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MULTIPLE PERFORMANCE DIMENSIONS TO MEASURE SUPPLY CHAIN PERFORMANCE

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ABSTRACT

There has been considerable academic and managerial attention devoted to understand contemporary developments in supply chain performance measurement. However the developments and implementations of performance measurement system from supply chain perspective is clearly in its infancy. To excel and win in the today's competitive environment, supply chain need continuous improvements. This can be achieved by having the performance measures that support supply chain process perspective rather than function specific. Based on literature survey, the role of performance measurement in the context of supply chain management is described and identified seven performance dimensions (cost, quality, time, productivity, flexibility, reliability, and customer service) which are specific to supply chain. The criticality of performance dimensions from the supply chain point of view is examined by collecting empirical data from supply chain professionals. Based on the insights gained, a framework of performance measures for measuring performance of supply chain from different performance dimensions is presented.

KEYWORDS: Performance Measurement System, Performance Measures, Supply Chain Management, Supply Chain Processes.

INTRODUCTION

With the fast developing world economy and global market place, there has been a drastic increase in the pressure on organizations to find new ways to create and deliver value to customers through supply chain management (SCM). For improved competitiveness, many firms have embraced SCM to increase organizational effectiveness and achieve organizational goals such as improved customer value, better utilization of resources, and increased profitability (Lee, 2000). The importance supply chain management has been increasingly recognized in the manufacturing environment. While a supply chain consists of a number of partners or components (such as suppliers, manufacturers, distributors and customers), its effective management requires integration of information and material flow through these partners from source to user. To excel and win in the today's competitive environment, supply chain need continuous improvements. To achieve this goal, an adequate performance measurement system (PMS) needs to be developed. The subject of performance measurement (PM) is encountering increasing interest in both the academic and managerial ambits. Organizations need to provide a performance measurement system to evaluate the resource utilization so

that they can strategically manage and properly control to achieve their objectives and goals. Schermerhorn and Chappell (2000) point out that performance measurement is vital part of controlling process in order to take action for ensuring desired results. Traditionally, the focus of performance measurement has been on process operations within the organizational boundaries of a firm (Short and Venkatraman, 1992). In the context of SCM, performance measurement involves not only the internal processes, but also requires an understanding of the performance expectation of other member firms in the supply chain, backward from the suppliers and forward to the customers (Normann and Ramirez, 1993). Coordination between the various parties in the supply chain is key to its effective implementation (Frohlich and Westbrook, 2001).

The performance of entire supply chain depends on various activities at each stage in supply chain. Samarnayakee (2005) described various activities of supply chain as sales and operational planning; demand management; customer order management; production planning; control and execution; materials, quality and inventory management; material procurement; distribution requirements planning; transportation and shipment management; and integrated supply and demand planning. The performance of these activities will govern the total supply chain performance. Further, the performance of these activities can be measured from different dimensions such as cost, quality, time, productivity, flexibility, reliability, and customer service. An attempt is made to understand the performance measurement in the context of supply chain. The objective of the paper is to identify performance dimensions that characterize the supply chain and develop a framework of performance measures based on criticality of each performance dimension.

LITERATURE REVIEW

Performance measurement can be defined as the process of quantifying the efficiency and effectiveness of an action (Neely *et al*., 1995). Effectiveness refers to the extent which customer requirements are met by the product/service, while efficiency is a measure of how economically the resources are utilized while providing a given level of customer satisfaction. Traditionally, financial performance has been the primary measure of success in most of the organizations. Traditional measures are providing a very limited and often misleading picture of the performance of the organization (Tarr 1995). Performance measurement incorporating non financial measures has been a topic of great interest throughout 1990s. This is mainly because non financial measures overcome the limitation of just using financial performance measure. Schonberger (1986) observes that the best companies use customer–oriented performance measures at the corporate level. The performance elements like cost, environment, quality and delivery express the relation of the organization with suppliers and customers. The other elements like productivity, flexibility, safety, morale, innovation are more associated with the internal system (Anantaraman *et al* 2006).

Performance measurement system must show the interdependencies of the different performance indicators. Several frameworks have been developed on performance measurement. Among these, the most popular is Balanced Scorecard (BSC) devised by Kaplan and Norton (1992). BSC and

similarly balanced performance measurement systems prove to be superior to systems based on traditional measurement systems. Measuring the performance of any system requires the determination of appropriate performance indicators. Most of the performance measurement methods lack the ability to evaluate a SCM since the supply chain is a dynamic system that requires a more thorough and flexible performance measurement technique. While measuring performance, various aspects, dimensions, and perspectives need to be considered. Performance measurement System must show the interdependencies of different performance indicators. Supply chain should be viewed as one single entity and managed as a whole, in which all the members are functionally integrated and synchronized with mutual goals. Elif Kongar (2005) presented a green balanced scorecard approach that includes financial, customer, business processes, learning and growth, and environmental perspectives in its evaluation process. The major road block to effective SCM is a "failure to develop and implement measures for monitoring alliances within the supply chain". Traditional measures are not always focused on measuring, motivating and optimizing intra-firm and inter-firm performance. They do not focus on the key boundary spanning activities that are critical to successful SCM (Brower and Spech 2000). The process of choosing appropriate supply chain performance measures is difficult due to the complexity of these systems. Beamon (1999) presented a framework for the selection of performance measurement systems for manufacturing supply chains.

Three types of performance measures are identified as necessary components in any supply chain performance measurement system such as resources, output and flexibility. Measuring the performance of any system requires the determination of appropriate performance indicators. Maltz *et al.* (2003) developed a performance evaluation frame work named dynamic multi-dimensional performance (DMP). DMP includes twelve potential baseline measures across five major success dimensions (financial, market, process, people and future) that can be examined as applicable to different firms and firm types.

Many companies have not succeeded in maximizing their supply chain's potential because they have often failed to develop the performance measures and metrics needed to fully integrate their supply chain to maximize effectiveness and efficiency. Gunasekaran *et al.* (2001) developed a framework for measuring the strategic, tactical and operational level performance in a supply chain and presented a list of key performance metrics. The emphasis is on performance measures dealing with suppliers, delivery performance, customer-service, inventory and logistics costs in a SCM. Later Gunasekaran *et al.* (2004) developed a framework to promote a better understanding of the importance of SCM performance measurement and metrics. Felix Chan and Qi (2003) proposed a process based approach to mapping and analyzing the practically complex supply chain network. Via this approach, a process–based performance of activity is used to identify the performance measures and metrics.

The Supply Chain Operations Reference (SCOR) model developed by the Supply Chain Council (Stewart G, 1997) provides a framework for characterizing supply-chain management practices and processes that result in best-in-class performance. The SCOR model views activities in supply chain as a series of interlocking inter-organizational processes with each individual organization comprising four components: plan, source, make, and deliver. Each of these components is considered a critical

intra-organizational process in the supply chain with four measurement criteria: (1) supply chain reliability, (2) responsiveness/flexibility, (3) costs, and (4) assets. Lai *et al.* (2002) developed a measurement structure to evaluate the supply chain performance in transport logistics based on the SCOR model. This work is then followed by Lai *et al.* (2004) involving the application of their proposed evaluation model depending on cost and service perspectives. Perspective based measurement system presents six unique sets of metrics to measure performance of SCM. The six different perspectives are system dynamics, operations research/ information technology, logistics, marketing, organization and strategy (Otto and Kotzab 2002). There are many aspects of performance in evaluating a specific process or activity. The performance measures should reflect the various performance dimensions which characterizes the supply chain and should be identified and linked to each of the supply chain process or activities. Performance of an activity or process can be measured from dimensions such as cost, quality, time, productivity, flexibility, reliability, and customer service (Prasad and Goel, 2008). The performance measures should reflect the performance dimensions listed above and should be identified and linked to each of the supply chain process or activities.

MULTIPLE PERFORMANCE DIMENSIONS TO MEASURE SUPPLY CHAIN PERFORMANCE

The literature review suggest that the key dimensions of supply chain performance can be defined in terms of cost/financial, quality, time, productivity, flexibility, reliability, and customer service. The performance measures reflecting performance dimensions listed above are also identified. The performance dimensions that characterize the performance of supply chain system are discussed individually.

- Cost: It the value of money that has been used to carry out an event or an activity. Cost is always one of the indispensable aspects in assessing the performance. This dimension records inputs consumed and also reflects the effectiveness of cost control. It is very important performance dimension as financial resources are used to carry out various activities with in the scope of SCM. It is observed from the literature that measures such as material cost, inventory cost, manufacturing cost, inbound logistics cost, outbound logistics cost, power/fuel cost, rework/rejection cost, labour cost, information carrying cost, and demand/supply planning cost are used to measure the performance of various supply chain activities from cost dimension.
- Quality: It is a measure of how closely an item conforms to the specified standard. It starts by certifying the supplier quality and ensuring that all purchased materials are free from defect. It has been defined in terms of conformance to specification and hence quality-based measures of performance have focused on issues such as the number of defects and degree of fulfilling the customer requirements. The performance measures such as forecast accuracy, accuracy of supply planning, accuracy of capacity planning, on time delivery, product quality, service quality, number of returns/rejection rate, incoming material quality, scrap/rework/wastage,

percent of defect items, in process failure rate, and customer complaints are used to judge the quality aspect of various supply chain processes and/or activities.

- Time: It is a component of a measuring system used to sequence events, to compare the durations of events and the intervals between them. Time is the duration between the beginning and completion of one specific event or activity. Time is an important resource in SCM environment. It measure how fast an activity is completed. Time has been described as both a source of competitive advantage and the fundamental measure of supply chain. The performance measures that are used to judge the performance from time dimension are cycle time, down time, supplier response time, lead time, number of days of inventory, and on time delivery.

- Productivity: Productivity refers to the ability of a company or a supply chain to use their assets as profitably as possible. It measures the extent to which the resources are being used efficiently in transforming inputs to outputs. It is an input – output ratio. It is ability of a firm utilising their resources as efficiently as possible. The measures such as return on investment, capacity utilization, work in process inventory, value added, wastage/scrap/rework, output, efficiency, finished goods inventory, raw material inventory, and value of non moving items are used to measure the supply chain performance from productivity dimension.

- Flexibility: it is the ability to adapt to both internal and external business changes.It is the ability of one specific activity to adapt to the varying functional requirements or respond to the changes. It is the capability to procure materials from different sources, producing different products and meeting different customer needs. The measures such as number of channels, number of supply sources, product variety, time to adapt to change in demand, raw material availability, source flexibility, upside production flexibility, and delivery flexibility are used to judge flexibility aspect of supply chain performance.

- Reliability: It is the ability of a system or component to perform its required functions under stated conditions for a specified period of time. It is the ability of one specific event or activity to perform a required function. It emphasizes the conditions under which the activity or process is performed. The measures such as forecast accuracy, number of plans that meets schedules, on time delivery, incoming material quality, percent of defect items, responsiveness to urgent deliveries, order fill rate, service reliability, number of returns/rejection rate, in process failure rate, degree of information sharing with partners, and stock out rate are used to judge reliability aspect of supply chain performance.

- Customer service: It is the ability to satisfy the customer requirements. Customer service measures the ability of supply chain to meet the expectations of its customers. Depending on the type of market being served, the customers in the market will have different expectations for customer service. Customers expect both high levels of product availability and quick delivery of goods. Supply chain must meet the customer service expectations. The measures such as

customer satisfaction index, on time delivery, fill rate, customer complaints, stock out rate, service reliability, reject rate/number of returns, percent defect items, product quality, service quality and customer retention are used to judge how best the supply chain is able to satisfy the customer requirements.

RESEARCH METHODOLOGY

A survey was conducted to examine the criticality of each performance dimension and prioritize the importance of each performance dimension. Different performance measures used for measuring supply chain performance from each performance dimension are also examined. A questionnaire was developed for collecting data. The questionnaires were mailed with a covering letter and addressed to the CEOs of each firm. Targeted recipients were instructed to complete the survey themselves or refer it to concerned supply chain professionals in their organization. A total of 100 manufacturing firms were selected for this purpose.

EMPIRICAL ANALYSIS

Of the 100 questionnaires mailed, 21 were completed and returned. The response rate was only 21%, but we felt that it was adequate to assist us in developing our framework. The criticality of each performance dimension is measured on a five- point Likert scale, with a score of one indicating 'not at all critical' and score five indicating 'very critical'. Figure 1 provides the mean score for criticality of various performance dimensions to the supply chain. The survey results show that cost is the most critical performance dimension in determining the supply chain performance with a critical score of 4.45 followed by quality with a critical score of 3.95, customer service with a critical score of 3.9, time with a critical score of 3.7, productivity with a critical score of 3.35, reliability with a critical score of 3.25 and flexibility with a critical score of 3.2. The mean score of criticality for these seven performance dimensions ranging from minimum of 3.2 to a maximum of 4.45 on a 5 point scale. This shows that performance dimensions such as cost, quality, customer service, time, productivity, reliability and flexibility are critical or important for measuring supply chain performance. Respondents are also asked about which of the performance measures are used or considered to measure supply chain performance from different performance dimensions. It is found from the study that the following seven sets of performance measures are used to measure supply chain performance from each performance dimension.

The first set of measures pertaining to cost performance dimensions are information carrying cost, demand/supply planning cost, material cost, inventory cost, inbound logistic cost, manufacturing cost, outbound logistics cost, power/fuel cost, rework/rejection cost, and labor cost. Among these, manufacturing cost, inventory cost, outbound logistics cost can be considered to be most important performance measures from the cost perspective as these are reported to be used by more than 60 percent of firms (respondents). Inbound logistics cost, material cost and labor cost can be considered to be important performance measures as these are reported to be used by more than 40 percent of firms. Power/fuel cost, rework/rejection cost, information carrying cost, and demand/supply planning cost are considered to be less important as these measures are reported to be used only by less than 40 percent of

firms. Figure 2 shows cost related performance measures along with the percentages of firms considered them as measures.

The second set of performance measures pertaining to quality performance dimension are forecast accuracy, accuracy of supply planning, accuracy of capacity planning, on time delivery, product quality, incoming material quality, number of returns/rejection rate, percent of defect items, in-process failure rate, scrap/rework/wastage, service quality and customer complaints. Among these, on time delivery can be considered to be the most important performance measure from the quality perspective as this is reported to be used by more than 60 percent of firms (respondents). Product quality, incoming material quality, forecast accuracy, number of returns/rejection rate, percent of defect items, and customer complaints can be considered to be important performance measures as these are reported to be used by more than 40 percent of firms. Scrap/rework, in-process failure rate, accuracy of supply planning, accuracy capacity planning, and service quality are considered to be less important as these are reported to be used only by less than 40 percent of firms. Figure 3 shows quality related performance measures along with the percentages of firms considered them as measures.

The third set of performance measures pertaining to time performance dimension are cycle time, lead time, supplier's response time, down time, number of days of inventory and on time delivery. Among these, cycle time, down time, lead time and on time delivery can be considered to be most important performance measures from the time perspective as these are reported to be used by more than 60 percent of firms (respondents). Number of days of inventory can be considered important performance measure as this is reported to be used by more than 40 percent of firms. Supplier's response time can be considered less important performance measure as this is reported to be used only by less than 40 percent of firms. Figure 4 shows time related performance measures along with the percentages of firms considered them as measures.

The fourth set of performance measures pertaining to productivity performance dimension are return on investment, capacity utilization, work in process inventory, wastage/scrap/rework, output, value added, finished goods inventory, efficiency, value of non moving materials, and raw material inventory. Among these, return on investment, efficiency, and output considered to be most important performance measures from productivity point of view as these are reported to be used by more than 60 percent of firms. capacity utilization, work in process inventory, finished goods inventory, value added and raw material inventory are considered to be important performance measures as these are reported to be used by more than 40 percent of firms. Waste/scrap/rework and value of non moving materials are considered less important performance measures as these are reported to be used only by less than 40 percent of firms. Figure 5 shows productivity related performance measures along with the percentages of firms considered them as measures.

The fifth of performance measures pertaining to flexibility performance dimension are product variety, time to adapt to change in demand, raw material availability, source flexibility, number of supply sources, upside production flexibility, delivery flexibility, and number of channels. Among these, source

flexibility, raw material availability, delivery flexibility, upside production flexibility, and number of supply sources are considered to be important performance measures from the flexibility perspective as these are reported to be used by more than 40 percent of firms. Product variety, time to adapt to change in demand, and numbers of channels are considered to be less important as these are reported to be used only by less than 40 percent of firms. Figure 6 shows flexibility related performance measures along with the percentages of firms considered them as measures.

The sixth set of performance measures pertaining to reliability performance dimension are degree of information sharing with partners, number of plans that meets schedules, forecast accuracy, incoming material quality, on time delivery, number of returns/rejection rate, percent of defect items, responsiveness to urgent deliveries, service reliability, order fill rate, stock out rate, and in process failure rate. Among these, on time delivery can be considered to be the most important performance measure from the reliability perspective as this is reported to be used by more than 60 percent of firms. order fill rate, incoming material quality, percent of defect items, forecast accuracy, and number of returns/rejection rate are considered to be important performance measures as these are reported to be used by more than 40 percent of firms. Responsiveness to urgent deliveries, service reliability, in process failure rate, number of plans that meets schedules, stock out rate, and degree of information sharing with partners are considered to be less important as these are reported to be used only by less than 40 percent of firms. Figure 7 shows reliability related performance measures along with the percentages of firms considered them as measures.

The seventh set of performance measures pertaining to customer service performance dimension are on time delivery, number of returns/rejection rate, percent of defect items, customer satisfaction index, customer complaints, service reliability, customer retention, stock out rate, product quality, service quality and order fill rate. Among these, on time delivery can be considered to be the most important performance measure from customer service point of view as this is reported to be used by more than 60 percent of firms (respondents). Customer complaints, product quality, percent of defect items, order fill rate, customer satisfaction index, and number of returns/reject rate can be considered to be important performance measures as these are reported to be used by more than 40 percent of firms. Customer retention, service reliability, stock out rate, and service quality can be considered to be less important performance measures as these were reported to be used only by less than 40 percent of firms. Figure 8 shows customer service related performance measures along with the percentages of firms considered them as measures.

A FRAMEWORK FOR MEASURING PERFORMANCE OF A SUPPLY CHAIN

In this section, a framework for performance measures is presented (see Table 1), considering the various performance dimensions that are very critical from supply chain perspective. This framework is based largely on measures discussed in literature and on the empirical analysis reported herein. Some measures appear in more than one dimension, indicating that measures may be appropriate in more than one performance dimension. For example performance measures such as forecast accuracy and in

process failure rate appearing in quality and reliability performance dimensions as these are appropriate to measure performance from quality and reliability perspective. On time delivery measure appearing in quality, customer service, time, and reliability dimensions. Performance measures such as number of returns, percent of defect items can be used to measure performance from quality, customer service, and reliability point of view. Measures such as product quality, service quality, and customer complaints are appropriate to measure performance from quality and customer service dimensions as these are appearing in both dimensions. Service reliability, stock out rate, order fill rate can be used to measure performance from customer perspective as well as reliability point of view. The appearance of some performance measures in more than one dimension indicates that performance dimensions are inter-related. The performance dimensions quality, reliability, and customer service are more inter-related. The approach we used in organizing the measures for the framework could be used by organizations in development of a performance measurement program for supply chain. Mangers could identify and select measures based on their importance attached to each performance dimension. The importance of each performance dimension may vary according to the goal or objective of supply chain. Based on importance attached to each performance dimension, management can select a mixture of performance measures to measure supply chain performance. Individual firms will certainly have different performance measurement needs that reflect the unique operations of their business and of course not all supply chains are identical. Thus other measures may be desirable and should be developed by firms and their supply chain partners to reflect their unique needs. It is important to note that the frame work is based on relatively small sample, and thus care should be taken in generalizing results to all supply chains. The criticality of each performance dimension presented herein might not apply to all supply chains in all industries. The framework is only a starting point. Specific firms can use this framework as a starting point from which to choose measures that would best fit their environment and strategic direction. It is hoped that this framework will assist practitioners in their efforts to asses supply chain performance.

CONCLUSIONS

In this paper, the role of performance measurement in the context of supply chain management is described and identified seven performance dimensions (cost, quality, time, productivity, flexibility, reliability, and customer service) which are specific to supply chain. Measures from each performance dimension are also identified through literature survey. The criticality of performance dimensions across various supply chain processes are examined by collecting empirical data from supply chain professionals. Based on the insights gained, a framework of performance measures for measuring performance of supply chain from different performance dimensions is presented. The framework can be used for assessing supply chain performance on a multitude of performance dimensions and measures, and is designed to help companies to continuously examine themselves and improve the chances for sustainable and on-going success.

Additional research and practical approach is needed in the area of Supply chain performance measurement. Creative efforts are needed to design new measures and new approaches for assessing the

performance of supply chain as a whole as well as the performance of each organization that is a part of the supply chain. Partners of supply chain should come together to discuss how they will address performance measurement in the context of supply chain.

REFERENCES

1. Anantharaman N. and Nachiappan R M. (2006), Performance Evaluation of World Class Manufacturing System: An Overview, The ICFAI Journal of Operations Management, Vol. 5, No.1, pp 29-49.

2. Beamon Benata M. (1999), Measuring Supply Chain Performance, International Journal of Operations and Production Management, Vol.19, No.3, pp 275-292.

3. Brower P.C. and Speh T.W. (2000), Using Balanced Scorecard to Measure Supply Chain Performance, Journal of Business Logistics, Vol. 21, No. 1, pp 75-93.

4. Elif Kongar. (2005), Evaluation Criteria for Environmentally Benign Forward and Reverse Supply Chain Management, International Journal of Operations & Quantitative Management, Vol.11, No.2, pp 147-173.

5. Flex T.S.Chan and Qi H.J., (2003), Feasibility of Performance Measurement System for Supply Chain: A Process-Based Approach and Measures, Integrated Manufacturing System, Vol. 14, No.3, pp 179-190.

6. Frohlich, M.T. and Westbrook, R. (2001), Arcs of Integration: An International Study of Supply Chain Strategies, Journal of Operations Management, Vol. 19, Ni. 2, pp 185–200.

7. Gunasekaran A., Patel C., and Mcgaughey R.E. (2004), A Framework for Supply Chain Performance Measurement, International Journal of Production Economics, Vol.87, No.3, pp 333-347.

8. Gunasekaran A., Patel C., and Tirtiloglu E. (2001), Performance Measures and Metrics in a Supply Chain Environment, International Journal of Operations & Production Management, Vol. 21, No. (1/2), pp 71-87.

9. Kaplan R. and Nortan D. (1992), The Balanced Scorecard: Measures that Drive Performance, Harvard Business Review, Vol. 70, pp 71-79.

10. Lai K., Ngai E.W.T. and Cheng T.C.E. (2002), Measures for Evaluating Supply Chain Performance in Transport Logistics, Transportation Research Part E: Logistics and Transportation Review, Vol. 38, No. 6, pp 439-456.

11. Lai K., Ngai E.W.T., and Cheng T.C.E (2004), An Empirical Study of Supply Chain Performance in Transport Logistics, International Journal of Production Economics, Vol. 87, pp 321-331.

12. Lee H.L. (2000), Creating Value through Supply Chain Integration, Supply Chain Management Review, Vol. 4, No. 4, pp 30–36.

13. Maltz A. C., Shenhar A.J. and Reilly R.R. (2003), Beyond the Balanced Scorecard: Refining the Search for Organizational Success Measures, Long Range Planning, Vol. 36, pp.187-204.

14. Neely A., Gregory M. and Platts K. (1995), Performance Measurement System Design, International Journal Operation and Production Management, Vol. 4, No. 4, pp 80-116.

15. Norman R. and Ramirez R. (1993), From Value Chain to Value Constellation: Designing Interactive Strategy, Harvard Business Review, Vol. 71, No. 4, pp 65-77.

16. Otto A. and 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, Vol. 144, pp 306-320.

17. Prasad Ch.V.V.S.N.V. and Goel T.C. (2008), Performance Evaluation of Supply Chain System: An Overview, Proceedings of the International Conference on Issues and Challenges in Supply Chain Management, Banaras Hindu University, India, March 28-30.

18. Samarnayakee P. (2005), Conceptual Framework for Supply Chain Management: A Structural Integration, Supply Chain Management: An International Journal, Vol. 10, No. 1, pp 47-59.

19. Schermerhorn, J.R. & Chappell, D.S. (2000), "Introducing Management – The Wiley/Wall street Journal Series", John Wiley & Sons, Inc., New York, USA.

20. Schonberger R J. (1986), World class Manufacturing: The lessons of Simplicity Applied, Free Press, New York, USA.

21. Short J. E.and Venkatraman N. (1992), 'Beyond Business Process Redesign: Redefining Baxter's Business Network', Sloan Management Review, Vol. 34, No.1, pp 7-21.

22. Stewart G. (1997), "Supply Chain Operations Reference model (SCOR): The First Cross-industry Framework for Integrated Supply Chain Management", Logistics Information Management, Vol. 10, No. 2, pp 62-71.

23. Tarr J D. (1995), Developing Performance Measurement System that Support Continuous Improvement, Hospital Material Management Quarterly, Vol. 17, No.3, pp 59-67.

APPENDICES

Table 1: A Framework of Performance Measures Using Multiple Performance Dimensions

Multiple Performance Dimensions to Measure Supply Chain Performance						
Cost	Quality	Time	Productivity	Flexibility	Reliability	Customer service
Information carrying cost	Forecast accuracy	Cycle time	Return on investment	Product variety	Degree of information sharing with supply chain partners	On time delivery
Demand/supply planning cost	Accuracy of supply planning	Lead time	Capacity utilization	Time to adapt to change in demand	Number of plans that meets schedules	Number of returns/rejection rate
Material cost	Accuracy of capacity planning	Suppliers response time	Work in process inventory	Raw material availability	Forecast accuracy	Percent of defect items
Inventory cost	On time delivery	Down time	Scrap/rework/wastage	Source flexibility	Incoming material quality	Customer satisfaction index
Inbound logistics cost	Product quality	Number of days of inventory	Output	Number of supply sources	On time delivery	Customer complaints
Manufacturing cost Outbound logistics cost	Incoming material quality	On time delivery	Value added	Upside production flexibility	Number of returns/rejection rate	Service reliability
Power/fuel cost	Number of returns/rejection rate		Finished goods inventory	Delivery flexibility	Percent of defect items	Customer retention
Rework/rejection cost	Percent of defect items		Efficiency	Number of channels	Responsiveness to urgent deliveries	Stock out rate
Labor cost	In process failure rate		Value of non moving items		Service reliability	Order fill rate
	Scrap/rework/wastage		Raw materials inventory		Order fill rate	Product quality
	Service quality				Stock out rate	Service quality
	Customer complaints				In process failure rate	

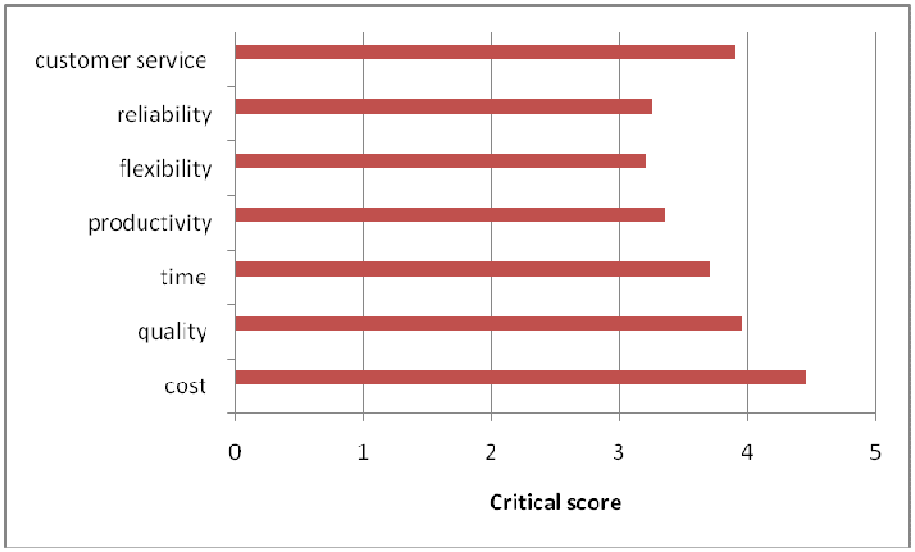

Figure 1: Criticality of Performance Dimensions to the Supply Chain

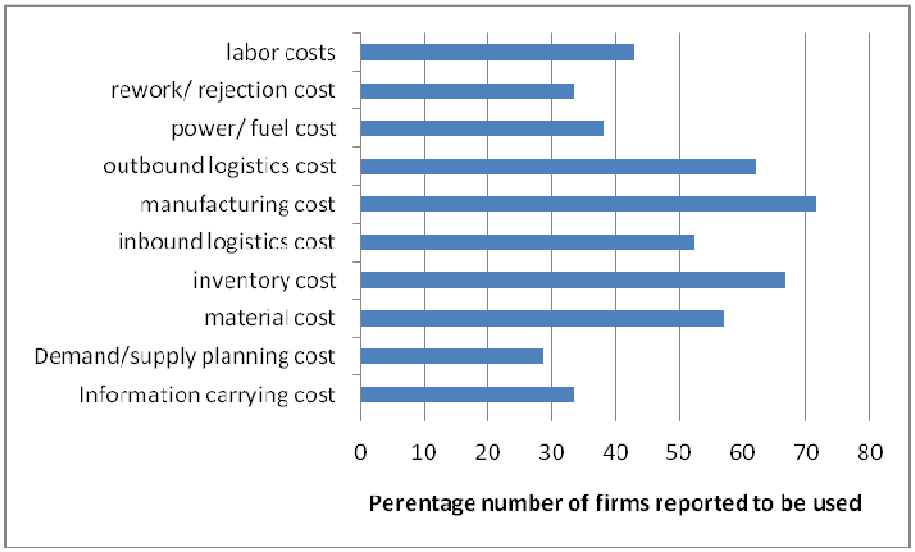

Figure 2: Cost Related Performance Measures

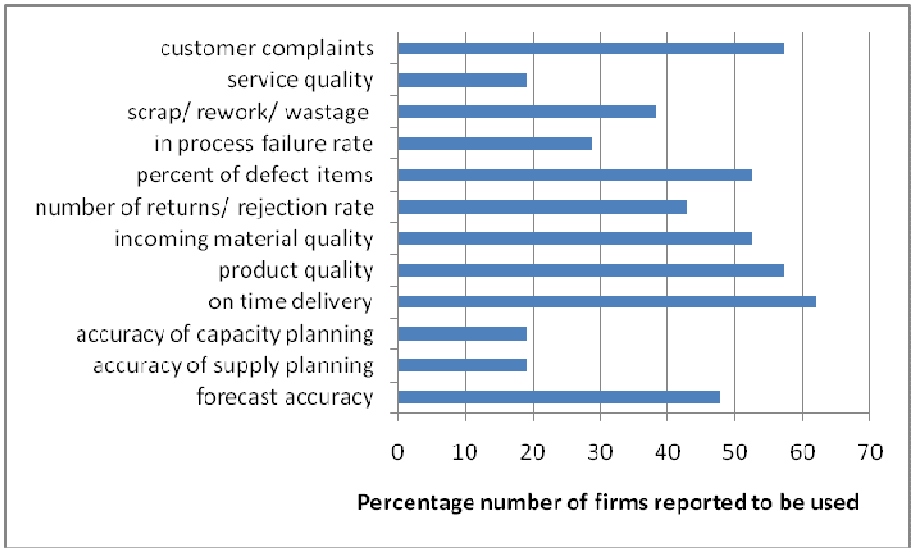

Figure 3: Quality Related Performance Meassures

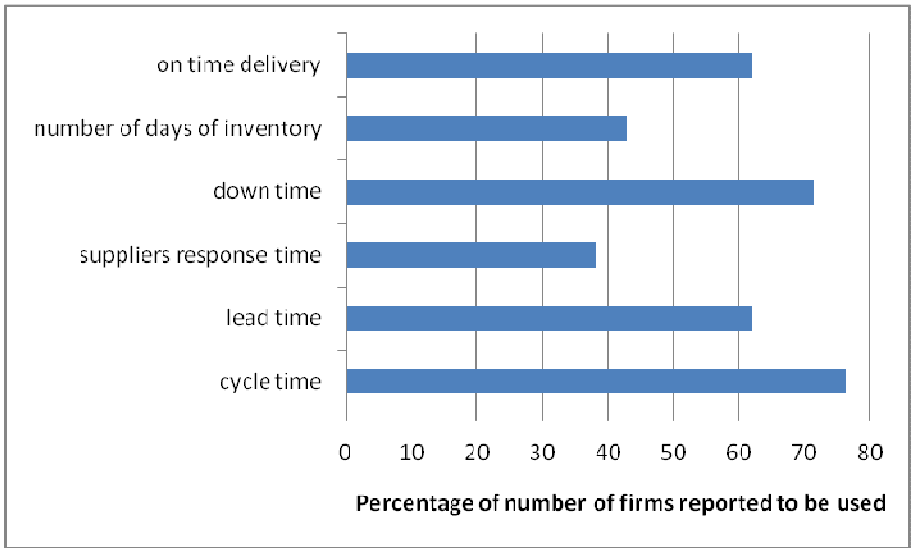

Figure 4: Time Related Performance Meassures

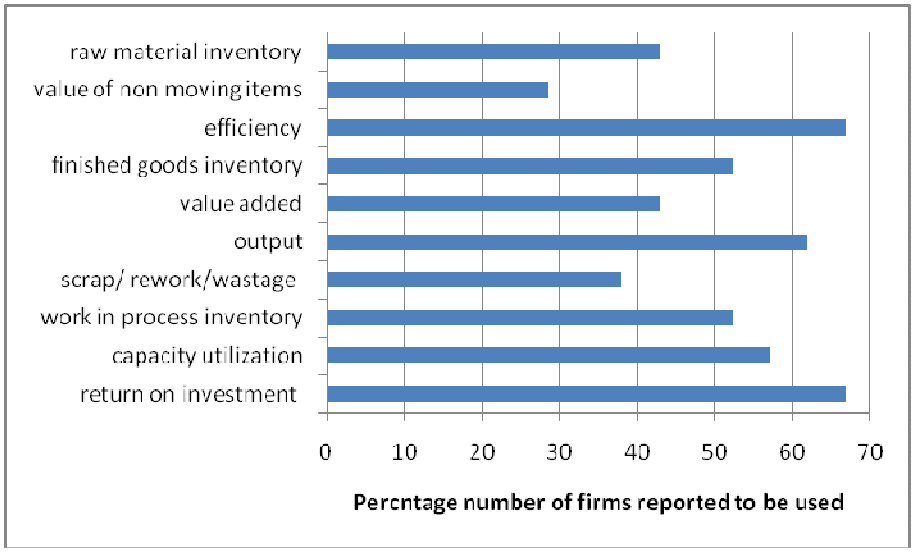

Figure 5: Productivity Related Performance Meassures

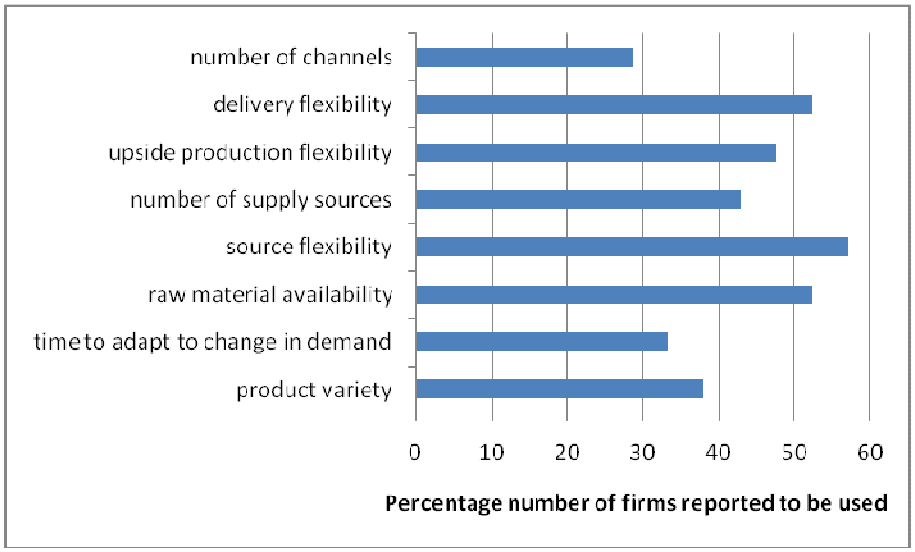

Figure 6: Flexibilty Related Performance Meassures

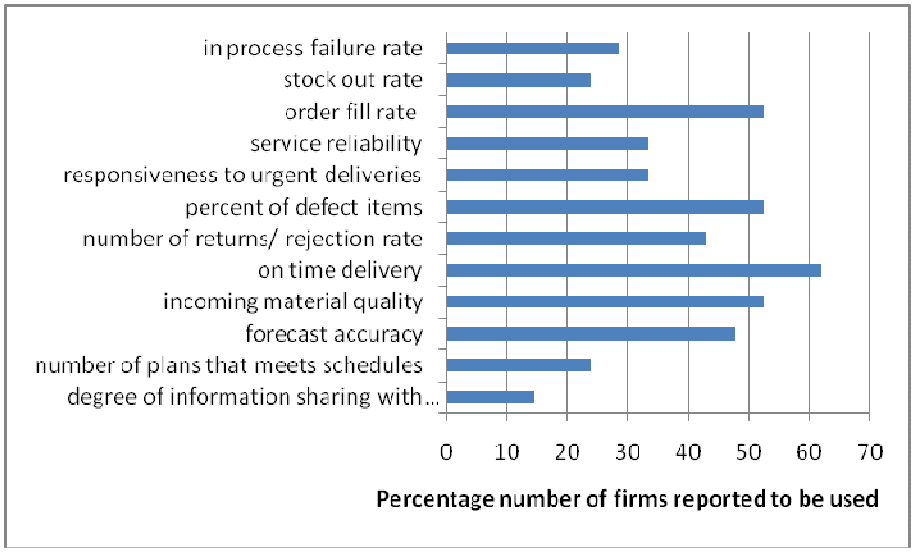

Figure 7: Reliability Related Performance Meassures

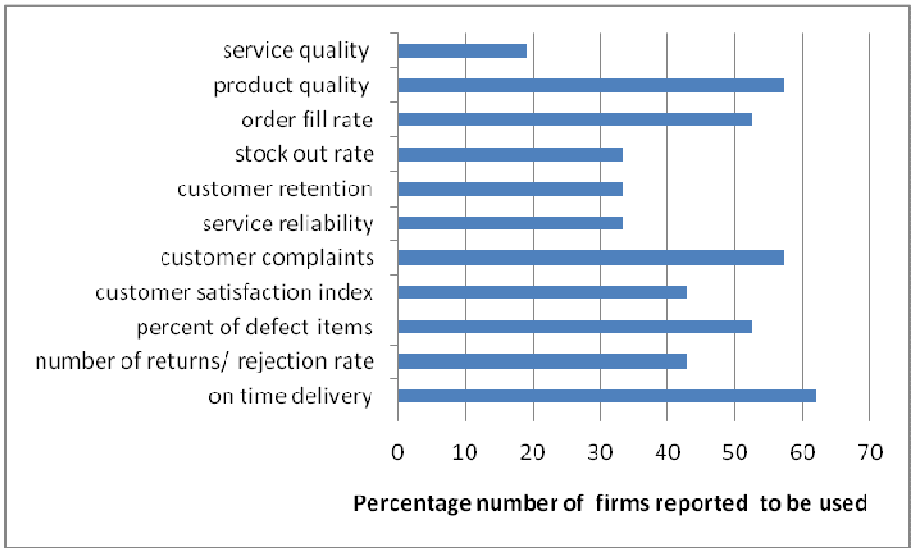

Figure 8: Customer Service Related Performance Measures