CATEGORIES OF SUPPLY CHAIN PERFORMANCE INDICATORS: 
AN OVERVIEW OF APPROACHES

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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.

![Diagram](image-url)

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.
D. Leonczuk. Categories of supply chain performance indicators: an overview of approaches

### Supply chain as logistic network

Supply chain management including logistics management (strategy, objectives)

- **Information**

Supply chain performance measurement for:
- strategic dimension
- tactical dimension
- operational dimension

- **Tools and methods** (from financial accounting, controlling/logistics controlling, logistics)

Levels of supply chain: objects (e.g. resources, business entities), processes (logistics and other processes in the supply chain), tasks, partnership, the whole supply chain

Areas of performance measurement: time, quality, productivity, flexibility, reliability, capacity, cost, results, customer satisfaction

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)

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

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).
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.

Fig. 4. The five performance attributes used in a SCOR model (based on Ganga, Carpinetti 2011)
Table 2. Goals and purpose of performance measure categories (source: Beamon 1999)

<table>
<thead>
<tr>
<th>Performance measure type</th>
<th>Goal</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resources</td>
<td>High level of efficiency</td>
<td>Impact on profitability</td>
</tr>
<tr>
<td>Output</td>
<td>High level of customer service</td>
<td>Avoiding the transition of customers to other supply chains</td>
</tr>
<tr>
<td>Flexibility</td>
<td>Ability to respond to a changing environment</td>
<td>Quick response to changes</td>
</tr>
</tbody>
</table>

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 (Kiperska-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.

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