A SUPPLY CHAIN PERFORMANCE MEASUREMENT SYSTEM: A CASE STUDY IN AUTOMOTIVE INDUSTRY

by

İSMAİL ÇAPAR

Submitted to the Graduate School of Engineering and Natural Sciences
in partial fulfillment of
the requirements for the degree of
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First of all, I would like to thank my advisor, Dr Bülent Çatay, for the great support and encouragement he has given me for the past two years. His critical support and suggestions enabled me to study in a well motivated manner throughout my graduate study and thesis. I would also like to thank committee members of my thesis, Dr. Dilek Çetindamar and Dr.Tonguç Ünlüyurt, for their insightful suggestions and contributions.

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I wish to thank for the industrial engineering graduate student for their valuable help, support, and friendship.

Finally, and most importantly, I would like to thank my family for their incredible love and support for which I am forever grateful.

ABSTRACT

Today's fierce market conditions drive companies to effectively evaluate their overall supply chain performance and identify improvement areas for gaining competitive advantages. In the last few decades, organizations have improved their internal processes by using initatives such as JIT, Kanban, Kaizen, and TQM. At the same time new methods and initiatives in the area of Supply Chain Management have forced organizations to improve not only their internal processes but also the supply chain to which they belong.

While companies have transformed their supply chain to Integrated Supply Chain, they have in need of a tool which will show the combined performance of the supply chain, the final outcome of the efforts of all integrated members, new improvement areas through the supply chain, and whether the supply chain is improved or not. This needed tool is a supply chain performance measurement system.

In this thesis, a new performance measurement framework is proposed. In this framework, in addition to Customer Satisfaction Perspective and Financial Perspective a new perspective with respect to new trends in Supply Chain Management is defined. This new perspective is Supply Chain Collaboration Perspective. Furthermore, the necessary steps to be followed during the implementation of a performance measurement in automotive industry are identified. The supply chain performance measurement in a leading automotive manufacturer in Turkey is also discussed within this framework.

ÖZET

Bugün içinde bulunulan piyasa koşulları organizasyonların içinde bulundukları tedarik zinciri performansının etkin bir şekilde değerlendirilmesini ve iyileştirme alanlarının belirlenerek rekabette öne geçilmesini zorunlu kılmıştır. Özellikle son on yıl içinde JIT, Kanban, Kaizen, Toplam Kalite Yönetimi metodları ve yönetim anlayışlarını uygulayan organizasyonlar kendi iç süreçlerinin geliştirdiler. Fakat yine son on yıl içinde Tedarik Zinciri Yönetimi alanındaki gelişmeler organizasyonların sadece kendi iç süreçlerini değil aynı zamanda içinde bulundukları tedarik zincirini de geliştirerek bütünleşik bir tedarik zincirine ulaşmayı hedeflemelerini gerekli kılmıştır.

Organizasyonlar tedarik zinciri dönüşümlerini yaparken, bütün tedarik zinciri üyelerinin son ürün üzerindeki etkilerini, tedarik zincirindeki yeni iyileştirme alanlarını ve tedarik zincirinin gelişip gelişmediğini gösterecek bir yapıya –tedarik zinciri performans ölçüm sistemine– ihtiyaçları bulunmaktadır.

Bu çalışmada tedarik zincirinin performansının ölçülmesi ile ilgili bir performans ölçüm ve uygulama sistemi önerilmiştir. Bu yöntemde tedarik zinciri performansı müşteri tatmini açısından, finansal performans açısından ve tedarik zinciri yönetimindeki yeni eğilimleride dikkate alan Tedarik Zincirinde İş Birliği performans kriterleri açısından değerlendirilmiştir. Bu önerilen performans ölçüm sistemi Türkiyenin lider otomotiv üreticilerinden birinde uygulanmış ve uygulama adımları değerlendirilmiştir.

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1. INTRODUCTION

During the last two decades, many upcoming trends in logistics management have emerged, with each broadening and improving the focus of the previous. The notion of cost-cost tradeoffs was introduced. That is, the lowest total cost might not be achieved by pursuing the lowest achievable cost in each individual part of the logistics process. This introduction has brought the concept of logistics integration.

Later, many companies began to realize that on the way of optimizing logistics costs, it was not sufficient to focus only on the organization itself, rather it was compulsory to include the members standing outside the organization but in relationship with in terms of physical and information flows such as suppliers, subtiers, and distribution network. The challenge for logistics managers became to integrate logistical performance across all operating facets of a business. This holistic concept has become known as Supply Chain Management (SCM). The Council of Logistics Management[1] defines SCM as follows:

> "*Supply Chain Management is the systemic, strategic coordination of the traditional business functions and the tactics across these functions within a particular company and across businesses with the supply chain for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole."*

The scope of SCM is clearly more than the physical movement of goods "from one location to another location." It is also information, money movement, and creation and deployment of intellectual capital, or as some call it "knowledge work."

[1] http://www.clm1.org/resource/downloads/glossary.PDF

The supply chain encompasses every effort involved in producing and delivering a final product or service, from the subtiers to end customers. SCM includes managing supply and demand, sourcing raw materials and parts, manufacturing, warehousing and inventory tracking, order management, distributions across all channels, and delivery to the customer. Due to its wide scope, SCM must address complex interdependencies, creating in effect an "extended enterprise" that reaches far beyond the factory's doors.

Today, material and service suppliers, channel supply partners (wholesalers, distributors, retailers) and customer themselves, as well as SCM consultants, supply chain application software suppliers, and system developers, are all key players in SCM (The Company Logistic Project Team Report, 2002).

While companies have transformed their supply chain to Integrated Supply Chain, they have in need of a tool which will show the combined performance of the supply chain, the final outcome of the efforts of all integrated members, new improvement areas through the supply chain, and whether the supply chain is improved or not. This needed tool is a supply chain performance measurement system. According to a multiyear study of supply chain excellence at Michigan State University, performance measurement is one of the top four drivers of supply chain excellence (Easton *et al.,* 2002). However, the importance of the supply chain performance measurement had been neglected during the SCM transformation efforts. According to research and case experience -in Asia- many companies are flying blind when it comes to performance measurement capabilities.

Today, the importance of the performance management in the context of SCM had been realized, and successful supply chain transformation efforts via effective supply chain performance measurement are being discussed both by practitioners and scholars.

In today's complex supply chain systems timely and accurate assessment of overall system and individual system component performance is of paramount importance in many aspects. Statements such as "You cannot manage what you do not measure," "Anything measured improves," "What you measure what you get," and "Anything measured gets

done" stress the importance of performance measurement. In addition, by using appropriate performance measurement systems, companies should be able to support and monitor continuous improvements, which is one of the best methodologies for supply chain transformation.

An effective performance measurement system provides companies with a broad assortment of both cultural and technical benefits, which are not commonly recognized. It provides basis to understand the system, influences the behavior throughout the system, provides information regarding the result of system efforts to supply chain members and stakeholders, and plays a major role in monitoring the implementation of strategy. In addition, measuring supply chain performance in and of itself leads to improvements in overall performance (Handfield and Nichols, 1999).

2. LITERATURE REVIEW

When traditional performance measurement systems are analyzed two properties of these measurement systems may be identified. First, tracked performance metrics are usually based on financial accounting systems. These performance measures allow companies to evaluate the past. Second, these performance measures are insufficient to measure supply chain performance. In order to overcome this insufficiency several performance measurement systems have been developed during the last decade.

In this chapter, the literature of performance measurement systems is reviewed and analyzed. The literature review is classified into three parts. First, the Balanced Scorecard based approach is examined. Secondly, Supply Chain Operation Reference (SCOR) Model developed by Supply Chain Council is analyzed. Thirdly, other literature on supply chain performance measurement are reviewed.

2.1. Balanced Scorecard

Kaplan and Norton (1996) developed the Balanced Scorecard (BSC) at the end of a sponsored one-year multicompany study. “The study was motivated by a belief that existing performance measurement approaches, primarily relying on financial accounting measures, were becoming obsolete.” The BSC complements financial measures of past performance with measures of the drivers of future performance. According to Kaplan and Norton (1996) financial and non-financial measures must be a part of the information system for employees at all levels of the organization. The pressures for short-term financial performance can cause companies reduce spending on new product development, process improvements, human resources developments, information technology, database

and systems as well as customer and market development. In the short run, the financial accounting model reports these spending as increases in reported income, even when the reduction have cannibalized company's stock of assets and its capabilities for creating future value.

Every selected measure should be part of a link of cause and effect relationship as illustrated in Figure 2.1.

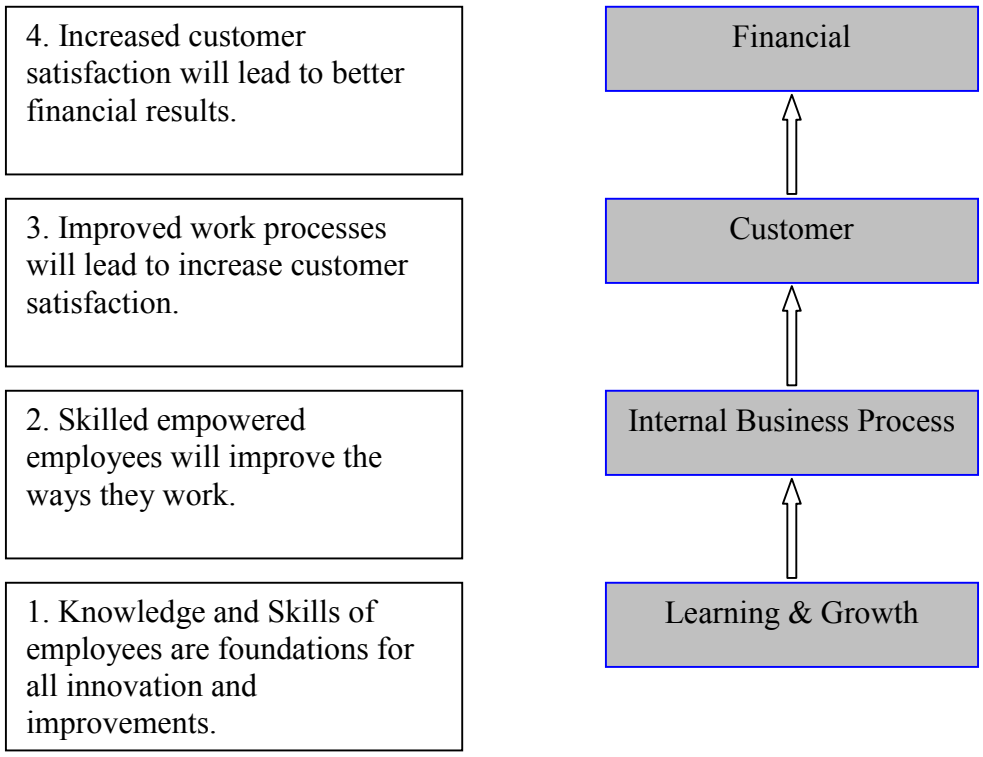

Figure 2.1 Balanced Scorecard cause-effect hypothesis

The BSC provides executives with a comprehensive framework that translates company's vision and strategy into a coherent set of performance measures organized into four different perspectives: Financial Perspective, Customer Perspective, Internal Business Process Perspective, and Learning and Growth Perspectives. In what follows is the description of those four perspectives.

2.1.1. Financial Perspective

Since financial measures are valuable in summarizing the readily measurable economic consequences of action already taken, the BSC retains the financial perspective. Financial measures indicate whether a company's strategy, implementation, and execution are contributing to a bottom line improvement. During the development phase of the BSC of the financial perspective, executives should determine appropriate financial metrics for their strategy. Every selected measure should be part of a link of cause and effect relationship that culminate in improving financial performance.

Kaplan and Norton (1996) identify three stages of business strategy: Growth, Sustain, and Harvest. They also state that the financial objectives for businesses in each of these stages are quite different, thus selected performance measures should also be different.

2.1.2. Customer Perspective

In the customer perspective of the BSC, managers identify the customer and market segments in which business units will compete. They also identify the measures of the business unit's performance in these targeted segments. The core measures include customer satisfaction, customer retention, new customer acquisition, customer profitability, and market and account share in targeted segments. The customer perspective enables business units managers to articulate the customer and market-based strategy that deliver superior future financial return. The case studies given in Kaplan and Norton (1996) show that virtually all value propositions typically incorporate measures related to the response time, quality, and price of customer-based processes. They also give a brief discussion of representative measures that can capture the time, quality, and price dimensions. These representative performance measures are given in Table 2.1.

Table 2.1 Representative performance measures

Time	Quality
Respond Rapidly	Defect free delivery
Reliability of Lead Times	Customer perceived quality
Short order to delivery lead times	Returns by customers
On time delivery	Warranty claim
Time to market	Field service request
	Performance of promised delivery time

2.1.3. Internal Business Process Perspective

In the internal business process perspective, executives identify the critical internal processes in which the organization must excel. These processes enable the business unit to deliver the value propositions that will attract and retain customers in the targeted market segment, and satisfy shareholder expectations of excellent financial returns. The internal business process measures focus on the internal processes that will have the greatest impact on customer satisfaction and on achieving an organization's financial objectives.

The difference between traditional performance measurement and the BSC is that, while traditional approaches attempt to monitor and improve existing business processes, the BSC approach will usually identify entirely new processes at which organization must excel to meet customer and financial objectives.

Kaplan and Norton (1996) provide a value-chain model template that can be used by companies to customize their internal business processes perspective. This model encompasses three principal business processes: (i) innovation, (ii) operations, and (iii) post sale service.

2.1.4. Learning and Growth Perspectives

The fourth perspective of the BSC identifies the infrastructure that the organization must build to create long-term growth and improvement. Organizational learning and

growth come from three principal sources: people, system, and organizational procedures. This perspective provides the infrastructure to enable ambitious objectives in the other three perspectives to be achieved. Kaplan and Norton (1996) identify three principal categories for the learning and growth perspective based on their experience in building BSC across a wide variety of service and manufacturing organizations. These categories are: (i) employee capabilities, (ii) information systems capabilities, and (iii) motivation, empowerment, and alignment.

For each principal category, the authors propose performance measures and a framework to measure the performance.

2.2. Supply Chain Operation Reference (SCOR) Model

The Supply Chain Operation Reference (SCOR) Model is developed by the Supply Chain Council (SCC), an independent, not-for-profit, global corporation with membership open to all companies and organizations interested in applying and advancing the state-of-the-art in SCM systems and practices. SCC was organized in 1996 by Pittiglio Rabin Todd & McGrath (PRTM) and AMR Research and initially included 69 voluntary member companies.

The SCOR model is a reference model that links process elements, metrics, best practices, and the features associated with the execution of a supply chain in a unique format. The model focuses on the activity involved and it contains five basic management processes that provide the organizational structure of the SCOR model. These processes are: Plan, Source, Make, Deliver, and Return. Currently the model does not attempt to develop supply chain transformation methodology in the areas of human resources, quality assurance, and training. The model also provides a balanced approach to measure overall supply chain.

SCOR is a hierarchical model with specific boundaries in regard to scope. There is at least four hierarchical level in the model. SCC focuses on three process levels and does not attempt to prescribe how a particular organization should tailor its systems. These hierarchical levels are: Level 1: Top Level (Process Types), Level 2: Configuration Level (Process Categories), Level 3: Process Element Level (Decompose Processes), and Level 4: Implementation Level (Decompose Process Elements). Level 1 defines the scope and content of the SCOR Model. In addition, basis of competition performance targets are set in this level. In Level 2, a company's supply chain can be "configured-to-order" from 26 core process categories. Companies also implement their operation strategy at this level. Companies fine-tune operation strategy at Level 3. This level defines a company's ability to compete successfully in its chosen markets. Level 3 also consists of process element definition, process element information inputs and outputs, process performance metrics, best practices –where applicable–, and system capabilities required to support best practices. At Level 4, companies implement specific SCM practices to achieve competitive advantage. Since this levele is company specific organizations that use the SCOR Model will need to extend the Model at least at Level 4.

In version 5.0 of the model, the performance measures are also intended to be hierarchical. Although not explicit in the model, Level 1 metrics are decomposed (Level 2 and diagnostic metrics) to the respective SCOR Model elements. Table 2.2 shows SCOR performance attributes and Level 1 metrics, and Table 2.3 shows the definitions for SCOR performance attributes and which Level 1 metrics are associated with each attribute.

In the Model, metrics are used in conjunction with performance attributes. These performance attributes are characteristics of the supply chain that permit it to be analyzed and evaluated against other supply chains with competing strategies. Since the metrics in the Model are hierarchical Level 1 metrics are created from lower level (Level 2) calculations. These lower level calculations are generally associated with a narrower subset of processes. For instance, delivery performance is calculated as the total number of products delivered on time and in full based commit date.

Table 2.2 SCOR Performance attributes and Level 1 metrics[2]

	Customer - Facing			Internal-Facing	
Performance Attribute	Reliability	Responsiveness	Flexibility	Cost	Assets
Delivery performance	✔				
Fill rate	✔				
Perfect order fulfillment	✔				
Order fulfillment lead time		✔			
Supply-chain response time			✔		
Production flexibility			✔		
Total SCM cost				✔	
Cost of Goods Sold				✔	
Value-added productivity				✔	
Warranty cost or returns processing cost				✔	
Cash-to-cash cycle time					✔
Inventory days of supply					✔
Asset turns					✔

Table 2.3 Definition for SCOR performance attributes and related Level 1 metrics

Performance Attribute	Performance Attribute Definition	Level 1 Metric
Supply Chain Delivery Reliability	The performance of the supply chain in delivering: the correct product, to the correct place, at the correct time, in the correct condition and packaging, in the correct quantity, to the correct customer	Delivery performance
		Fill rate
		Perfect order fulfillment
Supply Chain Responsiveness	The velocity at which a supply chain provides products to the customer	Order fulfillment lead time
Supply Chain Flexibility	The agility of a supply chain in responding to marketplace changes to gain competitive advantage.	Supply-chain response time
		Production flexibility
Supply Chain Costs	The cost associated with operating the supply chain.	Total SCM cost
		Cost of Goods Sold
		Value-added productivity
		Warranty cost or returns processing cost
Supply Chain Asset Management Efficiency	The effectiveness of an organization in managing assets to support demand satisfaction. This includes the management of all assets: fixed and working capital	Cash-to-cash cycle time
		Inventory days of supply
		Asset turns

[2]SCOR Model 5.0

2.3. Other Literature on Supply Chain Performance Measurement

Beamon (1998) categorizes performance measures in two groups: qualitative performance measures and quantitative performance measures. Qualitative performance measures are those for which there is no single direct numerical measurement. Customer satisfaction, flexibility, information and material flow integration, effective risk management, and supplier performance are presented as qualitative performance measures. Quantitative performance measures are the measures that may be directly described numerically. Beamon (1998) also categorizes quantitative measures as objective based on cost and objective based on customer responsiveness. Fill rate, product lateness, customer response time, and lead time are examples of measures based on customer responsiveness while cost, sales, profit, inventory investment, and return on investment are defined as measure based on cost. She uses these performance measures for supply chain design and analysis after evaluating them.

According to Gunasekaran, *et al*. (2001) companies often lack the insight for the development of the effective measures and metrics needed to achieve fully integrated supply chain because of lack of a balanced approach between financial and non-financial performance measures and lack of a clear distinction between metrics at strategic, tactical, and operational levels. They identify and discuss the metrics and measures along the four links of an integrated supply chain: Plan, Source, Make/assemble, Delivery/customer. They also discuss some of the most appropriate performance metrics and measures in a supply chain and they present a framework for measuring the performance of a supply chain. The metrics discussed in this framework are classified into strategic, tactical, and operational levels of management. This has been done so as to assign performance measures and metrics where they can be dealt with by the appropriate management level. For example, the total supply chain cycle time and order lead time are assigned at the strategic level based on an overall system decision in a supply chain. The metrics are also distinguished as financial and non-financial so that a suitable costing method based on activity analysis can

be applied. After the metrics are classified as strategic, tactical, and operational they are aligned with the four basic links (plan-source-make-deliver) that constitute the supply chain.

Beamon and Chen (2001) categorize performance measures into three groups: resource, output, and flexibility. They define performance measures for each category. The resource performance measures measure the level of resources in the system that are used to meet the objectives of the system. The output performance measures measure the effectiveness with which the supply chain is able to supply. The flexibility measures describe the range of possible operating conditions that are profitably achievable by the supply chain. They also run simulation concerning with the performance behavior of conjoined supply chain by observing five performance measures, belonging to three performance measure classes explained earlier. According to the simulation results system stock-out risk, the probability distribution of the demand, and the transportation time are the most important metrics in determining the effectiveness of the chain.

Basu (2001) makes a comparison of performance measures when performance criteria shift from enterprise to integrated supply chain. The main difference between the two levels is that the performance metrics should be more externally focused on the total network rather than the site excellence. According to Basu (2001) the collaborative culture of the integrated supply chain has triggered the emergence of new measures, especially in five areas. These areas are external focus, power to customer, value-based competition, network performance, and intellectual capital. Basu (2001) also recommends a six-step cycle to implement and sustain the benefits of a performance management system with new measures. These steps are establishing measures, monitoring systems, global sales and operations planning, performance improvement initiative, structured assessment and awards, and knowledge sharing.

Hausman (2000) gives information about the effect of the Internet on supply chain and claims that new performance metrics should capture the costs and benefits of the Internet. The author also claims that a supply chain needs to perform on three key

dimensions: service, assets, and speed. According to Hausman (2000) a good supply chain performance measurement system should have at least one measure on each of these dimensions and the author gives some examples of performance measures for each category. The author also emphasizes that supply chain performance metrics must be aligned with business strategy.

The Institute of Management Accountants (IMA)[3] presents a framework for determining and linking the critical success factors, performance metrics and goals. Figure 2.1 depicts this framework. A key step in the design of the logistics performance measurement system is the identification of critical success factors for all levels of the business. IMA also emphasizes the importance of linking overall business strategy to performance goals.

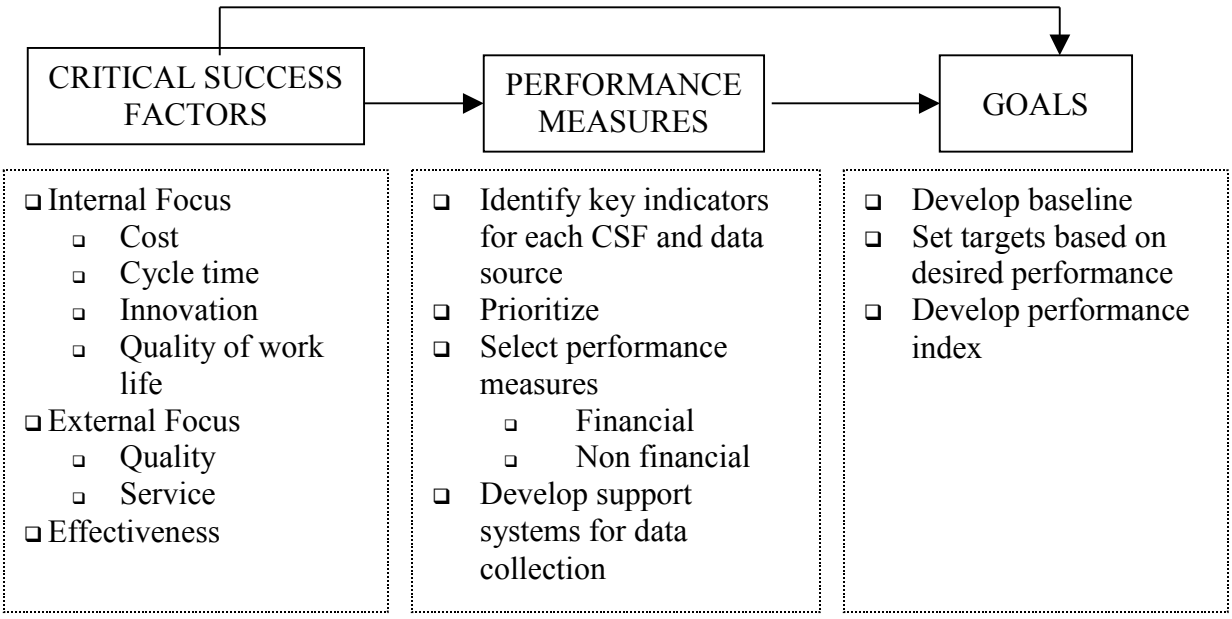

Figure 2.1 Developing performance metrics

Beamon (1999) evaluates and identifies the limitations of supply chain performance such as cost, activity time, responsiveness, and flexibility. She also evaluates the use of single performance measures. According to Beamon (1999) this single supply chain

[3] http://www.imanet.org/content/Publications_and_Research/Statements_on_Management_Accounting/sma4p/log-perf.htm

performance measures is attractive because of its simplicity. In addition, she claims that current supply chain performance measurement systems are inadequate because they rely on the use of cost as a primary (if not sole) measure, they are not inclusive, they are often inconsistent with the strategic goals of the organization, and do not consider the effects of uncertainty. She proposes a framework for measuring supply chain performance that relates supply chain performance measures to strategic goals. In this framework performance measures are categorized into three types and there is an inter-relationship among these three types as shown Figure 2.2.

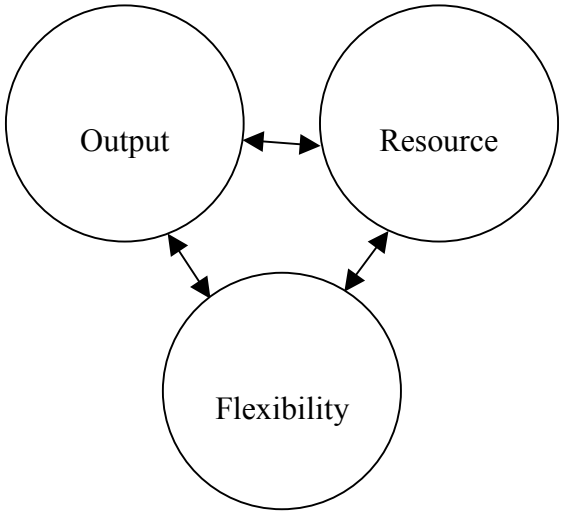

Figure 2.2 Inter-relationship between performance categories

She also claims that the supply chain performance measurement systems must measure each of the types (Resources, Output, and Flexibility). Table 2.4 illustrates the goals of those three types of performance measures.

Table 2.4 Goals of performance measure types [4]

Performance Measures Type	Goal	Purpose
Resources	High Level Efficiency	Efficient resource management is critical to profitability
Output	High level of customer service	Without acceptable output, customer will turn to other supply chains.
Flexibility	Ability to respond to a changing environment	In an uncertain environment, supply chains must be able to respond to change.

[4] Beamon (1999)

In addition, she gives a list of supply chain performance measures and the definition for each type. The author also states that flexibility measures are different from the others and presents a quantitative approach to flexibility measurement.

Ramdas and Spekman (2000) measure supply chain performance using a set of variables that capture the impact of SCM on both system wide revenues and costs. They draw on responses to a survey of 22 extended supply chains across five industry groups that include life sciences, oil and gas, consumer products, agricultural and food processing utilities, and manufacturing –high tech electronics and automotive. The authors define six variables that reflect different approaches to measure supply chain performance. These variables are inventory, time, order fulfillment, quality, customer focus, and customer satisfaction. Ramdas and Spekman (2000) also classify respondents according to their supply chain responsibilities as dealing with either functional or innovative product types. They also compare functional and innovative respondents and conclude that functional product supply chains and innovative product supply chains differ significantly in practices and thinking.

Chan *et al*.(I)[5] identify some in depth problems of performance measurement systems in the supply chain context. These problems are: 1) lack of a balanced approach to integrating financial and non-financial measures, 2) lack of a system thinking in which a supply chain must be viewed as one whole entity and the measurement system should span the entire supply chain, 3) loss of supply chain context, hence this kind of performance measurement systems encourage local optimization The authors propose supply chain performance measurement system with the assistance of the analytic hierarchy process method. The proposed system is supposed to assess the performance of all the involved nodes along the supply chain based on the core processes in the simplified supply chain model. They propose an eight-step method which identifies and decomposes the involved processes and measures the performance. Chan *et al*.(II)[5] extend supply chain performance measurement system with the assistance of the analytic hierarchy process method and fuzzy set theory.

[5] The University of Hong Kong, Industrial and Manufacturing System Engineering, Working Paper

Stewart (1995) claims that the integration of the supply chain requires philosophical, operational, and systems changes and the objective of the integrated supply chain structure is minimizing non-value-adding activities and their associated structure. During the integration of supply chain four categories of operational change must be considered. These are structure, policy, systems, and organization. Systems should enable performance measurement. In addition, the author points out that the business performance metrics must support a balanced view and a "balanced metric" framework is necessary to measure supply chain performance. Stewart (1995) presents a balanced metric framework based on integrated supply chain. This framework is given in Table 2.5.

Table 2.5 Balanced metric framework

		Perspective		
		Customer's	Shareholder's (financial, cost)	Internal Stakeholder's (quality, cycle time, continuous improvement, etc.)
BUSINESS PROCESSES	Plan	Published delivery lead time	Forecast accuracy	The author does not identify metrics which belongs to this category
	Source	Time to achieve sustainable 20 percent increase	Inventory days of supply	
	Make	Total order fulfillment cycle-time		
	Deliver	Delivery to schedule date	Days sales outstanding	
	Overall	Supply chain response time	Total supply chain cost Warranty cost	

Stewart (1995) also provides PRTM's Third Annual Supply Chain Performance Benchmarking Study results. The objective and scope of the benchmarking study is explained as to helping companies break free of reengineering paralysis and initiating a successful fact-driven implementation. The data collected for the benchmarking study

covers four areas –delivery performance, flexibility and responsiveness, logistics cost, and asset management- which are identified as "keys" to unlocking supply chain excellence. Nine metrics are measured for these four areas.

Hoffman (1999) states that there must be a balance between performance measures and using a few measures only or giving too much weight to one may cause problems. The author claims that companies should track fairly limited set of high-level performance metrics and there should also be process level performance metrics. The author also gives examples from different industries about how they measure performance, what managers of the companies think about supply chain performance measurement.

Stainer (1997) puts productivity in the context of logistics operations and shows how it can be measured. He states that productivity can be seen as a management of resource utilization, including time element. He proposes a framework for logistics productivity analysis, which consists of five distinct dimensions of service performance:

1) Tangibles: Physical facilities, equipment, appearance of personnel.
2) Reliability: Ability to perform the promised service, with dependability and accuracy.
3) Responsiveness: Willingness to help customers and provide prompt service.
4) Assurance: Knowledge and courtesy of employees and their ability to inspire trust and confidence.
5) Empathy: Caring, individualized attention provided to customers.

In addition, Stainer (1997) states that these dimensions must be incorporated in the strategic thinking.

In the article in Logistics News[6], the measures are categorized into two groups: enterprise-level measures and unit-level measures. The article suggests both groups should be incorporated and logistics performance measures, benchmarks, and supply chain performance indicators must be linked to the overall business strategy and performance measures.

[6] http://www.logisticsnews.co.za/march2001/march2001_02.htm

Bowesox and Closs (1996) discuss logistics performance measures and offer a framework for measuring integrated supply chain performance and for benchmarking across organization. They propose three objectives for developing and implementing performance measurement systems: *monitoring* measures track historical logistics systems performance, *controlling* measures track ongoing performance, and *directing* measures are designed to motivate personnel. The authors claim that a logistics performance measurement system perspective should also be determined. They define activity-based measures and process measures. While activity-based measures focus on individual task or process, process measures focus on overall process through supply chain. Bowesox and Closs (1996) define three levels of performance measurement. These are internal performance measurement, external performance measurement, and comprehensive supply chain measurement. Each of these measurement systems is classified into sub-categories and logistics performance measures are classified into these sub-categories. In addition, each metric is monitored as outcomes and as a diagnostic basis. Table 2.6 illustrates these categories.

Table 2.6 Classifications of logistics performance measurement systems

Internal Performance Measurement	External Performance Measurement	Comprehensive Supply Chain Measurement
Cost	Customer Perception Measurement	Customer Satisfaction/Quality
Customer service	Best practice benchmarking	Time
Productivity		Costs
Asset management		Assets
Quality		

The authors claim that the ideal measurement system possesses three characteristics; cost /service reconciliation, dynamic knowledge based reporting and exception based reporting. They also emphasize the relation between organizational hierarchy and level of information. Figure 2.3 depicts the relationship between information flow and levels of measurement.

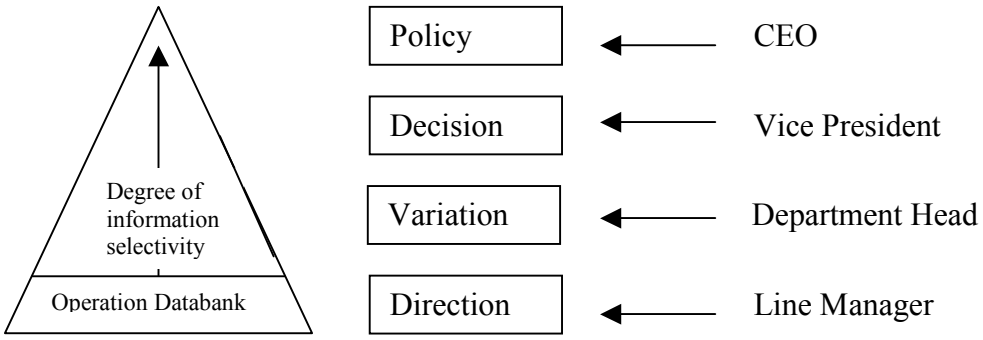

Figure 2.3 Information flow and levels of measurement

Miller (2001) presents a hierarchical framework for capturing and linking all key performance measures. In this framework the author differentiates measures both by their individual level in the hierarchy and by their focus. There are three hierarchical levels; strategic, tactical, and operational. Within these hierarchical levels performance measures are differentiated into two categories, namely external measures and internal measures. While internal measures focus on efficiency and productivity, external measures focus on effectiveness of an activity. The author also gives examples of internal and external measures to explain the relation between the measures in detail. According to the developed framework, at the strategic level, a few key performance metrics will measure overall company's performance; at the tactical level, performance of the each sub-function of a function will be monitored; and at the operational level, the performance of the each sub-function will be monitored. Miller (2001) claims that hierarchical measurement system allows both large and small functional units within a firm to develop and maintain their own measurement system, and contribute to and be part an overall measurement system. After reviewing some sample logistics performance measures, the author provides information about the balanced scorecard that is used for measuring company-wide performance.

Handfield and Nichols (1999) discuss the key elements in establishing successful supply chain reengineering effort and effective performance measurement. They define properties of an effective supply chain performance measurement system and give an example framework of BSC approach to supply chain performance measurement.

Lapide (1998) identifies that companies can generally fall into following developmental stages:

- *Functional Excellence* – a stage in which a company needs to develop excellence within each of its operating units such as the manufacturing, customer service, or logistics departments. Metrics for a company in this stage will need to focus on individual functional departments.
- *Enterprise-Wide Integration* – a stage in which a company needs to develop excellence in its cross-functional processes rather than within its individual functional departments. Metrics for a company in this stage will need to focus on cross-functional processes.
- *Extended Enterprise Integration* – a stage in which a company needs to develop excellence in inter-enterprise processes. Metrics for a company in this stage will focus on external and cross-enterprise metrics.

In addition, the author addresses that in order to increase of enterprise-wide integration and extended enterprise integration, companies' performance measurement systems will need to align to them. The author classify supply chain performance measurement system into three areas. These are function-based measures, process-based measures, and cross-enterprise measures. Lapide (1998) also emphasize that one of the major challenges for many companies during the development of supply chain performance measurement system is limiting the number of measures. During the development of a performance management systems, a reasonable number of metrics should be defined and only most important metrics which are aligned to strategic objective must be selected.

Another important aspect of the performance measurement is setting performance targets, which should always be jointly set in the context of strategic objectives. Lapide (1998) identifies four methods that can be used to set performance targets. Descriptions of these methods are as follows:

- *Historically based targets* method is the most frequently used and the easiest method among all the methods. In this method performance targets are set based on historical baseline levels.

- *External benchmark* is popular but difficult to use in practice. This method relies on collecting information on performance metrics of companies internal and external to one's industry. Once external benchmarking metrics are collected, internal metrics are generated and gap analysis is done. External benchmark may be a difficult due to comparable external benchmarks may not be available or too controversial,
- *Internal benchmark* is a common approach since it requires only internal measures. Within this method, comparable functional departments, processes, and facilities within a company are measured in the same way. Similar to the external benchmarking approach, "best-in-class" functional organizations are identified and their benchmark metrics are used as the basis for establishing performance targets for other functional organizations. The major disadvantage of this method is setting internal organization best-in class metric may limit the company's performance relative to its competitors.
- *Theoretical target* setting is a relatively new method advocated by some consultants. Under this method a company conducts an analysis to theoretically determine how its supply chain performance could be improved. It would then implement the business changes necessary to achieve these improvements and put a set of performance targets in place based on estimates made during the analysis. While companies setting performance target by using this method, first they start an analysis to determine how it should optimize supply chain performance. Then they use estimates made during the analysis to set its performance targets.

Rolstadås (1995) states that although many different performance definitions exist in the literature, these definitions can be defined by three dimensions: (i) effectiveness: to what extent are customers needs met, (ii) efficiency: how economically are the resources of the company utilized, and (iii) changeability: to what extent are the company prepared for future changes.

In addition, sufficient performance measurement system should possess the following properties: (i) measures should directly tie to operational effectiveness and efficiency; (ii) measures should relate important strategic objectives and non-financial performance; and (iii) measures should provide a forward-looking perspective. Easton *et al*.(2002) states that

today, efficiency is the dominating dimension of the most measurement systems and it is intuitive for companies to first focus on efficiency and to organize for efficiency.

3. A SUPPLY CHAIN PERFORMANCE MEASUREMENT SYSTEM

Today, competition is not between companies; it is rather between supply chains. Better supply chain means better competitive advantage and better customer satisfaction. In today's fierce competitive markets, "customers are increasingly demanding their precise specification, delivered to their local dealer in short order to delivery time – the so-called "ten-day car." That dictates super-slick response all the way down the lengthy supply chain, and so on. Competitive pressure will make this an issue that can't be fudged or avoided" (Cap Gemini Ernst & Young, 2002). To gain competitive advantage in this market and to meet customer expectations companies should focus on overall supply chain performance. As stated in Michigan State University multiyear study, supply chain performance measurement is one of the four driven of the supply chain excellence.(Easton *et al.*, 2002). The supply chain performance measurement system should provide managers with accurate, relevant, and timely information. In addition, there are technical and cultural requirements for the effective supply chain performance measurement system. Table 3.1 summarizes these cultural and technical requirements for an effective measurement system.

Table 3.1 Operational requirements for effective measurement system[7]

Technical Requirements	
Wholeness	All of the variables needed to completely define "good performance" are measured.
Performance Gap	Knowing there is a difference between desired and actual performance is one thing, its causes must also be understood.
Sufficient Detail	For the proper control of business, business performance measures must reflect that complexity.
Accuracy	Consistency in reporting, so any change in a performance measure is reliable indicator of a change in performance.
Timeliness	That depends on the situation and how quickly things can change
Frequency	A process must be measured with a frequency that is consistent with how fast it can change

[7] Adapted from Kaydos, 1999

Learning Cycle	How long it takes to make a measurement, implement a change to process, have process respond, and then obtain enough data to determine the effect of the process change
Systematic Operation	Not only collecting data and measuring performance on a regular basis, but it is also means reviewing the information on a regular basis and using it to make changes and priorities, procedures and how resource are allocated.
Long Term Consistency	It is important to be able to make reasonably accurate comparisons over longer periods such as a few years.
Financial Measures versus Operational Requirements	Financial measurements are not adequate for managing and measuring of the operations of a business.
Cultural Requirements	
Absence of Fear	There are two specific fears that will make a measurement system useless. The first is the personal fear of being reprimanded, embarrassed, or otherwise beaten by the measurement yardstick when the measures look bad for any reason. The second fear is the fear of getting one's co-workers or friends in trouble by reporting problems that reflect poorly on their performance.
Accountability	Accountability must be established to determine who should be responsible for improving a performance measure or solving a particular problem. Accountability is especially important when a performance problem is the result of several factors controlled by different departments and no one is clearly responsible for the whole problem.
Validity	When the measures are not understood or there are some faults in the performance measurement system, performance measures will not be accepted or trusted by the users.
Easily understood and relevant to the users	If the measures are not easily understood, they will be misused or more likely not used at all. In order to make measures easily understood, the most important factors are to employ terms that are familiar to users, and to give people only what is relevant to them in a way that reflects accountability, relative importance and logical relationship.
Easy to Use	It is important to make reporting the necessary data as easy as possible for everyone involved.

It is essential to know operational requirements for a supply chain performance measurement system prior to be able to develop a framework.

3.1. A Framework for Performance Measurement System

In this section, a supply chain performance measurement framework for the automotive industry will be introduced and performance metrics will be identified. The metrics are classified into three categories: Customer Satisfaction Perspective, Financial Perspective, and Supply Chain Collaboration Perspective. Customer Satisfaction Perspective metrics are divided into four sub categories. These are Manufacturing Quality Related Metrics, Supply Chain Operation and Service Related Metrics, Flexibility, and Responsiveness Related Metrics. In this framework, performance indicators related with product quality are not considered because it is assumed that product quality is given for the supply chain. Metrics of Financial Perspective are classified as Operational, Inventory, and Assets related metrics. In addition, the metrics are classified as strategic, tactical and operational levels in order to determine the corresponding management level that deals with the metrics. For instance, Delivery Performance is a Customer Satisfaction (Operation and Service) metric and it is assigned at the strategic level based on overall system decision in a supply chain since it is the top management's field of interest. Figure 3.1 depicts general structure of proposed framework. The overall framework is included in Appendix A.

While majority of studies focus on customer satisfaction and efficiency, an overall supply chain integration perspective is defined in this framework with respect to new trends in SCM. This perspective will help a company evaluate its ability to manage its extended supply chain. When a company manages its supply chain only by itself, it will not be sufficient to be a real competitor in today's market conditions. As mentioned earlier, if an organization focuses on only itself, it will not be able to benefit from further cost reduction opportunities and other tools that are important for customer satisfaction and competitiveness.

Figure 3.2 illustrates supply chain collaboration perspective metrics under strategic, tactical, and operational levels. In what follows the description and discussion of strategic, tactical, and operational level metrics.

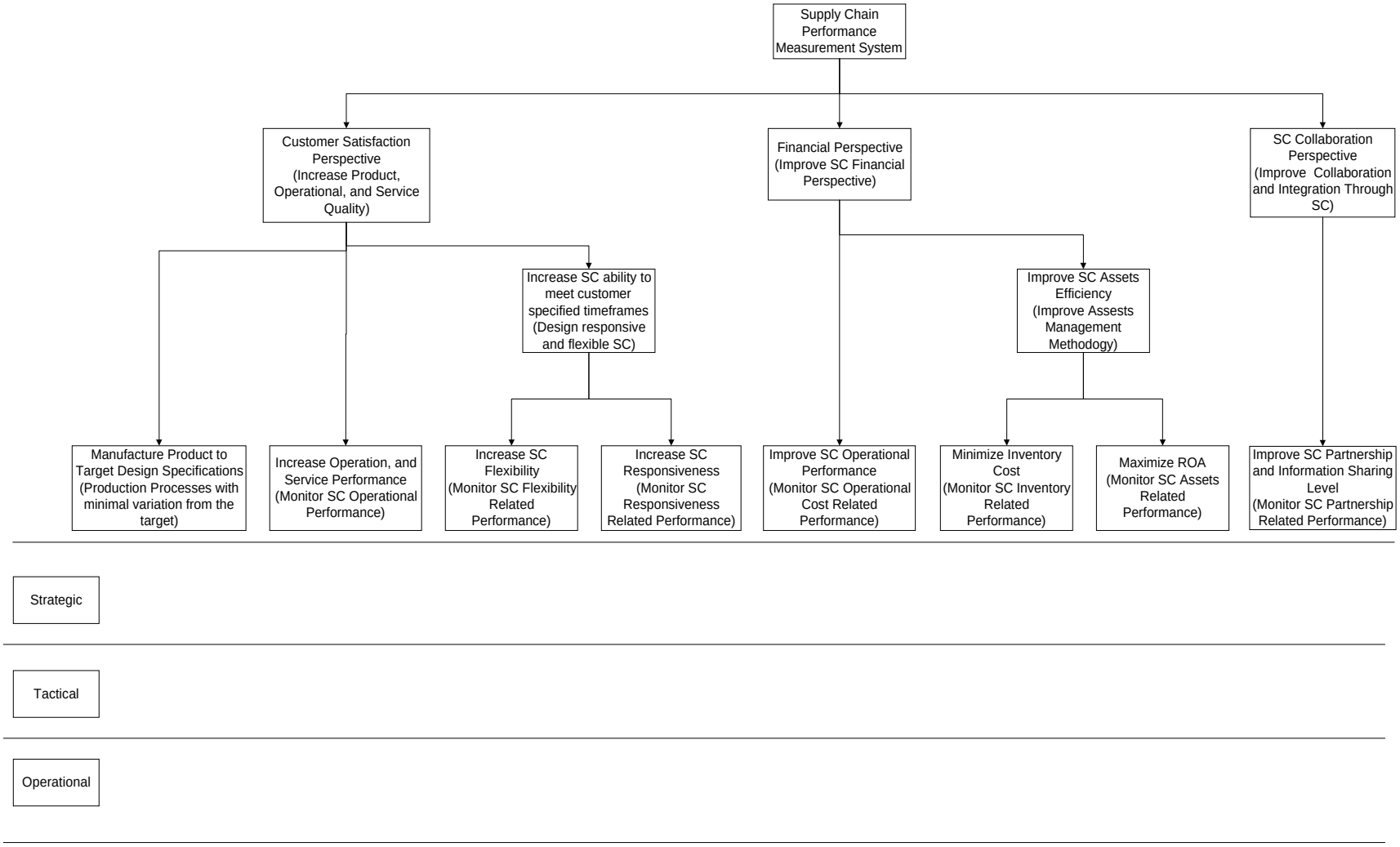

Figure 3.1 Presentation of proposed framework

3.1.5. Strategic Level Supply Chain Collaboration Metrics

The strategic level supply chain collaboration metrics are partnership level through supply chain and degree of information sharing. When the relationship among supply chain members are investigated, three different groups of relationships may be identified. In the first relationship group, members interact with each other for a specific event and generally the duration of relationship is for a short period of time. For instance, when a transporter is needed, it may be rented for one time only; if a supplier is not able to supply a product, the company may work with an alternative supplier for a limited time. The relationship with the rental company in first case and the alternative supplier in the second case is an "Event-Based Short Term Relationship." The second group of relationship is called as "Arm's-Length Relationship." Today, most of the relationships among supply chain members can be categorized in this group. Generally, two supply chain members make a contract which is valid for a year or two. The goals and strategic objectives of the buyers may not match with the strategic objectives and goals of the sellers. Although this kind of short-term contracts are enough to satisfy particular business needs for a specific time period, it does not bring the strategic advantage in the long run. "Strategic Relationship" is the third group of partnership level. In this category, companies are goal oriented and there is a long term relationship between companies. Risk and reward gained during the this type of relationship is also shared. In addition, mutual goals can lead companies develop new products or services jointly. Supply chain partners also collaborate in many areas such as production planning, replenishment, and forecasting.

The degree of information sharing is another important aspect of supply chain collaboration. In reality, integrated supply chain is not achievable without information sharing. The degree of information sharing is evaluated according to three levels. These level are "no information sharing," "production level information sharing," and "planning level information sharing." In no information sharing, buyer and supplier do not share any information about the supply chain they are in. Once the quantity and price are negotiated,

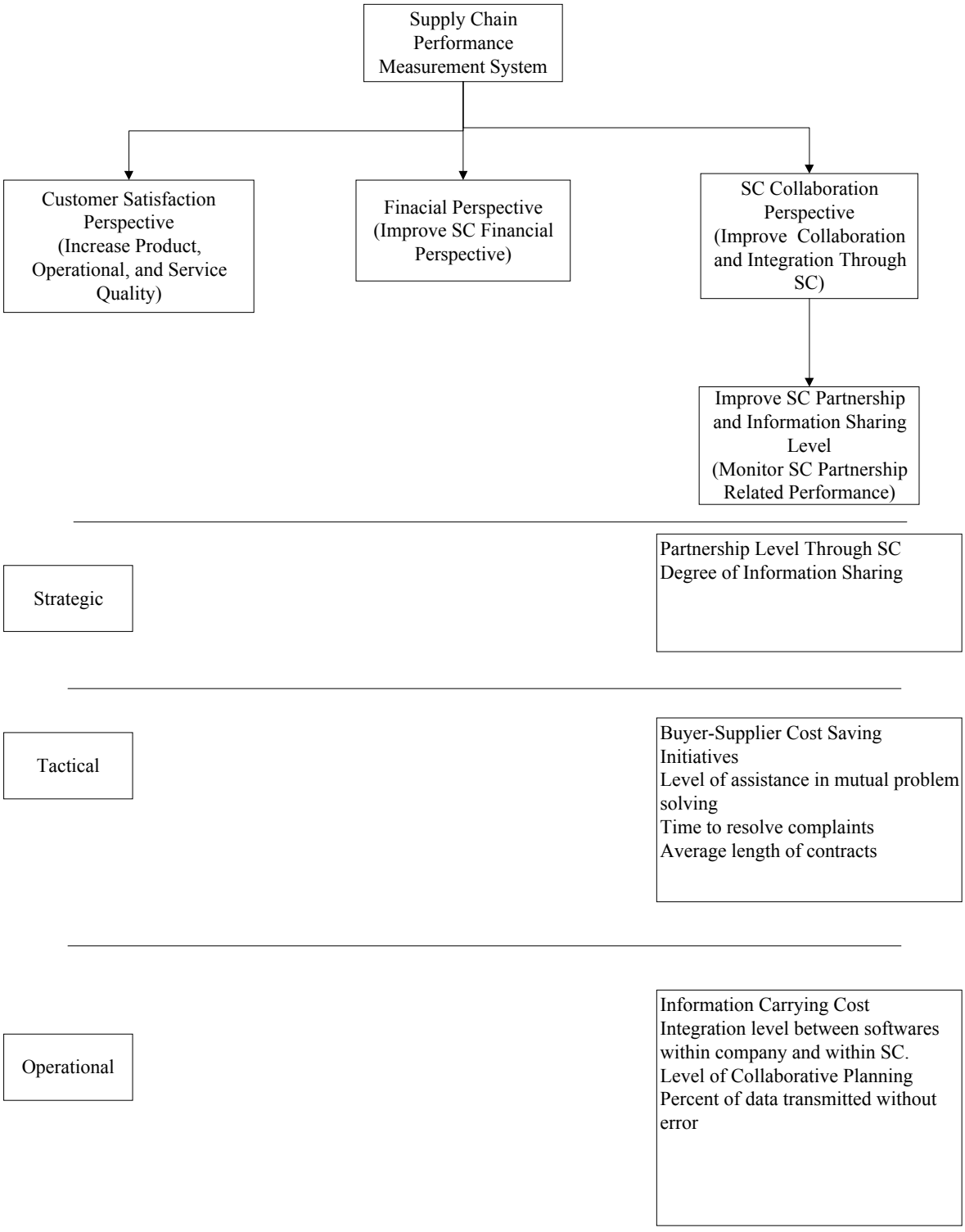

Figure 3.2 Supply chain collaboration perspective metrics

the buyer makes the orders and the supplier is responsible to fulfill these orders. In the production level information sharing, the buyer shares the information regarding its future demand and the supplier uses this information to fulfill the buyer's demands on time. Planning level information sharing may also be called as partnership level information sharing. Supply chain members share point of sales information, inventory levels, and collaborated forecasting and planning is made at this level.

3.1.6. Tactical Level Supply Chain Collaboration Metrics

The tactical level supply chain collaboration metrics are buyer-supplier cost saving initiatives, level of assistance in mutual problem solving, time to resolve problems, and average length of contracts. As stated earlier, the use of effective SCM techniques is important to decrease non-value-adding activities. In an extended-enterprise, it is important to know the member who initiates supply chain cost reduction activities to evaluate the marginal-value added by each player. Results of these initiatives are evaluated based on money gained at the end of these initiatives.

The level of assistance in mutual problem solving is also important for creating a competitive supply chain. Solving a problem may require more than one member's effort. In this case, the behavior of other member may be evaluated according to the following three levels of involvement. These categories are:

- No Assistance: Supply chain member does not attempt to solve problem.
- Insufficient Assistance: Member tries to solve problem, but it is not efficient in level of assistance.
- Full Assistance: Member is committed to solve problem.

Regarding customer satisfaction time to resolve complaints is critical, particularly in after sales service. It is defined as time interval between complaints received and complaints fully solved.

3.1.7. Operational Level Supply Chain Collaboration Metrics

The operational level supply chain collaboration metrics are information carrying cost, integration level between software within company and within supply chain, level of collaborative planning, and percent of data transmitted without error. Computer and information technologies are important initiatives of extended-enterprise. In order to manage the extended-enterprise, supply chain members must be able to reach the information created in each entity of the supply chain. The timely and correct information can be accessible only when the software and databases used in supply chain are able to share the information. The integration level between software within company and within supply chain is classified as fully integrated, partially integrated, and not integrated software.

Fully integrated software can access same databases and a software can easily transmit information to another software. Software is integrated by over local area network (LAN), wide area network (WAN), or Internet. Information is accessible in every place by people who have the required authorization. Partially integrated software need a transformation process in order for the data to be accessible by another software in this category. The information is transmitted by spreadsheet, text files, or another file type, and it is converted to necessary file format by the receiving software. The most important disadvantage of this integration is that information may be lost or disturbed even if it is transmitted electronically. In the no integration level, information created in one system is not accessible by another system electronically. In order to transfer the information, output of the one system is printed or faxed to another location and then it is entered manually to the new system.

Since some of the performance metrics are straight forward they are omitted here. The definitions of these metrics are given in Appendix B.

3.2. Implementation of a Performance Measurement System

Developing a performance measurement classification is only a beginning, the most important aspect in the supply chain performance measurement is the implementation of the system. Due to its wide-scope, supply chain performance measurement system needs to be implemented carefully. In addition, for a successful implementation, necessary steps that will be followed during the implementation should be clearly defined. Figure 3.3 illustrates the proposed supply chain performance measurement system implementation steps:

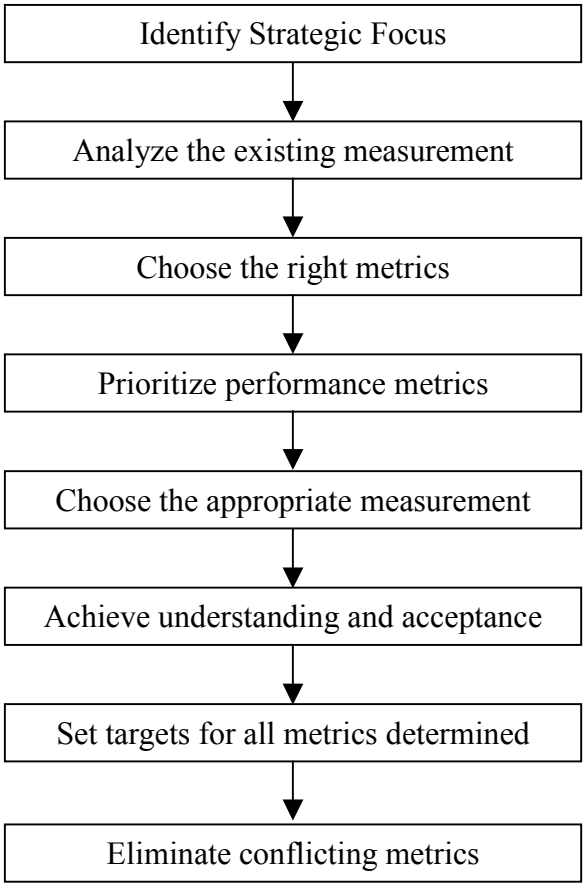

Figure 3.3 Supply chain performance measurement system implementation steps

3.2.8. Identify Strategic Focus

One of the important factors about performance measurement is alignment of strategic objective and organization's business objective to performance measurement system. Kaplan and Norton (1996) identify three distinct mechanisms that are used for alignment of an organization to strategy. These are communication and education programs, goal-setting programs, and reward linkage system. In this step, there are three fundamental questions:

- What are the most important business objectives for the organization to achieve?
- Which results are critical to achieve these objectives?
- What people drivers –for example leadership, training, diversity, and values– impact the performance on these result? [8]

The implementation may not be aligned with the identified and formulated strategy due to some barriers. These barriers may include visions and strategy that are not applicable, strategies that are not linked to departmental, team, and individual goals, strategies that are not linked to long and short-term resource allocation, and feedback that is tactical not strategic.

3.2.9. Analyze the Existing Measurement System

All existing metrics reported in each department or business process should be listed. This should be combined with a priority survey since there is a close relationship between priority and measurement. The survey should include the following three questions to be answered by each organizational unit:

- What are measured?
- What is reported?
- What should be measured?

[8] Metrus Group http://www.metrus.com

3.2.10. Choose the Right Metrics

An effective supply chain performance measurement system starts with the selection of the right metrics. There is a myriad of performance metrics available in the literature. Only well-defined purpose helps choosing the most suitable metrics. The metrics that support the performance priorities of the organization and that accord with what is needed to fulfill these priorities should be kept for further investigation. In this step, translating the company's strategy into measurement is of critical importance. In addition, if the metrics selected after analysis of the current system reveal uncovered needs, new performance metrics have to be developed.

While companies have started to transform their existing performance measurement system to a supply chain performance measurement system, they should start with clarification of strategic objectives. After objectives are clearly identified, a limited number of strategic level performance metrics should be selected based on these objectives. For instance, if a company's objective is increasing customer satisfaction, it should especially focus on Service Level, Delivery Performance, and Supply Chain Response Time.

3.2.11. Prioritize Performance Metrics

After choosing the right metrics, companies have to prioritize to identify the most important ones. This step can also be called as determination of key performance indicators (KPIs). KPIs describe where the company must achieve and maintain excellent performance in order to survive and thrive. In many respects, the difficulty in determining a company's KPIs lies not in identifying things to measure, but in deciding the critical few items that will drive a company's strategy and its success. A company's KPIs should be able to answer the question: "What do we have to be excellent at doing to get our potential customers' business." (Kaydos, 1999)

3.2.12. Choose Appropriate Measurement Method

The choice of measurement method is related with the choice of the right metrics measured. Validation of the measurement system is also important for an effective measurement. If the measurement system is validated then it can be claimed that "performance measurement system presents accurate and reliable picture of performance."

3.2.13. Achieve Understanding and Acceptance

Without the acceptance by the people involved, effectiveness of performance measurement system is arguable. Due to this reason, validation of performance system is important to convince people accept performance measurement system and take necessary action when needed.

3.2.14. Set Targets for all Metrics Determined

A target for each performance metric should be established by using historical performance, internal-external benchmark, and theoretical estimates should be established. A timeline for achieving the targets needs to be defined for each metric. This timeline should be consistent with the schedules developed for the supply chain initiatives.

3.2.15. Eliminate Conflicting Metrics

In fact, this stage is an ongoing process for a performance measurement system. Generally, removing obsolete metrics is not an easy task and this step is a necessary and integral part for the maintenance of the system.

4. CASE STUDY: SUPPLY CHAIN PERFORMANCE MEASUREMENT IN A LEADING AUTOMOBILE COMPANY IN TURKEY

The automotive industry is one of the most complex industries in the world. More than 10.000 parts are required in order to manufacture a vehicle and each of these parts should be designed and produced separately. This complexity requires more than what are done at other industries. Consequently, automotive industry is often selected as the first initiative of the new methods of doing business. For instance, in the 1980's the automotive industry introduced the concept of vendor managed inventories (VMI). "The Big Three automotive manufacturers Ford, GM, and Chrysler were re-organizing their firms to eliminate hundreds of purchasing functions whose primary role was to control the supplier flow of all parts used to assemble an automobile. Today, the use of Electronic Data Interchange (EDI) and a sophisticated ratings system allow the Original Equipment Manufacturers (OEMs) to trigger their requirements and have the right parts arrive just in time" (Preiditsch, 2000).

After first initiatives have started to manage their supply chain and gain competitive advantage, other companies change their focus in the same way to survive this lengthy competitive environment. To gain competitive advantage in this environment and to meet customer expectation companies should focus overall supply chain performance. When today's companies are analyzed it can be observed that each company has some kind of performance measurement system. Development of a performance measurement system is then a transformation process based on the existing system. In this chapter, first strategic objectives of the Company[9] are determined, then currently used performance metrics and performance evaluation system are analyzed. The chapter continues with the following implementation steps developed in the framework described in the previous chapter.

[9] Since the case company request the

4.1. Identifying Strategic Focus

During the last decade, by using initiatives such as JIT, Kanban, and Kaizen the Company has improved its own processes. Related suppliers have also improved their processes, if necessary. However, today's market competition is not between companies, and improving only itself is not sufficient to compete successfully. In past five years the Company has lost its leader position in the Turkish automotive market. Beside its outdated design and low quality products, prices are not less than the others' sold in the same customer segment. To gain an advantage in the Turkish and Fiat's competitive world, the Company Logistics Project was initiated in 2001. The objective of the project is reengineering and reorganizing overall Supply Chain of the Company. Other objectives of the project include:

- Decrease lead time,
- Shift focus from logistics to supply chain,
- Cost optimization through the Company's supply chain,
- Increase customer orientation,
- Improve IT integration and information flows between supply chain entities.

4.2. Analyzing the Existing Measurement System

Since the Company has focused on its own performance, in the current system only company wide performance metrics are evaluated. During the analysis process not only monitored performance metrics are investigated but also information regarding intended measures had been requested. Gathered information is summarized as (i) data available and already being monitored, (ii) data available but not monitored, (iii) gathering data possible, and (iv) gathering data impossible. At the next stage, all determined performance metrics classified according to related processes. Figure 4.1 depicts the number of performance measures in each of data availability status. Table 4.1 presents all metrics according to processes and data availability. From this table it can be observed that some of the

performance measures need to be monitored but nobody knows about availability of data or whether it is monitored or not.

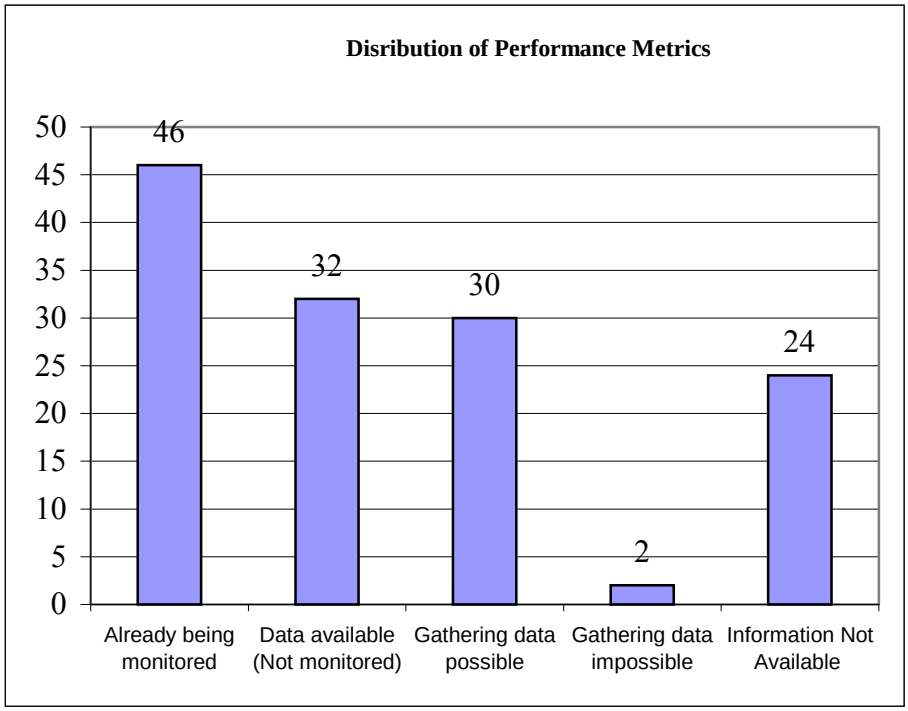

Figure 4.1 Number of performance measures in each data availability status

Table 4.1 The Company's performance indicators

PERFORMANCE INDICATORS	Already being monitored	Data available (Not monitored)	Gathering data possible	Gathering data impossible
1. PO PROCESS				
PO decision meeting lead time		X		
Time of PO decision meeting delay		X		
Percent deviation of ***local*** PO forecasts from the realized sales (strategic)	X			
Percent deviation of ***export*** PO forecasts from the realized sales (strategic)			X	
Percent deviation of ***other export*** PO forecasts from the realized sales (strategic)			X	
Lead time of monthly production plan preparation			X	
Percent order entries by dealer with respect to quote determined		X		
Realization of dealer sales target				
Performance of file transactions (Correctness of data transfer)		X		
Coherence of the production program with respect to orders	X			
Late orders quantity	X			
Late orders delay time		X		
Make to stock quantity		X		
Modification frequency of ***local*** PO's	X			
Modification frequency of ***export*** PO's			X	
Modification frequency of ***other export*** PO's			X	
Finished vehicles stock / turnover (days)				
Order to delivery lead time		X		

PERFORMANCE INDICATORS	Already being monitored	Data available (Not monitored)	Gathering data possible	Gathering data impossible
2. PRODUCTION PROGRAMMING				
Coherence between PDP and MRP	X			
Coherence between realized program and MRP	X			
Frequency of postponed validation		X		
Re-treatment quantity/frequency (based on type, period, vehicle)		X		
Urgent PO request quantity/frequency			X	
Urgent request fulfillment cycle time			X	
Frequency and percentage of monthly program changes			X	
Amount of backorders			X	
Number of simulations **to correct the system mistakes**			X	
Number of simulations activated for **feasibility**			X	
Number of simulations inactivated for **feasibility**				
Number of items simulated		X		
Percentage of local critical items with respect to total local items		X		
Percentage of import critical items with respect to total import items		X		
Production cycle time of CBU			X	
Quantity/frequency of scrap orders		X		

PERFORMANCE INDICATORS	Already being monitored	Data available (Not monitored)	Gathering data possible	Gathering data impossible
3. MATERIAL FOLLOW UP & PROCUREMENT				
Order modification ratio (P/E change)	X			
Number & Frequency of "Urgent material requests" from suppliers		X		
Percentage of incoherencies between physical and system records of material		X		
Amount of items requested for inventory (to correct records)		X		
Production with missing parts quantity/frequency	X			
Line-stop durations and frequency		X		
Quantities/ number of items transported by air , express TIR, cargo		X		
Volume/weight transported by air , express TIR, cargo	X			
Money spent for transportation by air, express TIR, cargo charged to CASE1	X			
Money spent for transportation by air, express TIR, cargo charged to suppliers	X			
Performance of information systems			X	
Performance of early/late delivery	X			
Time spent for part missing vehicle completions	X			
Frequency/percent change of mix		X		
Percentage/number of alternative material usage			X	
Percentage/number of deviant material usage			X	
Percentage/number of items supplied from alternative suppliers			X	
Indirect labor hour for follow up	X			
Quantity/percentage of items used which are not in BOM		X		

PERFORMANCE INDICATORS	Already being monitored	Data available (Not monitored)	Gathering data possible	Gathering data impossible
3. MATERIAL FOLLOW UP & PROCUREMENT				
Inbound stock levels in (Value/Days)	X			
Number of items in JIT	X			
Number of items in KANBAN	X			
Number of items in negative stock	X			
Percentage of firms in the Milk Run	X			
Delivery volume percentage of Milk Run		X		
Saturation percentage in Milk Run		X		

4. TRANSPORT - RECEPTION- CUSTOMS				
Transport costs (TIR, Ship, Plane)				
Transport lead times and deviations	X			
Extra customs clearance cost				
Warehouse address incoherencies		X		
Warehouse efficiency ratio			X	
Cycle time of the trucks in the plant			X	
Percentage/number of unsuitable packaging from suppliers				
Container delay costs		X		
Import material customs clearance lead time				
Information system incoherencies				
Amount and area of empty/full containers		X		
Percentage of wrong/missing/excess material delivered by suppliers			X	
Container/special packaging equipment returning cost				

PERFORMANCE INDICATORS	Already being monitored	Data available (Not monitored)	Gathering data possible	Gathering data impossible
5. VEHICLE DELIVERY				
Delivery cost per vehicle				
Number of vehicles returned from dealer				
Waiting time in the park area				
Number of defected vehicle after assignment point (CASE1 factory exit)				
Number of defected vehicle in park area				
TIR saturation				
Transport cycle time from invoicing until delivery to dealer				
Dealer CBU stock (Waiting time at dealer)				
Factory CBU stock (Assembly line output to assignment point)	X			
Lead time from point assignment to dealer			X	
Ready-to-deliver CBU stock levels more than 3,6,9,12 months				
Performance of transporters (lead time)			X	
Damaged cars during transport (unload from ship ,loading ,unload ,missing document)	X			
Final checking time per vehicle (at assignment point)			X	
Warranty cost/per vehicle (LOCAL/EXPORT)			X	
5.1 IMPORTED CARS				
Waiting time at free zone				
Waiting time at port				
Lead time from free zone outlet to end customer				
Transporter performance (Quality, lead time)				

PERFORMANCE INDICATORS	Already being monitored	Data available (Not monitored)	Gathering data possible	Gathering data impossible
6. FOREIGN TRADE SERVICE MANAGEMENT				
Packaging mistakes of suppliers			X	
Number/percentage of air shipments charged to CASE1	X			
Number/percentage of air shipments charged to supplier	X			
Packaging cost and percentage in total cost	X			
Percentage of on-time deliveries of suppliers in total deliveries	X			
Correctness of the programs sent to suppliers				X
Cycle time (waiting at warehouse)				X
Stock levels (export)	X			
Turnover (sales)	X			
Order modification ratio (P/E change)	X			
Transportation cost	X			
Percent saturation of containers / tır	X			
Warehouse usage percent		X		
Cost of normal customs operations	X			
Cost of extra customs operations	X			
Quality indicators of Fiat				
Undeclared missing parts	X			
Wrong shipments	X			
Production fault	X			
Packaging fault	X			
Protection fault	X			
Transportation fault	X			

PERFORMANCE INDICATORS	Already being monitored	Data available (Not monitored)	Gathering data possible	Gathering data impossible
6. FOREIGN TRADE SERVICE MANAGEMENT *(Continued)*				
Percentage of parts missing in Lot	X			
Percentage of late delivered Lot	X			
Order to delivery lead time			X	
Manual orders, order to delivery lead time			X	
Manual orders, cycle time of order inquiry in system		X		
Supplier packaged export ratio	X			

7. SPARE PARTS				
Lead time of urgent orders		X		
Amount of urgent orders (based on dealer)	X			
Stock replenishment level (TURNOVER)	X			
OTD lead time of normal orders (target 30 days)		X		
Request fulfillment ratio (Service level)	X			
Open orders ratio	X			
Way bill mistakes (Feedback from dealer)			X	
Suppliers' delivery performance (both OEM and Supplier)			X	
Time needed between purchase order until ready-to-deliver		X		
Packaging time			X	
Packaging cost		X		
Percentage of correct material shipments			X	
Lead time from temporary stock warehouse to permanent warehouse		X		

PERFORMANCE INDICATORS	Already being monitored	Data available (Not monitored)	Gathering data possible	Gathering data impossible
8. CLAIM				
Costs of service exceeding 24 hours				
Cost of changing the customer's car with a new one				
Vehicle hand over time (lead time from claim to hand over)				
Destruction cost				
Number of service calls				

When the performance metrics given in the Table 4.1 are analyzed, it will be realized that the majority of the currently monitored performance metrics measure operational effectiveness and cost related performance. Although flexibility and responsiveness metrics are very important regarding customer satisfaction, current performance measures do not focus on these metrics. This is a important weakness of the Company's performance measurement system.

Since the Company has changed its focus on its supply chain, newly developed performance measurement system will consist of not only company wide performance measures but also supply chain wide performance measures. In addition, although performance measurement system is designed to measure overall supply chain at the first phase it will be used only for evaluating the Company's performance to start creating a comparable supply chain.

4.3. Choosing the Right Metrics

When it comes to supply chain performance measurement there is a consensus about limiting the number of performance metrics. The number of metrics should be limited to ensure that the process is not too cumbersome to administer. A set of key performance metrics are selected from each perspective considering the alignment of performance measurement system to the strategic objectives, that are described in section 4.1.1. These key performance indicators are depicted in Table 4.2.

4.4. Prioritizing Performance Metrics

When the Company's supply chain is analyzed three different supply chains can be mainly identified. These are automotive and light commercial vehicle (LCV) supply chain, spare parts supply chain, and parts supply chain. Although some of the metrics are common for all supply chains, performance metrics should be prioritized and customized for each

supply chain because of certain different properties of these supply chains,. The prioritized supply chain performance metrics are presented in Table 4.3.

Table 4.2 Key performance indicators

CUSTOMER SATISFACTION PERSPECTIVE	***SUPPLY CHAIN FINANCIAL PERSPECTIVE***	***SUPPLY CHAIN COLLABORATION PERSPECTIVE***
Operation & Service Performance	***Operational Performance***	
Delivery performance	Total supply chain cost	Partnership level through supply chain
On time delivery (commit and request)	Warranty cost and returns processing cost	Level and degree of information sharing
Fill rate	Cost of goods sold	Level of assistance in mutual problem solving
Perfect order fulfillment	Dollar (money) fill rate	Time to resolve complaints
Service level		
Customer satisfaction		
Backorder rate and duration		
Forecast Accuracy (Unit forecast and Dollar forecast accuracy)		
Supply Chain Flexibility Performance	***Assets Efficiency Performance***	
Supply chain response time	Cash to cash cycle time	
Production flexibility (material, labor, capacity)	Inventory days of supply	
Order management cycle time	ROI	
	ROA	
Supply Chain Responsiveness Performance		
Order fulfillment lead-time		
Time-to-market new product		

Table 4.3 Prioritized supply chain performance metrics

P	General Automotive & LCV Supply Chain	P	Spare Parts Supply Chain	P	Parts Supply Chain
1	Cash to cash cycle time	1	Backorder rate and duration	1	Backorder rate and duration
1	Cost of good sold	1	Dollar (money) fill rate	1	Service Level
1	Customer satisfaction	1	Forecast Accuracy (Unit forecast and Dollar forecast accuracy)	2	Forecast Accuracy (Unit forecast and Dollar forecast accuracy)
1	Delivery Performance	1	Order management cycle time	2	Order management cycle time
1	Fill Rate	1	Perfect order fulfillment		
1	Inventory days of supply	1	Service level		
1	Level and degree of information sharing	2	Level of assistance in mutual problem solving		
1	On time delivery (commit and request)	2	Time to resolve complaints		
1	Order fulfillment lead-time				
1	Order management cycle time				
1	Partnership level through supply chain				
1	Production flexibility (material, labor, capacity)				
1	Supply chain response time				
1	Time-to-market new product				
1	Total supply chain cost				
1	Warranty cost and returns processing cost				
2	Forecast Accuracy (Unit forecast and Dollar forecast accuracy)				
2	ROA				
2	ROI				
2	Service level				

P: Priority

4.5. Choosing Appropriate Measurement Method

The appropriate measurement method is directly related with the definition of the metrics. Once definition of a performance metric is clarified, then suitable method can easily be developed for the Company. In addition, another important aspect of measurement is creating a comparable supply chain. In order to achieve creating a comparable supply chain commonly used definition of performance should be utilized. These definitions are given in Appendix B.

Other steps of the developed framework have not been applied in the Company yet. Hence in the thesis, the difficulties that may be faced with during the implementation of the new performance metrics and other experiences that will be gained at the end of the implementation are not evaluated.

5. CONCLUSION AND FURTHER RESEARCH

Considering the complexity of the manufacturing of an automobile the challenge of managing an automotive supply chain may be better appreciated. Despite te complexity of automotive supply chain there is an increasing expectation to decrease cost and order-to-delivery time while increasing service and product qualities. These expectations make automotive manufacturers decrease non-value-adding activities and develop new techniques to improve competitiveness of the supply chain they belong to.

The aim of this study is to develop a new performance measurement framework and implement this framework in the automotive industry. The proposed framework consists of customer satisfaction, financial, and collaboration perspetives. While customer satisfaction and financial perspectives are commonly considered on the literature, the collaboration perspective defined in this thesis is a new perspective.

The collaboration perspective is mainly focused on relationship, information sharing and integration level, and commitment among supply chain members. Although the performance metrics included in this perspective cover many aspect of the collaboration, new performance metrics especially in the area of resource sharing may be developed to create world class performance measurement system. Hence, new supply chain collaboration performance metrics and evaluation criteria in the area of resource sharing may be developed in the future.

In the Company case study, five of eight implementation steps are implemented. An overall evaluation of the proposed framework may be done after all steps are completed. The difficulties and experiences gained throughout the implementation process may also be identified in depth.

Another important aspect of the performance measurement is the evaluation of measured performance. However, due to the insufficiency of the Company's IT structure in measuring many of these performance metrics and the lack of historical performance measures data, the Company's performance cannot be presently evaluated. A benchmark study may be conducted in the future to evaluate the Company's overall supply chain performance

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APPENDIX A

APPENDIX B

Performance Metric	Definition	Reference
Backorder rate and duration	The percentage of undelivered product on time. Time between committed delivery time and actual delivery time.	
Cash to cash cycle time	Cash to cash cycle time= inventory days of supply+ days sales outstanding – average payment period for materials. Time it takes	Supply Chain Council
Cost of good sold	The cost associated with buying raw materials and producing finished goods. This cost includes direct and indirect cost	Supply Chain Council
Customer satisfaction	The degree to which customers are satisfied with the product and/or service.	Beamon, 1998
Delivery performance to customer commit date	The percentage of orders that are fulfilled on or before the original scheduled or committed date.	Supply Chain Council
Delivery Performance to Customer Request Date	The percentage of orders that is delivered on the customer's requested date.	Supply Chain Council
Dollar (money) fill rate	Value of product delivered within 24 hours of order receipt	
Fill rate	Percentage of product delivered within 24 hours of order receipt	Supply Chain Council
Forecast Accuracy (Unit forecast and Dollar forecast accuracy)	Forecast Accuracy= Forecast sum-Sum of variance; Forecast sum= The sum of units forecasted in each month. Sum of Variances=sum of the obsolute values at the forecasted line item level.	Supply Chain Council
Inventory days of supply	Total gross value of inventory at standard cost before reserves for excess and obsolescence.	

Level and degree of information sharing	No Information Sharing: Buyer and supplier do not share information, buyer gives the amount of products needed and supplier is responsible to fulfill this demand. Production Level Information Sharing: Buyer gives the information about its future demand and supplier use this information to fulfill buyer's demand on time. Planning Level Information Sharing: Supply chain members share point of sales information, inventory levels, and collaborated forecasting/ planning is made at this level.	
Level of assistance in mutual problem solving	No Assistance: Supply chain member does not attempt to solve problem. Insufficient Assistance: Member tries to solve problem, but due to some reasons it is not efficient in level of assistance. Full Assistance: Member is committed to solve problem.	
On time delivery	Percentage of order shipped before or on the requested delivery date.	Supply Chain Metrics Web Site
Order fulfillment lead-time	The average actual lead times consistently achieved, from Customer Signature/ Authorization to Order Receipt, Order Receipt to Order Entry Complete, Order Entry Complete to Start-Build, Start Build to Order Ready for Shipment, Order Ready for Shipment to Customer Receipt of Order, and Customer Receipt of Order to Installation Complete.	Supply Chain Council
Order management cycle time	The total amount of time required converting a customer order into a receipt by the customer.	Supply Chain Council

Partnership level through supply chain	Event-Based Short Term Relationship: Interaction among members occur for a specific event and generally duration of relationship is short. Arm's- Length Relationship: Supply chain members make a contract which is valid for a year or two years. Strategic Relationship: Companies are goal oriented and there is long term relationship between companies, and risk and reward gained during the relationship is also shared.	
Perfect order fulfillment	A "perfect order" is defined as an order that meets all of the following standards: Delivered complete; all items on order are delivered in the quantities requested Delivered on time to customer's request date, using your customer's definition of on-time delivery Documentation supporting the order including packing slips, bills of lading, invoices, etc., is complete and accurate Perfect condition: Faultlessly installed (as applicable), correct configuration, customer-ready, no damage	Supply Chain Council
Production flexibility (material, labor, capacity)	The number of days required to achieve an unplanned sustainable 20% increase in production.	Supply Chain Council
ROA	Net income divided by total assets	
ROI	Net income divided by investment	
Service level		
Supply chain response time		
Time to resolve complaints	The time interval between complaints received and complaint fully solved.	
Time-to-market new product		

Total supply chain cost	SC Inventory, material acquisition, order management, supply chain finance and planning; and supply chain IT cost	Supply Chain Council
Total supply chain cost	Inventory, material acquisition, order management, supply chain finance and planning; and supply chain information technology cost	Supply Chain Council
Warranty cost and returns processing cost	Warranty costs include materials, labor and problem diagnosis for product defects.	Supply Chain Council

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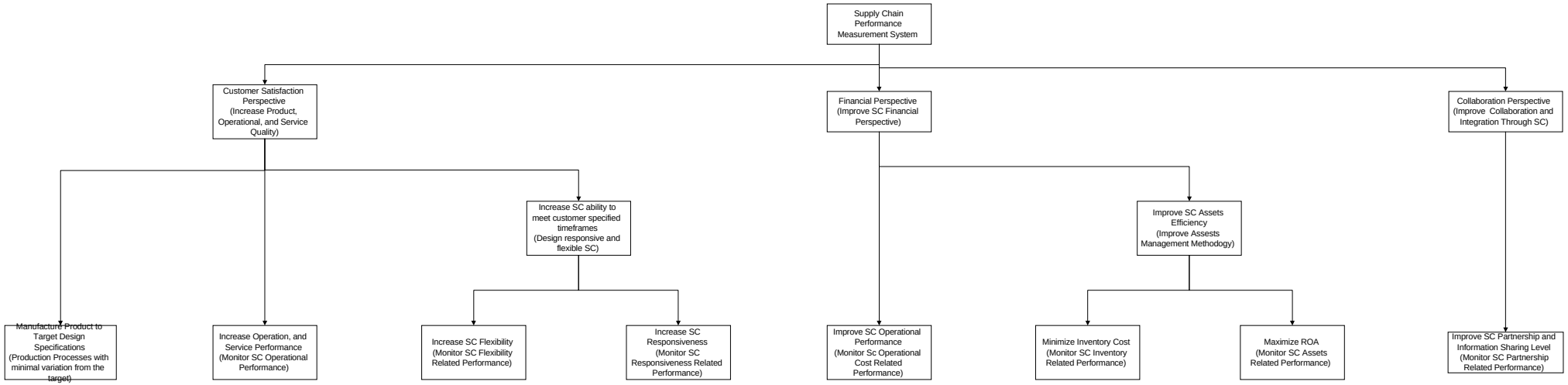

Strategic	Total SC Cycle Time Delivery Performance Delivery Lead Time Order to Delivery Lead Time Fill Rate Perfect Order Fill Rate Line Item Fill Rate Perfect Order Fulfillment Delivery to Request Date Delivery to Commit Date Service Level Customer Satisfaction Customer perception of service Supplier Lead Time Against Industry norm Level of Supplier's Defect Free Deliveries Backorder Rate Backorder Duration Degree of satisfaction with complaint resolution	SC Response Time Production Flexibility	Order Fullfilment Lead Time The customer query time Responsiveness lead Time Time to market with new products New Product time to first make	Total SC Management Cost Cost of Good Sold Warranty Cost and Returns Processing Cost Total Logistics Cost Variation against Budget SC Finance Cost Value-Added Productivity Dollar (Money) Fill Rate	Inventory Days of Supply Inventory Levels	Cash-to-Cash Cycle Time ROI ROA	Partnership Level Through Sc Degree of Information Sharing
Tactical	Forecast Accuracy Planned process cycle time Effectiveness of MPS (Production Plan Adherence) Effectiveness of distribution planning schedule Re-Plan Cycle Time Inventory Accuracy	Order Management Cycle Time Flexibility of delivery system to meet particular customer needs Approval Cycle Time Upside/Downside Production Flexibility Percentage of cross-trained personnel	Responsiveness to urgent orders Product Changeover Time Total Manufacture Time	Cost of Damage Total distribution cost Product Acquisition Cost Packaging Cost Overhead Cost MRO Cost Plant Level Order Management Cost	Inventory accuracy and error rates		Buyer-Supplier Cost Saving Initiatives Level of assistance in mutual problem solving Time to resolve complaints Coordination of processes Average length of contracts
Operational	Capacity Utilization Frequency of Delivery Achievment of Defect Free Deliveries Effectiveness of Scheduling Techniques Customs Clearing Cycle Time Export/Import Shipment Processing time		Packaging Cycle Time Time to update customer records and status	Cost per Operation Hour Service Cost Cost per invoice Product management and planning cost as a% of product acquisition cost Order Entry and Management Cost	Inventory Carrying Cost Inventory Stock Levels -WIP -Obselete Inventory -Finished Good in Transit -Incoming Stock Level		Information Carrying Cost Integration level between softwares within company and within SC. Level of Collaborative Planning % of data transmitted without error