

A Literature Analysis for Key Performance Indicators (KPI's) of Supply Chain

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Abstract—The purpose of this paper is to identify the key performance indicators (KPI's) responsible for supply chain's effective execution. The paper attempts to list these KPI's on the basis of literature review. Measuring or monitoring supply chain performance reveals the gap between planning and execution and helps companies to identify potential problems and areas for improvement. It is also recognized that developing key performance indicators (KPI's), or metrics, is very challenging as a set of practical guidelines is not readily available for the companies and supply chain management (SCM) practitioners.

Keywords—Key Performance Indicators, Supply Chain Performance, Supply Chain Management.

I. INTRODUCTION

The success of supply chain management (SCM) depends on, significantly on the closed-loop of planning and execution in regard to the process of minimizing possible gaps between planning and execution. In practice, it is impossible to remove such gaps entirely from one's supply chain. This is because the future cannot be fully known and hence decision-makers develop various operational plans under high uncertainty. Those in industry recognize this critical in operation and production planning. Thus, monitoring how planning and execution synchronization is critical for operational performance and SCM success. In this regard, SCM performance measurement or monitoring is the term for a set of metrics and processes related to assessing and evaluating how accurate the planning is and how well the execution is carried out. Despite its importance, however, putting performance measurement in place has always been a daunting task. Because of such reasons as the lack of incentives and top management support as well as an organizational culture unfavourable to performance measurement, developing a performance measurement tool set (also known as key performance indicators (KPIs) or metrics) involves a rather complicated process and can be very challenging for ordinary businesses. A typical firm already has a certain number of KPIs such as return on investment for assessing its financial performance, but supply chain related KPIs have not been widely adopted and businesses are typically uninformed of them. Companies often find that there is a lack of practical guidelines on how to develop KPIs. This seems to be in contrast to the fast adoption of various SCM related technologies and other best practices for the past decade.

II. LITERATURE REVIEW

A. Supply Chain Management

Supply chain management is the coordination of production, inventory, location, and transportation among the participants in a supply chain to achieve the best mix of responsiveness and efficiency for the market being served to fulfil the customer's request. The systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole. A supply chain is a network of facilities and distribution options that performs the functions of procurement of materials, transformation of these materials into intermediate and finished products, and the distribution of these finished products to customers. Supply chains encompass the companies and the business activities needed to design, make, deliver, and use a product or service. Businesses depend on their supply chains to provide them with what they need to survive. Every business fits into one or more supply chains and has a role to play in each of them. Those companies that learn how to build and participate in strong supply will have a substantial competitive advantage in their markets.

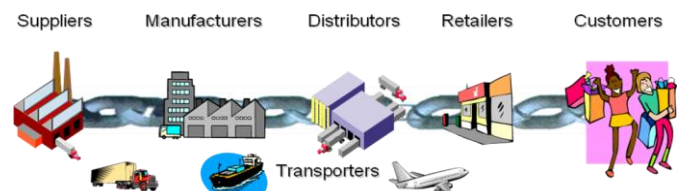


Figure.1 Supply Chain Network

B. Supply Chain Performance

Supply chain performance and effective management of supply chains have been increasingly recognized as critical factors in gaining competitive advantage for firms (Christopher, 1998; Simchi-Levi et al., 2000). Earlier studies on supply chain modelling utilized several different performance measures including cost, customer responsiveness, and activity time (e.g., Arntzen et al., 1995; Lee and Billington, 1993; Pyke and Cohen, 1994). Most of these studies had mainly relied on the use of cost as a primary measure of supply chain performance since it was

easier to implement in quantitative models. Beamon (1999) argued that the use of such simple performance measures that are limited in scope might be inconsistent with the strategic goals of an organization. The supply chain performance measurement system should not ignore any important tradeoffs among different objectives. Based on this argument, Beamon (1999) developed a framework for the selection of performance measures for supply chain systems. In this framework, three types of performance measures were identified as the necessary components of a supply chain performance measurement system: flexibility, resource, and output. Flexibility is the ability to respond changes. Supply chains should be evaluated based on their ability to respond any changes in products, delivery times, volume, and mix. Therefore, flexibility measures include new product flexibility, delivery flexibility, mix flexibility and volume flexibility. Resource measures are concerned with the efficiency in using the resources in a supply chain system. Resource measures include the costs of using several resources, inventory levels in the supply chain, and the return on investments. Output measures include customer satisfaction (in terms of on-time deliveries, order fill rate, and response times), sales quantities, and profit.

C. Supply Chain Performance Measurement

Performance measurement in the field of SCM is a very vital task. Timely and accurate assessment of overall system and individual system component performance is paramount. An effective performance measurement system (1) provides the basis to understand the system, (2) influences behavior throughout the system, and (3) provides information regarding the results of system efforts to supply chain members and outside stakeholders. In effect, performance measurement is the glue that holds the complex value-creating system together, directing strategic formulation as well as playing a major role in monitoring the implementation of that strategy. In addition, research findings suggest that measuring supply chain performance in and of itself leads to improvements in overall performance. In one study of U.S.-Mexican manufacturing operations, performance improvements were found in order cycle time reduction, routing and scheduling, and effective handling of border crossings of outbound freight. Another study found that implementation of performance measurement systems led to improvements in process cycle time, cost, quality, and delivery performance. Despite its importance, however, prior to 1990, supply chain performance often was measured in oversimplified and sometimes counterproductive (cost-reduction based) terms. Lack of an appropriate performance measurement system has been cited as a major obstacle to effective supply chain management.

D. Importance of Supply Chain Performance Measurement

The supply chain of any organization is the life line of that organization. The progress or decline of organization is depending on supply chain. In any organization there is always a need of improvement in every department & system. The extensity of improvement is decided by the performance of that department or system. Thus it is important to measure

the performance of supply chain as well. The supply chain is end to end i.e. Tier to end customer process. There are two types of supply chain internal & external. The performance measurement enables the organization to plan, measure & control its performance according to its predefined strategy. The performance measurement should consider the efficiency & effectiveness of supply chain. The system without performance measurement is nothing but aero plane without compass or a manager operating without strategy. The purpose of performance measurement is not only to know the system is performing but also to enable it to perform better. The ultimate aim of implementing the performance measurement system is to find out loop holes in the system & root causes of that & finally to improve the performance.

E. Developing Supply Chain Performance Measurement

The concept of SCM requires measuring overall supply chain performance rather than just the performance of the individual chain members. It is the combined performance of the supply chain, the final outcome of the efforts of all integrated members that is of greatest importance from a measurement perspective. Although measures of supply chain performance differ in terms of individual indicators employed, virtually all have one overriding focus continuous improvement of end customer service. After all, the final customer of the supply chain must be satisfied for the overall supply chain to succeed long-term. These customers care little about the time required to move materials between intermediate supply chain members or about the cost associated with this activity. The customer is concerned with the time required to meet its demands and the cost of doing so. This fundamental concern is reflected most generally in a desire to continually reduce total cycle time. A good performance measurement system also is "actionable." It allows managers not only to identify but also to eliminate causes of supply chain operational problems so that relationships with customers are not permanently harmed. Beyond these general customer-oriented aspects of effective supply chain performance measurement, researchers have stressed the desirability of assessing a wide variety of phenomena indicative of overall supply chain performance. These include measurement of (1) changes in both the average volume of inventory held and frequency of inventory turns across the supply chain over time, (2) the adaptability of the supply chain as a whole to meet emergent customer needs, and (3) the extent to which intra-supply chain relationships are based on mutual trust. Finally, effective measurement of supply chain performance entails looking beyond the integrated chain itself in a variety of ways.

III. GENERAL APPROACHES FOR SC MEASUREMENT

Traditionally, companies have tracked performance based largely on financial accounting principles, many which date back to the ancient Egyptians and Phoenicians. Financial accounting measures are certainly important in assessing whether or not operational changes are improving the financial health of an enterprise, but insufficient to measure supply chain performance for the following reasons:

- The measures tend to be historically oriented and not focused on providing a forward-looking perspective.
- The measures do not relate to important strategic, non-financial performance, like customer service/loyalty and product quality.
- The measures do not directly tie to operational effectiveness and efficiency.

In response to some of these deficiencies in traditional accounting methods for measuring supply chain performance, a variety of measurement approaches have been developed, including the following:

- The Balanced Scorecard
- The Supply Chain Council's SCOR Model
- The Logistics Scoreboard
- Activity-Based Costing (ABC)
- Economic Value Analysis (EVA)

A. The Balanced Scorecard

The Balanced Scorecard recommends the use of executive information systems (EIS) that track a limited number of balanced metrics that are closely aligned to strategic objectives. The approach was initially developed by Robert S. Kaplan and David P. Norton and was discussed in an article, titled "The Balanced Scorecard – Measures That Drive Performance," published in the *Harvard Business Review*, January-February 1992. While not specifically developed for supply chain performance measurement, Balanced Scorecard principles provide excellent guidance to follow when doing it. The approach would recommend that a small number of balanced supply chain measures be tracked based on four perspectives:

- Financial perspective (e.g., cost of manufacturing and cost of warehousing)
- Customer perspective (e.g., on-time delivery and order fill rate)
- Internal business perspective (e.g., manufacturing adherence-to-plan and forecast errors)
- Innovative and learning perspective (e.g., APICS-certified employees and new product development cycle time)

Industries have grown around the Balanced Scorecard approach with a variety of firms that provide consulting and solutions for implementing performance measurement, such as:

- Renaissance Worldwide, Inc. (Newton, MA) got its start doing this Balanced Scorecard consulting and grew to be one of the 30 largest consulting firms.
- Gentia Software Inc. (Boston, MA) markets a software application, Gentia's Renaissance Balanced Scorecard that incorporates Renaissance Worldwide's performance measurement approach.
- Corvu Corp. (Edina, MI) sells a Balanced Scorecard System software application that provides interactive scorecard functionality.

B. Supply Chain Council's SCOR Model

The Supply Chain Council's SCOR Model provides guidance on the types of metrics one might use to get a balanced approach towards measuring the performance of one's overall supply chain. The SCOR Model approach advocates a set of supply chain performance measures comprised of a combination of:

- Cycle time metrics (e.g., production cycle time and cash-to-cash cycle)
- Cost metrics (e.g., cost per shipment and cost per warehouse pick)
- Service/quality metrics (on-time shipments and defective products)
- Asset metrics (e.g., inventories)

In contrast to the Balanced Scorecard, which is focused on executive enterprise-level measurement, the SCOR Model approach directly addresses the needs of supply chain management with balanced measurements. Figure.2 depicts an illustrative set of supply chain measures balanced among the SCOR Model's top-level processes.

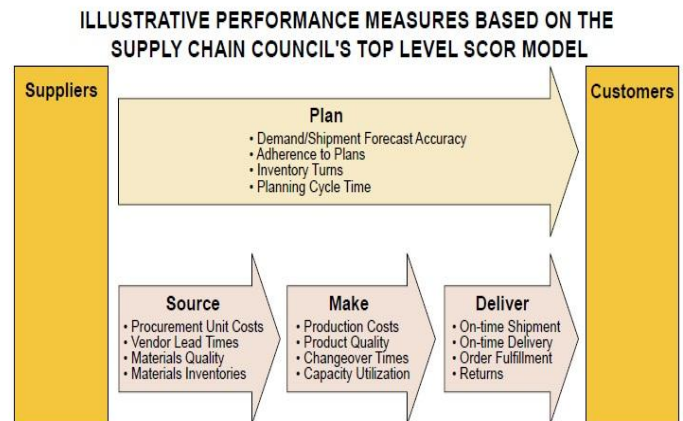


Figure.2 Illustrative Performance Measures

C. The Logistics Scoreboard

Another approach to measuring supply chain performance was developed by Logistics Resources International Inc. (Atlanta, GA), a consulting firm specializing primarily in the logistical (i.e., warehousing and transportation) aspects of a supply chain. The company recommends the use of an integrated set of performance measures falling into the following general categories:

- Logistics financial performance measures (e.g., expenses and return on assets)
- Logistics productivity measures (e.g., orders shipped per hour and transport container utilization)
- Logistics quality measures (e.g., inventory accuracy and shipment damage)

• Logistics cycle time measures (e.g., in transit time and order entry time)

Logistics Resources sells a spreadsheet-based, educational tool called The Logistics Scoreboard that companies can use to pilot their supply chain performance measurement processes and to customize for ongoing use. The tool and a monograph (Logistics Performance, Cost, and Value Measures that documents the tool and its use) are distributed by The Penton Institute (Cleveland, OH). In contrast to the other approaches discussed, the Logistics Scoreboard is prescriptive and actually recommends the use of a specific set of supply chain performance measures. These measures, however, are skewed toward logistics, having limited focus on measuring the production and procurement activities within a supply chain.

D. Activity Based Costing

The Activity-Based Costing (ABC) approach was developed to overcome some of the shortcomings of traditional accounting methods in tying financial measures to operational performance. The method involves breaking down activities into individual tasks or cost drivers, while estimating the resources (i.e., time and costs) needed for each one. Costs are then allocated based on these cost drivers rather than on traditional cost-accounting methods, such as allocating overhead either equally or based on less-relevant cost drivers. This approach allows one to better assess the true productivity and costs of a supply chain process. For example, use of the ABC method can allow companies to more accurately assess the total cost of servicing a specific customer or the cost of marketing a specific product. ABC analysis does not replace traditional financial accounting, but provides a better understanding of supply chain performance by looking at the same numbers in a different way. ABC methods are useful in conjunction with the measurement approaches already discussed as their use allows one to more accurately measure supply chain

Process/task productivity and costs by aligning the metrics closer to actual labour, material, and equipment usage.

E. Economic Value-Added

One of the criticisms of traditional accounting is that it focuses on short-term financial results like profits and revenues, providing little insight into the success of an enterprise towards generating long term value to its shareholders – thus, relatively unrelated to the long-term prosperity of a company. For example, a company can report many profitable quarters, while simultaneously disenfranchising its customer base by not applying adequate resources towards product quality or new product innovation. To correct this deficiency in traditional methods, some financial analysts advocate estimating a company’s return on capital or economic value-added. These are based on the premise that shareholder value is increased when a company earns more than its cost of capital. One such measure, EVA,

developed by Stern, Stewart & Co., attempts to quantify value created by an enterprise, basing it on operating profits in excess of capital employed (through debt and equity financing). Some companies are starting to use measures like EVA within their executive evaluations. Similarly, these types of metrics can be used to measure an enterprise’s value added contributions within a supply chain. However, while useful for assessing higher level executive contributions and long term shareholder value, economic-value added metrics are less useful for measuring detailed supply chain performance. They can be used, however, as the supply chain metrics within an executive-level performance scorecard, and can be included in the measures recommended as part of the Logistics Scoreboard approach.

IV. LIST OF EVOLVED KEY PERFORMANCE INDICATORS (KPI's) ON THE BASIS OF LITERATURE REVIEW

S. No.	Type of Supply Chain Measures	Key Performance Indicators (KPI's)
I	Customer Service Measures	Order Fill Rate
		Line Item Fill Rate
		Quantity Fill Rate
		Backorders/stockouts
		Customer satisfaction
		% Resolution on first customer call
		Customer returns
		Order track and trace performance
		Customer disputes
		Order entry accuracy
		Order entry times
		Cycle time components and variability
		Customer satisfaction survey results
II	Process and Cross-Function Measures	Forecast accuracy
		Percent perfect orders
		New product time-to-market
		New product time-to-first make
		Planning process cycle time
		Schedule changes
		Product availability
		Order entry accuracy
		Warehouse picking accuracy
		Production accuracy
		On-time product shipment
		On-time product delivery
		Paperwork accuracy
Customer inquiry service		
Invoice accuracy		
Payment accuracy		
III	Extended Enterprise Measures	Total landed cost
		Point of consumption of product's availability
		Total supply chain inventory

		Retail shelf display			Shipment accuracy
		Channel inventories			On-time shipment
		EDI transactions*			Delivery times
		Percent of demand/supply on VMI / CRP*			Warehouse space utilization
		Percent of customers sharing forecasts			End-of-life inventory
		Percent of suppliers getting shared forecast			Obsolete inventory
		Supplier inventories			Inventory shrinkage
		Internet activity to suppliers /customers			Cost of carrying inventory
		Percent automated tendering			Documentation accuracy
IV	Purchasing Related Measures	Material inventories			Transportation costs
		Supplier performance			Warehousing costs
		Material/component quality			Container utilization
		Material stockouts			Truck cube utilization
		Unit purchase costs			In-transit inventories
		Material acquisition costs			Premium freight charges
		Expediting activities			Warehouse receipts
V	Manufacturing Related Measures	Product quality		VII	Administration/ Financial Measures
		WIP inventories			Cash flow
		Adherence-to-schedule			Income
		Yields			Revenues
		Cost per unit produced			Return on capital employed
		Setups/Changeovers time			Cash-to-cash cycle time
		Setup/Changeover costs			Return on investment
		Unplanned stockroom issues			Revenue per employee
		Bill-of-materials accuracy			Invoice errors
		Routing accuracy			Return on assets
		Plant space utilization			Various costs
		Line breakdowns			Orders versus forecasts
		Plant utilization			Shipments versus forecast
		Warranty costs		VIII	Marketing Related Measures
		Source-to-make cycle time			Market share
		Percent scrap/rework			Percent of sales from new products
		Material usage variance			Time-to-market
		Overtime usage			Percent of products representing 80% of sales
		Production cycle time			Repeat versus new customer sales
		Manufacturing productivity			Detailed Sales Forecast
		Master schedule stability			Sales Plan - family product level
		Materials Inventory Accuracy		IX	Other Measures
		Master Schedule Performance			APICS trained personnel
		Production Plan			Patents awarded
		Waste and Scrap			Employee turnover
VI	Logistics Related Measures	Finished goods inventory turns			Number of employee suggestions
		Finished goods inventory days of supply			
		On-time delivery			
		Lines picked/hour			
		Damaged shipments			
		Inventory accuracy			
		Pick accuracy			
		Logistics cost			

(Note : EDI-Electronic Data Interchange, VMI-Vendor Managed Inventory and CRP- Capacity Requirements Planning)

V. SELECTION OF MEASURES AND PERFORMANCE MEASUREMENT

While the approaches described above provide guidance for supply chain measurement, they provide less help in assessing specific metrics to be used. In this regard, a key driving principle, as espoused by the Balanced Scorecard, is that measures should be aligned to strategic objectives. Supply chain strategy, however, differs for every company and depends upon its current competencies and strategic direction. Companies, for example, can generally fall into the following developmental stages that will dictate the types of measures and the degrees to which they will need to focus:

REFERENCES

- *Functional Excellence* – a stage in which a company needs to develop excellence within each of its operating units such as the manufacturing, customer service, or logistics departments. Metrics for a company in this stage will need to focus on individual functional departments.
 - *Enterprise-Wide Integration* – a stage in which a company needs to develop excellence in its cross-functional processes rather than within its individual functional departments. Metrics for a company in this stage will need to focus on cross-functional processes.
 - *Extended Enterprise Integration* – a stage in which a company needs to develop excellence in inter-enterprise processes. Metrics for a company in this stage will focus on external and cross enterprise metrics.
- Historically most companies have focused their performance measurement on achieving functional excellence. With the advent of Supply Chain Management (SCM) principles aimed at integrating their supply chains, many have objectives to increase their degree of enterprise-wide integration and extended enterprise integration. In order to achieve these types of objectives, their performance measurement systems will need to align to them. Advice for these supply chain measurement systems falls into five areas that include:
- Function-based measures
 - Process-based measures
 - Cross-enterprise measures
 - Number of measures to be used
 - Alignment of executive to management level measures
- ### VI. CONCLUSIONS
- The study revealed that supply chain performance measurement is still a fruitful research area and very distinctive supportive statements have been traced for the need of further research on supply chain performance measurement during the review. The SC performance measurement is a very wide concept and may have different set of KPI's for different type of supply chains. This study is simply a literature review on various types of supply chains and generates a common set of metrics for different supply chains. Further research in this field may involve development of more precise frameworks, empirical testing of the performance measures and validation of developed performance measures.
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