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Relationship between Key Performance Indicators in Supply Chain Management

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Abstract

Supply Chain Management has caught the imagination of the industry in the last decade or so. Supply Chain Management (SCM) has gained significance as one of the 21st century manufacturing paradigms for improving organizational competitiveness. Supply chain ensures improved efficiency and effectiveness of not only product transfer, but also information sharing between the complex hierarchies of all the tiers. The literature on SCM that deals with strategies and technologies for effectively managing a supply chain is quite vast. In recent years, organizational performance measurement (PM) and metrics have eceived much attention from researchers and practitioners. Indian agriculture equipment industry has been implementing the SCM practices for a long time. The paper takes a look at various PM elements and there inter casual relationship by testing some hypothesis developed for the same. A questionnaire based survey is condcted to develop the hypothesis.

INTRODUCTION

A key feature of present day business is the idea that it is supply chains that compete, not companies and the success or failure of supply chains is ultimately determined in the marketplace by the end consumer. Getting the right product, at the right price, at the right time to the consumer is not only the linchpin to competitive success but also the key to survival. Hence, customer satisfaction and marketplace understanding are crucial elements for consideration when attempting to establish supply chain strategy. Only when the requirements and constraints of the marketplace are understood can an enterprise attempt to develop a strategy that will meet the needs of both the supply chain and the end customer. In today's markets, technological and

competitive forces are changing at an ever increasing rate. To respond to these forces, radical changes in organizations have become necessary. The viability of a firm now depends largely on how well it is capable of responding to customer requirements while becoming lean. According to a definition of supply chain is" *Supply chain management (SCM) is management of a network of interconnected businesses involved in the provision of product and service packages required by the end customers in a supply chain. Supply chain management spans all movement and storage of raw materials, work-in-process inventory, and finished goods from point of origin to point of consumption.*

Supply Chain Management (SCM) as a term captures the essence of integrated logistics and goes beyond it. SCM emphasizes the logistics interactions that take place among the functions of marketing, manufacturing and logistics within a firm and also between the different firms within that production flow channels and facilitates the co ordination and collaboration amongst the channel members. SCM has evolved over a period of time, starting off being referred to as physical distribution management, materials management, Industrial logistics etc. It is only in the last decade or so that manufacturing sector organizations are showing success in sharing information with the suppliers, retailers, distribution centers and the final customer.

Need for Performance Measurement & Metrics in SCM

A number of organizations, both in India and abroad, have realized the potential of SCM but the Industry lacks the insight about the development of effective performance measurement parameters and metrics to achieve maximum integration and benefits by designing and implementing the supply chain. Such measures and metrics are also required to test the viability and initiate a process of continuous improvement in the organization. Further, supply chain being an integrated concept, discrete sites in supply chain does not lead to an improved productivity if each link in the chain is to pursue its goals independently. Performance measurement is one of the most important topics for the industrial engineer as it checks the efficiency and effectiveness of a concept. The supply chain typically consists of two echelons, a system of communication between these echelons and a cost structure that encompasses the two echelons.

Another point that has to be kept in mind is the conflict that arises in measuring the performance of a supply chain is the mechanism of different approaches by the industrial engineer and the factory manager. The factory manager might give more importance to the financial measure while the industrial engineer might like to concentrate on the operational measures. This phenomenon does not lead to performance metric that can present a clear picture of the effective supply chain. For a balanced approach, the financial metrics are important for strategic decision and external reporting whereas day to day control of manufacturing and distribution activities is better handled with operational measures.

The strategic, operational and tactical levels are hierarchies in a function, wherein different and suitable control is exerted. The strategic level measures influence the top level management decisions, very often reflecting investigation of broad based policies, corporate financial plans, competitiveness and level of adherence to organizational 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. Measurement of performance at this level provides valuable feedback on mid-level management decisions. Operational level measurements and metrics require accurate data and assess the results of decisions of low level managers. Supervisors and workers are to set operational objectives that, if met, will lead to the achievement of tactical objectives. An area where inequality persists is deciding upon the number of metrics to be used. Quite often companies have a large number of performance measures to which they continue to add based on suggestions from employees and consultants. They fail to realize that performance assessment can be better addressed using a trivial few—they are not really trivial, but instead are those few areas most critical to success. The metrics that are used in performance measurement and improvement should be those that truly capture the essence of organizational performance. A measurement system should facilitate the assignment of metrics to where they would be most appropriate. For effective performance measurement and improvement, measurement goals must represent organizational goals and metrics selected should reflect a balance between financial and non-financial measures that can be related to strategic, tactical and operational levels of decision making and control.

India being agriculture based economy; a lot of emphasis has to be put on the automation in the agriculture industry. The automotive farm equipment sector consists of the Tractor and other agriculture implements like wheat threshers, harvest combines etc. A number of organizations in India are working in this area, but the concept of performance measurement has never been applied to them to check the effectiveness and efficiency of such companies. In fact, the concept of supply chain management is comparatively new in this field, although it has been in news for the last decade or so. The concept of SCM has been more confined to areas of fast moving consumer goods (FMCG), process industry and other related areas. There is an urgent need to check the correct implementation of Supply Chain Management in the automotive farm equipment sector, verifying the efficiency and effectiveness of SCM techniques as applied to the sector. Having a unique face, the farm equipment sector has its own set of parameters and problems in SCM implementation.

Literature Review and Development of Hypothesis

Manufacturing Lead Time refers to the time taken by the organization to convert the raw material into finished product. Keeping the manufacturing lead time to a minimum is one of the main focus of the top management's strategy

in the organization. However, along with that the focus of management is also to use its resources to the most optimal level. Researchers like (Xiande Zhao & T.S. Lee,1993) have shown the impact of demand conditions and uncertainty on Master Production Schedule can result in higher cost and lower customer service levels. (Chen-Hua Chung, Lee J. Krajewski, 1984) show how a short term stable MPS acts as a tool for saving costs in the organization. Manufacturing Lead Time has been discussed as a important tool for improving cost benefit by (Z.Kevin Weng,1996); (George Ioannou,Stavrianna Dimitriou,2012) further take the discussion to a new level by integrating MPS with an MRP system. Other published work like (Z.Kevin Weng,1996) is limited to studying manufacturing lead time problems and its co relation with asset utilization in Made To Order companies. Other work like (Greg Filbeck, Raymond F. Gormanb, 2000) discuss asset utilization in refernence to large capital intensive industries. These observations help in formation of Hypothesis 1

H1: ***Manufacturing Lead time of an organization improves significantly by i) Stabilized Master Schedule; ii) Forecasting Accuracy & iii) Asset Utilization***

(Tiaojun Xiao, Danqin Yang2009) dwell upon the subject of risk sharing in Supply Chain in a one retailer scenario. Lack of information sharing can lead to serious problems like bullwhip effect that results in a lose-lose situation for all partners of a supply chain. (Haluk Demirkan[a], Hsing Kenneth Cheng 2008) examine the supply chain's performance under different coordination strategies involving risk and information sharing. Other researchers like (Jao-Hong Cheng,2011) have worked on the aspects of SCM performance and Information sharing along with risk sharing. Other contributors who have done significant research in this area include (Haluk Demirkana, Hsing Kenneth Cheng, 2008); (Yuanjie Hea, , Jiang Zhang, 2008); (Sijie Li, Zhanbei Zhu, Lihua Huang,2009); The second hypothesis is

H2: ***Risk sharing by supply chain partners is a function of i) Profitable Relationship between Supply Chain Partners and ii) Information sharing on Product development***

(Yugang Yu, Zheng Wang, , Liang Lianga,2012) have developed a model for calculating cost associated with total inventory to be managed in case of a perishable supply chain. (Kung-Jeng Wang, Y.S. Lin, Jonas C.P. Yu,2011) empirically investigates how different deterioration rates in each echelon affect performances of individuals and integrated inventory policies. Sensitivity analysis is given to justify that the impact of changes in deterioration rates of each echelon is significant and the joint cost of the proposed integrated inventory policy is found to be much less than the individual policies. In addition, a compensation policy is applied to evaluate cost reduction and benefit losses under different individual policies. Through the proposed coordination mechanism, the timing and quantities of deliveries can be determined optimally in cooperation with up-/down-stream members to achieve

a minimum overall cost. (M. Sepehri,2011) has talked about order lead time and its impact on Inventory turnover ratio. (C.A. Garcia, A. Ibeas, J. Herrera, R. Vilanova,2012) have developed a new technique called Internal Model Control (IMC). This coupled with personal interviews conducted during the survey leads us to the third hypothesis:

H 3: ***Inventory reduction is influenced by i) Order Delivery Lead Time ii) Information sharing among all stakeholders***

Research Methodology

In the present research we are focusing on the Agricultural equipment sector In Indian context. The main aim of this research is to establish relationship between different parameters for measuring performance establishing a casual relationship between various elements of the Supply Chain in this sector.

A questionnaire based survey was taken to address various issues related to performance measurement in supply chain in the farm equipment sector in Indian industries. The questionnaire was designed on the basis of available literature and previous surveys. Practicing managers and academicians in the field of SCM were also consulted for development of this questionnaire. Based on available literature, the survey was done with eleven broad perspectives. The above questionnaire was based on research done by many researchers like (Hervani and Helms, 2005), (Bhagwat and Sharma, 2007), (Otto and Kotza, 2003; Yeh *et al.*, 2007; Chia *et al.*, 2009); measure performance across supply chain processes at the operational level (e.g. SCOR model) (Huang *et al.*, 2005; Berrah and Cliville, 2007; Chae, 2009) or measure performance in the decision making levels (strategic, tactical and operational) (Gunasekaran *et al.*, 2001; 2004).

Using the postal survey method for administrating the questionnaire, a total of 500 copies were mailed to various companies in the Agri Automotive farm equipment sector..Out of these 113 responses were received back, which included 6 responses which were found blank. The rest 107 responses were found to be in order. The response rate although was only 27%, it is felt to be adequate for the present research.

To ensure the content and construct validation, the questionnaire was subjected to a pre-testing. It was tested for two main types of validity: (i) content validity, and (ii) construct validity. Content validity primarily depends on an appeal to the propriety of content and the way it is being presented (Nunally 1978).Before distributing the questionnaires to the targeted respondents, a pilot study was conducted with several industry experts and academic professionals. Based on their feedback, modifications were made to enhance the clarity of the items in the questionnaire.

Response Bias:

One test that is used for testing non response bias is to compare the answers

of early and late respondents. The logic behind this is that the late respondents are more likely to answer the questionnaire like non respondents than early respondents. Therefore non response bias was tested by comparing these responses, which were received late, i.e after sending two or more reminders with those who had sent the questionnaires without any reminder or with one reminder. There were a total of 52 respondents who sent the questionnaire after two reminders while 65 respondents sent the questionnaire in time. The results of t-tests on some key variables suggest that early respondents do not significally differ from the late respondents. Therefore non-response bias is ruled out.

As already discussed, the questionnaires were filled by the respondents based on the above mention performance metrics. The research methodology adapted was to formulate hypothesis based on the questionnaire, and our one to one meetings with the industry experts.

Hypothesis Formulation:

Three major hypotheses were formulated, based on literature available and the questionnaire.

- H1: Manufacturing Lead time of an organization improves significantly by i) Stabilized Master Schedule; ii) Forecasting Accuracy & iii) Asset Utilization
- H2: Risk sharing by supply chain partners is a function of i) Profitable Relationship between Supply Chain Partners and ii) Information sharing on Product development
- H3: Inventory reduction is influenced by i) Order Delivery Lead Time ii) Information sharing

Hypothesis Testing:

The hypotheses developed earlier were tested using SPSS Version 17.0 software. Multiple linear-stepwise-regression analysis was conducted to test the proposed hypothesis. Each of the hypothesis is reproduced below for reference purposes.

In H1, The dependent variable is Manufacturing Lead Time , while the independent variables are Master Schedule, Forecasting accuracy and asset utilization.

H1: Manufacturing Lead time of an organization improves significantly by i) Stabilized Master Schedule; ii) Forecasting Accuracy & iii) Asset Utilization

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.490	.538		4.630	.000
	Asset utilization	.234	.108	.252	2.165	.000

	Stable Master schedule	.187	.093	.199	2.016	.001
	Forecasting accuracy	.117	.088	.158	1.337	.001

Thus as per the result the regression model will look like

Manufacturing Lead Time= 0.234(Asset Utilization)+0.187 (Stable master Schedule) +0.117 (Forecasting Accuracy) + 0.49

As the two independent variables affect the dependent variables at a high significance levels ($p<0.05$), the hypothesis is accepted.

In the second hypotheses, Risk sharing among all members of SCM is the dependent variable, while Profitable relationship and information sharing are taken as the dependent variables.

H2: Risk sharing by supply chain partners is a function of i) Profitable Relationship between Supply Chain Partners and ii) Information sharing on Product development

Coeffients Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.199	.464		2.586	.000
	Information sharing related to purchasing	.665	.077	.064	.839	.000
	Profitable relationship with the suppliers	.733	.080	.697	9.206	.000
a. Dependent Variable: Risk sharing among all partners						

The regression model here becomes

Risk Sharing= 0.665(Information sharing related to purchasing) + 0.733 (Profitable relationship with the suppliers)+ 0.199

As the value of p is less than 0.05, the hypothesis is deemed as accepted.

H3: Inventory reduction is influenced by i) Order Delivery Lead Time ii) Information sharing among all stakeholders

Regression applied to this hypothesis yields the following table

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.259	.475		4.758	.000
	Information sharing related to purchasing	.506	.066	.152	1.599	.000
	Order delivery lead time	.320	.072	.421	4.423	.000
a. Dependent Variable: Inventory turnover ratio						

As the regression has been achieved, the hypothesis is accepted. The regression table in this case becomes

Inventory turnover Ratio= 0.506(Information sharing related to purchasing) + 0.320(Order delivery lead time)+ 0.259

Discussion:

This study is of significance as it establishes a relation between different aspects of performance metrics in a typical supply chain. The present study establishes the relative importance of independent performance indicators, which influence a key issue in SCM : Performance Measurement. From a practicing managers point of view, the role of various variables in improving performance of the supply chain is highly significant. Also, all three hypotheses have a role for the top management to play. Results from the study show that Manufacturing Performance Indicators have a pivotal role in SCM whether it is related to Manufacturing Lead Time (hypothesis 1), risk sharing (hypothesis 2), or inventory reduction (hypothesis 3). Significantly it can be noted that the effectiveness and efficiency of the supply chain in any organization has to be linked to its business strategy. This shall lead to better monitoring of the performance of the supply chain.

In the first hypothesis (H1), three enablers of good performance that facilitate low customer complaints and low stock outs are tested . It is observed that all three elements have a greater impact on the manufacturing lead time, and thus overall efficiency of the supply chain.

The second hypothesis (H2) enlightens about the relationship between the kind of relationship that is enjoyed between different echelons of a supply chain and how the performance of supply chain is impacted by positive relationship and sharing of information on new developments in products. It can be seen from this hypothesis that management should work in tandem with its suppliers and keep them in the loop "with regards to any new product line being developed and also minor modifications being carried out.

In the third hypothesis (H3), one of the most important aspect of measuring performance of a Supply Chain: Inventory reduction is talked about. The independent variables are Order delivery lead time and Information sharing. this hypothesis is very significant in light of the fact that inventory reduction is one of the best measure of performance of a supply chain. It can also be seen that by reducing Order delivery lead time, we can improve Inventory reduction. With a R^2 value of 0.568, it can be seen that 57% of the times this model will hold its ground.

Conclusion

The main findings of this study will enhance the already available body of literature on Supply Chain Management. The hypothesis developed and discussed not only validate some widely discussed aspects of SCM but also

significantly deduce interrelationships among the various performance metrics. The statistical technique of regression analysis used in the research gets relative importance of every element discussed. For a practicing SCM manager, the analysis reveals that placing emphasis on information sharing and improving buyer supplier relationships can benefit the firm. SCM is a viable manufacturing strategy as can be seen from this research. Inventory reduction leads to increase in performance of the supply chain. Improving SCM performance leads to the ultimate business goal: Improving profits for the organization.

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