to provide a given level of customer satisfaction (Neely *et al.* 1995). In turn, the performance measuring system should be understood as a set of indicators used to quantify the efficiency and effectiveness of operations (Shepherd, Günter 2012).

Performance measurement system may be analysed on three different levels:

- individual performance indicators;
- a set of performance indicators (as a whole);
- the relationship between the performance measurement system and the environment in which it operates.

The relationships between them are shown in Figure 1.

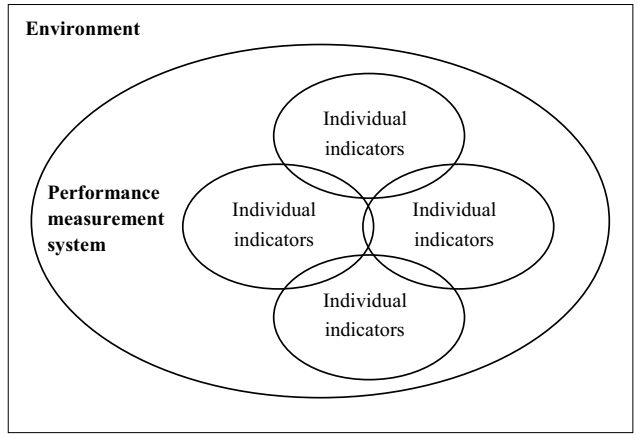

Fig. 1. A framework for performance measurement system design (source: Neely *et al.* 1995)

The fundamental objectives of performance measurement systems include (Akyuz, Erkan 2010; Parker 2000):

- identification of success;
- monitoring of the degree of meeting customer expectations;
- better understanding of the processes taking place in the company and its environment;
- identification of bottlenecks, wastage, problems and opportunities for development;
- making decisions based on facts, not on assumptions or emotions;
- creating conditions for development;
- tracking the progress of the introduction of improvements;
- facilitation of open communication and cooperation.

The development of a performance measurement system of the supply chain requires the proper selection of indicators. An important practical problem is the analysis of too many indicators (sometimes hundreds), which greatly hinders their interpretation. Furthermore, it stresses the lack of their relationship with the organization's and the supply chain's strategies (Shaw, Grant 2010). Supply chain performance management (SCPM) has become one of the key ways of achieving perfection. SCPM aims to provide information and insight into the functioning of the supply chain by tracking key indicators, for example product quality, inventory levels etc. (Louw, Goedhals-Gerber 2014).

A well-organized system for measuring the performance of the supply chain is crucial for better supply chain management. It is necessary to identify problems, areas of measurement, and relationships between economic operators. In addition, the right tools and measurement methods should be chosen (Dobroszek 2012). Performance measurement as part of supply chain management (Fig. 2) has an impact on the effective planning, controlling, monitoring and conducting analyses of logistics processes. It provides relevant information on costs, profits and results presented in the form of appropriate reports useful in decision-making.

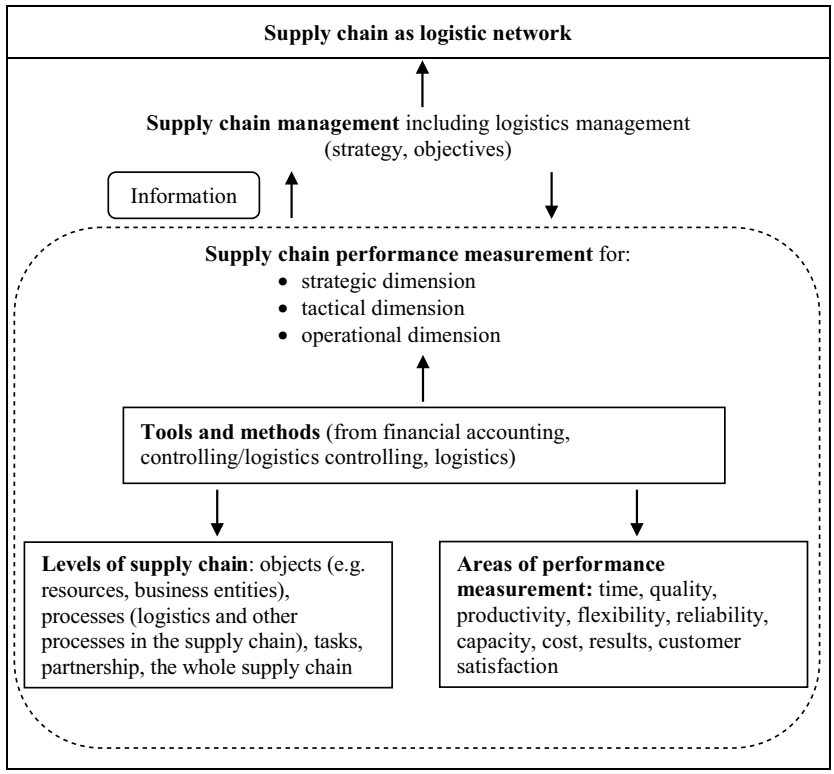

Fig. 2. Performance measurement as a part of management in supply chain (source: Dobroszek 2012)

An adequate performance measurement system helps to identify problem areas. Performance measurement is crucial in managing the organization in a turbulent environment and competitive global markets. An appropriate set of metrics enable companies to observe the progress in implementing the strategy, identify areas that need improvement, as well as compare themselves with competitors and leaders. They provide the necessary information for managers so they can take the right decisions at the right time. One of the most important problems associated with performance measuring is attempt to analyse too many indicators, hundreds of them which, however, are not related to the company's strategy (Shaw, Grant 2010). Performance measurement should be performed in a particular context, the analysed dimensions of indicators resulting from the purpose and focus of the measurement should be determined.

3. Categories of supply chain performance indicators

Developing a framework for assessing the performance of the supply chain requires certain assumptions, including the ones related the areas of its measurement. The catalogue

of selected categories of indicators proposed in literature, which can be used to assess the performance of the supply chain is shown in Table 1.

Table 1. The categories/dimensions of the supply chain performance indicators (source: own)

Source	Categories/Dimensions	Framework
Shepherd, Günter 2012; Chan *et al.* 2003	qualitative, quantitative	–
Gunasekaran *et al*. 2004	strategic, tactical, operational	decision level
De Toni, Tonchia 2001	cost and non-cost: time, quality, flexibility	–
Neely *et al.* 1995; Elrod *et al.* 2013; Arif-Uz-Zaman, Ahsan 2014; Bozarth, Handfield 2007	time, cost, flexibility, quality	–
Shepherd, Günter 2012	time, cost, flexibility, quality, innovativeness	–
Chimhamhiwa *et al.* 2009	cost, time, quality, technological innovation, society, customer satisfaction	–
Angerhofer, Angelides 2006; Beamon 1999	resources, output, flexibility	–
Cai *et al.* 2009	resource, output, flexibility, innovativeness, information	–
Cho *et al.* 2012	financial, competitiveness, quality of service, flexibility, resource utilization, innovation	service supply chain
Ganga, Carpinetti 2011	reliability, flexibility, responsiveness, cost, assets	SCOR metrics focus on five performance attributes
Golrizgashti 2014; Rodriguez-Rodriguez *et al.* 2010	financial, internal processes, innovation and improvement, customers	balanced scorecard perspectives
Bullinger *et al.* 2002	financial, customer, organisational, innovation (for each supply chain perspective, customer perspective, function perspective)	balanced scorecard perspectives
Gunasekaran *et al*. 2004; Chae 2009	plan, source, make, deliver	SCOR model
Shepherd, Günter 2012; Arif-Uz-Zaman, Ahsan 2014	planning and product design (plan), supplier (source), production (make), delivery (deliver), customer (return)	SCOR model

End of Table 1.

Source	Categories/Dimensions	Framework
Zailani *et al.* 2012	operations, economic, social, environment	the extent of implementation of sustainable supply chain
RajaGopal 2009	customer orientation, distribution, internal operations, supply	–
Kowalska 2011	quality, delivery, total cycle time, loss	–
Witkowski 2010	added value and customer satisfaction, cost of operations, financial results, added value of the chain	–
Kisperska-Moroń 2006	logistics, production, purchasing, new product development, customer order management, supply chain diagnostics	used in IBM
van Hoek 1998	cost effectiveness, integration, customer service	–
Otto, Kotzab 2003	system dynamics, operational research, logistics, marketing, organization, strategy	–
Carvalho, Azevedo 2012	operational performance, economic performance	–
Anand, Grover 2015	transport optimization, inventory optimization, information technology optimization, resource optimization	retail supply chain

Based on review of literature it may be noted that the authors look at the problem of assessing the performance of the supply chain from different angles. They distinguish indicators according to the level of the decision-making process: strategic, tactical, and operational (Gunasekaran *et al*. 2004). They are also divided into cost and the non-cost ones (De Toni, Tonchia 2001) or qualitative and quantitative (Shepherd, Günter 2012; Chan *et al.* 2003). Examples of qualitative measures can be customer satisfaction, flexibility, information and material flow integration, effective risk management, supplier performance. Among the quantitative measures authors indicate (Chan *et al.* 2003):

1. Associated with the cost: cost, sales, profit, inventory investments maximisation;
2. Associated with the customer: product lateness, fill rate, customer response time, lead time;
3. Related to productivity: capacity utilisation, resources utilisation.

In literature there are also approaches using the already well known methods and models. An example of this is the selection of perspectives according to the Balanced Scorecard (BSC) proposed by Kaplan and Norton (Fig. 3): financial, internal processes, innovation, improvement, and customers (Bullinger *et al.* 2002; Golrizgashti 2014; Rodriguez-Rodriguez *et al.* 2010). This method is used frequently to assess the company's activities on the strategic level, but it can also be used in supply chain management.

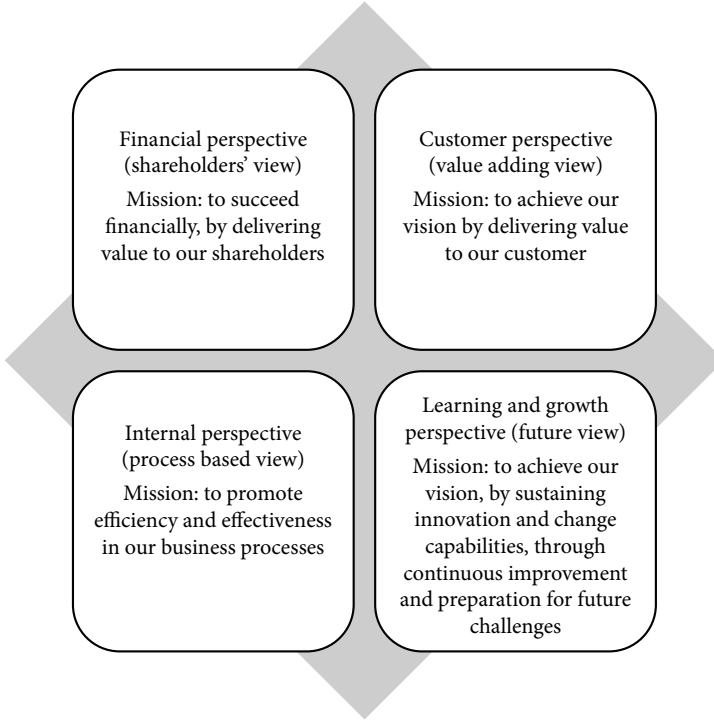

Fig. 3. The four perspectives in a balanced scorecard (based on Golrizgashti 2014)

The measurement concept in the form of the SCOR model (Supply Chain Operations Reference Model), proposed by the American Supply Chain Council Association is also often used (Shepherd, Günter 2012; Arif-Uz-Zaman, Ahsan 2014; Gunasekaran *et al*. 2004; Chae 2009). This model is designed for the management of business processes extending beyond the limits of one a single company. In this model indicators relate to the following aspects: planning, sourcing, manufacturing, delivery and returns. It also takes into account five performance attributes: reliability, responsiveness flexibility, cost and asset management efficiency, which are described in Figure 4 (Ganga, Carpinetti 2011).

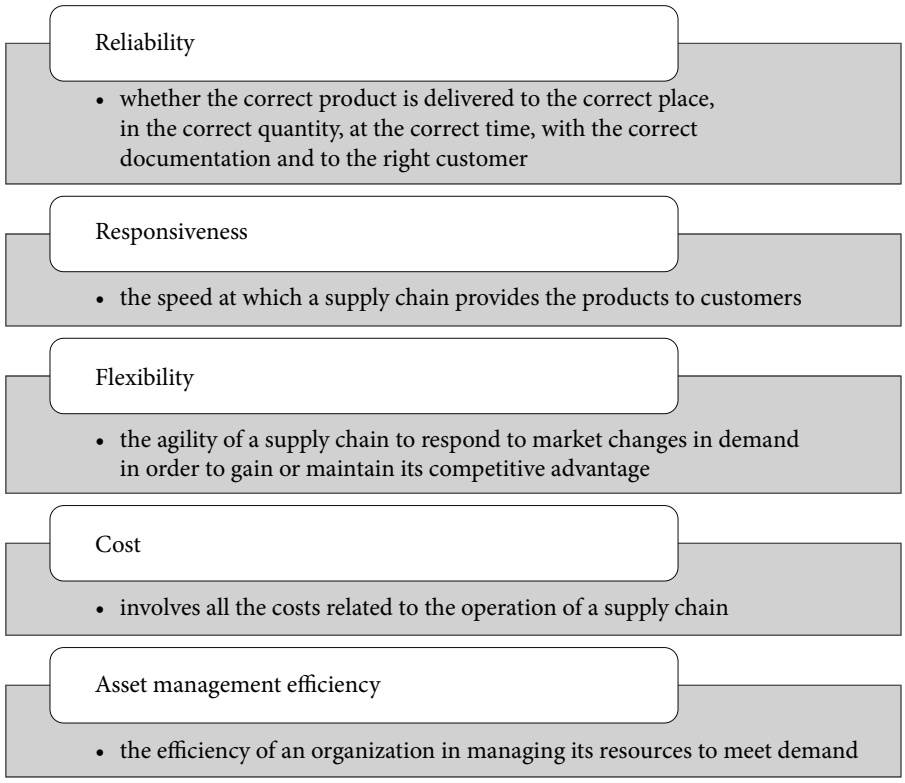

Fig. 4. The five performance attributes used in a SCOR model (based on Ganga, Carpinetti 2011)

In the article (De Toni, Tonchia 2001) authors identified two types of performance measurement systems: traditional cost performances (the production costs and the productivity) and more innovative non-cost measures (quality, time, and flexibility). Traditional performances are related to the results of the company, for example profitability or net income. The second group are measured by non-monetary units of measure. In addition to these four categories of performance (cost, time, flexibility and quality), authors also propose innovativeness (Shepherd, Günter 2012).

Moreover, many authors agree that a measurement system should use three types of measures: flexibility, resource, and output. Resource measures, can help to minimize costs, and maximize resource utilisation. The goal of them is to ensure a high level of cost efficiency. The next category, which measure the outputs of a supply chain, attempt to provide means to optimise performance. Flexibility measures are used to measure the supply chain's ability to cope with volume and schedule variations from customers and suppliers (Angerhofer, Angelides 2006; Beamon 1999). These measures have different objectives and purpose which is shown in Table 2.

Table 2. Goals and purpose of performance measure categories (source: Beamon 1999)

Performance measure type	Goal	Purpose
Resources	High level of efficiency	Impact on profitability
Output	High level of customer service	Avoiding the transition of customers to other supply chains
Flexibility	Ability to respond to a changing environment	Quick response to changes

The study described in the article (Zailani *et al.* 2012) investigates the extent of implementation of sustainable supply chain management practices (environmental purchasing and sustainable packaging), and also the outcomes of these practices on sustainable supply chain performance. Factor analysis of the survey data (survey was carried out among 400 manufacturing firms in Malaysia) resulted in four categories of outcomes:

1. Economic, covering the following items:
   – Sales and market share;
   – Waste and its disposal costs;
   – Resources management efficiency.
2. Environmental, covering the following items:
   – Compliance to environmental standards;
   – Consumption for hazardous/harmful/toxic materials;
   – Energy consumption.
3. Social, covering the following items:
   – Image in the eyes of its customers;
   – Relations with community stakeholders, e.g. community activists, and non-governmental organizations (NGO);
   – Product image.
4. Operational, covering the following items:
   – Manufacturing operating cost;
   – Response time to unexpected fluctuations in demand;
   – Reaction to changes to the competitors' product offerings;
   – Inventory turnover rate;
   – Perfect order fulfilment.

In the article (RajaGopal 2009) author analyses the issue of supply chain performance measurement, based on research conducted in the Indian market. The supply chain performance has been measured by identified variables in four major elements of supply chain: supply, internal operations, distribution, and customer service.

Kisperska-Moroń cites a number of approaches to the performance measurement systems. One of them is a set of indicators used in IBM, recommended by APQC and Council of Supply Chain Management Professional, collected in the following areas

of activity: logistics, production, purchasing, new product development, customer order management, and supply chain diagnostics (Kisperska-Moroń 2006).

(Carvalho, Azevedo 2012) describe agile and resilient approaches to supply chain management. They differentiate two dimensions of supply chain performance: economic and operational. Figure 5 provides an overview of operational and economic measures that can be used to evaluate the influence of the agile and resilient approaches on supply chain performance.

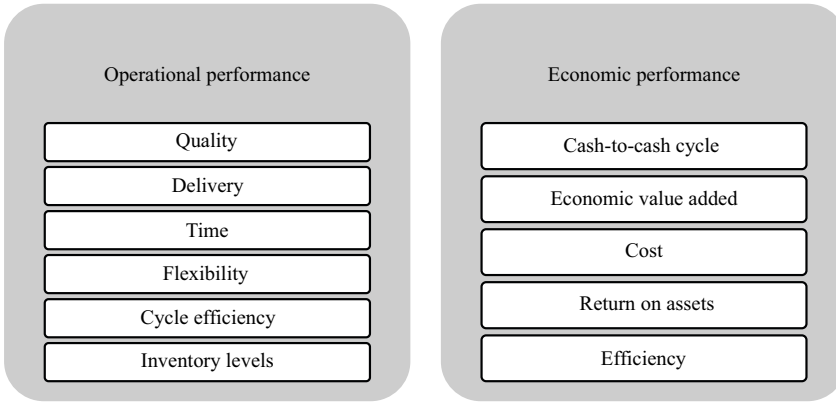

Fig. 5. Measures to evaluate the influence of agile and resilient approaches on supply chain performance (source: based on Carvalho, Azevedo 2012)

4. Conclusions

The performance measurement system should be adapted to the specific needs of each supply chain. Proper selection of a set of indicators, and their dimensions helps to identify problem areas, and is crucial in managing the organizations and whole supply chains in a turbulent environment and competitive global markets. An adequate system of performance measurement, taking into account the strategies of the company and the supply chain, provides the necessary information for decision-makers.

The multitude of indicators mentioned in literature (there are as many a few hundred) makes it necessary to introduce certain measurement assumptions. Therefore, this may be the cause of the diverse approach to this issue in the literature.

The developed catalogue of the categories of indicators can help the process of selecting the dimensions of performance measurement, both for individual companies, and entire supply chains. Only taking into account a sufficient number of dimensions allows to obtain a comprehensive picture of performance.

The developed in the article catalogue of categories of indicators that can be used to assess the performance of a supply chain is not exhaustive, but may be a prelude to further research. It is necessary to carry out a more extensive analysis of the proposed

indicators and their categories, as well as expand it with information concerning the fact whether the dimensions of performance specified in the work have been verified using statistical methods and expert knowledge.

Funding

The research were conducted within S/WZ/1/2014 project and were financed from Ministry of Science and Higher Education funds.

References

Akyuz, G. A.; Erkan, T. E. 2010. Supply chain performance measurement: a literature review, *International Journal of Production Research* 48(17): 5137–5155. http://dx.doi.org/10.1080/00207540903089536

Anand, N.; Grover, N. 2015. Measuring retail supply chain performance, *Benchmarking: An International Journal* 22(1): 135–166.

Angerhofer, B. J.; Angelides, M. C. 2006. A model and a performance measurement system for collaborative supply chains, *Decision Support Systems* 42: 283–301. http://dx.doi.org/10.1016/j.dss.2004.12.005

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. http://dx.doi.org/10.1108/IJPPM-05-2013-0092

Beamon, B. M. 1999. Measuring supply chain performance, *International Journal of Operations & Production Management* 19(3): 275–292. http://dx.doi.org/10.1108/01443579910249714

Bozarth, C.; Handfield, R. B. 2007. *Wprowadzenie do zarządzania operacjami i łańcuchem dostaw: kompletny podręcznik logistyki i zarządzania dostawami*. Gliwice: Helion.

Bullinger, H.-J., *et al.* 2002. Analysing supply chain performance using a balanced measurement method, *International Journal of Production Research* 40(15): 3533–3543. http://dx.doi.org/10.1080/00207540210161669

Cai, J.; Liu, X.; Xiao, Z.; Liu, J. 2009. Improving supply chain performance management: a systematic approach to analyzing iterative KPI accomplishment, *Decision Support Systems* 46: 512–521. http://dx.doi.org/10.1016/j.dss.2008.09.004

Carvalho, H.; Azevedo, S. G. 2012. Agile and resilient approaches to supply chain management: influence on performance and competitiveness, *Logistics Research* 4: 49–62. http://dx.doi.org/10.1007/s12159-012-0064-2

Chae, B. 2009. Developing key performance indicators for supply chain: an industry perspective, *Supply Chain Management: An International Journal* 14(6): 422–428.

Chan, F. T. S.; Qi, H. J.; Chan, H. K.; Lau, H. C. W.; Ip, R. W. L. 2003. A conceptual model of performance measurement for supply chains, *Management Decision* 41(7): 635–642. http://dx.doi.org/10.1108/00251740310495568

Chimhamhiwa, D.; van der Molen, P.; Mutanga, O.; Rugege, D. 2009. Towards a framework for measuring end to end performance of land administration business process – a case study, *Computers, Environment and Urban Systems* 33: 293–301. http://dx.doi.org/10.1016/j.compenvurbsys.2009.04.001

Cho, D. W.; Lee, Y. H.; Ahn, S. H.; Hwang, M. K. 2012. A framework for measuring the performance of service supply chain management, *Computers & Industrial Engineering* 62: 801–818. http://dx.doi.org/10.1016/j.cie.2011.11.014

De Toni, A.; Tonchia, S. 2001. Performance measurement systems – models, characteristics and measures, *International Journal of Operations & Production Management* 21(1/2): 46–71. http://dx.doi.org/10.1108/01443570110358459

Dobroszek, J. 2012. Review of sample concepts of supply chain performance measurement, *Zeszyty Teoretyczne Rachunkowości* 68(124): 21–43.

Elrod, C.; Murray, S.; Bande, S. 2013. A review of performance metrics for supply chain management, *Engineering Management Journal* 25(3): 39–50. http://dx.doi.org/10.1080/10429247.2013.11431981

Estampe, D. 2014. *Supply chain performance and evaluation models*. London: ISTE.

Ganga, G. M. D.; Carpinetti, L. C. R. 2011. A fuzzy logic approach to supply chain performance management, *International Journal of Production Economics* 134: 177–187. http://dx.doi.org/10.1016/j.ijpe.2011.06.011

Golrizgashti, S. 2014. Supply chain value creation methodology under BSC approach, *Journal of Industrial Engineering International* 10(67): 1–15. http://dx.doi.org/10.1007/s40092-014-0067-5

Gunasekaran, A.; Patel, C.; McGaughey, R. E. 2004. A framework for supply chain performance measurement, *International Journal of Production Economics* 87: 333–347. http://dx.doi.org/10.1016/j.ijpe.2003.08.003

Hausman, W. H. 2004. Supply chain performance metrics in T. P. Harrison, H. L. Lee, J. J. Neale (Eds.). *The practice of supply chain management: where theory and application converge.* Springer, US, 61–73. http://dx.doi.org/10.1007/0-387-27275-5_4

Kisperska-Moroń, D. (Ed.) 2006, *Pomiar funkcjonowania łańcuchów dostaw.* Katowice: Wydawnictwo Akademii Ekonomicznej im. Karola Adamieckiego w Katowicach.

Kowalska, K. 2011. Efektywność procesów logistycznych in K. Kowalska, S. Markusik (Eds.). *Sprawność i efektywność zarządzania łańcuchem dostaw*. Dąbrowa Górnicza: Wyższa Szkoła Biznesu w Dąbrowie Górniczej.

Louw, J.; Goedhals-Gerber, L. 2014. *Logistics and supply chain management. Research themes/focus areas.* Stellenbosch University.

Neely, A.; Gregory, M.; Platts, K. 1995. Performance measurement systems design: a literature review and research agenda, *International Journal of Operations & Production Management* 15(4): 80–116. http://dx.doi.org/10.1108/01443579510083622

Otto, A.; Kotzab, H. 2003. Does supply chain management really pay? Six perspectives to measure the performance of managing a supply chain, *European Journal of Operational Research* 144: 306–320. http://dx.doi.org/10.1016/S0377-2217(02)00396-X

Parker, C. 2000. Performance management, *Work Study* 49(2): 63–66. http://dx.doi.org/10.1108/00438020010311197

RajaGopal, A. 2009. Supply chain model: operational and financial performance, *Global Management Review* 4(1): 1–12.

Rodriguez-Rodriguez, R.; Alfaro Saiz, J. J.; Bas, A. O.; Carot, J. M.; Jabaloyes, J. M. 2010. Building internal business scenarios based on real data from a performance measurement system, *Technological Forecasting and Social Change* 77: 50–62. http://dx.doi.org/10.1016/j.techfore.2009.07.006

Shaw, S.; Grant, D. B. 2010. Developing environmental supply chain performance measures, *Benchmarking: An International Journal* 17(3): 320–339.

Shepherd, C.; Günter, H. 2012. Measuring supply chain performance: current research and future directions, in J. C. Fransoo (Eds.). *Behavioral Operations in planning and scheduling*. Berlin Heidelberg: Springer-Verlag.

van Hoek, R. I. 1998. Measuring the unmeasurable – measuring and improving performance in the supply chain, *Supply Chain Management* 3(4): 187–192. http://dx.doi.org/10.1108/13598549810244232

Whitten, G. D.; Green Jr, K. W.; Zelbst, P. J. 2012. Triple-A supply chain performance, *International Journal of Operations & Production Management* 32(1): 28–48. http://dx.doi.org/10.1108/01443571211195727

Witkowski, J. 2010. Zarządzanie łańcuchem dostaw: koncepcje, procedury, doświadczenia. Warszawa: Polskie Wydawnictwo Ekonomiczne.

Zailani, S.; Jeyaramana, K.; Vengadasana, G.; Premkumarb, R. 2012. Sustainable supply chain management (SSCM) in Malaysia: a survey, *International Journal of Production Economics* 140(1): 330–340. http://dx.doi.org/10.1016/j.ijpe.2012.02.008

Zhang, H.; Okoroafo, S. C. 2015. Third-party logistics (3PL) and supply chain performance in the Chinese market: a conceptual framework, *Engineering Management Research* 4(1): 38–48. http://dx.doi.org/10.5539/emr.v4n1p38

Dorota LEOŃCZUK. MA, lecturer in the Department of Business Informatics and Logistics on the Faculty of Management at Bialystok University of Technology. Main research interests: supply chain performance measurement and management, road transport.