Management and Production Engineering Review
Volume 3 • Number 2 • June 2012 • pp. 79–88
DOI: 10.2478/v10270-012-0017-x

THE LITERATURE REVIEW OF SUPPLY CHAIN PERFORMANCE MEASUREMENT IN THE MANUFACTURING INDUSTRY

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Received: 10 February 2012
Accepted: 9 May 2012

Abstract
The article addresses the issues of Supply Chain (SC) performance measurement – the process of qualifying the efficiency and effectiveness of the supply chain. The aim of this study is to present a supply chain measurement approaches for manufacturing industry. The research is based on a review of the current understanding of supply chain management and literature related to supply chain performance measurement. This study creates a framework for supply chain measurement by presenting the main theory framework of supply chain performance measurement.
It is stated that supply chain performance measurement is extremely important in developing supply chain. The measurement framework in this study offers guidelines for measuring the supply chain in manufacturing industry.

Keywords
supply chain, performance measurement, supply chain management, manufacturing industry, strategy, operations.

Introduction

This paper addresses the problems of developing a Supply Chain (SC) performance measures in practice. The pressures in rationalizing set by management create a significantly large challenge for Supply Chain Management (SCM). The SC has to be made more streamlined, lead-times have to be decreased, excess processes need to be eliminated and developed as a whole in such a manner that new, more efficient processes can be established. The basis for development work is a survey of the present state and measuring efficacy of the current SC. Tools for this have been scarce. This study provides a resolution to the problems of measuring the SC.

The first part of article is a literature study of the available frameworks and points of view for the development of the supply chain performance measurement in the manufacturing industries. The second part draws a conclusion as a general framework to answer the research question about SC performance measurement framework.

Supply chain performance measurement approached

Process and management based metrics

Gunasekaran et al. [1] present that SCM performance measures can be divided into financial and non-financial measures. Top management needs financial measures for management level decisions, but lower management and workers need operational measures for daily business. [2] Gunasekaran presents a framework with the metrics of SC performance:

- Metrics for planning: order entry method, order lead-time, the customer order path.
- Evaluation of supply link, evaluation of suppliers, strategic level measures, tactical level measures, operational level measures.

- Measures and metrics at production level: range of product and services, capacity utilization, effectiveness of scheduling techniques.
- Evaluation of delivery link, measures for delivery performance evaluation, total distribution cost.
- Measuring customer service and satisfaction: flexibility, customer query time, post transaction measures of customer service
- SC and logistics cost: cost associated with assets and return on investment, information processing cost.

Gunasekaran et al. [1] state that there should be several kinds of measures to be used in performance metrics: balanced approach, strategic, tactical and operational levels and financial as well as non-financial measures. SCM could be measured in various management or operation levels. Strategic level measures influence the top management decisions and also very often reflect the investigation of broad based policies and level of adherence to organisational goals. The tactical level deals with resource allocation and measuring performance against targets to be met in order to achieve results specified at the strategic level. Operation level measurements and metrics require accurate data and decision is made by low level managers. In operational level, metrics are relevant for day to day business and hence the main metrics are time related and non-financial metrics. Non-financial metrics include such as order lead-time and delivery lead-time. Many of these metrics are time-related but also cost-related. These metrics are for top management for making strategic decisions as well as long-term plans and strategies [1, 2].

According to Gunasekaran, SCM performance metrics can be defined as in Table 1 [1, 2].

Table 1
SCM performance metrics

SCM performance metrics		
Strategic level	Tactical level	Operational level
Total SC cycle time, non-financial metrics	Accuracy of forecasting techniques, financial and non-financial metrics	Cost per operation hour, financial metrics
Total cash flow time, financial and non-financial metrics	Product development cycle time, non-financial metrics	Information carrying cost, financial and non-financial metrics
Customer query time, financial and non-financial metrics	Order entry methods, non-financial metrics	Capacity utilisation, non-financial metrics
Level of customer perceived value of product, non-financial metrics	Effectiveness of delivery invoice methods, non-financial metrics	Total inventory as financial metrics:
Net profit vs. productivity ratio, financial metrics	Purchase order cycle time, non-financial metrics	– Incoming stock level
Rate of return on investment, financial metrics	Planned process cycle time, non-financial metrics	– Work in progress
Range of product and services, non-financial metrics	Effectiveness of master production schedule, non-financial metrics	– Scrap level
Variations against budget, financial metrics	Supplier assistance in solving technical problems, non-financial metrics	– Finnish goods in transit
Order lead-time, non- financial metrics	Supplier ability to respond to quality problems, non-financial metrics	Supplier rejection rate, financial and non-financial metrics
Flexibility of service systems to meet particular customer needs, financial metrics	Supplier cost saving initiatives, financial and non-financial metrics	Quality of delivery documentation, non-financial metrics
Buyer-supplier partnership level, financial and non-financial metrics	Supplier booking in procedures, non-financial metrics	Efficiency of purchase order cycle time, non-financial metrics
Supplier lead-time against industry norm, non-financial metrics	Delivery reliability, financial and non-financial metrics	Frequency of delivery, non-financial metrics
Level of supplier's defect free deliveries, non-financial metrics	Responsiveness to urgent deliveries, non-financial metrics	Driver reliability for performance, non-financial metrics
Delivery lead-time, non-financial metrics	Effectiveness of distribution planning schedule, non-financial metrics	Quality of delivered goods, non-financial metrics
Delivery performance, financial and non-financial metrics		

Measures for supply chain actions

Shepherd [3] categorize SC performance measures into five SC processes: plan, source, make, deliver and return or customer satisfaction, whether they measure cost, time, quality, flexibility and innovativeness and whether they are quantitative or qualitative measures. As stated before, the measures can be categorized into business process at strategic, operational and tactical management levels.

The plan category measures are mainly cost and time based measures. Metrics are mainly quantitative measures. Cost-based measures are sales, profit, rate of return on investment, cost of goods sold and value added productivity. Time-based measures are, for example, total SC response time, order lead-time, order fulfillment lead-time, product development cycle time and percentage decrease in time to produce a product. In plan category there are also quality-based measures such as accuracy of forecasting techniques, fill rate, perceived effectiveness of departmental relations, order flexibility and also some flexibility and innovativeness measures.

The source category consists mainly of quality-based measures like buyer-supplier partnership level, level of supplier's defect-free deliveries, supplier rejection rate and extent of mutual planning cooperation leading to improved quality. These measures are mainly qualitative ones. There are also some cost- and time based measures.

The make category presents mainly cost-based measures like total cost of resources, manufacturing cost, inventory investment inventory obsolescence and work in process. In the make category the measures are mainly quantitative. There are also time-based measures like planned process cycle time, manufacturing lead-time, time required to produce a particular item tor set of items and also flexibility measures like production flexibility, capacity flexibility and volume flexibility.

The delivery category approaches are mainly cost-, time- and quality-based measures. These are mainly quantitative measures. Cost-based measures are total logistics cost, distribution cost, delivery costs and transport cost per unit of volume. Time based-delivery measures are, for example, delivery lead-time, average lateness of orders and percent of on-time deliveries.

Quality measures are delivery performance, delivery reliability, quality of delivered goods and flexibility measures are like delivery flexibility and transport flexibility. Return on investment category includes mainly quality measures such as customer satisfaction, level of customer perceived value of product, customer complaints and product quality.

Supply chain operations reference model

The supply chain operations reference (SCOR) model was introduced in 1996 by the Supply-Chain Council, which is a global organization of firms interested in SCM. The SCOR model is a business process reference model and it provides a framework that includes SC business processes, metrics, best practices, and technology features. The SCOR model attempts to integrate the concepts of BPR, benchmarking, process measurement as well as best practice analysis and apply them to SC's. According ..Theeranuphattana [4] the SCOR model offers users the following benefits:

- standard descriptions of management processes that make up the SC,
- a framework of relationships among the standard processes,
- standard metrics to measure process performance,
- management practices that produce best-in-class performance, and
- standard alignment to software features and functionality that enable best practices.

Theeranuphattana [4] present that the SCOR model is based on five core processes: deliver, make, plan, return and source. The SCOR model advocates hundreds of performance metrics used in conjunction with five performance attributes: reliability, responsiveness, flexibility, cost, and asset metrics.

Supply Chain Council presents five attributes of SC performance [4]:

SC reliability. The performance of the SC in delivering the correct product to the correct place, at the correct time, in the correct condition and packaging, in the correct quantity, with the correct documentation, to the correct customer.

SC responsiveness. The speed at which a SC provides products to the customer.

SC flexibility. The agility of a SC in responding to marketplace changes to gain or maintain competitive advantage.

SC costs. The costs associated with operating the SC.

SC asset management. The effectiveness of an organization in managing assets to support demand satisfaction. This includes the management of the both assets: fixed and working capital.

Map model – framework

Lambert [5] present a "map model" – framework for developing SCM performance metrics. The framework consists of seven steps:

1. Map the SC and identify where the key linkages exist

2. Use the customer relationship management and supplier relationship management processes to analyze each link and determine where additional value can be created.

3. Develop customer and supplier profit and loss statements to assess the effect of the relationship on profitability and shareholder value of the two firms

4. Realign SC processes and activities to achieve performance objectives

5. Establish non-financial performance measures that align individual behavior with SC process objectives and financial goals

6. Compare shareholder value and market capitalization across firms with SC objectives and revise process and performance measures as necessary

7. Replicate steps at each link in the SC

Inventory, time, order fulfilment, quality, customer focus and customer satisfaction

Ramdas [6] present six approaches to measuring SC performance: inventory, time, order fulfilment, quality, customer focus and customer satisfaction. These approaches are defined as follows: inventory means inventory levels, inventory turns and inventory costs. Time is defined as product-development time, time to market and time to break even. Order fulfilment captures the extent to which a SC partner affects order-processing time and shipment accuracy. Quality is seen as continuous improvement made by SC partners. Customer focus captures the extent to which a SC partner influences contribution margin, value added and customer value. Customer satisfaction means that a SC partner influences end customer satisfaction and account penetration.

Six constructs approach

Li [7] identify six constructs of SCM practices: strategic supplier partnership, customer relationship, information sharing, information quality, internal lean practices and postponement. Strategic supplier partnership is a long-term relationship between an organization and its suppliers. It is designed to leverage the strategic and operational capabilities of individual participating organization to help it achieve significant ongoing benefits. Customer relationship includes managing customer complaints, building long-term relationships with customers and improving customer satisfaction. Close customer relationship is one device to differentiate from competitors and bring value to customers. Information sharing refers to the extent to which critical and proprietary information is communicated to one's SC partner. Information sharing is seen to be quite an important point in SCM research. Information quality refers to accuracy, timeliness, adequacy and credibility of information exchanged. This approach is connected very closely to information sharing. Sharing qualified information can lead to flexibility. Internal lean practices are the practices of eliminating waste in a manufacturing system. Waste is cost, tie, set-up times, small lot sizes and pull-production. LT and lean practices have become extremely important for effective SCM. Postponement means practice of moving forward one or more operations or activities to a much later point in the SC. In this context SCM activities include making, sourcing, delivering, time and postponement.

Li [7] identify performance outcomes as delivery dependability and time to market. Delivery reliability means capability of providing products to customer. Time to market means the time to introduce new products to market more quickly than competitors are able to do.

Internal and external time performance

According to Ghalayini [8], the time performance measurement approach is a new strategic performance measure that should be used to promote improvement. Time-based performance measurement has the limitation of over-emphasizing the role of time and not considering the impact of other operational performance measures with respect to time. In order to improve time performance, all operational performance measures should be measured, controlled and improved. They present the main time-based metrics that companies could use in different areas:

1. New product development includes time from idea to market; rate of new-product introduction.

2. Decision making includes: decision cycle time as well as the time lost when waiting for decisions to be made.

3. Processing and production includes: value added as percentage of total elapsed time; uptime yield; inventory turnover and cycle time.

4. Customer service includes: response time; quoted lead-time; percentage deliveries of time; and time from customer's recognition of need to delivery.

Toni [9] present several indicators of internal and external time performance. According to their research, time performance indicators in order of superiority are the following: time-to-market, distribution lead-times, delivery reliability, supplying lead-times, supplier delivery reliability, manufacturing lead-times, standard run times, actual run times, wait times, set-up times, move times, inventory turnover, order carrying-out times and flexibility. Time performances are divided into external and in-

ternal times. Internal times can be split into run and set-up times on one hand and wait and move times on the other. Externally-perceived time performances can be divided in three parts: system times (including supplying, manufacturing and distribution leas times), delivery speed and delivery reliability (both from suppliers and to customers) and time-to-market (or time required to develop a new product). These time measures presented are called time performance [9].

Furthermore, [9] state that performance can be present in four indicators: 1. cost/productivity, 2. time, 3. flexibility, 4. quality. First measure is cost-based and other three are non-cost performance measures. Cost-based performance include the following measures: affordability of the production cost, the productivity and the control of the working capital. Time is a performance measure which covers internal times and external times. Internal time stands for the time controlled by a firm but that is not perceived by a customer. External time is understood as the time that the customer perceives, such as delivery time and frequency of introducing new products. Performance measures in the quality approach are produced quality, perceived quality (customer satisfaction), in-bound quality (supplier's quality) and quality in terms of costs (cost of maintaining a high standard of quality). The most measured performance metrics are direct costs, labour productivity, the inventory and the net process times. Time-to-market, non-value-added times, delivery, quality produced and customer satisfaction are not measured as often [9].

System dynamics, operational research, logistics, marketing, organization and strategy

Otto [10] present six ways of measuring SCM capability. Main groups are system dynamics, operational research, logistics, marketing, organization and strategy. The idea of system dynamics is to manage trade-offs along the complete SC. Performance metrics are capacity utilization, cumulative inventory level, stock-outs, time lags, time to adapt and phantom ordering. The aim of operational research and information technology is to calculate optimal solutions within given degrees of freedom. Metrics are logistics costs per unit, service level and time to deliver. Logistic perspective target is to integrate generic processes sequentially, vertically and horizontally. In this category capability is measured by integration, lead-times, order cycle time, inventory level and flexibility. Marketing approach is to segment customers and connect them with the right channel. Measures are customer satisfaction, distribution cost per unit and market share/channel costs. Organization approach is to manage SC relations with measures of transaction costs, time to network, flexibility and density of relationships. The aim of the strategy perspective is to connect competencies and the ability to make profit. Performance metrics are time to network, time to market and ROI of focal organization.

Quantitative and qualitative measures

Chan [11] presents SCM performance measurement approach which consists of qualitative and quantitative measures. Quantitative measures are cost and resource utilization and qualitative measures are quality, flexibility, visibility, trust and innovativeness. Cost is one of the quantitative measures and it can be measured by distribution cost, manufacturing cost, inventory cost, warehouse cost, incentive cost and subsidy, intangible cost, overhead cost and sensitivity to long-term cost. Resource utilization means labor, machine, capacity, energy resource utilization and performance measurement investigates the percentage of excess or lack of that particular resource within a period. Optimization can save both time and money and it can minimize the size of the company as well as improve its performance.

Qualitative measures are quality, flexibility, visibility, trust and innovativeness. Time-based qualitative measures are the following: customer responses time, lead-time, on-time delivery, fill rate, stock out probability and accuracy. An especially important measure is lead-time which stands for the time required once the product began its manufacture until the time it is completely processed. Flexibility measurement metrics are divided into input, process, output and improvement categories. Input category is measured by labor and machine flexibility. Process flexibility is presented as material handling flexibility, routeing flexibility and operation flexibility. Output flexibility is presented as volume flexibility and mix flexibility. Delivery flexibility and improvement are divided into modification flexibility, new product flexibility and expansion flexibility. Visibility is measured by time and accuracy. Trust is measured by consistency, which means the percentage of late or wrong delivery to the next tier which leads to an inconsistent supply. Innovativeness is presented as a new launch of product and new use of technology [11].

Beamon [12] presents SCM performance measures in two groups: qualitative and quantitative, where customer satisfaction and responsiveness, flex-

ibility, supplier performance, and cost are presented. He identifies three types of measures: resources, output and flexibility. Beamon [13] also identifies two performance measures: cost and combination of cost and customer responsiveness. Cost consists of inventory costs and operating costs. Customer responsiveness measures include lead-time, stock out probability and fill rate.

Beamon [13] identifies new SCM performance framework, in which there are three separate types of performance measures: resource measures, output measures and flexibility measures. The goal of the resource measures is a high level of efficiency and the purpose of the resource measures is efficient resource management that is critical to profitability. The general goal of the resources is resource minimization. Resource performance measures include total cost of resources used, total distribution cost, total cost of manufacturing, costs associated with held inventory and return on investment (ROI). The goal of output measure type is a high level of customer service and the purpose of output measurement is that without acceptable output, customers will turn to other SCs, without acceptable output. Output measures include customer responsiveness, quality and quantity of final product produced such as number of items produced, time required to produce a particular item or set of items, number of on-time deliveries, proportion of orders filled immediately, profit, sales, backorder/stock out, customer response time, manufacturing lead-time, shipping errors and customer complaints. Flexibility goal is the ability to respond to a changing environment and purpose is that in an uncertain environment, supply chains must be able to respond to challenges that emerge due to changes. Flexibility is presented in four categories: volume flexibility, delivery flexibility, mix flexibility and new product flexibility. A measure that is chosen in the performance measure type categories must coincide with the organization's strategic goals.

Innovative performance measurement method

Chan [14, 15] present an innovative performance measurement method. The aim of the method is to build up a measurement team and members should be from different organizations. SCM should be measured beyond the organizational boundaries rather than focusing locally. SCM can be categorized into six general processes which are linked together: supplier, inbound logistics, manufacturing, outbound logistics, marketing and sales and end customers.

Chan [14, 15] present input measures, output measures and composite measures. Input measures are time and cost. Time is a measurement for management performance and it is important for both internal and external customers. One important measure is operation time, which is closely related to customer satisfaction. Cost dimension is a measure for example labours capital, knowledge, facility and cost of scrap. Output measures include semi-finished products and finished products. Popular output measures are delivery reliability, and error-free and flexible production and new product introduction. Productivity, efficiency and utilization are performance measures. These measures are mainly operational performance measures which provide information regarding effectiveness of the management. The performance measurement team is composed of the representatives from various management areas of supply chain members. Members can be from shop floor, supervisors, manager and similar areas. The advantage of the members being from various management areas is that they have extensive skills to analyze performance in SCM [14–16].

Process based approach

With timely information, process-based measurement provides a great deal of support in enhancing integration and improvement of the cross-organizational processes. According to [11, 14], the main advantages of adopting process-based performance measurement in SCM are:

- Providing the opportunity of recognizing the problems in operations and taking a corrective action before these problems escalate.
- Facilitating linking with the operational strategies, identifying success, and testing the effect of strategies.
- Support in monitoring the progress.
- Assisting in directing attention of the management attention and resources allocation.
- Enhancing communication of process objectives involved in the supply chain, thus increasing trust and common understanding.

According to Chan, the steps and processes of analyzing and decomposing the process to be measured are the following [14]:

- Identifying and linking all the involved processes of internal- and intra-organization.
- Defining and confining the core processes.
- Deriving the missions, responsibilities and functions of the core processes.
- Decomposing and identifying the sub-processes.
- Deriving the responsibilities and functions of sub-processes.
- Decomposing and identifying the elementary activities of sub-processes.

- Linking goals to each hierarchy from processes to elementary activity.

Process-based approaches are cost, time, capacity, capability, productivity, utilization, and outcome. Cost is the financial expense for carrying out one event or activity. It is always one of the indispensable aspects in assessing the performance of the business activities and processes. Time is an important resource in modern business environments. Capacity is the ability of one specific activity to complete a task or perform a required function.. Capability measures include effectiveness, reliability, availability and flexibility measures. Utilization means the utilizing rate of the resources to carry out one specific activity. Outcome is the results or value added of one specific activity or event [14].

Balanced scorecard approach

Several researchers have proposed using Balanced ScoreCard (BSC) to measure SCM capability [1, 17–23].

Kaplan [24] presented BSC model to evaluate corporate performance in four types of approaches: the financial, the internal business process, the customer as well as learning and growth. The name of this concept comes from of a set of items that maintain a balance between short term and long term objectives, between financial and non-financial measures, between lagging and leading indicators and between internal and external performance perspectives. BSCs have two main approaches: customer perspective and financial perspective. Customer perspective, which is a value-adding view and financial perspective, is the shareholders' view. The approach mission of customer perspectives is to achieve vision by delivering value to customers. It is also an internal perspective (process-based view) and its aim is to promote efficiency and effectiveness in the business processes. Mission of financial perspective is to succeed financially, by delivering value to the shareholders and to achieve the vision, by sustaining innovation and change capabilities, through continuous improvement and preparation for future challenges. This approach has also learning and growth perspective in future view [24–26].Bhagwat and Sharma introduce BSC approach: financial metrics, customer perspective, internal business perspective as well as innovation and learning perspective. Financial performance measures the company's financial result. Profitability, growth in sales turnover and maximizing wealth of shareholders are also the metrics of BSC financial metrics. Evaluating customer perspective approach is to find out how customers see the business. Measures also include lead-time, quality of products and services, company's performance service and cost effectiveness. Internal business perspective measures business processes that have the greatest impact on customer's satisfaction factors. Innovation and learning perspectives can win efficiency to firm's operative business in the future [24–26].

According to Thakkar [27], SCOR and BSC are to ensure the greater effectiveness of PMS system on the following grounds:

- BSC does not provide a mechanism for maintaining the relevance of defined measures. SCOR adopts a building block approach and offers complete traceability.
- BSC fails to integrate top level, strategic scorecard, and operational level measures potentially making execution of strategy problematic. SCOR clearly defines the type of process (planning, execution and enabling) and configures them to suit the SC requirements.
- BSC fails to specify a user-centred development process. A detailed exercise on SCOR generates sufficient information to even develop tailor-made soft-ware system.

Thakkar present the SCOR-BSC framework that is related to various decision areas of SCOR model in Level 1. For each SCOR decision area various SC planning processes are considered. Level 2 SCOR category and an appropriate plan-source-make-deliver configuration are chosen by an individual organization. The processes determined at Level 2 are now decomposed to sub-processes at Level 3 and process element definition, inputs-outputs, process, and performance metrics are summarized. Analysis is carried out to gain understanding regarding the difference between the present scope of performance measurement and proposed scope of SCOR-BSC framework to derive a suitable implementation plan (at Level 4) [27].

Challenges for supply chain performance measurement

One of the main challenges in SCM performance measurement is that measures are mainly internal logistics performance measures and do not capture the way the SC has performed as a whole. Internal logistics measures such as fill rate, lead-time, on-time performance, damage and responsiveness do not measure the whole SCM performance [5].

There are some in-depth problems of PMSs in the SC context [1, 14]:

1. The lack of a balanced approach in integrating financial and non-financial measures.

2. The lack of system thinking, in which a SC must be viewed as a whole entity and the measurement system should span the entire SC.

3. The loss of the SC context.

According to Lin [28], there are four challenges in SC performance measurement. First, the majority of articles are focused on the study of intra-organizational performance – measures that do not measure SC performance as a whole. Secondly, the previous research did not consider the variation of measured values. The decision makers found it difficult to find real performance values, identify weak areas, take corrective actions, and make continual improvements. Thirdly, no common metrics existed for evaluating different processes on the same scale. Different characteristics of associated processes cannot be compared without using the correct metrics. Fourthly, the process teams should have motivation, capacity, and authority to improve processes and their results. Human attributes such as cooperation, skill, communication, etc. should have been considered as important dimensions of SC performance, but previous researches did not integrate these human attributes into the SC performance measurement model [28].

Almost every researcher states in their articles that SCM performance measurement is not studied enough. Furthermore, almost every researcher identifies that more research regarding SCM performance or capability measurement should be carried out. Research-related issues are the factors influencing the successful implementation of performance measurement systems [29, 30] the forces which shape the evolution of performance measurement systems [31, 32] and the way performance measurement systems are maintained over time so they remain aligned with dynamic environments and changing strategies [29, 31].

[2,34] state that problems in performance measurement frame of references include:

- Incompleteness and inconsistencies in performance measurement and metrics.
- Inability to represent a set of financial and non-financial measures in a balanced framework, some measures concentrating on financials, others concentrating on operational measures.
- Large number of metrics, makes it difficult to identify the critical few among trivial many.
- Inability to connect the strategy and the measurement.
- Biased focus on financial metrics.
- Too much inward looking.

Conclusion of supply chain performance measurement

According to the literature research, Supply Chain capability can be measured by using different kind of approaches. Chan [14] proposed a process-based PMS for mapping and analyzing complex SC networks; van Hoek [19] emphasizes the importance of performance measurement from the point of view of the third-party logistics alliances in SC; Gunasekaran [1] develop performance measures and metrics in a SC environment from a managerial point of view. Morgan (2004) offers nine preconditions necessary for effective and dynamic performance measurement within SC's. These preconditions include cheap and reliable identification of units in transition, standard protocols, communication systems that are capable of handling the volume of data, hardware and software, multi-layered control systems, system handshake protocols, routing and rerouting protocols that allow SC cost control, speed and flexibility of delivery response, high velocity electronic cash transfers instigated automatically; and robust systems with inbuilt automatic recovery abilities [35]. Thakkar [27] proposed a balanced scorecard (BSC) framework for a case organization using an integrated approach of interpretive structural modelling and analytic network process.

According to the literature review it is possible to nominate the following principal approaches for SC performance measurement:

- Management approach
- Time based approaches
- Quantitative and qualitative measures

Managerial approach

Gunasekaran [2] divide performance categories in SC activity/processes (plan, source, make/assemble, and deliver) and management approach to strategic, tactical and operational management perspectives. As stated before, measurement metrics were chosen based on a research in which companies were asked which of the metrics is the most important for their business. They further present that SCM performance can be measured in three different management levels. The levels are strategic, tactical and operational level. Strategic level measures performance for needs of top management. These measures are usually corporate level performance measures. The tactical levels measure performance against targets and also collect feedback from mid-management level. Operational level metrics require data that is relevant to low level management.

Time based approach

The time-based measuring approach seems to be one of the most wide-known SCM capability measures among researchers. Time is also identified as the important source of competitive advantage. Therefore it seems that even though time has been quite a common measure in SC performance it is still an accurate and useful measure. Lead-time, order cycle time, time-to-market and other time measures are actually relevant for every management level. Operational, tactical and strategic management are of interest for time measurement of SC performance. Time is the same for everyone and every company, every production line and all people and therefore it is easy to measure. When comparing cost or financial metrics and time, it is clear that time is a more stable measure than other financial metrics and cost. It is not possible to change the time currency like money.

Quantitative and qualitative measures

Chan [14, 15] presented SCM performance measurement approach which consists of qualitative and quantitative measures. Quantitative measures are cost and resource utilization, and qualitative measures are quality, flexibility, visibility, trust and innovativeness. Beamon [12] presents SCM performance measures in two groups – qualitative and quantitative – where customer satisfaction and responsiveness, flexibility, supplier performance, costs and other measurements for SC modelling are presented. As stated before, Beamon [13] identifies two performance measures: cost and combination of cost and customer responsiveness. Cost consists of inventory cost and operating costs. Customer responsiveness measures include lead-time, stock out probability and fill rate.

Conclusion

It is very clear that SC performance should be measured using various types of approaches. In measuring SC performance it seems to be relevant to use the following Supply Chain operations: plan, source, make, deliver and return. Furthermore, there should be financial and non-financial metrics as well as quantitative and qualitative measures. SCM should be measured at multiple levels [3]. It is important to develop more non-financial metrics due to the fact that these metrics can present more information than the basic financial metrics. The total SC performance measurement is challenging. However, even if it is challenging it is possible.

Further studies

After setting up the framework of Supply Chain performance measurement the framework should tested in scientific terms in real case situations. This would either a) approve the operationalization capabilities of the framework or b) give feedback for further studies and improvements in the framework.

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