

# State of the art of Supply Chain Performance Measurement in Danish industrial companies

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## ABSTRACT

### Purpose

We have examined which dimensions are used by the largest Danish manufacturing companies to measure SCPM at operational, tactical and strategic level, how can these dimensions be classified, and how do these empirical results have implications for practice and selected SCPM-theories.

### Design/methodology/approach

A deductive structure based on a theoretical framework was used to design an empirical investigation of 54 Danish manufacturing companies, which all have revenue of more than DKK 500 million. Furthermore, qualitative investigation was done by analyzing four case-companies in order to get a more in-depth picture of how SCPM is used in practice.

### Findings

The four most used SCPM metrics have downstream focus. Companies that use SCPM have a more deliberated split between metrics with focus on operational, tactical and strategic level. While the quantitative data indicates that non-financial measurements are most frequently used, the qualitative data implies that the companies use financial measures as basis for performance measurement and that results from non-financial measures have second priority.

### Research limitations/implications (if applicable)

The model is limited to large Danish industrial companies and we propose to widen the model to upstream and downstream supply chain partners.

### Practical implications (if applicable)

The paper shows the most important and most frequently used supply chain relevant key performance indicators as well as a process model of how to implement supply chain performance measurement in a company.

### Original/value

This paper closes the gap between theory and practice within the area of performance measurement and management within the context of supply chain management. The proposed SCPM model has been theoretically developed and empirically validated.

*Keywords:* Supply Chain Performance Measurement, key performance indicators, Danish industrial companies.

# **1 INTRODUCTION**

The major goal of SCM has been identified with the maximization of the effectiveness of a chain's outcome, providing superior service to the ultimate customer of the chain (e.g. Bowersox et al., 2010). Supply chain performance is the bottom line for supply chain strategies but it is difficult to measure as this includes the observation of economic components like sales volumes and costs as well as qualitative components such as flexibility or delivery ability (e.g. Keeber et al., 1999; van Hoek, 1998). Every supply chain manager knows this dilemma to balance costs, productivity, customer service and quality as well as financial benefits (see Brewer and Speh, 2000).

However, Supply Chain Performance Measurement (SCPM) is recognized as an important tool for managing supply chain behavior and orientation (e.g. Karrer, 2003). Its purpose is to establish supply chain goals, evaluate supply chain performance and determine future supply chain directions and activities (Gunasekaran et al., 2001 or Gunasekaran et al., 2004).

Our research project was focusing on Danish manufacturing companies and their SCPM. The scientific purpose of the project was to see which dimensions the largest Danish manufacturing companies use in their SCPM at operational, tactical and strategic level. In this paper, we will classify the used dimensions and compare theoretical recommendations with empirical practice.

Hereby, we hypothesize that SCPM has to include the cross-functional performance measurement of business processes within the firm as well as between the suppliers and customers of the firm in order to achieve its short-term and long-term objectives. It is essential for SCPM to be synchronized with the overall corporate strategy as the supply chain strategy is derived from that.

We developed for our project a theoretical frame of reference that we empirically tested in two waves based on a quantitative survey based on a standardized questionnaire and qualitative case study approach using qualitative interviews.

This paper continues with the presentation of our theoretical frame of reference, the presentation of our methodological approach and a presentation and discussion of our findings. The paper closes with a critical summary and a discussion including an outlook for future research.

## **2 LITERATURE REVIEW ON SUPPLY CHAIN PERFORMANCE INDICATORS AND MEASUREMENT**

### **2.1 Definitions and purpose on Supply Chain Performance Indicators and measurement**

When measuring supply chain performance, it is necessary to identify the supply chain performance indicators that constitute the overall supply chain performance (see Lambert and Pohlen, 2001 or Lebas, 1995). A supply chain performance indicator (SCPI) is understood as an empirically observable numerical reference or illustration that is relevant for the supply chain success of an organization (see Neely, 2003; Lapide, 2000). SCPIs show regularly how well supply chain processes are executed and they can be expressed in absolute or in relative terms (see e.g. Keebler et al., 1999).

For the measurement of supply chain performance the efficiency or the effectiveness of an outcome of a supply chain activity is analyzed (e.g. Fugate et al., 2010). Efficiency describes an input/output relation while effectiveness shows how well supply chain goals have been achieved (see e.g. Bowersox et al. 2010). In this sense, supply chain performance can be seen as a function of the utilization of supply chain resources or as a function of supply chain results as compared to supply chain targets.

There are basically three functions attributed to (supply chain) performance indicators (SCPI) (see e.g. Morgan, 2004 or Lapide, 1999 or Gilmour, 1999):

- Information function in order to inform management, support decision making and to identify problem areas;
- Steering function in order to set targets and give directions to desired outcomes;
- Controlling function in order to supervise process execution.

Overall, any supply chain manager has to ensure that a certain service level can be guaranteed to the customers and that this service level is achieved at minimal costs and at the highest quality level. The cost aspect includes the total costs for order management, storage and commissioning, inventory management and transport (see Bowersox et al. 2010).

The service level represents the intended relationship between the number of orders received and the number of orders executed, while the quality level refers to the way of how the orders are executed. Service quality includes the reliability of the service performance including the quality of the shipment and the quality of the delivery as well as the availability of the supply chain service (see e.g. Chopra and Meindl, 2007 or Mentzer and Konrad, 1991).

## **2.2 Development of a comprehensive and extensive frame of reference for measuring supply chain performance**

### **2.2.1 Linking supply chain performance with the overall competitive strategy**

Within the literature, numerous suggestions are provided on how to measure supply chain performance and what kind of SCPI should be focused on (see e.g. Baghwat and Sharma, 2007; Chan, 2003). However, which SCPI to be targeted depends on the supply chain strategy of a company and can therefore be different from company to company. Based on the notions of Treacey and Wiersema (1997) there are three strategies companies can apply:

1. Achieving operational excellence meaning that the company is able to execute its operations and services in an efficient manner offering a reasonable quality at a low price.
2. Innovation or product leadership meaning that a company is strong in branding and in innovation that requires bringing new products fast to the market, focus on design and continuous development. Here a company can gain high margins in short time.
3. Customer intimacy where the company focuses on excelling the expectations towards customer service. Such companies offer tailored product solutions, deliver products and services on time and above the expectations of their customers.

Consequently the targeted SCPIs for various supply chain processes such as the fulfillment process or the sourcing/procurement process can look quite different as shown in Table 2.1.

**Table 2.1 Different SCPIs for the same supply chain processes depending on overall strategy adapted from Keebler et al. (1999)**

Strategy =	Operational Excellence	Innovation/ Product leadership	Customer service/ Customer intimate
Supply Chain Process	Fulfillment		
SCPI in focus	<ul style="list-style-type: none"> <li>• Total delivered costs</li> <li>• Order cycle time variance</li> <li>• Accurate product selection</li> <li>• Accurate invoice</li> <li>• Availability of information</li> </ul>	<ul style="list-style-type: none"> <li>• Order cycle time</li> <li>• Damage-free products</li> </ul>	<ul style="list-style-type: none"> <li>• On-time delivery</li> <li>• Order cycle time variability</li> <li>• Transportation costs</li> <li>• Complete order (fill rate)</li> <li>• Approved exceptions to standard practices (minimum order quantities, change order timing, etc.)</li> <li>• Availability of information</li> </ul>
Supply Chain Process	Sourcing/Procurement		
SCPI in focus	<ul style="list-style-type: none"> <li>• On-time delivery/receipt</li> <li>• Order cycle time variance</li> <li>• Total delivered costs</li> <li>• Complete order (fill rate)</li> <li>• Damage-free products</li> <li>• Accurate invoice</li> <li>• Availability of information</li> </ul>	<ul style="list-style-type: none"> <li>• Order cycle time</li> <li>• Complete orders (fill rate)</li> <li>• Approved exceptions to standard practices (minimum order quantities, change order timing, etc.)</li> </ul>	<ul style="list-style-type: none"> <li>• Response time</li> <li>• Damage-free products</li> <li>• Approved exceptions to standard practices (minimum order quantities, change order timing, etc.)</li> </ul>

Companies focusing on operational excellence try to reduce costs and variance in their supply chains while innovative as well as customer intimate companies focus on a mix of qualitative measures such as damage-free, fast order cycle times or increased order cycle variance (due to different customer expectations).

### **2.2.2 Comprehensive and extensive Supply Chain Performance Measurement**

Comprehensive SCPM includes multiple dimensions including financial and non-financial metrics describing costs, capacity, lead times and service levels (see e.g. Gunasekaran et al., 2001). Financial metrics give an indication on the success of the business, while non-financial metrics attempt to address the underlying factors for success (see Karrer, 2003 or Fisher

1992). While the comprehensive SCPM ensures internal and external integration, an extensive SCPM ensures sufficiency in terms of having all the relevant aspects included in the measurement (e.g. Bowersox et al., 2010). Here metrics like total supply chain costs, total supply chain response time and supply chain inventory days are used as these automatically require collaboration between various areas and organizations.

Strategic supply chain performance indicates the ability of the whole supply chain to deliver a required customer value. From that point of view, measurement needs to be cross-functional and needs to be applied throughout the whole supply chain without focusing on an individual company (see Chow et al., 2003 or Beamon, 1999).

SCPM that vertically as well as horizontally integrates performance measurement is known as fully integrated SCPM systems. Vertical integration thereby means that SCPM is linked with the overall business strategy in order to allow goal compliance thus rewarding their achievement correctly (see Caplice and Sheffi, 1995). Horizontal integration means the coordination of all processes, functions and branches instead of only one function (e.g. Lee and Billington, 1992). This lack of horizontal integration has often been seen as the primary pitfall for total supply chain integration.

Supply chain performance can also be measured from a strategic, tactical and operational SCM point of view (see Gunasekaran et al. 2004 as well as Table 2.2).

**Table 2.2 Overview of supply chain performance indicators referring to strategic, tactical and operational levels as well as financial and non-financial aspects (adapted from Gunasekaran et al. 2004)**

Level	Performance metrics	Financial	Non-financial
Strategic	Total supply chain cycle time		X
	Total cash flow time		X
	Customer query time		X
	Level of customer perceived value of product		X
	Net profit vs. productivity ratio	X	
	Rate of return on investment	X	
	Range of products and services		X
	Variations against budgets	X	
	Order lead time		X
	Flexibility of service systems to meet particular customer needs		X
	Buyer-supplier partnership level		X
	Level of suppliers' defect free deliveries		X
	Delivery lead time		X
	Delivery performance	X	X
Tactical	Accuracy of forecasting techniques		X
	Product development cycle time		X
	Order entry methods		X
	Purchase order cycle time		X
	Planned process cycle time		X

	Effectiveness of master production schedule		X
	Supplier cost saving initiatives	X	
	Supplier assistance in solving technical problems		X
	Supplier ability to respond to quality problems		X
	Suppliers' booking in procedures		X
	Delivery reliability	X	X
	Responsiveness to urgent deliveries		X
	Effectiveness of distribution planning schedule		X
Operational	Cost per operation hour	X	
	Information carrying cost	X	
	Capacity utilization		X
	Total inventory costs as incoming stock level, work-in-progress, scrap value, finished goods in transit	X	
	Supplier rejection rate		X
	Quality of delivery documentation		X
	Efficiency of purchase order cycle time		X
	Driver reliability for performance		X
	Quality of delivered goods		X
	Achievement of defect free deliveries		X

Because of the interplay between financial and non-financial metrics and the aspect of balancing a number of various parameters the Balanced Scorecard has been approved to be the appropriate tool for measuring and managing supply chain performance (Brewer and Speh 2000; Baghwat and Sharma, 2007). The Balanced Scorecard was originally proposed by Kaplan and Norton (1992) in order to evaluate the performance of a company from a financial, internal business process, customer and a learning and growth point of view.

### 2.2.3 The barriers for Supply Chain Performance Measurement implementation

The major barriers for implementing SCPM have been identified as the lack of tools and a lack of access to information as a consequence of the employees' reluctance to hand over data which led to the use of less accurate information as a common problem in supply chains (Andersen et al., 2006). Based on these issues, SCPM is rather developed with an internal focus than with an external focus.

Successful implementation of SCPM thus requires support and recognition from top management, which can be achieved by justifying SCPM with benefit/cost analysis. The access to reliable information is provided by collaboration between supply chain partners. This requires mutually trusting relationships where the involved actors need to understand the value creation by including inter-organizational performance indicators (see Lambert and Pohlen, 1999).

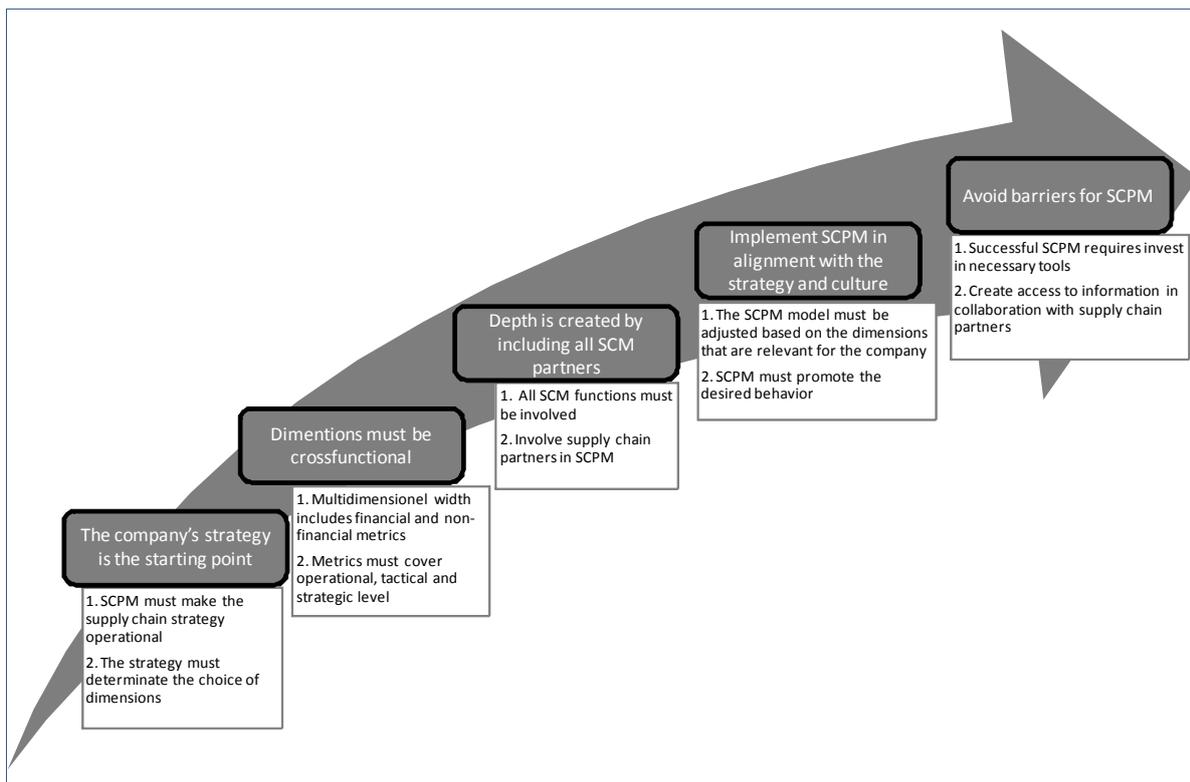
## 2.3 Developing a theoretical frame of reference

We can summarize the discussion in the previous section as follows (see also Figure 2.1):

1. SCPM has its origin in the overall strategy of the company. The chosen dimensions that are covered by SCPM are derived from the company strategy and translated into a supply chain strategy.
2. Comprehensive SCPM requires the inclusion of financial and non-financial SPIs which can be used to measure on a strategic, tactical and operative level.
3. Extensive SCPM requires internal as well as external measurement of all supply chain activities.
4. The successful implementation of SCPM is based on those measures that are relevant for the company.
5. Successful SCOM requires adequate tools which deliver valid information to supply chain decision makers.

For the purpose of our research we have focused – in accordance with Chan and Qi (2003) - on 11 comprehensive SCPIs referring to customer satisfaction, results, utilization, productivity, flexibility, reliability, availability, efficiency, capacity, time, and costs. In regards to extensive SCPM we refer to horizontal as well as vertical integration of SCPM-systems.

**Figure 2.1 Elements of the theoretical frame of reference for SCPM**



### 3 METHODOLOGY

We have chosen a dual approach for our empirical study consisting of a quantitative survey amongst Danish manufacturing companies and a qualitative case-based analysis based on mixed method. The quantitative survey focus on the representative that can be generalized, while the while the qualitative analysis gives more in depth knowledge.

For the quantitative study we developed a self-administered web-based questionnaire consisting of 16 closed (ordinal and nominal scales) and open-ended questions. The questions were developed based on a deductive approach, so each question were directly linked to a focus area in SCPM theory. In order to strengthen the validity of the questionnaire we conducted two pilot tests and adjusted the questions according to feedback received. When administering the study we followed the rules for web-based survey as proposed by Dilman et al. (2009). Our population referred to 180 Danish manufacturing companies with annual revenue of more than 500 million DKK as we assumed these companies to be very affine to SCPM as well as being capable to have good performance measurement systems in general. The response rate was 33 %, which we considered to be good and the valid answers of 54 respondents were included into our analysis. We tested the sample for non-response bias and could not identify one. The data was analyzed with SAS. Because the main goal of the questionnaire was to get an overview of the used dimensions and SCPI we were applying univariate analysis methods.

For the qualitative study, we selected four companies where we conducted semi-structured interviews (see Kvale 1997) in order to gain more deep insight into the interrelations of the focus areas of our SCPM model and to validate the results of the quantitative study. All interviews were held at the respective companies' office, which has the advantage that sensitive information is more easily obtained. Selection of respondents for qualitative interviews was based on respondents' approval in the questionnaire to be contacted for a more in depth analysis. The selected companies represent different industries, different geographical locations in Denmark as well as have SCM differently organized.

## **4 SELECTED RESULTS**

### **4.1 Usage of supply chain performance indicators in an extensive manner**

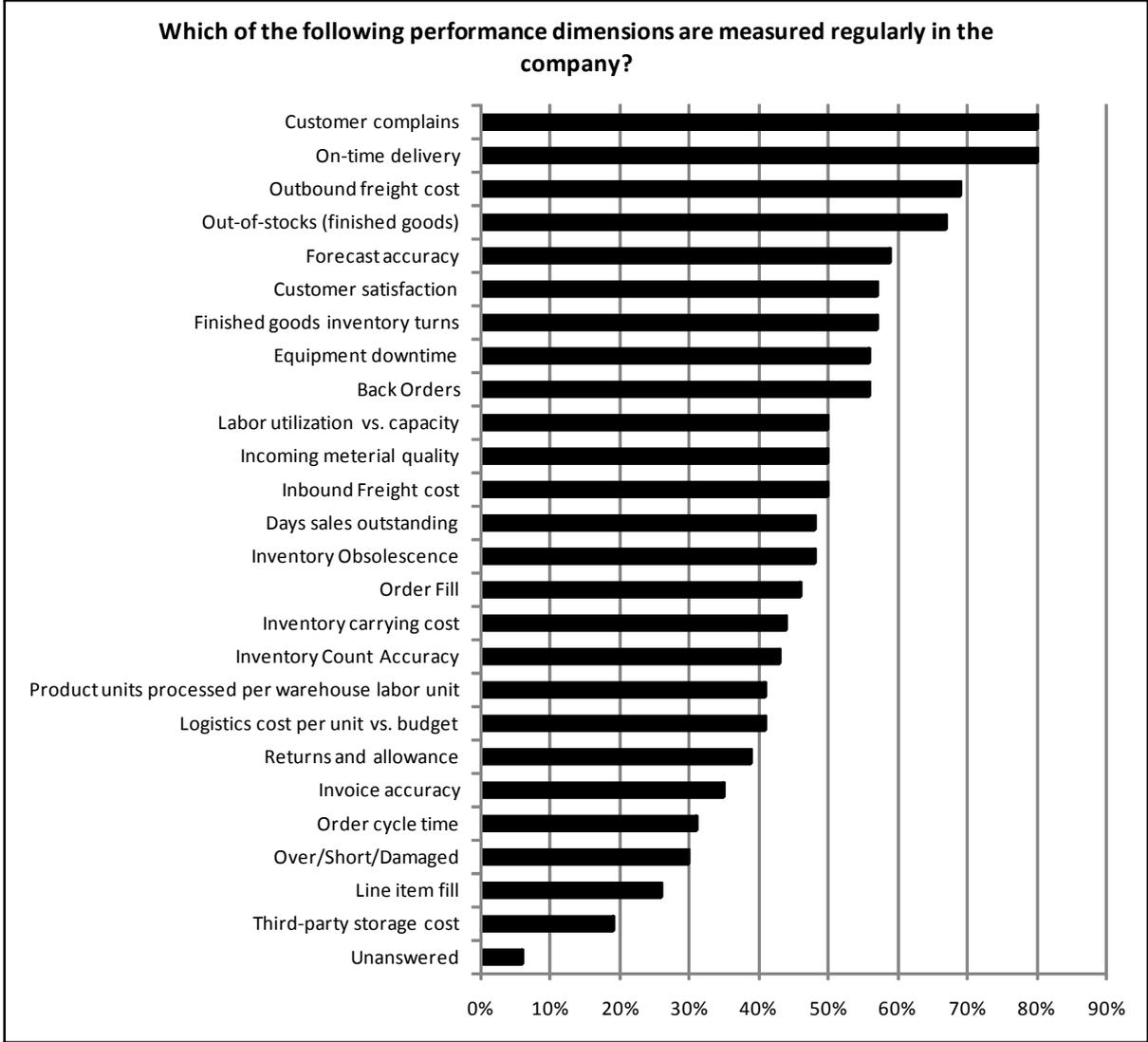
Figure 4.1 shows the frequency distribution on the various SCPIs, which our respondents indicated to use in their companies on a regularly basis. The SCPI used in the survey are based on a study by the University of Tennessee Logistics Survey 1998, as presented in Keebler et al., 1999.

The usage ranges between 19 % on the lowest level (third-party storage cost) and 80 % for the highest level (customer complaints and on-line delivery). The four most used SCPIs have a clear downstream supply chain focus which can be explained by the customer focus the companies are having. However, it is also remarkable that the most frequently used SCPIs are also easy to measure.

When differentiating between financial and non-financial measures, our results showed that the average use of non-financial measures (50 %) was higher than financial measures (46 %). This is surprising as literature often criticizes the focus of financial measures within SCPM (e.g. Lapide 1999; Lapide, 2000 or Lambert and Pohlen, 2001).

Looking at the supply chain areas where these measures are used we were able to see that more SCPM is used in the areas of outbound transport, demand planning and warehousing. It was also remarkable to see that in the area of customer relationship management we identified a high number of unanswered questions.

**Figure 4.1 Identified SCPIs in Danish manufacturing companies**

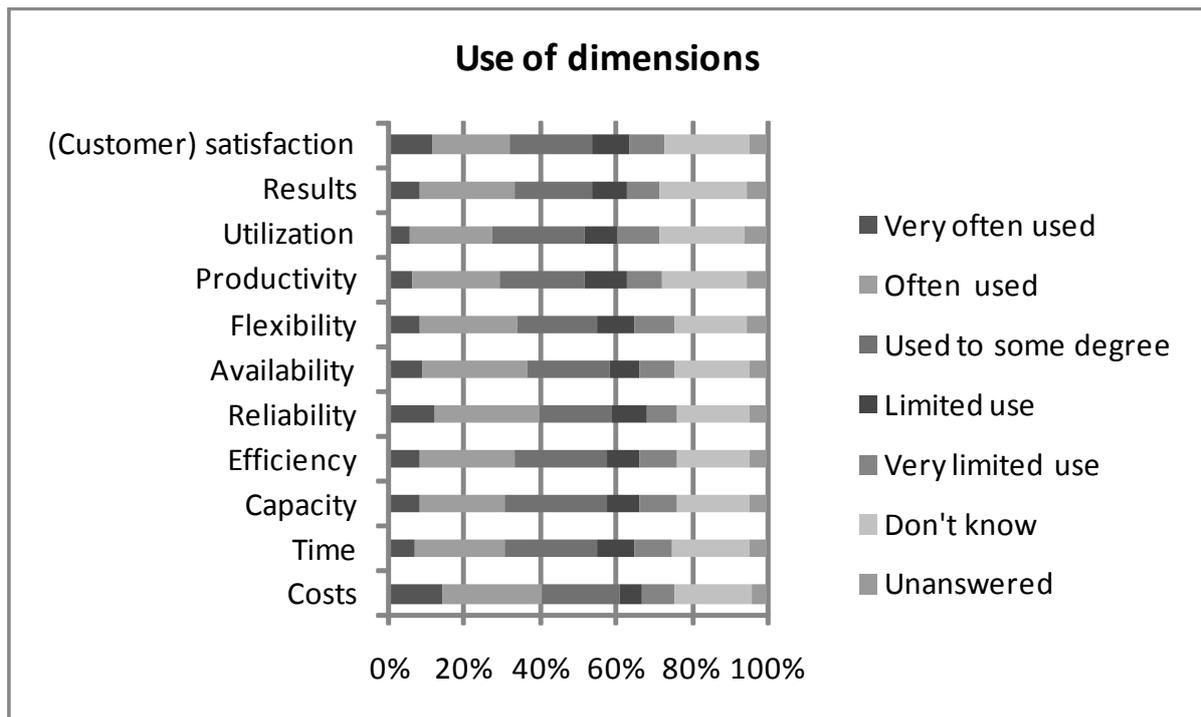


**4.2 Usage of supply chain performance indicators in a comprehensive manner**

Figure 4.2 presents the pattern of the examined companies when it comes how comprehensive their SCPM is. Here we find that the frequency distribution is quite equal amongst the eleven categories that we were examining. However, cost and reliability are the two areas that are covered most but productivity and utilization are covered least.

Detailed analysis on the supply chain function showed that reliability is more often used in the procurement and in the inbound transportation area than in other areas while efficiency is the most used category in the demand planning area.

**Figure 4.2 In which supply chain areas are SCPIs used?**



When it comes to the degree of external integration of SCPM, outbound transport and demand management were the areas with the highest level of external integration.

### 4.3 Selecting relevant dimensions for operative, tactical and strategic SCPM and degree of the supply chain focus of SCPM

The analysis of the qualitative interviews with the respondents of the case companies brought the following interesting results:

- SCPM was mainly used as an internal approach as there are barriers for external measurement as well as the internal measurement process was not considered to be adequate enough for being used externally.
- The frequently used measures were rather short-term oriented and financial and the linkage between the overall strategy and the supply chain strategy was rather neglected.
- The choice on the SCPI was rather unstructured and not top-down and the degree of variation on the usage of SCPIs was very high.
- Suppliers and customers report on certain measures in an informal way as well as the companies inform their counterparts also rarely.

Overall we were able to identify certain gaps between empirical reality and theoretical discussions, especially when it comes to a SCPM that should be done in a continuous manner, as suggested in the theory, while the empirical results, especially from the case studies, have shown that it measurement is done more in an ad-hoc manner. Very often, it is too late for changes.

### 4.4 Developing an improved SCPM-system

Based on the identified results, we quote in Table 4.1 examples for SCPIs for a strategic, tactical and operative SCPM as outlined in the table. Here we also show which SCPI that can

be used in the specific supply chain area. The point is that no matter what the company's strategy is, it is necessary to have metrics with focus on operational, tactical and strategic level within each of the SCM functions. This ensures that the company assesses the performance of all SCM functions on the level that is necessary for the achievement of the strategy.

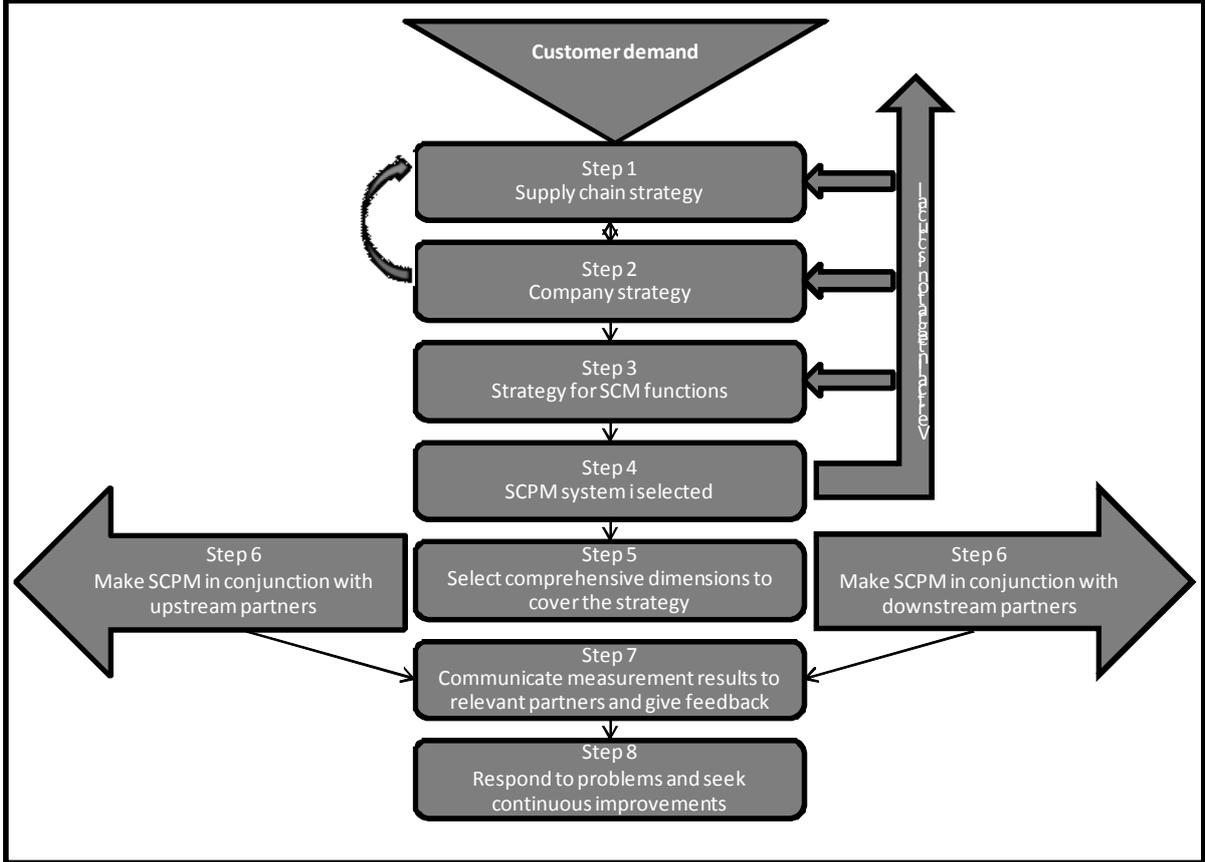
**Table 4.1 Suggestion for extensive and comprehensive SCPM based on empirical findings**

SCM-Area	Operative SCPI		Tactical SCPI		Strategic SCPI	
	Financial	Non-financial	Financial	Non-financial	Financial	Non-financial
Sourcing	Error in products delivered	Success level of introduction of new materials	Deviation from budget	Buyer-supplier relationship level	Supplier initiatives for savings	Lead-time compared to industry standard
Inbound logistics	Cost per unit	Delivery rate	Adherence to budgets	The composition of transport modes	Return on investment	Co2 emissions
Demand Planning	Costs for information sharing	The ability to forecast demand for new products	Forecast accuracy of available products - MAPE	Response to urgent orders	Forecast levels: company, unit, product level	Interaction via S&OP
Warehouse	Waste	Capacity utilization	Costs for handling a unit	Employee productivity	Total storage costs	Cycle time
Outbound logistics	Waste / broken products during transport	Delivery frequency	Costs for handling a unit	Flexibility	Delivery performance	Delivery lead-time
Customer Relationship Management	Product availability	Mode of customer order entry	Cost of complaint handling	Cost of complaint handling	Flexibility of systems to meet customer needs	Reliability, Product selection

The suggested SCPIs are all capable to measure financial as well as non-financial criteria. The specific usage is however dependent on the overall strategy of the company. In that sense the suggestion can be considered as a morphological box.

For the implementation of SCPM within a company we suggest an eight-step-model as outlined in Figure 4.3. The model is developed based on input from the empirical data combined with the authors' interpretation of the theoretical framework for SCPM.

Figure 4.3 How to set up and to implement SCPM based on the empirical findings



This model is based on a top-down approach starting with the identification of demand and the supply chain strategy and the overall strategy in a kind of interplay in order to avoid conflicts. This is followed by the development of the strategy selection for the individual supply chain areas (see Chan and Qi, 2003).

Based on this, the relevant SCPM model is developed by selecting the required extensive, comprehensive and external measurement level. It is also necessary to communicate the SCPM results in a regular manner with the internal and external stakeholders, so that feedback loops can be inserted and the whole SCPM approach can be adapted.

## 5 CONCLUSIONS

In this paper we studied how Danish manufacturing companies are using SCPM and which dimensions they use for measuring the performance of their supply chains. Based on our theoretical findings we can conclude that literature criticises the non-existing linkage between supply chain performance and the overall strategy of the company. Our empirical results however showed that the SCPM of the observed companies is vertically well integrated. When it comes to horizontal integration with supply chain partners, we were only observing sobering results. We identified controversial differences in the use of financial and non-

financial SCPIs between our quantitative and qualitative study. The quantitative survey showed that the majority of the sample companies use non-financial SCPIs, which is in contradiction with the literature. The in-depth qualitative study though showed the opposite and confirmed in that sense the findings from literature as here we were able to see (again) the foremost use of financial measures. In these companies, financial measures for SCPM represent the starting point for a measurement using non-financial measures.

Based on our theoretical and empirical findings we developed an eight-stage-process of SCPM-implementation suggesting a top-down approach for linking the overall strategy with SCPM. Our model also includes a communication part that is needed in order to overcome the barriers for a horizontal integration of SCPM. With this suggestion, decision makers in companies are 'forced' to invest into trust-based relations, which is also a prerequisite for successful SCM.

## 6 DISCUSSION

This paper contributes with new findings that have implications for both practice and theory. Practice must overcome an isolated view on SCPM that can lead to sub-optimization and use trust-based relations to expand SCPM to include customers and suppliers. Theory must take into consideration the fact that most companies select SCPM rather unstructured and introduce SCPI on an ad hoc basis. Therefore, the theoretical field is strengthened by the introduction of a model that can be used by companies to select one of the existing SCPM systems.

As we limited our focus on Danish manufacturing companies, it would be interesting to see, how our framework can be transferred into different industrial sectors as well as into different countries. It would also be interesting to see, how the supply chain partners of the examined companies work with SCPM. Another limitation was our empirical approach in the quantitative study as we were applying mainly uni-variate analysis methods in order to get an overview. For future studies it would be interesting to examine correlations as well as causal paths between certain elements of SCPM and contingency factors such as overall implementation level of SCM within the company and between its suppliers and customers, the positioning of a company within a supply chain and the overall performance of the company and/or the supply chains the company is operating in.

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