

SUPPLY CHAIN PERFORMANCE

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Author: M.P. Kleverlaan

Supervisor: Prof. dr. J. Semeijn

2nd supervisor: Prof. dr. A. van Riel

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Matthijs Kleverlaan

1. Introduction

Since the term supply chain management was introduced, there has been a great deal of confusion about what it actually involves. It is widely acknowledged that there has been relatively little interest in developing measurement systems and metrics for evaluating supply chain performance (Shepherd and Günter, 2006). While some managers and researchers continue to use it interchangeably with logistics, there is an increasing understanding that supply chain management is much more than logistics (Rogers et al., 2001).

Increasingly SCM is being recognized as the management of key business processes across the network of organizations that compromise the supply chain. According to the Global Supply Chain Forum SCM is the integration of key business processes from end user through original suppliers, which provide products, services, and information that add value for customers and other stakeholders (Global Supply Chain Forum, 1998). Mentzer et al. (2001) define supply chain management as 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.

There are several implications for practitioners and researchers. Perhaps unsurprisingly, criticisms of measurement systems designed to evaluate the performance of supply chains mirror those in the wider performance management literature. According to Shepherd and Günter, 2006 they include:

- lack of connection with strategy;
- focus on cost to the detriment of non-cost indicators;
- lack of a balanced approach;
- insufficient focus on customers and competitors;
- loss of supply chain context, thus encouraging local optimization;
- lack of system thinking.

Executives should be aware that the successful integration and management of key business processes across members of the supply chain will determine the success of an enterprise.

Usually managing the supply chain is left to chance. For this reason, executives usually are striving to interpret and to determine how to manage the company's supply chain network, and thereby achieve the potential of SCM (Lambert et al., 2000).

Motivation and contribution

There have been relatively few attempts to systematically collate measures for evaluating the performance of supply chains. Moreover, there is dissensus over the most appropriate way to categorize them. It is also argued that supply chain performance must be measured at multiple levels (Shepherd and Günter, 2006).

In the research of Gunasekaran et al. (2004) participants were asked whether their return on investment had increased to expected levels after implementing contemporary supply chain management (SCM) practices. The research showed that effort focused on carefully managing supply chains produced financial benefits for participating firms.

From a financial perspective alone, a proactive approach to SCM is advisable for firms wanting to enhance competitiveness. Literature on SCM suggests that effective SCM help to win customers and improve customer service. SCM has a positive effect on market share, providing more evidence of the strategic importance of successful SCM. The potential benefits of SCM make it attractive, but improved performance is not automatic. As with any other organisational undertaking, it must be done well to yield positive results. To bring about improved performance in a supply chain and move closer to attainment of the illusive goal of supply chain optimization, performance measurement and improvement studies must be done throughout the supply chain (Gunasekaran et al., 2004).

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-organisational process 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 organizations. Care must be exercised in developing such an effective system in order that it promotes mutually advantageous exchange among participants, so that relationships endure the test of time. Additional research and practitioner-driven initiatives are needed in the area of SCM performance measurement. 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. Organisation, suppliers and customers should come together to discuss how they will address the measurement and improvement of SCM performance. Industry consortiums, consultants, and researchers could be helpful in promoting SCM performance measurement generally, and in developing measures and measurement techniques specifically. They could play a significant role in helping firms address the present and future challenges of managing supply chains (Gunasekaran et al., 2004).

Supply chain management is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses and stores, so that merchandise is produced and distributed at the right quantities, to the right locations and at the right time, in order to minimize system wide costs while satisfying service level requirements. The concept includes the broad range of activities needed to plan, implement and control manufacturing and delivery processes from the point of raw material origin to the point of consumption. Faster time to market, reduced inventory, flexibility and responsiveness to changing market demand, secure visibility to critical information are some of the benefits supply chain management has to offer. Supply chain management can cut total costs while increasing performance. Additionally, it generally involves integration, coordination, collaboration and performance measurement across organizations and throughout the supply chain. Finally, there is a need to investigate whether implementing measurement systems to evaluate supply chain performance is cost effective, especially for small and medium enterprises. (Shepherd and Günter, 2006).

This research paper aims to get an understanding of how these elements are implemented in the Dutch MRO&OEM market. The research question guiding the present study will, therefore, be:

How effective are supply chain performance measurement systems for small and medium sized enterprises?

The two most important research opportunities (sub-research questions) for this study are:

- What specific metrics should be introduced to evaluate performance within and beyond the borders of the firm?
- The benefits of supply chain performance measurement systems are outweighed by the cost of implementing and maintaining them. The third sub question therefore is: Are supply chain performance measurement systems cost effective for SME's?

Approach

This paper focuses on performance measurements and metrics in supply chain management in the Dutch MRO&OEM market. This study is to develop a case study that illustrates the implementation of metrics in SCM in order to continue to develop the theory that will move supply chain to its next evolutionary stage. Taking into consideration whether implementing measurement systems to evaluate supply chain performance is cost effective, especially for small and medium enterprises (Shepherd and Günter, 2006).

A literature study was done in order to investigate what metrics can be used in supply chain measurement systems. This is presented in chapter two. The research methodology will be presented in chapter three. In order to gain better understanding about the phenomena of how supply chain management performance metrics are applied in real-life, an exploratory case study was chosen as the research methodology. According to Yin (2003) a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. Case study is also a research strategy, which seeks to understand the dynamics present within single settings (Eisenhardt, 1989).

Building theory from case studies is a research strategy that involves using one or more cases to create theoretical constructs, propositions and/or midrange theory from case-based, empirical evidence (Eisenhardt, 1989). Case studies are rich, empirical descriptions of particular instances of a phenomenon that are typically based on a variety of data sources (Yin, 2003). A major reason for the popularity and relevance of theory building from case studies is that it is one of

the best (if not the best) of the bridges from rich qualitative evidence to mainstream deductive research. Sound empirical research begins with strong grounding in related literature, identifies a research gap, and proposes research questions that address the gap (Eisenhardt and Graebner, 2007).

In this paper, the findings of this research will be presented in chapter four followed by the discussion and conclusion in chapter five.

2. Literature review

2.1 *Introduction to Supply Chain Management*

It has been noted that discussions of SCM often use complicated terminology, thus limiting management's understanding of the concept and its effectiveness for practical application (Ross 1998). This section is dedicated to reviewing, classifying, and synthesizing some of the widely-used definitions of "supply chain" and "supply chain management" in both academia and practice. The goal of this discussion is the development of one, comprehensive definition upon which managers and future researchers can build.

In a typical supply chain, raw materials are procured and items are produced at one or more factories, shipped to warehouses for storage and then shipped to retailers or consumers. To reduce cost and improve service levels, effective supply chain strategies must take into account the interactions at the various levels in the supply chain. The supply chain consists of suppliers, factories, warehouses, distribution centres and retail outlets, as well as raw materials, work-in-process inventory and finished products that flow between the facilities. In their book *Designing and Managing the Supply Chain*, Simchi-Levi et al. (2002, p. 1) define supply chain management as follows:

"Supply chain management is a set of approaches utilised to efficiently integrate suppliers, manufacturers, warehouses and stores, so that merchandise is produced and distributed at the right quantities, to the right locations and at the right time, in order to minimise system wide costs while satisfying service level requirements."

Defining the Supply Chain

The definition of "supply chain" seems to be more common across authors than the definition of "supply chain management" (Cooper and Ellram 1993; La Londe and Masters 1994). La Londe and Masters proposed that a supply chain is a set of firms that pass materials forward. Normally, several independent firms are involved in manufacturing a product and placing it in the hands of the end user in a supply chain—raw material and component producers, product assemblers, wholesalers, retailer merchants and transportation companies are all members of a supply chain (La Londe and Masters 1994). By the same token, Lambert, Stock, and Ellram (1998) define a supply chain as the alignment of firms that brings products or services to market. Note that these concepts of supply chain include the final consumer as part of the supply chain. Another

definition notes a supply chain is the network of organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services delivered to the ultimate consumer. In other words, a supply chain consists of multiple firms, both upstream (i.e., supply) and downstream (i.e., distribution), and the ultimate consumer. Other definitions are alike. For example, Stank et al. (2001) describe supply chain management as maximizing service to customers of choice at the lowest total cost. Cooper et al. (1997, p. 2) describe supply chain management as the “integration of business processes from end user through original suppliers that provide products, services and information that add value for customers”.

Supply chain management generally involves integration, coordination and collaboration across organizations and throughout the supply chain. The concept includes the broad range of activities needed to plan, implement and control manufacturing and delivery processes from the point of raw material origin to the point of consumption (Stank et al. 2001).

2.2 Supply chain activities

A supply chain can be seen as a network consisting of suppliers, manufacturers, distributors, retailers, and customers (Figure 1). At the operational level, this network supports three types of flows that require careful planning and close co-ordination:

- . *material flows*, which represent physical product flows from suppliers to customers as well as the reverse flows for product returns, servicing, and recycling;
- . *information flows*, which represent order transmission and order tracking, and which coordinate the physical flows; and
- . *financial flows*, which represent credit terms, payment schedules, and consignment and title ownership arrangements.

The network, in turn, is supported by three pillars:

- . *processes*, which embed the firm’s capabilities in logistics, new product development, and knowledge management;
- . *organizational structures*, which encompass a range of relationships from total vertical

integration to networked companies as well as management approaches, and performance measurement and reward schemes; and

enabling technologies, which include both process and information technologies.

2.2.1 Supply chain collaboration

Stank et al. (2001), have studied the relationship between collaboration and service improvement in supply chains. Collaboration is a process of decision making among interdependent parties. It involves joint ownership of decisions and collective responsibility for outcomes. Key dimensions are a cross department scope, a commitment to work together and a common bond or goal. Higher levels of internal and external collaboration are expected to result in improved logistical service performance, and, internal and external collaboration have a positive influence on each other (Stank et al. 2001).

The findings reveal that internal collaboration considerably influences logistical service performance, which implies that firms should promote cooperation and collaboration across internal processes to achieve logistical efficiency. The lack of support for a direct link between external collaboration and service performance is remarkable and, suggests that collaboration with customers and suppliers will not improve performance. Additional investigation revealed that collaboration with external supply chain entities influences increased internal collaboration, which consequently improves logistical service. Collaboration is needed both within and beyond the firm's boundaries. The benefits are synergistic. Collaborating and information sharing focuses more resources, both human and financial, on business operations. This leads to more informed decisions and reduces risks (Stank et al. 2001).

External collaboration (i.e. collaboration with suppliers) is essential. Personnel from trading partners collect the necessary intelligence, such as information on order patterns, planned product promotions and valuable service feedback. It is critical that the information they pass on reach the right people within the organisations and mere delivery may not be adequate, they may have to sell ideas internally to convince the appropriate people to follow through. Internal collaboration (i.e. collaboration between different departments in the same firm) is essential as well as it facilitates close interactions that bring greater expertise to day to day operations, focussing on efforts and targeting resources as needed (Stank et al. 2001).

2.2.2 Supply chain performance

As mentioned in the introduction, the benefits of supply chain performance measurement systems are outweighed by the cost of implementing and maintaining them. This is likely to be especially applicable for small enterprises which may lack the resources, time or information to undertake the analyses required to optimize supply chain activities (Shepherd and Günter, 2006). In order to get a thorough understanding of supply chain metrics and measurement systems, the literature review is about supply chain metrics and measures. They are discussed in the context of the following supply chain activities/ processes: plan, source, make/assemble, and delivery/customer (Gunasekaran et al., 2001).

2.2.2.1 Metrics for order planning

The order entry method

This method determines the way and extent to which customer specifications are converted into information exchanged along the supply chain.

Order lead-time

The total order cycle time, refers to the time elapsed in between the receipt of customer order until the delivery of finished goods to the customer. The reduction in order cycle time leads to reduction in supply chain response time, and as such is an important performance measure and source of competitive disadvantage. It directly interacts with customer service in determining competitiveness.

The customer order path

The path from order entry till delivery is another important measure whereby the time spent in different channels can be determined. By analyzing the customer order path, non-value adding activities can be identified so that suitable steps can be taken to eliminate them.

2.2.2.2 Evaluation of supply link

Traditionally supplier performance measures were based on price variation and on time delivery. The selection of suppliers and product choice were usually based on price competition with less attention afforded to other criteria like quality and reliability. More recently, the whole approach to evaluating suppliers has undergone a major change.

The evaluation of suppliers in the context of the supply chain (efficiency, flow, integration, responsiveness and customer satisfaction) involves measures important at the strategic, operational and tactical level:

Strategic level measures include lead time against industry norm, quality level, cost saving initiatives, and supplier pricing against market.

Tactical level measures include the efficiency of purchase order cycle time, booking in procedures, cash flow, quality assurance methodology and capacity flexibility.

Operational level measures include ability in day to day technical representation, adherence to developed schedule, ability to avoid complaints and achievement of defect free deliveries.

Purchasing and supply management analyze on a periodic basis their supplier abilities to meet the firm's long-term needs. The areas that need particular attention include the supplier's general growth plans, future design capability, role of purchasing and supply management in the supplier's strategic planning, potential for future production capacity and financial ability to support such growth. Supply chain partnership is a collaborative relationship between a buyer and seller. Such a partnership emphasises direct, long-term association, encouraging mutual planning and problem solving efforts. Partnership formation is vital in dolphin choir operations and as such for efficient and effective sourcing. Partnership maintenance is no less important. Performance evaluation of buyers or suppliers is not enough, relationships must be evaluated. The parameters that need to be considered in the evaluation of partnerships are vital in promoting and strengthening them. For example, the level of assistance in mutual problem solving is indicative of the strength of supplier partnerships. Partnership evaluation based on such criteria will result in win-win partnerships leading to more efficient and more thoroughly integrated supply chains (Gunasekaran et al., 2001).

This brings us to the first sub question:

What specific metrics should be introduced to evaluate performance within and beyond the borders of the firm?

2.2.3 Measures for delivery performance evaluation

According to Stewart (1995), an increase in delivery performance is possible through a reduction in lead-time attributes. Another important aspect of delivery performance is on-time delivery.

On-time delivery reflects whether perfect delivery has taken place or otherwise and is also a measure of customer service level. A similar concept, on time order fill, was used by Christopher (1992), describing it as a combination of delivery reliability and order completeness. Another aspect of delivery is the percentage of finished goods in transit, which if high signifies low inventory turns, leading to unnecessary increases in tied up capital. Various factors that can influence delivery speed include vehicle speed, driver reliability, frequency of delivery, and location of depots. An increase in efficiency in these areas can lead to a decrease in the inventory levels. Number of faultless notes invoiced: An invoice shows the delivery date, time and condition under which goods were received. By comparing these with the previously made agreement, it can be determined whether perfect delivery has taken place or not, and areas of discrepancy can be identified so that improvements can be made. Flexibility of delivery systems to meet particular customer needs: This refers to flexibility in meeting a particular customer delivery requirement at an agreed place, agreed mode of delivery and with agreed upon customised packaging. This type of flexibility can influence the decision of customers to place orders, and thus can be regarded as important in enchanting and retaining customers (Gunasekaran et al., 2001).

2.2.4 Total distribution cost

The most important research concerning logistics is in the area of design of efficient and cost effective distribution systems. An understanding of total distribution cost is essential, so that trade-offs can be applied as a basis for planning and reassessment of distribution systems. The urgency of dealing with transportation cost was highlighted by Thomas and Griffin (1996), who argued that since transportation cost accounts for more than half of the total logistics cost, more active research is needed in the area. To deal with distribution costs, measuring individual cost elements together with their impact on customer service encourages tradeoffs that lead to a more effective and efficient distribution system (Gunasekaran et al., 2001).

2.2.5 Measuring customer service and satisfaction

A happy and satisfied customer is of the utmost importance. In a modern supply chain any customer must be well served. Without a contented customer, the supply chain strategy cannot be deemed effective. To assess supply chain performance, supply chain metrics must centre on customer satisfaction (Gunasekaran et al., 2001).

Of the factors by which supply chains compete, flexibility is the most critical one. Being flexible means having the capability to provide products/services that meet the individual demands of customers. Some flexibility measures include: product development cycle time, machine/toolset up time, economies of scope and number of inventory turns. Customer query time relates to the time it takes for a firm to respond to a customer query with the required information. It is not unusual for a customer to enquire about the status of order, potential problems on stock availability, or delivery. A fast and accurate response to those requests is essential in keeping customers satisfied. The function of a supply chain does not end when goods are provided to the customer. After-sale activities play an important role in customer service and provide valuable feedback that can be used to further improve supply chain performance.

2.2.6 Supply chain and logistics cost

The efficiency of a supply chain can be assessed using the total logistics cost. It is necessary to assess the financial impact of broad level strategies and practices that contribute to the flow of products in a supply chain. Care must be taken to assess the impact of actions to influence costs in one area in terms of their impact on costs associated with other areas. For example, a change in capacity has a major effect on cost associated with inventory and order processing.

2.2.6.1 Cost associated with assets and return on investment

Supply chain assets include accounts receivable, plant, property and equipment, and inventories. With increasing inflation and decreased liquidity, pressure is on firms to improve the productivity of capital. It is essential to determine how the cost associated with each asset, combined with its turnover, affects total cash-flow time. One way to address this is by expressing it as an average days required to turn cash invested in assets employed into cash collected from a customer. Thus, total cash-flow time can be regarded as a metric to determine the productivity of assets in a supply chain. Once the total cash flow time is determined, this can be readily combined with profit to provide insight into the rate of return on investment. This determines the performance by top management in terms of earnings on the total capital invested in a business. With customer service requirements constantly increasing, effective management of inventory in the supply chain is crucial. In a supply chain, the total cost associated with inventory can be broken down into the following (Gunasekaran et al., 2001):

- Opportunity cost, consisting of warehousing, capital and storage; Cost associated with inventory at the incoming stock level and work in progress;
- Service costs, consisting of cost associated with stock management and insurance;
- Cost of finished goods including those in transit;
- Risk costs, consisting of cost associated with pilferage, deterioration, and damage;
- Cost associated with scrap and rework;
- Cost associated with too little inventory accounting for lost sales/lost production.

2.2.6.2 Information processing cost

Information processing costs include costs such as those associated with order entry, order follow/updating, discounts, and invoicing. Information processing costs are the largest contributor to total logistics cost. The role of information technology is shifting from a general passive management enabler through databases, to a highly advanced process controller that can monitor activities and decide upon an appropriate route for information. Modern information technology, through its power to provide timely, accurate, and reliable information, has led to a greater integration of modern supply chains than possible by any other means (Gunasekaran et al., 2001).

2.2.7 Supply link evaluation metrics

Outsourcing, whereby firms outsource a major part of their products, evaluation of supply link performance is very important in managing the supply chain for peak efficiency and effectiveness. The importance of performance measures/metrics in a supply chain link are rated in importance. Based on the literature six key performance indicators (KPI) pertaining to the supplier link were included in the survey and ranked, by participants. 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
- supply booking procedures

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 (Gunasekaran et al., 2001).

Table 1:

Importance of supplier metrics		
Assessment	Metrics	Percentage importance
Highly important	Supplier delivery performance	23.20
Moderately important	Supplier lead-time against industry norm	19.69
	Supplier pricing against market	18.30
	Efficiency of purchase order cycle time	15.42
Less important	Efficiency of cash-flow method	12.38
	Supplier booking in procedures	11.01

Source: A. Gunasekaran et al. (2004)

The percentage importance ratings of the six measures are included in Table 1. As can be seen in Table 1, supplier delivery performance emerged as the most important measure to the evaluation of supplier performance. It was the only highly important measure. One can see from the table that it is clearly set apart from the others by its percentage importance rating. 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 increasingly 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. Firms 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. Such improvement contributes to the overall success of a supply chain. (Gunasekaran et al., 2001)

This brings us to the second sub question:

The benefits of supply chain performance measurement systems are outweighed by the cost of implementing and maintaining them. The second sub question therefore is: Are supply chain performance measurement systems cost effective for SME's?

2.3 Building a preliminary framework

2.3.1 Supply relationships

Both the logistics and supply chain management literature provide evidence of the impact of SCM practices on performance. The logistics literature suggests that inter-firm coordination, functional integration, for example of logistics or purchasing functions, a customer focused logistics strategy, and the management of logistics as an integrated activity are all positively associated with operational performance. From the supply perspective, supplier development, supplier partnerships, supplier involvement, and strategic sourcing all positively influence the buying firm's operational performance. In addition, supplier partnerships, supplier development, and supply chain flexibility, all positively impact the buying firm's business performance (Kannan et al. 2005).

Closer coordination of activities within and among firms throughout the supply chain creates flexible operating systems characterised by co-ordinated source, make, and deliver operations that drastically cut raw material to consumer cycle times, enabling the firm to respond to actual market needs rather than anticipate demand with inventory. Co-ordinated planning and control of marketing and promotions, distribution, manufacturing, and raw materials/sub-component procurement characterise intrafirm integration. Externally, an emphasis on communications, information exchange, partnering, and performance monitoring integrates individual firm processes with source, make, and deliver activities of suppliers and customers. Integrated supply chain management has been linked to performance improvement in customer service areas such as order cycle time reductions and increases in on-time delivery of shipments, as well as

indicators of cost performance, i.e. decreased expedited shipments of freight and routing and scheduling improvements (Stank et al. 1996).

Strong information linkages are essential to support inter-organisational communications. While these linkages could take any number of forms, the focus must be placed on providing access to timely, accurate information. Electronic Data Interchange (EDI) is commonly used to achieve such information exchange. When EDI implementation is cost prohibitive or unavailable, the Internet may offer an economically feasible way to exchange information. Rather than relying upon sales forecasts, inventory replenishments are driven by precise sales information regarding specific stock items in the market. Computer systems and information technology provide data for improving managerial decision-making. Developing tailored information systems that enable supply chain firms to meet customers' needs is crucial (Stank et al. 1996).

2.3.2 Performance monitoring

The potential benefits of SCM make it attractive, but improved performance is not automatic. As with any other organisational undertaking, it must be done well to get positive results. This is why it is important to assess performance in SCM. To bring about improved performance in a supply chain and move closer to attainment of the illusive 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 and they must be tailored to varying needs of participants. A good SCM program will bring about improved cross functional and intra-organisational process planning and control and more complete supply chain integration (Gunasekaran et al. 2004).

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 (Gunasekaran et al. 2004).

Once the infrastructure for enhanced supply chain information and product flow is in place, sophisticated performance measurement systems are required to manage integrated supply chains. Performance measurement should monitor both the effectiveness and efficiency of members in accomplishing supply chain goals. Good measurement systems also assist continuous process improvement by allowing managers to focus on eliminating the causes of process variations. Performance feedback allows firms to use information to prevent problems or correct them in a timely manner (Rogers et al. 2001).

Process monitoring deals with the supervision and analysis of process instances at run-time. Using monitoring information, administrators and process managers can adjust the behavior of current process instances and react to problems that arise during process enactment. Furthermore, process monitoring can be used to improve the responsiveness of an organization to customer inquiries. The analysis of current processes in the supply chain is a task of operational supply chain management. Using a formal process definition as the framework for analysis, managers are enabled to detect deviations from agreed-upon process paths as well as differences in material or financial flows. Since monitoring activities are performed in real-time an automated system is necessary that collects relevant monitoring metrics across the entire supply chain (inter-organizational monitoring) and merges this information with detailed monitoring data from the business processes of the individual organizations (Holten et al., 2002)

2.3.3 Interfirm coordination

Coordination among independent firms, such as raw-material suppliers, manufacturers, distributors, third-party logistics providers and retailers, is the key to attaining the flexibility necessary to enable them to progressively improve logistics processes in response to rapidly changing market conditions. Poor coordination among the chain members can cause dysfunctional operational performance. Some of the negative consequences of poor coordination include higher inventory costs, longer delivery times, higher transportation costs, higher levels of loss and damage, and lowered customer service. Since changes that occur in any one of the chain members are likely to affect the performance of the others, coordination is useful for managing interdependent logistics activities in order to mitigate demand variability and unnecessary inventory. A process of planning, executing and controlling the interdependencies of activities carried out by different supply chain members or business units in order to create value for the

end customer is known as supply chain management. Given the critical importance of coordination, few researchers have appeared to develop and test the concept of coordination in the supply chain. System thinking can be used to understand the reality of logistics and coordinate the chain members in order to create collective knowledge (Simatupang et al., 2002).

Internal and external integration are correlated and external integration leads to a better logistical performance. The impact on performance of internal integration depends on the functional areas that are being integrated and the level of external integration. When companies are not externally integrated, the Logistics-Production integration leads to a better absolute performance, while the Logistics-Marketing integration does not. Hence, when companies are externally integrated, the level of internal integration in any of the two internal interfaces does not have any impact on performance. (Gimenez et al. 2005).

External collaboration among supply chain members contributes to achieving costs, stock-outs and lead-time reductions. The greatest influence on firms' logistical service performance is for external integration. However, for the least collaborating relationships, the internal Logistics-Production integration has also a high impact on distribution performance (Gimenez et al. 2005).

2.3.4 Research framework

The research questions are summarized in the preliminary theoretical framework presented in figure 1.

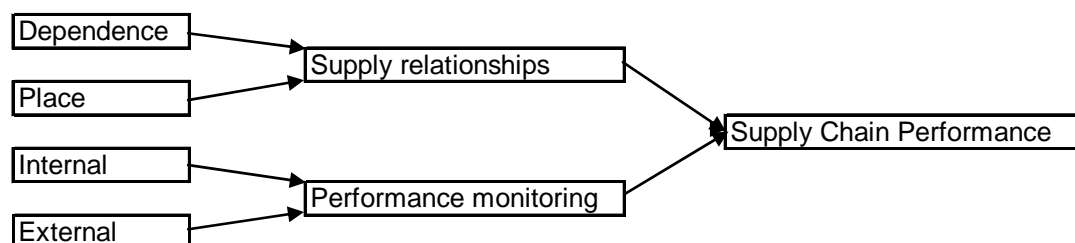


Figure 1: Preliminary conceptual framework.

3. Methodology and research design

3.1 *Research Methodology*

In order to gain better understanding about the phenomena of supply chain management, an exploratory case study was chosen as the research methodology. According to Yin (2003) a case study is an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident. Case study is also a research strategy, which seeks to understand the dynamics present within single settings (Eisenhardt, 1989).

This project investigates how supply chain management practices are used in the Dutch MRO&OEM market. Because of the complexity and exploratory nature of the research, a flexible research method was needed. The study explored the relationships between suppliers and purchasers and addressed the research questions outlined in the literature review. It needed a methodology that allowed the handling of rich and multiple sources of data and data collection (Easton, 1995). A case study approach was chosen for this task because it provided the ability to use in-depth qualitative methods such as open-ended interviews and participant observation. Next to the interviews, a questionnaire was developed. The case study approach is particularly useful because it allows purchaser/provider relationships to be studied in a naturalistic setting (Zinkhan and Zinkhan, 1994).

3.2 *Interview protocol, data collection and processing*

First, field research was done in order to get a good understanding of the company. Information was collected from several in-depth semi structured interviews with purchasers and users. Data were collected over the current situation. The interviewees are all involved with logistics and/or supply chain management. The interviews were conducted in an as open format as possible, and were structured based upon the literature and research model presented in chapter two. The topic list, based on the literature in chapter two, can be found in appendix I.

The topic list is categorized according to the literature in chapter two, focussing on performance measurement:

- Questions one through thirteen are dealing with performance measurement systems, presented in paragraph 2.2.2.
- Questions fourteen and fifteen are about measuring customer satisfaction, as presented in paragraph 2.2.5.
- Questions sixteen and seventeen are about supply chain activities as discussed in par. 2.2.
- Questions eighteen through twenty-one are about supply link evaluation metrics as discussed in par. 2.2.7.

4. Results

This chapter will deal with describing the results obtained by the case study. First, the three aspects of supply chain management, presented in the literature, will be dealt with. Second, propositions are made based upon the case study results.

4.1 *Inventory management*

From the interviews, it became clear that the company has an advanced inventory system. The ERP system contains a database where inventory levels can be monitored and adjusted. The stock management department controls stock levels of over 600.000 articles. About 50.000 items are V1/V2 controlled which means there is active inventory management, including formulas like the Economic Order Quantity (EOQ). The remaining 550.000 articles are available on request. Each article has a predefined delivery time (replenishment lead time). Active inventory management involves forecasting: The ERP system automatically adjusts the order frequency and quantity. In addition, the ERP system automatically calculates with variables like transport, warehouse and order costs. However, to avoid claims from OEM customers, which often use the Just In Time concept, larger safety stocks are held for a limited number of articles. In this case inventory management is done manually.

With selected customers, advanced logistical systems are implemented. Vendor Managed Inventory is applied, as well as Kanban and shop floor. EDI is applied when customers use the same ERP system (SAP).

It is, therefore, proposed that:

P1: structured inventory management has a positive effect on stock levels and customer satisfaction.

P2: A structured inventory management systems has a positive effect on supply chain performance.

4.2 *Performance monitoring*

Performance monitoring plays a major role in the organization. The organization identified several key performance indicators (KPI's) which are measured by the ERP system and reported in the weekly management and process information report. In addition, the ERP system also

contains about fifty queries regarding nine functional areas of which purchase, sales, logistics, and finance are the most important.

Strategical measures like lead time against industry norm, quality level and supplier pricing against market are not measured.

Supply link measures at the tactical level are measured. Efficiency of the purchase order cycle time is measured. Booking in procedures and quality assurance methodology are measured as well.

Operational measures include external turnover, order intake, inbound delivery performance, outbound delivery performance, value of open purchase orders, number of orders over due, WIP, stock taking percentage, questionable invoices, percentage of orders sent back.

Norms are addressed to each KPI. These norms are mainly based on what the market demands from the firm. The norms have no specific link to industry norms or market norms but are tailor made by the managers involved. The board of directors has a final say in the acceptance or norms and KPI's. KPI's make the firm capable to respond quickly to market needs at low cost. In addition, process-information is generated in order to continuously facilitate BPR.

This leads to the following propositions:

P3: Performance monitoring has a positive effect on supply chain performance.

P4: By identifying KPI's (and norms) the firm creates a competitive advantage.

4.3 *Supplier relations and collaboration*

Within the company, there is a strong commitment to fulfil almost every need or wish of the customer. This implies the need for good supplier relationships and fulfilment of the pre defined agreements. Hence, there is a focus on long-term relationship and trust. On the other hand, there is also a strong focus on low cost prices. As one interviewee stated: "We are a customer driven organization with a strong focus on high margins. From time to time we are pampering our suppliers too much, which has a negative effect on logistical efficiency." Low purchase prices are sometimes more important than other factors which have a positive effect on logistical performance. Flexibility is difficult, mainly with major Asian manufacturers. The company's dependency on a single supplier (no alternative supplier) plays a major role in the relationship.

Bargaining is sometimes difficult or impossible due to the fact that there is a limited range of suppliers.

The question whether this company collaborates with suppliers was answered negative by most interviewees.

Conversely, one interviewee had the impression that this was not the case and needed improvement. All interviewees agreed that closer collaboration would have a positive effect on logistical performance.

It is, therefore, proposed that:

P5: Supplier collaboration has a positive effect on supply chain performance.

P6: Long-term relationships and trust result in sub-optimal supply chain performance.

5. Discussion and Conclusion

The results presented in the previous chapter will be used to develop recommendations for further research. The recommendations should result in the ability to apply the elements that affect supply chain performance. Together with the elements extensively discussed throughout this paper, other elements that could have an influence on supply chain performance are discussed as well. The combination of previous research and outcomes of this research will be interesting for both the firm and the academic world.

5.1 Discussion

From the interviews, it became clear that there is a structured inventory system. There is a database or ERP system where inventory levels can be monitored. Since inventory management has a positive effect on overall performance, a good inventory system is needed.

Performance monitoring, like benchmarking, plays a major role in the organization. First, there should be an infrastructure for enhanced supply chain information and product flow. Sophisticated performance measurement systems are required to manage integrated supply chains. Performance measurement monitors both the effectiveness and efficiency of members in accomplishing supply chain goals. Good measurement systems also assist continuous process improvement by allowing managers to focus on eliminating the causes of process variations. Performance feedback allows firms to use information to prevent problems or correct them in a timely manner.

Preferred performance monitoring systems consist of both internal and external performance measures. Internal measures should monitor the costs and service levels of several different specific logistics functional areas, including warehousing, order processing, inbound and outbound transportation, and inventory. Internal accounting methods such as activity-based costing allow managers to understand the links between performance levels of specific activities and the demands they place on a firm's resources, identifying opportunities for taking costs out of the supply chain. Additionally, managers should compare internal processes to external standards benchmarked from leading target firms. External performance measurement should enable firms to monitor the activities of supply chain members as well as assess the degree to which the supply chain is creating value and satisfying customers (Rogers et al., 1995).

As mentioned in the introduction, there is a need to investigate whether implementing measurement systems to evaluate supply chain performance is cost effective, especially for small and medium enterprises. The firm discussed in this case study has decided to start using an integrated ERP system in 1999 as part of a long term strategy. Cost effectiveness was and is not an issue, because performance measurement is embedded with an integrated ERP system.

5.2 Recommendations

5.2.1 Performance monitoring

Performance monitoring is, because of the present ERP system, easy to measure. Two objectives should be taken into account. The marketing objective is to maximize long term profitability, while the logistics objective is to minimize total costs. The best way to measure performance is by the value created for customers and the profitability of the supply chain and its members. Internal accounting methods such as activity-based costing allow managers to understand the links between performance levels of specific activities and the demands they place on a firm's resources, identifying opportunities for taking costs out of the supply chain.

5.2.2 Supply chain management

To implement elements of supply chain management successfully, the following aspects should be taken into account:

- Executive support, leadership and commitment to change;
- Understanding of the degree of change;
- Agreement on the supply chain management vision and the key processes;
- Commitment of the resources and empowerment is necessary to achieve the stated goals.

5.3 *Limitations and suggestions for future research*

Multiple sources of information were combined in this study. The purpose and scope of this study were essentially exploratory. Based upon data, observations and interviews, a number of propositions were developed and integrated into a theoretical framework that should be refined and validated in future research. The scope of the research was limited in the sense that the suppliers' side of the supply chain was not taken into account. It is worthwhile to extend the case study and include the entire supply chain. Because of a lack of time and resources, this could not be realized in the current study. In a future research, the suppliers' side of the supply chain needs to be studied as well.

In addition, some interviewees could not elaborate on specific details since some aspects of this case study are considered a company secret. In addition, not everything was explained as well.

The present case study only involves one industry, the Dutch MRO&OEM industry, and within that industry only one company. Since the firm is the major player in this industry, one can assume that this company is representative for this industry. The sample of interviewees is one sided. They all work for the firm. One can therefore argue how representative this study is. It is necessary to involve and compare other large players in the industry in a future research as well.

The case study was limited in another sense as well. There are many other elements that affect supply chain performance. For example, the willingness to change, trust in suppliers and customers are some of the other factors that affect supply chain performance. These elements should be taken into account in a future research as well.

Future research should also focus on the suitability of this industry and how supply chain management practices should be implemented.

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Appendix I: Interview protocol and interview questions

Introduction

The interviewer starts with background information about the study and supply chain management, and emphasizes the importance of the interviews. It is pointed out that the interviews have a confidential character and will be treated as such.

Interview questions, semi-structured questions:

1. Wordt er binnen uw afdeling gebruik gemaakt van een prestatie meet systeem?
Ja Nee
2. Zo ja, welke elementen worden gemeten?
.....
.....
.....
3. Welke KPI's worden gemeten (met name in de supply chain)
.....
4. Hoe worden de KPI's gemeten?
.....
5. Wordt er op meerdere niveaus gemeten?
Ja Nee

Zo ja, welke.....
6. Bestaan er hiernaast nog andere interne en/of externe meetsystemen?
Ja Nee

Zo ja, welke.....
7. Maakt het bedrijf gebruik van meetsystemen gemaakt door derden (klanten/leveranciers)?
Ja Nee
Zo ja, welke.....

8. Welke afdelingen zijn met hoeveel medewerkers betrokken bij het opzetten/beheren van de meetsystemen?

.....

9. Hoe flexibel zijn de meetsystemen? Zijn ad hoc rapportages mogelijk?

Ja Nee

10. Hoe worden de resultaten gerapporteerd, geïnterpreteerd en gecommuniceerd?

.....

11. Wordt klanttevredenheid gemeten qua: kwaliteit, prijs, beschikbaarheid en technische innovatie?

Ja Nee

12. In hoeverre wordt ingespeeld op de wensen van de markt?
(geef aan in een schaal van 1 tot 10, 1 = laag, 10 = hoog)

1 2 3 4 5 6 7 8 9 10

Geef kort aan hoe hierop wordt ingespeeld.

.....

13. Wordt er gebruik gemaakt van geavanceerde logistieke concepten als VMI, JIT, Kanban?

Ja Nee

Zo ja, kunt u een voorbeeld noemen?

.....

14. Hoe wordt ketenoptimalisatie mogelijk gemaakt? Wordt er in de keten gedacht?

Ja Nee

Zo ja, geef aan hoe.....

15. Hoe is de relatie met leveranciers?

(geef aan in een schaal van 1 tot 10, 1 = laag, 10 = hoog)

1 2 3 4 5 6 7 8 9 10

16. Is er sprake van inkoopkracht?

(geef aan in een schaal van 1 tot 10, 1 = laag, 10 = hoog)

1 2 3 4 5 6 7 8 9 10

17. Is er sprake van solidariteit in de markt (klant-leverancier)?

(geef aan in een schaal van 1 tot 10, 1 = laag, 10 = hoog)

1 2 3 4 5 6 7 8 9 10

18. Wat zijn belangrijke argumenten om met een bepaalde leverancier zaken te doen?

(geef aan in een schaal van 1 tot 10, 1 = laag, 10 = hoog)

Prijs	1	2	3	4	5	6	7	8	9	10
Kwaliteit	1	2	3	4	5	6	7	8	9	10
Leverbetrouw- Baarheid	1	2	3	4	5	6	7	8	9	10
Anders.....	1	2	3	4	5	6	7	8	9	10

19. Wat zijn de kosten en baten van het prestatie-meetsysteem? Wat is de toegevoegde waarde van het systeem?

.....

Closure of the Interview

The interviewer indicates that the end of the interview is reached and points out the next steps: the interviewer will make a written record of the meeting, and this document (in concept) will be sent to the interviewee in order to check whether the answers given have been correctly recorded. If necessary, comments and corrections are incorporated.

The interviewer thanks the interviewee for his/her cooperation.