SUPPLY CHAIN'S PERFORMANCE MEASUREMENT SYSTEM AN INTEGRATED FRAMEWORK

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Abstract: *The effective supply chain management is used as a global competitive tool in increasing productivity and profitability of a company as a whole. In recent years, the researches are related to measuring the performance of companies; therefore a general picture of the events outside the company is lacking, and has a substantial impact on its operations. The measurements and metric expressions (Key Performance Indicators - KPIs) are essential for the company's success, but they should not be overestimated because of the influence over strategy, tactical and operational planning and control. They play an important role in establishing goals, evaluating performance and determining the future course of action. Considering that the basic characteristic of the market conditions in today's economy is its dynamic, a continuous feedback between the strategy of a company and established performance measurement systems is required. In literature, usually there are models for re-organization of the companies where the main attention is directed to the systematization of complex processes and determination of the key parameters in making decisions. By defining the variables and their segmentation as a key to success and sub-key variables for success, efforts are made to cover all areas in a company. This research is a step forward, a system for measuring the performance of supply chains is explained in order to promote the importance of supply chain as a whole. As a source, the existing literature and data obtained by empirical analysis of questionnaires sent to selected group of Macedonian companies from the field of production machinery, the ribbons are used.*
Keywords: SUPPLY CHAIN, PERFORMANCE MEASUREMENT, METRIC PERFORMANCE, EMPIRICAL ANALYSIS, SYSTEMS

1. Introduction

Development of cross-functional teams aligns companies with process oriented structure, which is much needed to realize a smooth flow of resources in a supply chain. Such teams promote improved supply chain effectiveness. They minimize or eliminate functional and departmental boundaries and overcome the drawbacks of specialization, can distribute the knowledge of all value adding activities such that no one, including upper level managers, has complete control over the process. Such teams helped in the formation of modern supply chains by promoting greater integration of companies with their suppliers and customers.

Today many companies have taken bold steps to break down both inter and intra companies barriers to form alliances, with the objective of reducing uncertainty and enhancing control of supply and distribution channels. Such alliances are usually created to increase the financial and operational performance of each channel member through reductions in total cost and inventories and increased sharing of information. Rather than concerning themselves only with price, manufacturers are looking to suppliers to work co-operatively in providing improved service, technological innovation and product design [1].

To meet objectives, the output of the processes enabled by the supply chain must be measured and compared with a set of standards. In order to be controlled, the process parameter values need to be kept within a set limit and remain relatively constant. This will allow comparison of planned and actual parameter values, and once done, the parameter values can be influenced through certain reactive measures in order to improve the performance or re-align the monitored value to the defined value. Thus, control of processes in a supply chain is crucial in improving performance and can be achieved, at least in part, through measurement. Well-defined and controlled processes are essential to better SCM.

There are number of conceptual frameworks and discussions on supply chain performance measurements in the literature; however, there is a lack of empirical analysis and case studies on performance metrics and measurements in a supply chain environment.

The strategic, operational and tactical levels are the hierarchies in function, wherein policies and trade-offs can be distinguished and suitable control exerted. Such a hierarchy is based on the time horizon for activities and the pertinence of decisions to and influence of different levels of management [2]. 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 company's 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.

The metrics that are used in performance measurement and improvement should be those that truly capture the essence of company's 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 company's 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.

2. The research methodology and empirical analysis

A survey was used to study performance measures and metrics used in a supply chain environment. The questionnaire was divided into four basic sections. They are as follows: plan (including strategy), source/supply (order), produce (make/assemble), and delivery (to customer). These four categories correspond to the four basic activities or processes in a supply chain—(1) plan–(2) source–(3) make/assemble–delivery. The questionnaires were mailed with a cover letter and addressed to the CEO of each firm. Targeted recipients were instructed to complete the survey themselves or refer it to an appropriate person for the same. As a source, the existing literature and data obtained by empirical analysis of questionnaires sent to selected group of Macedonian companies from the field of production machinery, the ribbons were used. Of the 30 questionnaires mailed, 4 were completed and returned. Nearly all the responses were received within 4 weeks of mailing. Two of the companies said that because of the larger number of such inquiries they were unable to reply. One of the companies returned the questionnaire stating that they were not suitable candidates for the survey because of changes in their operations. The response rate was only 13%, but we felt that it was adequate to assist us in developing our framework.

2.1 Planning performance evaluation metrics

This section deals with financial and nonfinancial strategic level performance measures. The importance of these parameters was established by calculating the mean of all responses and ranking them accordingly. The ranks were converted to relative percentages by dividing each rank, by the total of all ranks for the group of measures/metrics. This approach is similar to the method used in Pareto analysis wherein problem frequencies are converted to percentages to show relative importance. The percentages better highlight differences in the importance of performance measures in each group (we used this approach in analyzing performance measures in all groups discussed herein). We further categorized the measures based on importance (highly important, moderately important and less important). The methodology employed for such was similar to the methodology used in ABC inventory (inventory item's annual cost is stated as a percent of total inventory costs) to prioritize inventory management decisions (item cost percentages sorted in descending order and grouped into A—most important, B—moderate importance, and C—less important based on their contribution to total costs). We used this approach in analyzing performance measures in all groups discussed herein. Please note that categorizing a measure as less important does not mean it is unimportant, but rather it seems less important compared to others in the measurement group. We believe a similar approach could be used by managers in setting priorities in the development of a measurement system for supply chain performance [3,5].

Our small sample size precluded the use of more powerful statistical techniques. The first set of measures (five non-financial and three financial) pertain to planning, but more specifically to strategic planning. Table 1 shows the measures and their relative importance as determined by our analysis of the survey data. The importance rating survey results show that the level of customer perceived value of product is of the most importance. It was deemed highly important which clearly reflects the perception of practitioners that customer satisfaction is paramount in importance in increasing competitiveness. The measures considered moderately important in descending order include variances against budget, order lead-time, information processing cost, net profit vs. productivity ratio, total cycle time and total cash flow time. Variances against budget, information-processing cost and net profit vs. productivity are of course financial measures and reflect the importance of financial measures in strategic planning and control—financial stability is essential to company's success. The only strategic planning measure deemed less important was level of energy utilization which may suggest that it is not of strategic significance. That, of course, could vary from company to company, depending on energy cost as a percent of total manufacturing cost and on energy price levels relative to the prices of other manufacturing inputs.

Table 1: *Raitings strategic planing metrics*

Assessment	Strategic performance metrics	Percentage Importance (%)
High important	Level of customer Perceived value of product	16.4
Moderately Important	Variances against budget	14.2
	Order lead time	13.5
	Information processing costs	12.7
	Net profit versa productivity ratio	12.5
	Total cycle time	11.8
	Total cash flow time	10.3
Less important	Level of energy utilisation	8.4

The percentage importance (relative importance) of the strategic performance metrics clearly suggests that non-financial measures of performance are considered by practitioners to be important in assessing the competitiveness of an organization. This is not to say that financial measures are no longer important, but rather that non-financial measures are important and necessary in assessing a firm's ability to compete.

In Table 2, the order of priority for the order planning level metrics is presented. At the order planning level, *customer query time was highly important*, which would seem to emphasize the importance of customer service. Product development cycle time and forecasting was moderately important. These two factors related to meeting customer needs and doing so in a timely fashion. Cross-functional teams, rapid prototyping, and concurrent engineering involving suppliers would seem appropriate in efforts to improve product development cycle time. Many alternative techniques are available for forecasting. Due to the forecasts of all supply chain links can influence supply chain performance, a concerted effort by all should be made to assure accurate forecasts.

Table 2: *Importance of order planning metrics*

Assessment	Planning performance metrics	Percentage Importance (%)
High important	Customer query time	19.1
Moderately Important	Product development cycle time	17.4
Less important	Accuracy of forecasting	16.6
	Planning process cycle time	16.0
	Order entry methods	15.5
	Human resource productivity	15.4

By benchmarking their forecasting methods with those of the best, a better understanding the techniques might be gained and greater accuracy achieved. Also, by integrating production schedules with others in the supply chain, more accurate day to day demand forecast might be possible for all links in the supply chain. *Planning process cycle time, order entry methods, and human resource productivity were the less important order planning measures.* Planning process cycle time and order entry methods could be improved through re-engineering efforts that include multiple links in the supply chain, because the actions of multiple participants interact to influence performance in these areas. Improvements in customer query time, product development cycle time and planning process cycle time might be brought about by greater human resource productivity, so although it was rated last in importance, human resource productivity should not be dismissed as unimportant. Improvement in order entry methods, customer query time, forecasting accuracy and customer query time might be brought about through the application of information technology to increase accuracy and expedite the flow of information throughout the supply chain. Process cycle time can be tackled by using techniques like single minute exchange of die and group technology, whereby similar facilities for production will be grouped to reduce manufacturing lead-time.

2.2 Supply link evaluation metrics

Evaluation of supply link performance is very important in managing the supply chain for peak efficiency and effectiveness [1]. In this section, the importance of performance measures/metrics in a supply chain link (includes purchasing and supplier management activities) are rated in importance. The main objective here is to identify the KPI in supply link performance evaluation. The KPI can be defined as the performance indicators that have significant impact on the overall performance of an organization in the areas of strategic, tactical and operational planning and control. Six key performance indicators (KPI) pertaining to the supplier link were included in the survey and ranked by participants, see Table 3. These measures include: supplier delivery performance, lead-time against industry norm, supplier pricing against market, efficiency

of purchase order cycle time, efficiency of cash flow method, and supply booking procedures [5].

Table 3: *Importance of supplier metrics*

Assessment	Supplier performance metrics	Percentage Importance (%)
High important	Supplier delivery performance	23.2
Moderately Important	Supplier lead time against industry norm	20.0
	Supplier pricing against market	18.3
	Efficiency of purchase order cycle time	15.5
Less important	Efficiency of cash-flow method	12.4
	Supplier booking in procedures	10.6

As can be seen in Table 3, *supplier delivery performance* emerged as *the most important measure* pertaining to the evaluation of supplier performance. It was the only highly important measure. *The moderately important measures in descending order are supplier lead time against industry norm, supplier pricing against market and efficiency of purchase order cycle time. The less important supplier measures were efficiency of cash flow method and supplier booking in procedures.* Most notable about the supplier metrics is that firms regard the supplier's capability to reliably deliver goods in a timely fashion as more important than price. Price has increasing become an order qualifier rather than an order winner. Other aspects of supplier performance such as adherence to agreed upon schedules and terms of the order as well as prompt delivery of goods have become order winners. Companies would do well to not just use supplier metrics for selection of suppliers, but rather they should work closely with suppliers to see that they have in place within their organizations, measurement systems that will foster significant improvement in all of these areas.

2.3 Production performance evaluation metrics

The performance measures for the production link included percentage of defects (a measure of product quality), cost per operation-hour, capacity utilization, range of product and services, and utilization of economic order quantity [4,5]. Table 4 contains the measures and their percentage importance ratings. From the table one can see that the percentage of defects emerged to be the most important, but two others, cost per operation hour and capacity utilization, were also highly important. The latter two are essentially measures of the efficiency with which resources are used in manufacturing (produce/assemble), and good performance in these two areas translates into lower cost per unit to manufacture products/provide services. Efficiency of operations is important for all supply chain partners, if the elusive goal of supply chain optimization is to be achieved. We should caution that maximum efficiency of each partner in all areas might not be a desirable because trade offs are necessary in order to achieve a global optimum for the supply chain—local optimums in all parts do not necessarily lead to global optimization for a system. The only measure rated moderately important was range of products and services. A broader range of products tends to result in fewer new products being introduced and a more narrow range is associated with greater product innovation. For this reason, the measure does seem worthy of the attention of managers, especially in making decisions about the breadth and depth of product lines.

Table 4: *Importance of product metrics*

Assessment	Metrics	Percentage Importance (%)
High important	Percentage of defects	24.2
	Cost per operation hour	22.5
	Capacity utilization	22.0
Moderately Important	Range of products and services	18.0
Less important	Utilization of economic order quantity	13.6

2.4 Delivery performance evaluation metrics

After the orders are planned and goods sourced, produced and assembled, the remaining task is to deliver them to customer. Table 5 shows the order of importance of delivery performance measures. *Quality of delivered goods is first in importance, followed by on time delivery of goods and flexibility of service systems to meet customer needs. Here again, we believe that these three are* related to the perceived customer value of the product, the top ranking strategic planning measure. Providing the customer with a quality product in a timely fashion, and maintaining customer satisfaction with a service system designed to flexibly respond to customer needs are key in producing value for the customer. *The effectiveness of the enterprise distribution planning schedule, effectiveness of delivery invoice methods, number of faultless delivery notes invoiced, percentage of urgent deliveries and information richness in carrying out the delivery are moderately important.* In the survey, companies were asked to express their views on reducing the cost of a delivery system. Their responses tended to emphasize techniques like JIT and the application of automation alternatives to reduce costs.

Table 5: *Importance of delivery performance measures*

Assessment	Delivery performance metrics	Percentage Importance (%)
High important	Quality of delivered goods	12.3
	On the time delivery of goods	12.2
	Flexibility of service systems to meet customers needs	11.4
Moderately Important	Effectiveness of enterp. distribution planning schedule	10.3
	Effectiveness of delivery invoice methods	10.2
	Number of faultless delivery notes invoiced	10.0
	Percentage of urgent deliveries	9.3
	Information richness in carrying out delivery	9.0
Less important	Percentage of finished goods in transit	8.0
	Delivery reliability performance	7.3

3. Results and discussion

3.1 A framework for performance measurement in a supply chain

Table 6 presents a framework for performance measures and metrics, considering the four major supply chain activities/processes (plan, source, make/assemble, and deliver). These metrics were classified at strategic, tactical and operational to clarify the appropriate level of management authority and responsibility for performance. Measures are grouped in cells at the intersection of the supply chain activity and planning level. For example, Supplier delivery performance can be found at the intersection of the Source activity and Tactical planning level indicating that it pertains to sourcing activities (source) and the tactical planning level. Supplier delivery performance would thus be a measure useful in analyzing the performance of mid-level managers as they undertake sourcing activities — mid-level

managers who are generally the ones responsible for tactical decisions.

The items in each cell are listed in the order of importance based on percentage importance ratings. Those ratings can be seen in Tables 1–5. Some measures appear in more than one cell, indicating that measures may be appropriate at more than one management level. Measures used at different management levels will most assuredly require adjustment to tailor them to planning and control needs of the different levels. For example, appropriate measurement may require that data used by the lower level of management be aggregated in some form or fashion to make the data appropriate for the next higher level (convert data into information appropriate for the context). There is nothing new in this approach, as it has been used for years in management planning and control systems.

The approach we used in organizing the measures for the framework could be used by organizations in development of a performance measurement program for SCM.

4. Conclusion

In the survey participants were asked whether their return on investment had increased to improved performance is not automatic. As with any other company undertaking, it must be done well to yield positive results. This is why we believe it is important to assess performance in SCM and the reason we developed the SCM performance measurement framework.

To bring about improved performance in a supply chain and move closer to attainment of the goal of supply chain optimization, performance measurement and improvement studies must be done throughout the supply chain. All participants in the supply chain should be involved and committed to common goals, such as customer satisfaction throughout the supply chain and enhanced competitiveness. A performance measurement program for a supply chain should be complete—important aspects of performance in any link are not ignored—and they must be tailored to varying needs of participants. A good SCM program will bring about improved cross-functional and intra-company processes planning and control and more complete supply chain integration. A supply chain wide performance measurement initiative would seem most appropriate. This is not to suggest that one party dictate measurement programs for all supply chain participants, but rather that all participants take part in developing a well planned, well coordinated, supply chain-wide performance measurement initiative to which all can and will be committed. A comprehensive control system will be necessary in order to assure effective and efficient performance measurement all along the supply chain, but it must not be done in such a way as to unduly limit the decision making authority of managers in participating companies.

Creative efforts are needed to design new measures and new programs for assessing the performance of the supply chain as a whole as well as the performance of each organization that is a part of the supply chain. Company, suppliers and customers should come together to discuss how they will address the measurement and improvement of SCM performance. Industry consortium, consultants, and researchers could be helpful in promoting SCM performance measurement generally, and in developing measures and measurement techniques specifically. Clearly tremendous opportunity exists to develop measures that facilitate progress and promote greater supply chain integration.

Table 6: *Supply chain performance metrics framework*

SCM activity/ process	**Strategic**	**Tactical**	**Operational**
Plan	Level of customer perceived value of product, Variances against budget, order lead cost, Net profit Vs productivity ratio, total cycle time, Total cash flow time, Product development cycle time	Customer query time, Product development cycle time, Accuracy of forecasting techniques, Planning process cycle time, Order entry methods, Human resource productivity	Order entry methods, Human resource productivity
Source	…… …	Supplier delivery performance, supplier lead-time against industry norm, Efficiency of purchase order cycle time, Efficiency of cash flow method, Supplier booking in procedures	Efficiency of purchase order cycle time, Supplier pricing against market
Production /Assemble	Range of products and services	Percentage of defects, Cost per operation hour, Capacity utilization, Utilization of economic order quantity	Percentage of Defects, Cost per operation hour, Human resource productivity index
Deliver	Flexibility of service system to meet customer needs, Effectiveness of enterprise distribution planning schedule	Flexibility of service to meet customer needs, Effectiveness of enterprise distribution planning schedule, Efficiency of delivery invoice method, Percentage of finished goods in transit, Delivery reliability performance	Quality of delivered goods, on time delivery of goods, Effectiveness of delivery invoice methods, Number of faultless delivery notes invoiced, Percentage of urgent deliveries, information richness in carrying out delivery, Delivery reliability performance

5. References

1. THOMAS, D.J., GRIFFIN, P.M., Coordinated supply chain management, European Journal of Operational Research 94 (3), 1–15, 1996
2. GUNASEKARAN, A., PATEL, C., TIRTIROGLU, E., Performance measure and metrics in a supply chain environment, 2001
3. VAN HOEK, R.I., The contribution of performance measurement to the expansion of third party logistics alliances in the supply chain, International Journal of Operations & Production Management 21 (1/2), 15–29, 2001
4. MAPES, J., SZWEJCZEWSKI, M., Performance trade-offs in manufacturing plants, International Journal of Operations & Production Management 17 (10), 1020–1033, 1997
5. STEPHEN LACKEY, What is the right supply chain for your product?, Harvard Business Review, v75, 199, 2004