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1 Introduction

For about three decades, the increasingly competitive environment of efficient cost management and quicker customer responsiveness has forced firms to develop new strategies and technologies to reach and sustain competitive advantages (Chan, Chan, & Qi, 2006). This constantly changing competition creates enormous challenges for the individual firms themselves and for the supply chains they are part of (Lee, 2002). A major challenge in supply chain management is the coordination of the different activities taking place between all the involved participants. Understanding the interdependencies and the complexity of these activities in a supply chain is elementary to actually managing it (Holmberg, 2000). Considering the philosophy "What you cannot measure, you cannot manage", measuring the supply chain performance becomes tremendously important for companies and their supply chains in order stay competitive. What is challenging is that only a small number of performance measurement systems which can help to understand and improve a supply chain's overall performance exist (Chan et al., 2006). It can rather be found that the supply chain performance measurement theory is often not considering the evaluation of the whole supply chain (Holmberg, 2000; Lambert & Pohlen, 2001; van Hoek, 1998). Generally it is believed that a well organized system of supply chain metrics can help to improve processes across multiple companies, target promising markets and gain competitive advantages through better service and lower costs. Many companies which refer to their metrics as "Supply chain metrics" use primarily internal logistic measures such as lead time or complete fulfilled orders. Often these measures focus on financial values, instead of presenting information of how key business processes perform or how well customer requirements are met within the supply chain (Lambert & Pohlen, 2001). In order to develop effective and efficient supply chain performance measurement systems there is a high interest in the problems and challenges which might occur when trying to measure the performance of the whole supply chain.

1.1 Purpose

The purpose of this master thesis is therefore to analyze supply chain performance measurement systems and to identify problems and challenges in measuring the performance of a supply chain. To achieve this, the following sub-purposes need to be fulfilled:

- Review of existing theoretical supply chain performance measurement approaches, systems and tools.
- Identification of problems and challenges in supply chain performance measurement theory.
- Evaluation of problems and challenges from a practical point of view in the operations of a supply chain.
- Development of a list of common challenges when measuring the performance in the operations of a supply chain.

By fulfilling these sub-purposes this master thesis will provide a guidance of what problems and challenges might arise when developing a supply chain performance measurement system for the whole supply chain.

1.2 Disposition

To fulfill the purpose seven chapters (see figure 1.1.) will be carried out in this master thesis. Chapters one and seven build the frame of this thesis, with the introduction and conclusion. The researched problem is stated here, and a summary of the thesis is provided in the end.

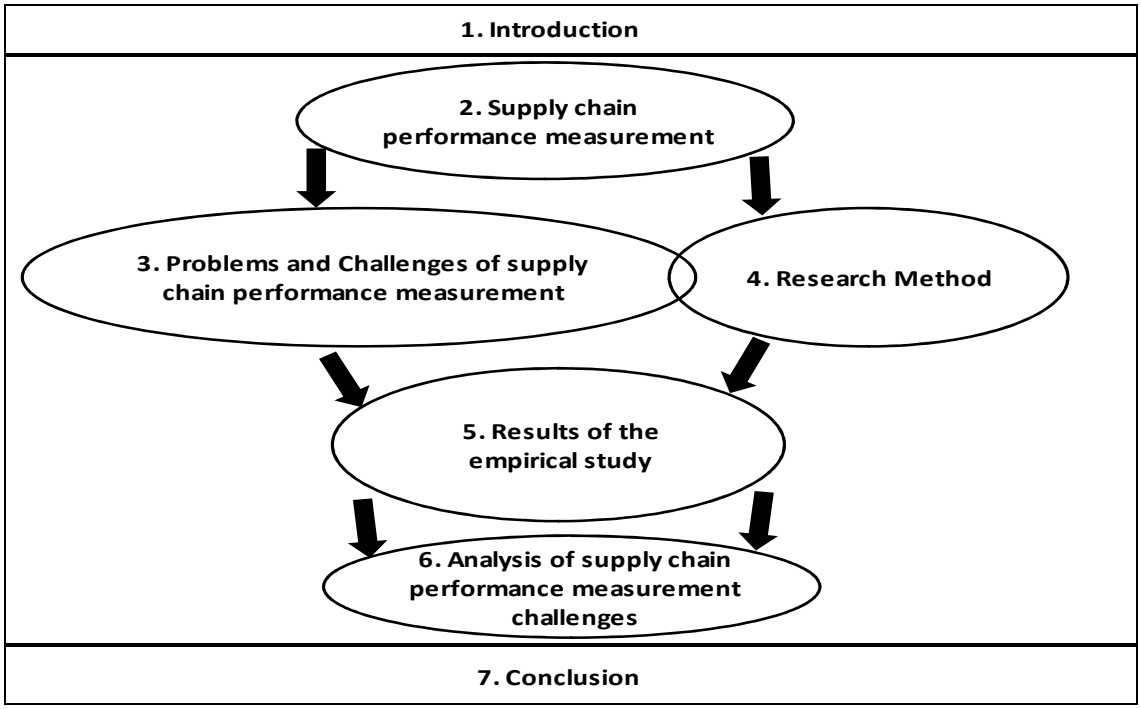

Figure 1.1: Disposition of the master thesis

The second chapter will offer the reader a theoretical background of supply chain performance measurement; a definition, systems, and different measures are presented. Built on this information, chapter three gives an idea of what problems and challenges in supply chain performance measurement have been found in previous research. The chapter will end with a list of most important problems and challenges in supply chain performance measurement theory. The fourth chapter introduces the research method that was chosen and therefore describes details of the questionnaire used and the trustworthiness of the empirical study. In the first section of chapter five the results of the empirical study are described, details revealed and it is shown how supply chain performance measurement is conducted in practice. The second section summarizes problems and challenges and presents the most important ones. In chapter six, problems and challenges of supply chain performance measurement are analyzed by accounting the theoretical and practical findings of this work. The thesis ends with a conclusion and a recommendation for further research.

2 Supply chain performance measurement

This chapter focuses on the theoretical background of supply chain performance measurement and fulfills the first sub-purpose of the thesis. Therefore supply chain performance measurement will be defined and restrained to other concepts such as supply chain controlling and monitoring. Furthermore, the differences of internal and external supply chain performance measurement will be described, followed by an explanation of performance measurement systems and metrics.

2.1 Definition and scope

The main objective of performance measurement is to provide valuable information which allows firms to improve the fulfillment of customers' requirements and to meet firm's strategic goals (Chan, 2003). Therefore there is a need to measure how effectively the customers' requirements are met and how efficient the utilization of resources to reach a certain level of customer satisfaction has been (Neely, Gregory, & Platts, 2005). To support such measurement, Hellingrath (2008) suggests supply chain performance measurement which he understands as a system of measures to evaluate the effectiveness and efficiency of organizational structures, processes and resources not only for one firm but also for the entire supply chain. To properly run a supply chain performance measurement system, the participants of a supply chain should jointly decide on one commonly used system. Such an effective performance measurement system can provide the basis for understanding the whole system, influence the behavior and supply information about the performance of the supply chain to participants and stakeholders (Simatupang & Sridharan, 2002). A performance system can therefore help to link all the actions taken by the participants of the supply chain to the overall performance of the whole supply chain. The usage of performance measurement systems also supports the objectives of transparency and a mutual understanding of the whole supply chain (Simatupang & Sridharan, 2002).

2.1.1 Differences to supply chain controlling

One of the main tasks of supply chain controlling is to implement a common knowledge and understanding of the processes in the whole supply chain (Otto & Stölzle, 2003). The phrase 'supply chain controlling' indicates the construction and steering of the interactions within the whole supply chain by using adequate controlling concepts (Hellingrath, 2008). The objectives of supply chain controlling can be divided into direct and indirect objectives. The direct objectives focus on the performance measurement of processes and resources, while the indirect objectives concentrate on more strategic objectives, such as competitiveness or gaining market shares (Westhaus, 2007).

Considering this brief description it is seen that supply chain controlling includes the strategic objectives of companies, while supply chain performance measurement focuses on effective and efficient operations only. Therefore supply chain performance measurement could be seen as an element to support the supply chain controlling objectives. Supply chain controlling defines the strategic objectives of the supply chain performance measurement systems. In this master thesis supply chain performance measurement will be seen as an element of supply chain controlling. The concept of supply chain controlling covers all aspects of trying to control, measure or evaluate the performance in a complete supply chain on the strategic, tactical or operational levels (Seuring, 2006).

2.1.2 Differences to supply chain monitoring

Theory states that the performance of supply chains should be monitored providing cost-measures and non-cost related measures (Gunasekaran, Patel, & Tirtiroglu, 2001). The central concept to monitor the supply chain and achieve higher visibility is called supply chain monitoring (Hultman, Borgström, & Hertz, 2006). Hultman et al. (2006) define supply chain monitoring as the effort of actors in a supply chain to manage and control visibility of information regarding flows of products and services in different levels and directions in a supply chain. The central key of a supply chain monitoring system is the exchange of information in form of standardized data between all the participants of the chain (Hultman et al., 2006).

Therefore supply chain monitoring focuses on sharing information and data among the entire supply chain, while supply chain performance measurement is directly connected with specific goals, such as achieving effectiveness and efficiency.

In general it can be seen that the three approaches of supply chain controlling, supply chain performance measurement and supply chain monitoring build up on each other.

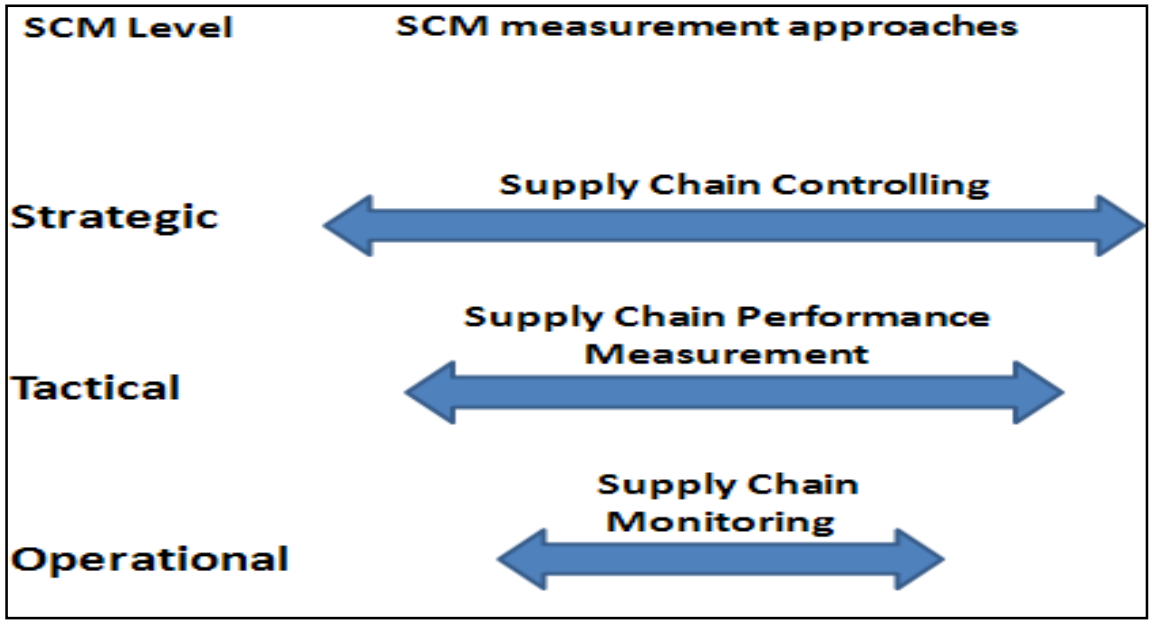

Figure 2.1: SCM level and the different measurement approaches (Own Source)

Figure 2.1 shows how these approaches can be related to the different strategic, tactical and operational levels in supply chain management. On the strategic level, supply chain controlling focuses on the entire supply chain and the controlling of the objectives of the whole supply chain. The tactical level is covered by supply chain performance measurement measuring the effectiveness and efficiency of resources and processes based on the strategic objectives of the supply chain. And last, on a more operational level, the supply chain monitoring concept is based on the exchange of information and data. In sum, supply chain controlling is the main phrase for measuring the performance of a supply chain, including or using the other two approaches. Therefore supply chain performance measurement, which will further be researched in this thesis, is a substantial element in controlling and managing a supply chain.

2.2 Internal and external supply chain performance measurement

Lambert and Pohlen (2001) state that in most cases articles about supply chain metrics mainly consider internal logistics performance measures. In order to understand the problems and challenges of performance measurement in supply chains it is therefore significant to separate internal and external performance measurement. The internal performance measurement mainly focuses on the value chain or logistics supply chain within a single company with its operational functions sourcing, inbound storage/transportation, operations, outbound storage/transportation and consumer distribution (Coyle, Bardi, & Langley, 2003), while the external performance measurement has an emphasis on measuring the performance of the efficient and effective flows of material/products, services, information and financials from the supplier's supplier through various organizations/companies out to the customer's customer (Coyle et al., 2003). The different characteristics of these two fields of supply chain performance measurement will be further described in the following two sub-chapters.

2.2.1 Internal supply chain performance measurement

Internal supply chain performance measurement primarily focuses on such measures as lead time, fill rate or on-time performance (Lambert & Pohlen, 2001). These measures are generated within a company and do not evaluate the whole supply chain. Taking only one company into account can lead to situations where seemingly good measures lead to inappropriate outcomes for the entire supply chain. For example, if a company implements a metric of complete orders shipped and thereby checks order fulfillment or customer service, it might happen that the company still finds delayed orders, since some components of the final product produced from other companies are not available in time. This causes unacceptable lead or replenishment times, even though completely shipped orders of one company might be 100% (Coyle et al., 2003).

The central roles of these internal supply chain performance measurement systems are highlighted by Chan et al. (2006) as measuring the performance of business processes, measuring the effects of the companies' strategies and plans, diagnosing of problems, supporting decision-making, motivating improvements and supporting communication within a company. Furthermore, Chan et al. (2006) criticized such traditional roles of performance measurement as short-term and finance oriented, lacking strategic relevance, strong internal focus, avoiding overall improvements, inconsistent measures and the quantification of performance in numbers.

Bearing these roles of internal performance measurement and the connected criticism in mind, it becomes obvious that these internal performance measurement systems can not be adapted to external performance measurement systems, measuring the entire supply chain. Therefore in modern environment it has become necessary to develop external supply chain performance measurement systems which extend the limited scope of single companies and their individual functions (Coyle et al., 2003).

2.2.2 External supply chain performance measurement

Even though it might seem simple to extend old or design new performance measurement systems which measure the performance of an entire supply chain, this task has created

many problems for researchers and practitioners. Performance measurement systems are seldom connected with overall supply chain strategies, lack balanced approaches to integrate financial and non-financial measures, lack system thinking and often encourages local optimization (Gunasekaran et al., 2001). Due to increasing requirements of supply chain management it is necessary to explore suitable performance measures and how accurate performance measurement systems can meet the need of support in decision-making and continuous improvement in supply chains (Chan et al., 2006).

Taking these challenges and the fact that more and more firms recognize the potential of supply chain management into account, it becomes obvious that there is much request for supply chain performance measurement systems for the supply chain as a whole. The existing performance measurement systems in supply chain environment often fail to fulfill the needs due to the different vertical and horizontal influences in supply chains (Chan et al., 2006).

2.3 Supply chain performance measurement systems

Neely, Gregory & Platts (2005) define a performance measurement system as the set of metrics used to quantify the efficiency and effectiveness of actions. Supply chain performance measurement systems put more emphasis on the two distinct elements of customers and competitors than internal measurement systems do. Truly balanced performance measurement systems provide managers with information about both of these elements (Neely et al., 2005). According to Neely (2005), performance measurement systems consist of three levels:

1. the individual performance measures;
2. the set of individual performance measures – the performance measurement system as an entity; and
3. the relationship between the performance measurement system and the environment within which it operates.

Since the emphasis of this thesis is to identify the problems and challenges when applying such a performance measurement system (step 2) to the environment of a whole supply chain (step 3), two performance measurement system examples measuring the performance of the whole supply chain will be described. The systems or models were chosen according to their ability to evaluate a whole supply chain and their popularity in theory and practice.

2.3.1 SCOR-model

The supply chain operation reference model (SCOR) is a tool which offers the opportunity to describe a complete supply chain (Becker, 2005). This model, a reference model, has been developed by the Supply Chain Council (SCC), a non-profit organization, to implement a standard when modeling complete internal and external supply chains (Weber, 2002). Today the Supply Chain Council includes more than 1000 participants involved in the constant improvement of the model (Bolstorff, Rosenbaum, & Poluha, 2007). Every new version includes new organizational processes, figures for performance measurement or best practice examples. The main objective of the model is to describe, analyze and evaluate supply chains (Poluha, 2007). The idea behind the model is that every company or supply chain can be described with some basic processes. The SCOR-model offers a de-

tailed description, analysis and evaluation of a supply chain for the physical, information and financial flows. A main emphasis of the model lays on the information flow.

Framework

As already mentioned, the SCOR-model (figure 2.2) can be used to consider the entire supply chain from the supplier's supplier to the customer's customer. Thereby it is necessary to describe all involved participants of the supply chain with standardized criteria. The criteria are process types, SCOR-processes and the different hierarchy levels.

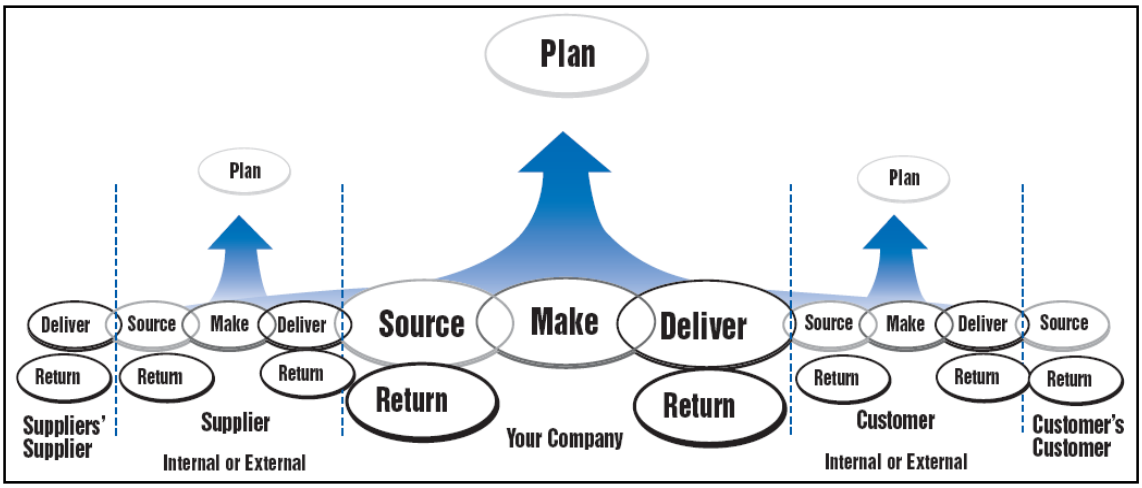

Figure 2.2: Scope of the SCOR-model (SupplyChainCouncil, 2009)

The criteria process types is separated in planning, executing and enabling processes and is used to ensure the overall connection towards the SCOR-processes (Bolstorff et al., 2007). The reason is that this way a more transparent documentation of the physical, information and financial flows becomes possible. For further documentation the model also separates the following company functions or SCOR-processes (Bolstorff et al., 2007):

Plan: The SCOR-process includes all planning issues from strategy to operational manufacturing planning

Source: All purchasing activities are summarized here.

Make: This process focuses on the production, while also including quality check-ups or the ordering of materials, for example with a Kanban-system.

Deliver: This SCOR-process is very comprehensive and complex since it combines many different functions such as sales, finance and distribution.

Return: The process return considers all retour products which are defect or have been broken. The element is seen twice for each company, since return can be from customers or can be for suppliers, if they do not deliver the required standard.

With this classification of process types and SCOR-processes it is possible to easily standardize the documentation of completely different companies. The objective is to allow companies to communicate and cooperate easily, however the separation of processes is not enough. To achieve its objectives the SCOR-model includes hierarchy levels which enable the user to analyze specific processes or the complete supply chain (See figure 2.3).

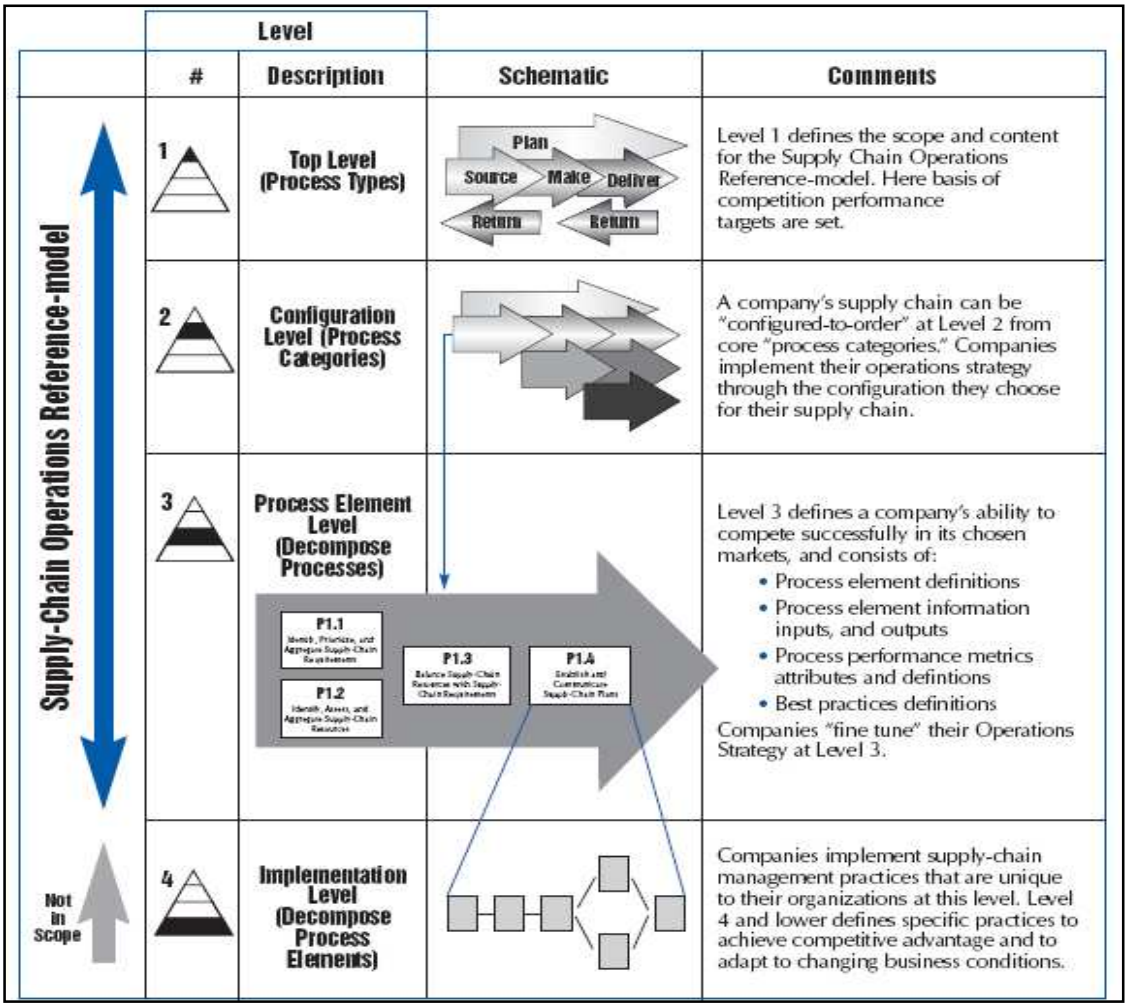

Figure 2.3: The hierarchy of the SCOR-model (SupplyChainCouncil, 2009)

The figure 2.3 illustrates how these hierarchy levels of the SCOR-model are structured and organized. After the framework of the model has been described, it needs to be shown how this model can help to measure the performance and how a performance measurement system is included to analyze and improve a supply chain.

The SCOR-model is also called 'Process Reference model', since it combines such well known concepts as business process reengineering, benchmarking and best-practice approaches (Bolstorff et al., 2007). The business process reengineering aims to document actual processes and set new ambitious objectives for the processes. The benchmarking concept actually includes the significant performance measurement system of the model. All the processes receive figures which enable the comparison with other companies (Poluha, 2007). The SCOR-performance measurement system thereby covers the first three hierarchy levels. The first level contains figures for the entire supply chain focused on customers or internal values. The customer focused figures are evaluating reliability, responsiveness and agility, while the internal figures concern costs and assets (SupplyChainCouncil, 2009). Examples for used figures are perfect order fulfillment, order fulfillment times or upside supply chain flexibility. The figures on the following level two and level three present the broken down figures of the first level. This way a performance measurement system of interdependent figures is created to measure the effects between the different levels. In some cases there are measures used next to the system of diagnostic measures to

avoid unforeseen results or errors (SupplyChainCouncil, 2009). A great advantage of the SCOR-model is that these figures can be benchmarked with the data of more then 1000 different companies. It also allows using a best-practice approach which offers the companies the opportunity to compare procedures and processes with successful companies and learn from them.

The SCOR-model helps to document, analyze and evaluate the entire supply chain. Especially the performance measurement system as an important element allows measuring the performance of the supply chain in a standardized way and helps to solve problems of communication or complexity.

2.3.2 Modified balanced scorecard (Brewer and Speh)

Brewer and Speh (2000) state that the companies which will be competitive in the future are distinguished by the ability to effectively coordinate their processes, focus on delivering customer value, eliminate unnecessary costs of key functional areas and create a performance measurement system that provides data on whether the supply chain is meeting the expectations or not. The actual danger is that companies talk about the importance of supply chain concepts but continue to evaluate their performance with performance measurement systems that are either only slightly affecting or completely unaffecting supply chain improvements. However, if a company takes action by linking their performance measurement system to their supply chain practices, they will be in a better position to achieve their supply chain initiatives (Brewer & Speh, 2000). In order to achieve such competitive advantages for a company, Brewer and Speh (2000) developed a 'modified balanced scorecard' which aims for being competitive in the future.

Framework

The key of the model is the linkage between supply chain management and the balanced scorecard (see figure 2.4). Brewer and Speh (2000) found four essential supply chain management areas:

Supply chain management goals:

The essence of supply chain management goals is that waste reduction and enhanced supply chain performance come only when there is high integration, sharing and cooperation between internal and external supply chain processes. Therefore companies must foster a high coordination and integration of internal functions and the external participants of a supply chain. These goals of supply chain management include waste reduction, time compression, flexible response and unit cost reduction.

Waste reduction is achieved, for example, through minimizing duplication, harmonizing operations and systems, and enhancing quality. Time compression is focusing on reducing order-to-cycle time through accomplishing production and logistics in shorter times to save costs. The next objective, flexible response, stresses the point of flexible actions towards order handling or demand variation. The final objective, unit cost reduction, aims at reducing the costs per unit for the customer, for example, by reducing the logistics costs of a product (Brewer & Speh, 2000).

Customer benefits:

If the supply chain achieves its goals which have been discussed previously, it will eventual-

ly create benefits for the customer. Generally these achievements should be passed on to the customer, but it needs to be known to which extent the customer realizes these benefits and what factors force that realization. Thus it is an objective to know the different demands and desires of customers all along the supply chain and effectively manage them (Brewer & Speh, 2000).

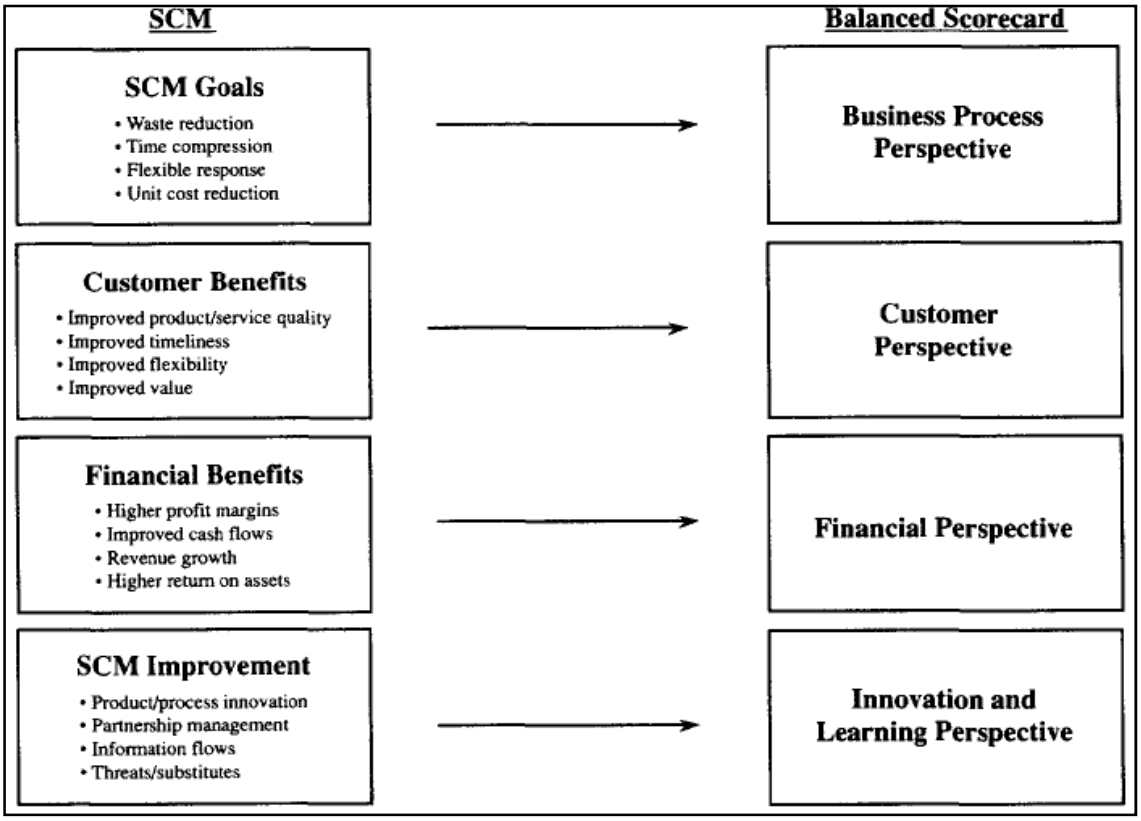

Figure 2.4: Linking supply chain management to balanced scorecard (Brewer & Speh, 2000)

Financial benefits:

If supply chain management goals are achieved and the benefits flow down to the customer, financial success should be experienced. The best-known financial benefits are lower costs, leading to higher profit margins, enhanced cash-flow, revenue growth and higher rate of return on assets. Therefore the financial benefits are closely dependent on the previous two areas (Brewer & Speh, 2000).

Supply chain management improvements:

This area adds a dynamic element to the framework by accounting the fact that companies need to continuously learn and innovate for their future. Companies thereby need to continuously improve their processes by redesigning processes and products, by sharing knowledge between the supply chain partners, by continuously improving the information flows, and by exploring new threats or substitutes affecting the value delivered to the customer (Brewer & Speh, 2000).

Taking these areas of supply chain management into account, the areas were then adapted to the balanced scorecard approach (see figure 2.5) with the following perspectives of measurement:

Business Processes:

There are many examples for business performance measures. The measures for this modified approach vary depending on the company. Alternatives could be supply chain cost of ownership measuring purchasing costs, inventory costs, poor quality or delivery failure. Other suggested measures are supply chain efficiency, number of choices, average response time or percentage of supply chain target costs achieved. It is important to recognize that all these measures intend to measure the performance of the whole supply chain (Brewer & Speh, 2000).

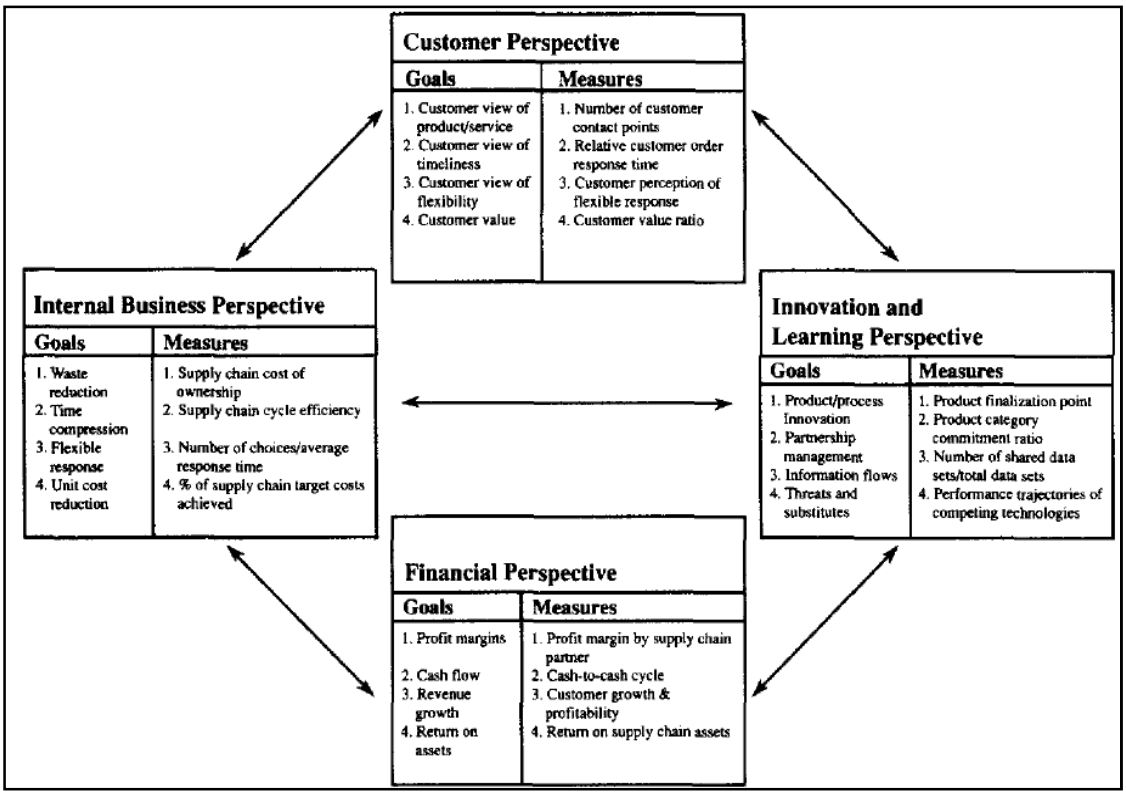

Figure 2.5: A supply chain balanced scorecard framework (Brewer & Speh, 2000)

Customers:

Under the same setting as previously described, measures for customers might be number of contact points, relative customer order response time, customer perception of flexible response and customer value ratio. The intent of these measures is to measure and monitor improvement of customer service of a supply chain over a certain time period (Brewer & Speh, 2000).

Financial:

The financial measure could, for example, be profit margin by supply chain partner, cash-to-cash cycle, customer growth and profitability and return on supply chain assets (Brewer & Speh, 2000).

Innovation and Learning:

These measures focus on the inter-organizational innovation and learning. The measures could be product finalization, product category commitment ratio, number of shared data

sets per total data sets or performance trajectories of competing technologies (Brewer & Speh, 2000).

Considering these perspectives Brewer and Speh created their modified balanced scorecard model (see figure 2.5). As the system is implemented, dialogues evolve among the participants of the supply chains to further develop new measures when using this supply chain performance measurement system. Applying this model can thereby achieve measurement of the objectives of supply chain management from a holistic point of view, while gaining competitive advantage through a better control and the possibility of constant improvements (Brewer & Speh, 2000).

2.3.3 Advantages and disadvantages of the models

After describing the framework and functionalities of the SCOR-model and modified balanced scorecard, it becomes necessary to evaluate their advantages and disadvantages. The following table 2.1 shows advantages and disadvantages of using these performance measurement systems. Considering these two approaches it becomes clear that it is very challenging to develop a supply chain performance measurement system which can include all the multiple influences of a supply chain. The presented models show one model being more standardized in its structure (SCOR-model) and another more flexible (modified balanced scorecard).

Table 2.1: Advantages and disadvantages of the SCOR-model and modified balanced scorecard (Own Source)

Advantages	Disadvantages
SCOR-model	
• Knowledge improvement of the employees • Standardized documentation and metrics • Benchmarking and best practice with other companies • Better communication between supply chain participants • Defined measures that build up on each other • Processes to be measured are defined	• High abstraction • Not all processes are included • Overall performance measurement still difficult • Individual measures after the third hierarchy level • No flexibility when changing measures • High workload to apply the model to practice • Constant actualization of the model provides uncertainty
Supply chain balanced scorecard	
• Wide range of metrics • Flexible adaptation of metrics • A successful model creates the basis • Standardization along supply chain • Management strengthened through better control • Procedure for the generation of metrics	• No coordination along the supply chain • No optimization of interfaces • Causes and effects are not visible • Lack of synchronization of management processes and metrics

These two different approaches offer a good overview of supply chain performance measurement systems and what kind of advantages and disadvantages are connected with usage of such models.

2.4 Metrics of external supply chain performance measurement

The basis of every supply chain performance measurement system are the metrics. Unfortunately, most traditional measures of individual performance are irrelevant to the maximization of supply chain profits (Simatupang & Sridharan, 2002). Using traditional metrics is often problematic since they lack strategic focus and are not integrated (Neely et al., 2005). It is often found that there is an inability to connect measurement activities and the overall supply chain strategy in many supply chains (Holmberg, 2000). This problem forces the development of isolated metrics, resulting in outputs linked to the local companies rather than the overall supply chain. Gunasekaran et al. (2001) state that many companies use a large number of performance metrics without realizing that a smaller number would be better for fulfilling their requirements. The problem of supply chain performance measurement seems to be that many companies add new metrics to their measurement systems without reviewing whether the metrics that have been used are still suitable for the overall supply chain strategy (Holmberg, 2000).

Many authors agree that there is much need to develop new metrics for supply chain management to meet the new objectives of supply chains (Holmberg, 2000; Lambert & Pohlen, 2001; Neely et al., 2005; Simatupang & Sridharan, 2002). Therefore in this chapter supply chain metrics concerning traditional fields, such as costs, time, quality and flexibility, will be illustrated. These characteristics were chosen because they include very important points of interest in supply chain management. There are other alternatives, such as financial and non-financial metrics, but the chosen characteristics are believed to give the most appropriate overview of supply chain metrics.

In the following, examples for possible supply chain measures are provided (Coyle et al., 2003; Neely et al., 2005):

Costs: Finished goods inventory turns, days sales outstanding, cost to serve, cash-to-cash-cycle time, total delivered cost, cost of goods, transportation costs, inventory carrying costs, material handling costs, administrative costs, cost of excess capacity or cost of capacity shortfall.

Time: On-time delivery/receipt, order cycle time, order cycle time variability, response time or forecasting, planning cycle time.

Quality: Overall customer satisfaction, processing accuracy, perfect order fulfillment, on-time delivery, complete order, accurate product selection, damage-free, accurate invoice, forecast accuracy or planning accuracy.

Flexibility: New products, modified products, deliverability, volumes or resource mix.

These examples of measures could be continuously added and extended, but for the actual use in supply chain performance measurement systems the interrelatedness of the metrics needs to be considered as well (Lambert & Pohlen, 2001). It is important that the companies understand that their own performance is only under their own control to a certain extent due to the strong interdependencies with the environment that most companies are part of (van Hoek, 1998). Therefore supply chain performance measurement systems need to combine integrated and non-integrated measures so that companies are in the position to evaluate the overall performance of the supply chain, as well as to improve the internal processes which have a great impact on the competitiveness (van Hoek, 1998). Such a performance measurement system will help to further increase the visibility and the under-

standing of the supply chain processes and interdependencies (Lambert & Pohlen, 2001; Simatupang & Sridharan, 2002). A greater visibility does not only help companies to determine the priorities of improvement concerning their customer expectations, but also enables an effective integration and optimization of inter-company processes, further increasing the supply chain performance (Lambert & Pohlen, 2001). A challenge is, since the focus lays on overall supply chain optimization, that some companies' internal efficiency might suffer. Therefore metrics are needed that are able to measure the benefits and burdens of resulting functional shifts and cost trade-offs (van Hoek, 1998). While some companies benefit from realignment, others suffer; therefore metrics must also provide a basis for sharing benefits among the supply chain participants (van Hoek, 1998).

To support benefit sharing and to encourage aiming for an excellent overall performance, supply chains must provide incentives that supply chain members really value (Simatupang & Sridharan, 2002). Therefore many supply chain metrics focus, largely, on non-financial aspects, since companies are better able to recognize weak performance in time or quality (Erdmann, 2002). Financial measures are further used to overcome the weaknesses of non-financial measures and thereby provide supply chain performance measurement systems with financial results (Erdmann, 2002). Such measures enable supply chain participants to evaluate the other participants' performance concerning the overall objectives and thereby allowing rewards and sanctions based on customer or supply chain issues instead of internal optimization (Lee & Billington, 1992).

The objective of supply chain metrics is to help companies to understand where their competitiveness derives from, which is especially important in times of increasing competition since it forces companies to differentiate products and services from the competitors' (Keebler, Manrodt, Durtsche, & Ledyard, 1999). Selection of appropriate measures thereby remains a huge challenge in supply chain performance measurement, since each supply chain has its individual characteristics.

3 Problems and challenges of supply chain performance measurement

The following chapter reveals problems and challenges of supply chain performance measurement. In order to do that, relevant literature is reviewed and analyzed. The chapter discusses five main issues: supply chain information sharing, learning, relationships, complexity and flexibility. These issues are described and later produce the basis for the empirical survey carried out for this thesis. The chapter ends with a critical evaluation of the problems and challenges complicating the supply chain performance measurement. Thereby the fulfillment of the second sub-purpose of the thesis is ensured.

3.1 Supply chain information sharing

Uncertainty in supply chains is observed quite often, since perfect information about the entire chain cannot be secured. Most participants have perfect information about themselves, but uncertainties arise due to lack of information about others. In order to reduce uncertainties, supply chain participants should collect information about others. The basis for information sharing is that others are willing to share information, leading to a situation where each member in a supply chain has more information about others. Information sharing would improve the entire system's performance, because each supply chain participant can improve its performance (Yu, Yan, & Cheng, 2001).

To be able to respond and quickly process information throughout an organization or a supply chain, companies have invested large sums of money in information technologies. It can be found that managers are seeking to improve operational and competitive performance by developing more efficient and effective information sharing capabilities. Most of the information sharing theories and practical approaches focus on the technological aspects of information sharing (Fawcett, Osterhaus, Magnan, Brau, & McCarter, 2007). Still many companies are not content with the returns on their investments (Jap & Mohr, 2002). A possible explanation for this might be that the implemented technologies have not been supported by investments in the organizational culture of promoting open sharing of information. Therefore it can be found that the connectivity, for example, in the form of technologies, and the willingness to share information are two fundamental elements of information sharing (Fawcett et al., 2007).

Connectivity has a very important role in information sharing. In most cases high connectivity is reached through information technologies enabling companies to collect, analyze and evaluate information among the participants of the chain to improve the decision making. Connecting the participants of a chain across functional and organizational boundaries provides them with relevant, accurate and actual information, reduces temporal and spatial distances, allowing better and more coordinated decisions (Fawcett et al., 2007). Advanced connectivity offers the change in competitive capabilities as well. The best known capability of information is to replace inventory in the supply chain (Constant, Kiesler, & Sproull, 1994). Another aspect of actual connectivity enables detection of less tangible elements such as environmental trends or inflection points to discover changing competitive rules or changing customer demands (McGee, 2004).

Connectivity creates the basis for information sharing but people make the decision what will be shared and when. In many cases individuals are unwilling to share information which might place their organization in a competitive disadvantage. Even though these fears might not be justified, an enormous amount of useful information is never shared and

stays unavailable to decision makers (Fawcett et al., 2007). Organizational theory implies that the company culture influences how willing an organization and its people are to share information (Constant et al., 1994). Therefore to take full advantage of integrated information in a supply chain, the participating companies must have a high level of willingness among all key players. In sum, the technological connectivity of a company, combined with the cultural willingness, will determine how much useful information will be shared to improve the supply chain performance (Fawcett et al., 2007).

Furthermore, Fawcett et al. (2007) identified four different barriers of information sharing. The first barrier concerns the costs and complexity when implementing such an information sharing system. In many cases budgets are exceeded and the systems do not perform as intended. The second barrier is found in system incompatibility. Sometimes different IT-systems do not function together or some companies have not been able to invest in such systems and still work manually. The third barrier are the costs created by incompatible systems, and since the investment and implementation costs for such systems are high, it is important to reach the intended cost-saving through more effective and efficient processes. Unfortunately, in some cases companies have advanced IT-solutions, but, for example, all the orders from customers are sent by fax instead of e-mail and must be entered manually into the system, leading to enormous extra costs. The last barrier states that managers simply do not understand the unwillingness of individuals to share information. Therefore there are no investments into the organizational culture and valuable information is not shared among the supply chain participants.

Effects on supply chain performance measurement

Information sharing is the basis for every functional performance measurement system. Especially when trying to develop a supply chain performance measurement system for the entire supply chain, the sharing of information beyond boundaries of organizations becomes essential. In sum, it can be stated that the barriers of information sharing need to be overcome for a successful supply chain performance measurement system, since it can be seen as an advanced development of information sharing in the supply chain.

3.2 Supply chain learning

Sharing information is essential for organizations to learn from each other in the supply chain. The opportunity to learn from others can encourage continuous improvement of the supply chain performance. Learning is very valuable for innovation and improvement. To create innovative behaviors, organizations need to develop and support learning behaviors. Learning offers the opportunity to question and challenge existing processes that different workplaces institutionalize as standard behavior (Hyland, Soosay, & Sloan, 2003). One extreme is that the existing or repetitive learning occurs through standardized or routine behavior, called "single-loop" or "lower-level" learning (Fiol & Marjorie, 1985), while the other extreme, behaviors that verify, challenge or question existing processes, have been named "double-loop" or "higher-level" learning (Senge, 1990). These capabilities of learning can only be implemented over time by progressive consolidation of behaviors, or by actions aimed at developing new assets or recognizing the stock of existing resources (Hyland et al., 2003). Hyland et al (2003) identified four key capabilities of learning:

The management of knowledge

Managing and cultivating knowledge is a procedure of building, changing, displaying and

proving organizational competence. In the right setting and circumstances, such a process may lead to knowledge that can be shared with others and benefit the organization. Knowledge can be recorded, stored and distributed in the form of information sharing.

The management of information

Information and knowledge are no substitutable terms. Knowledge is new information gained through interpretation, analysis and the context in which it is discovered (Kidd, Richter, & Li, 2003), while information concerns known data that have been organized, analyzed and interpreted by computers or people. One of the biggest mistakes is to ignore the differences between knowledge and information or to assume that information technologies can overcome the difficulties of information gathering or knowledge generation (Hyland et al., 2003). Concerning the management of information an organization should generate, acquire, process and use information (Myburgh, 2000). Information sharing is not perfect, especially in supply chains, and this complicates decision making and communicating with a holistic approach.

The ability to maintain and manage information technologies

Technology plays a very important role for supply chain learning. On the one hand, technology stores information, and on the other hand it can also help to search, structure, categorize and analyze the information. The use of information technologies is the basis for organizations and supply chains to maintain or extend their learning abilities (Hyland et al., 2003). Furthermore, information technology can provide support in overcoming one of the primary challenges of supply chain management, which involves the coordination of people and processes between organizations (Clements, 2007).

The management of collaborative operations

Collaboration between internal and external partners is essential to create knowledge and information in the supply chain. The creation of knowledge takes place when individuals with different backgrounds collaborate and share information. This development is gaining a growing importance in organizations in order to improve the overall supply chain performance and to stay competitive.

These capabilities of learning can be seen as the basis of supply chain learning, but for the implementation of a supply chain performance measurement system it is also interesting what kind of learning behaviors exist for individuals and organizations. Hyland et al. (2003) thereby found the following learning behaviors:

- Individuals and groups use the organization's strategic goals and objectives to focus and prioritize their improvement and learning activities.
- Individuals and groups use innovation processes as opportunities to develop knowledge.
- Individuals use a part of the available time or resources to experiment with new solutions.
- Individuals integrate knowledge between different parts of the operation.
- Individuals transfer knowledge among different processes.

- Individuals abstract knowledge from experience and generalize it for application to new processes.
- Individuals try to understand and internalize knowledge from external sources.
- Individuals and groups make knowledge available to others by incorporating it in such vehicles as reports, databases, product and process standards that can be more widely disseminated and retained over time.

In most cases only a limited number of these learning behaviors can be found. Not all companies are willing to learn or have a culture supporting organizational learning. The most challenging element for organizational learning is trust (Kidd et al., 2003). Lack of trust often hinders the sharing of information and therefore limits ability to learn from others. A key element therefore is to develop trust throughout supply chain participants.

Effects on supply chain performance measurement

Learning from others in the supply chain and understanding the capabilities and learning behaviors in organizations or supply chains is tremendously important when implementing a supply chain performance measurement system. For the implementation it is relevant to know how individuals react, analyze and adapt to a new measurement system and how they learn from each other. The benefit recognition of a supply chain performance measurement system is particularly challenging, as well as inspiring the supply chain participants to learn to share information on the basis of trust.

3.3 Supply chain relationships

Supply chain relationships are complex, multi-stranded arrangements of exchange between different actors in short, medium and long terms. Not only might there be several relationships between two organizations around different products and services, but often there are many individuals involved in establishing and maintaining supply chain relationships. Research views relationships as processes involving short-term transactions of products, services and payments, giving rise to an increase of social relations such as trust and reputation between the involved parties and thereby forcing social, informational and technological exchange (Easton & Lundgren, 1992).

Such supply chain relationships have two major dimensions. The first dimension focuses tangible aspects of relationships such as the volume and timing of materials and information flows, product quality improvement, and cost minimization. The second concentrates on intangible aspects such as trust, cooperation, and communication (Naude & Buttle, 2000). Trust is seen as the belief of a firm that another company will perform actions that will result in positive actions for them, as well as not to take unexpected actions that would result in negative results for them (Anderson & Narus, 1990). Cooperation refers to situations in which firms work together to achieve mutual goals (Heide & John, 1988). Communication is the formal and informal sharing of meaningful information between firms (Anderson & Narus, 1990).

In terms of high intensity of involvement, supply chain relationship may take the form of partnerships or strategic alliances. A Partnership is a long-term process and should not be seen as an instant cost saving exercise, but rather as an investment. Buying organizations recognized that supplier are the experts in their own field of technology and that they can

draw upon this expertise to create synergies within a supply chain. A partnership involves the supplier as 'co-producer', working with fewer suppliers per customer, developing long-term relationships, managing close interaction among all functions, and sharing physical proximity (Cousins, 2002).

The most sophisticated form of cooperation between companies occurs when a strategic alliance is formed between partnering firms. Strategic alliances enable the buying and supplying firms to combine their individual strength and work together to reduce non-value adding activities and improve performance. In order for both parties to remain committed to this form of relationship, mutual benefit must exist. This is termed as developing "win-win" relationships (Whipple & Frankel, 2000).

Trust is also often recognized as the important element in successful strategic relationships with suppliers. It is related to many other elements such as reputation and credibility. Trust can be examined from two distinct perspectives. Character-based trust examines qualitative characteristics of behavior in partner's strategic philosophies and cultures, and competence-based trust examines specific operating behaviors and day to day performance (Whipple & Frankel, 2000).

Since supply chains are made up of organizations linked by relationships, transparency may also be of relevance when managing a supply chain. The concept of cost transparency within the development of supply chain relationships was defined as the sharing of cost information between customer and supplier, including data which would traditionally be kept secret by each party. The purpose of this is to make it possible for customer and supplier to work together to reduce costs and improve other factors (Lamming, 1993). It is important to note that transparency refers to a two-way exchange of information; that is, that the customer shares data with the supplier about its own operations, as well as requiring the supplier to share. The development from a simple provision of data to two-way sharing of sensitive information in the pursuit of a new value creation heightens the richness of the knowledge environment between customer and supplier and in the supply chain (Jeong & Phillips, 2001). Therefore, Lambert and Pohlen (2001) proposed 6 steps for forming and maintaining supply chain relationships:

1. Perform Strategic Assessment
2. Decision to form relationship
3. Evaluate alternatives
4. Select partners
5. Structure operating model
6. Implementation and continuous improvement

These 6 stages are critical to the formation and success of supply chain relationships. It is very important for supply chain participants to concentrate on improving quality, speed, dependability, flexibility and cost through relationships.

Further aspects that need to be kept in mind are the different power positions the supply chain participants can have. Power, in a more general sense, refers to the ability of an individual or a group to control or influence the behavior of another (Hunt & Nevin, 1974). Therefore when developing a supply chain performance measurement system it is impor-

tant to know who has the power to influence others in a relationship and how can this power position be used.

Effects on supply chain performance measurement

Considering the different relationships a company is involved in, it becomes especially difficult to implement a supply chain performance measurement system accounting for the entire supply chain. A functional measurement system relies highly on the relationships with customers and suppliers in order to measure and evaluate important information and data. These complex, multi-dimensional relationships involving internal and external partners are the basis for performance measurement systems and are very challenging to manage, for example, due to constant changes. Furthermore, a lack of trust or transparency between partners can complicate the development of a reliable performance measurement system.

3.4 Supply chain complexity

The more participants and levels are included in a supply chain, the more complex the management becomes. The complexity of most supply chains makes it difficult to understand how activities at multiple tiers are related and influence each other. It is challenging for performance measures that they must reflect the complexity and consider cross-company operations from original suppliers to the end customer (Lambert & Pohlen, 2001).

In general, the complexity of supply chains can be described in terms of several interconnected aspects of the supply chain, including (Yates, 1987):

- Number of elements or subsystems.
- Degree of order within the structure of elements or subsystems.
- Degree of interaction or connectivity between the elements, subsystems and the environment.
- Level of variety, in terms of the different types of elements, subsystems, and interactions.
- Degree of predictability and uncertainty within the system.

Complexity refers to the level of structural and dynamic complexity exhibited by the products, processes and relationships (Bozarth, Warsing, Flynn, & Flynn, 2009). From this definition two classes of complexity can be defined. The structural complexity, defined by Frizelle and Woodcock (1995), as associated with the static variety characteristics of a system. The operational or dynamic complexity can be defined as the uncertainty associated with a dynamic system (Frizelle & Woodcock, 1995).

In a dynamic environment such as a supply chain, even simple supplier-customer relationships with structurally simple information and material flows have a tendency to demonstrate operational complexity. The operational complexity of supplier-customer relations is associated with the uncertainty of information and material flows within and across organizations (Sivadasan, Efstathiou, Calinescu, & Huatuco, 2006). It can be observed within organizations on a daily basis in the form of orders, unreliable deliveries, changes to what has

been ordered, alterations to specifications and other unpredicted variations (Sivadasan et al., 2006).

The level of operational complexity that must be managed in supply chains is also determined by the dynamics of the markets companies are involved in. Different types of markets will have different levels of complexity, with regard to how predictable the market conditions are. The location of the organization within the supply chain (whether it is located towards the final customer or towards the raw material end) is governed by the different interactions that exist at various tiers within the supply chain. This means that adding more levels to a system increases the complexity because each additional tier within the supply chain acts as a further obstacle to the flow (Frizelle & Woodcock, 1995).

Supply chains are inherently complex in many different perspectives, since a large number of firms operate simultaneously with many supply chain partners, interacting through a variety of information and material flows in an uncertain way. These characteristics of supply chains also rule the complex nature of individual supplier-customer relationships. According to Bozarth et al. (2009), the complexity of a supply chain can therefore be examined by considering these elements:

- The complexity of the internal organization.
- The complexity at the supplier-customer interface.
- The complexity associated with the dynamic environment.

The internal complexity of organizations can be considered in terms of individual operational processes and organizational structures. The complexity of supplier-customer interface is closely connected with characteristics of the products that a company manufactures, both in terms of the variety of product categories and complex nature of the products. Complex products embody more information than simple products and require greater control. The dynamic environment causes constant changes, for example, due to changing customer requirements (Sivadasan et al., 2006).

Effects on supply chain performance measurement

All of the aforesaid suggests that supply chains are complex. The complexity of supply chains influences all suppliers and customers that participate in a supply chain. It is important that companies are aware of complexity-inducing activities and actions in order to effectively control it. The significant challenge for performance measurement in supply chains is to identify what should be measured and to focus only on the important elements of the entire supply chain to reduce complexity.

3.5 Supply chain flexibility

Flexibility is viewed as an action against uncertainty. In a more global sense it can also be a competitive advantage for supply chain management (Sánchez & Pérez, 2005). Flexibility is described in two types: offering flexibility and partner flexibility. Offering flexibility is linked to the ability of an existing supply chain to change products or services due to environmental influences. Partner flexibility is linked to the ability of changing supply chain partners because of changes in the business environment (Gosain, Malhotra, & Sawy, 2004). Next to these two types that separate the description of supply chain flexibility into

products or partners, the following dimensions can be used to illustrate the flexibility (Stevenson & Spring, 2007):

1. *Robust network flexibility:* The range of events an existing supply chain structure is able to handle.
2. *Re-configuration flexibility:* The ability with which the supply chain can be re-configured (adaptability). The need to reconfigure is mainly determined by the range of the existing supply chain structure.
3. *Active flexibility:* The possibility to act as a chain when responding to or in anticipation of changes.
4. *Potential flexibility:* The flexibility for a supply chain is partly a contingent resource, it does not have to be a demonstrable capability.
5. *Network alignment:* The supply chain participants focus on combining their capabilities to meet the supply chain objectives and compete as a whole.

The dimensions of supply chain flexibility offer a great opportunity to understand and evaluate the flexibility of a supply chain. The disadvantage of these dimensions is that they are not describing where the flexibility can be routed back to. Therefore in the following table 3.1 several flexibility elements, described by Sanchez and Perez (2005), are arranged to further explain the previously presented dimensions of flexibility. This offers the opportunity to better understand the flexibility in supply chains and how it can cause enormous problems and challenges.

Table 3.1: Flexibility dimensions and elements (Own source)

1. Robust network flexibility
• *Product flexibility:* The handling of non-standard orders and the ability to meet special customer specifications. This flexibility requires high collaboration internally between the different functions from purchasing to sales, while externally the suppliers and customers of the supply chain need to be closely involved.
• *Volume flexibility:* The ability to effectively increase or decrease volumes of the supply chain or production depending on the customers demand. This often requires close collaboration and coordination between the manufacturers and their suppliers.
2. Re-configuration flexibility
• *Distribution or access flexibility:* This flexibility covers the access to different markets. This includes the geographical access, for example, through transportation networks, or the access to large companies such as Wal-Mart through volumes or products desired by the customers.
• *Response to market flexibility:* This flexibility captures an organization's ability to respond to the needs and requirements of target markets. In most cases the responsibility for this flexibility is spread throughout the entire supply chain, since the customers' requirements need to be transported from the customer's-customer to the supplier's-supplier.

3. Active flexibility:

- *Routing flexibility:* This is the capability of processing parts through various alternative routes by using different machines, flexible material handling and a flexible transport network. Thereby negative environmental uncertainties and inefficiencies in the production process can be reduced.
- *Postponement flexibility:* Implies the capability of keeping a product in a generic form as long as possible, so that the customer's requirements are implemented in a later stage.
- *Delivery flexibility:* An organizations capability to adapt lead times to customer requirements. For example, Just-in-Time deliveries.

4. Potential flexibility:

- *Launch flexibility:* Launching new products quickly and with high reliability in the market is very important. Therefore a high integration among many participants of the supply chain is important. The ability to launch products quickly can gain competitive advantage, for example, by being the first in the market.
- *Sourcing flexibility:* Reflects the ability of an organization to easily replace or substitute suppliers for specific components or raw materials. Many companies compete through sourcing flexibility, making it quite important.

5. Network alignment

- *Trans-shipment flexibility:* Ability to move stock between locations that are far apart, with the same productivity where physical distances between demand and supply location are small.

These elements provide a deeper overview of supply chain flexibility and where this flexibility is found and why it is needed. The types, dimensions and elements of flexibility also give a general idea of how complex the flexibility in a supply chain is. Even though it is widely recognized as an important competitive advantage (Neely et al., 2005; Sánchez & Pérez, 2005), it is difficult to measure the flexibility and existing measures are often criticized to be subjective and situational. Furthermore, flexibility is multi-dimensional, meaning that a supply chain might be flexible in one dimension such as supplier sourcing, while in another, such as volume flexibility, it is not flexible at all. Until a solution is found to measure supply chain flexibility in a sufficient way, it will be difficult to manage or to compare the flexibility of different supply chains (Stevenson & Spring, 2007).

Effects on supply chain performance measurement

Considering the implementation of a supply chain performance measurement system, flexibility becomes a challenge. A functional supply chain performance measurement system must be able to adapt to changes, but at the same time it needs to ensure comparable data over longer time periods. Furthermore, such a system should include flexibility by measuring the relevant figures and by accounting the different flexibility types, dimensions and elements for a supply chain. Comparing the flexibility of different supply chains might still be too complex to achieve due to many different factors influencing the flexibility.

3.6 Summary of occurring problems and challenges

In the previous sub-chapters the most relevant problems for supply chain performance measurement have been described. It was shown how supply chain information sharing, learning, relationships, complexity and flexibility could affect the implementation of a supply chain performance measurement system. The following table 3.2 summarizes the problems found in the literature review and documents the challenges arising when implementing a supply chain performance measurement system.

Table 3.2: Theoretical problems and the arising challenges for supply chain performance measurement systems (Own Source)

Problems	Challenges for Performance Measurement
1. Supply chain information sharing • Connectivity between supply chain participants • Willingness to share information among companies • Technologies are thought to ensure information sharing • Incompatible information sharing systems	• Support efficient and effective information sharing in a supply chain (reliable data) • Make disparate information integrated and compatible (technology as a supporting tool) • Support the willingness to share information by creating trust • Overcome the four barriers of information sharing (see 3.1)
2. Supply chain learning • No differentiation between knowledge and information • Insufficient sharing of knowledge and information hindering the learning process • Technology needs to be used right to support the organization of learning • Little collaboration between supply chain participants • Individual learning behaviors • Lack of trust	• Understand the impact of new knowledge and known information on the supply chain performance system • Learning and improving through sharing of knowledge and information • Technologies are only a supporting tool • Support collaboration among the supply chain participants • Consider individual learning behaviors and create trust
3. Supply chain relationships • Tangible aspects of relationships o Volume, timing, quality and costs • Intangible aspects of relationships o Trust, cooperation and communication • Relationship types (Partnership = cost savings, or strategic alliance = investment) • Lack of cost transparencies • Power distribution	• Measuring the tangible elements of relationships • Measuring the intangible elements of relationships • Be able to measure the performance of relationships • Provide transparency throughout the supply chain • Consider the power distribution within a supply chain • Achieve trust and excellent communication

4. Supply chain complexity • Complex relations and influences between the supply chain participants • Operational complexity (Changing elements such as the environment) • Internal complexity in an organization • Supplier-customer interface complexity • Environmental changes causing high uncertainty, which can not be properly controlled due to the complexity of the supply chain	• Reduce complexity in the supply chain • Create an understanding of the complex relations and influences between the supply chain participants • Consider the operational complexity so that it can be mutually understood • Simplify and make internal, supplier-customer interface and dynamic environment complexity visible • Increase understanding of each supply chain partner • Avoid cultural misalignment through better understanding • Reduce uncertainties in the supply chain
5. Supply chain flexibility • Different types of flexibility in a supply chain • Many dimensions of supply chain flexibility • Many different elements causing flexibility • Measuring and evaluating supply chain flexibility	• Defining the type of flexibility which is intended to be measured • Defining the dimension of supply chain flexibility which is intended to be measured • Identifying measures that can measure the flexibility • Identifying the cause and effects of flexibility in supply chains

Table 3.2 indicates that the implementation of a supply chain performance measurement is highly complex and difficult. Each of the five analyzed problem fields already contains enough challenges which are difficult to overcome on their own, but the combination of all the fields makes it almost impossible. The difficulty for a supply chain performance measurement system is also to evaluate the trade-offs between and within these problem fields. For example building up close relationships with suppliers might cause trust and at the same time lower flexibility to react to environmental changes. The problems themselves and the connected complexity of these problems might also be an explanation to why such models as the SCOR-model or the modified balanced scorecard are not very successful.

Even though there are many problems and resulting challenges found in the literature review, some are more important for the overall success for a supply chain performance measurement system than others. Following is a ranking of the most significant challenges (beginning with the most important), based on the previous literature review:

1. ***Trust:*** Is the key for a successful supply chain performance measurement. The participants of a supply chain need to trust each other in order to share information about their performance. Therefore trust is the basis for all activities when implementing a supply chain performance measurement system.

2. ***Willingness to share information:*** In order to measure performance it is mandatory to share information with others. The sharing of information and learning from others is highly dependent on the organizational cultures and willingness to share information. If this is not created, a supply chain performance measurement system does not function.

3. ***Collaboration among supply chain participants:*** Working and improving processes together in the supply chain is another challenge which needs to be solved so that a measurement system can work and actually improve the weaknesses found from a holistic point of view.

4. ***Transparency of processes and relationships:*** To support the understanding among the supply chain participants it is necessary to have a high transparency of processes and relationships to support the understanding of a supply chain. If this is not provided, it is impossible to understand the complexity of a supply chain.

5. ***Understanding of the supply chain with effects and causes of action:*** In order to explain and justify actions with a holistic view over the supply chain, it is important to understand the effects and causes of actions. A supply chain performance measurement system needs to provide this very reliably and flexibly in order to create and maintain the trust of the supply chain participants.

6. ***Reduce complexity of the supply chain:*** Providing sufficient and understandable measurement results implies that the complexity of the supply chain or the scope of measurement is reduced to a manageable amount of nodes in the supply chain.

7. ***Technology is a supporting tool:*** Many managers see technology as a solution, but even if a supply chain performance measurement system is implemented based on information technology, it needs to be lived by the employees working with it.

8. ***Implementation and maintenance costs:*** Implementing and maintaining a supply chain performance measurement system will have costs. These costs need to be weighted off by the savings such system could produce. The challenge here is to communicate the benefits throughout the entire supply chain and justify the extra costs.

Taking these challenges into consideration when implementing a supply chain performance measurement system can provide a general idea about the challenges that could occur. An interesting aspect after reviewing literature is now, what challenges arise in practice and how this ranking should be changed or extended accordingly.

4 Research method

This chapter states the applied research method of this thesis and how the empirical data is collected. A qualitative research approach is described, as well as the process of data collection and analysis. Furthermore, the trustworthiness and the research method are evaluated. In sum the chapter describes the process of how problems and challenges for supply chain performance measurement are found in a practical environment.

4.1 Qualitative research

The purpose of this thesis is to discover problems and challenges arising in supply chain performance measurement. After reviewing literature and identifying problems and challenges stated in theory, it is necessary to reveal practical problems and challenges. Therefore both qualitative and quantitative research methods are applicable. A qualitative research offers the opportunity to carefully communicate with and capture the experience of the interviewed participants, while a quantitative research requires standardized measures and is often expressed in form of numbers to verify and test facts (Berkeley, 2005; Patton, 2002). Since this thesis aims at finding problems and challenges which highly differ and depend on the individual companies and branches, a qualitative approach has been chosen due to the wide variety of expected results.

In qualitative research a large amount of information and data is often gathered, in many cases a surplus of information is collected (Hardy & Bryman, 2004). The actual problem of qualitative research is not so much the collection of data, it is rather the making of useful and valuable data relevant to the defined purpose. The qualitative data is often messy as a result of a lack of clarity in the data required to answer the research questions (Richards, 2005). To organize the work and handle the collected data, researchers should divide it into different categories or topics to simplify the transcribing process (Hardy & Bryman, 2004). The information collected for this thesis was therefore separated into general information about supply chain management and specific information about supply chain performance measurement. This differentiation allowed to distinguish the different knowledge levels of the participants about supply chain management and offered the opportunity to let the participants become familiar with the general topic before answering more questions in detail. Furthermore, the specific part was divided into general and detailed questions concerning supply chain performance measurement problems and challenges. This way the questions used provided a guidance to answer the questionnaire and at the same time forced the participants to intensively think about their answers.

In general, qualitative research is based on three different kinds of data collection methods: interviews, observation and written documents (Patton, 2002). Due to lacking access to resources and time limitations, it was only possible to use interviews, even though the use of all methods would have been preferred.

4.2 Sampling and collection of empirical data

The empirical data is the basis for every study, it is important to know where and how data is collected in order to understand the final conclusion of a research. When choosing companies or objects for research, there are two well-known alternative strategies: probability and non-probability sampling. On the one side for probability sampling data is randomly chosen out of a known set and all units have the same chance of being chosen, while on

the other side non-probability sampling is used when the researcher lacks a sampling framework of the researched set or a probabilistic approach is not seen as a necessary requirement. This is often the case when sensitive and personal data is collected based on trust between the researcher and the participants (Blaxter, Hughes, & Tight, 2006).

In this thesis a non-probability sampling has been chosen, or more precisely, a purposive sampling has taken place, choosing typical or specifically interesting cases (Blaxter et al., 2006). Thereby the companies for this study were chosen through previously existing contacts. The companies were contacted by the author through telephone and mostly replied positively to participate in this study. From the 8 contacted companies 6 participated in the study and agreed to be interviewed. The most important issue for the participating companies was to ensure the confidential handling of the collected data. Furthermore, the companies were chosen due to their potential attractiveness in this study, based on the author's knowledge, as well as the ability to present a medium-sized business.

The study carried out for this thesis is based on 6 interviews including 9 participants. The interviewed companies were 5 medium-sized businesses from different branches in Germany. In order to ensure a broad representation of the medium-sized businesses in Germany the most significant branches were picked. The researched branches were mechanical engineering, automobile spare-parts, clothing textiles, electrical engineering and consulting. This way the study allowed making general assumptions about problems and challenges for supply chain performance measurement in German medium-sized businesses. Besides the objective of presenting a general overview, the companies were chosen according to number of employees, turnover and supply chain involvement to guarantee the affiliation to medium-sized businesses. The number of employees in these firms range from approximately 3000[1] to 50 employees, the turnover has a maximum of around 500 million down to 15 million Euros and the supply chain involvement was taken into consideration to ensure that the interview guide could be answered by the participants. A special position in this study was taken by the consulting company, which differed from the other companies since it does not produce or sell goods. It was still taken into account for this study, because of its great experience and involvement in supply chain management projects and the ability to support the validity of this research. In conclusion, the study of this thesis focused on medium-sized business in Germany *(where)* researched with interviews *(how)*.

4.3 Interviews

To better understand how the empirical data has been collected, the interviews and the applied procedure will be described in more detail. For a qualitative research, interviews are the dominating method. Interviews can be held and structured in many different ways (Richards, 2005). For example, interviews can be done via mail, e-mail, telephone or personal face-to-face interviews. Furthermore, interviews can involve only two individuals with a participant and researcher or they can take place in group events concerning several participants and/or researchers (Blaxter et al., 2006).

[1] Even though a company with 3000 employees and turnover of 500 million Euros exceeds the definition of a medium-sized business, they were included in the study due to the fact that they see themselves as a big medium-sized business and manage their business accordingly.

Most of the interviews of this thesis were conducted face-to-face, which offered the opportunity of personnel reflection and to explain the asked question in more detail and to have better control of the answers (Berkeley, 2005). Only one interview was conducted per telephone because the participant did not have enough time. The telephone interview was supported by a software-program making it possible to share the computer-screen of the researcher and thereby highly increasing the quality of the telephone interview due to shared information. Therefore the conducted interviews in this study all had a similar quality with an average questioning time of approximately 45 to 60 minutes. Four of the six interviews were conducted with two individuals (researcher and participant), while the other two were carried out in groups of three or four, with two or three participants and one researcher. These group interviews provided a special opportunity since they allowed the participants to further discuss their thoughts and to generate data which would have not been contributed in single interviews (Blaxter et al., 2006). The interviews of this study therefore created a balanced mixture of individual and group interviews offering a great basis of empirical data.

As the interviews can be held in different ways, the structure can be different. Interviews can use the form of informal conversational interviews, general interview guide approaches or standardized open-ended interviews (Patton, 2002). The informal conversational interview offers maximum flexibility to pursue in every direction which seems appropriate. It also relies entirely on the spontaneous generation of questions in a natural flow of interactions; therefore this type of interviews is often used when using an observation method. The general interview guide approach involves an outline of issues which are necessary to be explored with every participant. Such a guide serves as a checklist to ensure that all relevant topics are covered. In comparison, the standardized open-ended interview includes carefully worded and arranged questions aimed at taking each respondent through the same set of questions. In such interview flexibility is more or less limited, depending on the characteristics of the interview and the interviewer's experience. A standardized open-ended interview is mostly used when it is important to minimize the variation of the questions asked (Patton, 2002). In this thesis a standardized open-ended interview approach has been chosen in order to be able to directly compare the asked questions. The main reason for this approach was that the different companies and their different branches already create a high complexity for the study, and it was therefore essential to ask standardized questions to achieve comparable results. The used standardized interview guide included 9 general and 36 specific questions (see appendix A).

The types of questions in an interview can mainly be in two different forms. The open question where no answer categories are given and the closed questions which provide answer categories. When using open questions it is likely that the answers differ from each other. For an open question the participants have to think on their own and can answer individually, while for a closed question the researcher provides possible solutions and thereby may influence the participants' answers (Berkeley, 2005). For this thesis a combination of both question types is used, and the reason for this approach is that the topic of supply chain performance measurement is very complicated and therefore on the one hand a guidance for the participants is needed, while on the other hand the participants are supposed to provide their individual knowledge to the study. The questions were often used in a mixture by starting with an open question to give a hint of a certain topic and then continuing with a closed question to elaborate the thoughts. Furthermore, open questions were used in the beginning and end of the interview to start the thinking process of the participants and to ensure that all ideas are captured in the end.

The last important element for the interviews is the capturing of information. Blaxter et al. (2006) suggest two alternatives: audio-taping or taking written notes. Audio-taping allows the researcher to concentrate on the interview and to have eye contact to show interest of what the participant is saying. In contrast, it might make the participants anxious and not willing to answer openly or, in the worst case, even to participate in the interview. Taking written notes allows capturing key points of an interview easily and there is no need to worry about initial sorting and categorizing of the collected data. A disadvantage is that taking notes is very complex, since simultaneous note taking, listening and question asking is very challenging. Taking notes will not provide a verbatim record (Blaxter et al., 2006). Due to the requirement of the participating companies to keep the data confidential and the fact that in 4 out of 6 interviews the participants refused audio-taping, the study has been conducted through note taking. This still provided excellent data due to the fact that the used questionnaire was standardized open-ended, offering good guidance to take detailed notes.

4.4 Analysis of empirical data

A qualitative research is characterized by the interaction of data collection and analysis (Hardy & Bryman, 2004). The major challenge of a qualitative analysis lies in making use of the enormous amounts of data. This includes reducing the volume of raw information, transferring data from trivial to significant, identifying important patterns and developing a framework for communicating the results of the revealed data. It is problematic for the analysis of a qualitative research that there are no common procedures for the analysis; the only existing help are guidelines or procedural suggestions. But the application of guidelines requires critical judgment and creativity, since each qualitative study, as well as the used analytical approach, is unique (Patton, 2002). For valuable results, it is important to provide a systematical interpretation of the empirical data to be able to understand the final conclusions of the study (Berkeley, 2005). Furthermore, it is necessary to recognize that the decisions on how the data is collected and analyzed can have a long-term analytical consequences on the results and therefore a holistic planning of the study from the beginning should be encouraged (Hardy & Bryman, 2004).

The collected data of this study was processed in two separate steps, which offered the opportunity to reduce the amount of data and generate valuable results. The following steps were conducted (see appendix B):

1. Collecting the answers of all interviews for each question
2. Interpreting the results of the answers for each question

The application of this procedure allowed a structured analysis of the empirical data. A problem in the interpretation of the empirical data was that the interviews were conducted in German and therefore may affect the result of the study due to translation errors. In order to still ensure a high quality of the findings the processed data was sent out to the participants for approval and confirmation, 2 or 3 days after the interviews.

4.5 Trustworthiness

The trustworthiness of the data is directly attached to the trustworthiness of the person who is collecting and analyzing the data and his or her competences. The competence can be demonstrated through verification and validation procedures necessary to ensure the

quality of the analysis and the development of a record for quality work (Patton, 2002). Thereby the researcher needs to ensure that the found empirical data is valid and reliable. The validity refers to what extent the research reflects reality, and reliability defines to what extent the findings of the study can be applied to other situations (Mirriam, 1998). Furthermore, the researchers should be as objective as possible when collecting empirical data, meaning that they should keep neutrality during interviews and not influence the participants' opinions (Huberman & Miles, 2002).

The trustworthiness of this thesis was ensured through three elements. The first element was to stay as neutral as possible during the interviews and explain questions in general context without expressing any opinion. The second element was to confirm the contents of the interviews with the participants shortly after it was conducted. This procedure ensured validity and reliability of the collected empirical data and reduced errors in the data collection. This step was taken particularly seriously, since errors in the database might affect the findings of the entire study. The third element concerned the analysis procedure, which was designed to be a transparent and easily understandable process. Thereby the author aimed for valid, reliable and objective results to ensure a high trustworthiness of the study.

4.6 Method evaluation

Evaluating the problems and challenges of supply chain performance measurement in medium-sized businesses in Germany is very complicated. Therefore the qualitative research approach with purposive sampling, standardized open-ended interviews and transparent analyses was used in this study. This procedure is believed to generate valuable and sufficient findings for the study. It allowed choosing potentially good participants for the interviews, providing high quality answers. To further improve and ensure the quality, the standardized interviews offered guidance as well. At last, the transparent analysis guaranteed understandable results of the study. It was positive for the study that the trust between the researcher and the participants allowed more open answers and detailed information.

Negative impacts for the study were difficulties to organize the company interviews from Sweden, which reduced the contacting time, and the fact that companies without personal contacts were not willing to participate in the study. Another problem was that the German medium-sized companies differ in size/turnover and are involved in many different branches. On the one hand, this made the comparison of the findings more comprehensive and detailed, while on the other hand it became more complex. The last problem of the study was the interview guide, which was of high quality concerning the contents, but turned out to be a little too long to keep a high concentration of the participants throughout the whole interview. In general, the chosen method was well organized and developed from the beginning of the study and therefore provided the requested information.

5 Results of the empirical study

The chapter describes the findings of the study conducted in this thesis. The empirical study also ensures the fulfillment of the third sub-purpose of the thesis. In the first section the most important findings will be described in detail and the second section summarizes the problems and challenges of supply chain performance measurement systems.

5.1 Findings of the empirical study

Further on the findings of the study carried out in this thesis will be described. After evaluating the complete study (see appendix B) the most important findings were chosen to be presented here. In order to understand which company gave which kind of statements, the companies and their interviews were numbered from 1 to 6.

1. **Mechanical engineering**
2. **Electrical engineering**
3. **Automobile spare-parts**
4. **Textile clothing**
5. **Consulting 1**
6. **Consulting 2** [2]

Using this procedure makes it simple to understand the answers of the companies and to describe the findings in a more detailed way. While evaluating the study, the following problems concerning supply chain performance measurement were revealed.

Different understandings of supply chain management.

An enormous problem found for the implementation of a measurement system covering the entire supply chain was created by the different understandings of supply chain management. The findings show that the knowledge about supply chain management varies widely in German medium-sized businesses

Companies 1 and 2 connect supply chain management with the complete supply chain from supplier suppliers to the final customer. In comparison, companies 4 and 6 reduce the supply chain management to manage transportation from production to the final customer, while company 3 has a more internally focused view on supply chain management concentrating on the supply of goods. In contrast, company 5 only emphasizes that supply chain management is important to manage the processes.

This creates a very challenging problem for the communication between the participants of a supply chain, since almost everybody understands and means different things when talking about supply chain management. Therefore a huge problem found is the communication about supply chain management and what is actually meant by it. The result is that if

[2] Consulting 1 and 2 are the same company. Since it is more convenient for the following description, they are company 5 and 6.

an advanced management tool such as a supply chain performance measurement system is supposed to be implemented, it will lead to a lot of confusion and will cause much need of communication and education throughout the supply chain.

Cost savings are essential in supply chain relationships

Working with others is always a challenge, especially in a supply chain where many different interests are combined and are in conflict with each other. During the study, the German medium-sized businesses evaluated the following characteristics: trust, commitment, costs, quality, time, personal sympathy, gaining competences, reducing costs, and creating value.

From the result of the study one can assume that reducing costs, creating value, trust and commitment are the most important to the participants. This indicates that the companies strongly intend to save costs when they work together with others and thereby create extra value. Furthermore, it was found that the companies see trust and commitment as essential elements of effective cost savings. The participants evaluated cost, quality and time as important characteristics, showing that the second most important objective is process optimization under the requirement of saving costs. The weakest ratings were given to personal sympathy and gaining of competences which were only ranked as rather important, demonstrating that learning from others seems to play an inferior role when working in relationships.

In sum it can be noted that companies have a major focus on cost savings when they work with other participants in the supply chain. Therefore the other characteristics are seen as necessities that need to be more or less fulfilled to reach cost savings and to see relationships as successful.

The effects of the financial crisis on supply chain relationships

In order to implement a performance measurement system in the future it is interesting to understand how the previously evaluated characteristics are jeopardized by such an event as the financial crisis. It is particularly appealing to know which characteristics are most likely to be affected.

The results in the study all confirm that the financial crisis will have negative effects on the characteristics of supply chain relationships. There were two main aspects found that will be particularly affected by financial crises. The first is the trust in relationships. For example, it was feared that liquidity of the companies might not be ensured throughout a crisis and hence the fear of losing money rules the relationships. This leads to situations of mistrust and skeptical behavior among supply chain partners. The second effect identified is increased competition caused by falling prices. It was often found that in order to avoid high inventories the companies started to sell products below production prices and therefore increased the competition in an economically difficult situation. Therefore these two effects – forced by the financial crisis – cause the companies to see themselves more as heterogenic entities competing against each other in an environment of mistrust.

These findings are supported by other answers (see appendix B), where the participants of the study argued that a mentality of "save what you can save" arose, no matter how it affected others. If such a development occurs, it might make the supply chain management philosophy obsolete, since companies focus on their own business and not the complete supply chain when it comes to surviving an economic crisis.

Challenges arising when implementing a supply chain performance measurement system

Whenever new approaches are going to be implemented, challenges occur. Therefore it is important to identify them before the implementation of supply chain performance measurement systems.

The study revealed a great variety of challenges when implementing a supply chain performance measurement system. Important findings are that the measurement data has to be consistent, available and analyzed to be properly processed. Furthermore, company 1 mentioned that it is important that the employees and all involved participants in a supply chain live and support a performance measurement system. Therefore it seems to be necessary to successfully convince the supply chain participants to actively contribute to such a system. Other important challenges identified were communication and coordination. The participants were concerned about how information is shared and how goods are delivered. The answer of company 6 was also interesting, which stated that costs, time, quality and coordination will be enormous challenges during the implementation of a supply chain performance measurement system, demonstrating that these dimensions need to be kept in mind as well during the implementation phase.

In sum, the most important challenge found during the implementation phase was the communication of advantages and disadvantages to convince the supply chain participants to contribute to a supply chain performance measurement system.

Expectations for a supply chain performance measurement system

When implementing a new system it is also very significant to know what a system can and cannot do. Providing this knowledge is tremendously important to avoid misunderstandings and misguided expectations among the supply chain participants.

Many different reasons are illustrated in this study for why a supply chain performance measurement system should be implemented. The most significant objectives the participants connected to a measurement system included transparency, cost reduction, inventory management, control and optimization of processes, risk reduction and continuous improvement. One of the most desired reasons was to ensure and offer the opportunity to better manage the supply chain with a measurement system. It was also seen that each company had different expectations from a performance measurement system.

Knowing these expectations can be the key to success for the design and the implementation of a measurement system, since it can help to clearly communicate the strengths and weaknesses of a performance measurement system. Thereby the commitment of the supply chain participants to such a measurement system can be further ensured.

Internal and external measures for supply chains

To understand how challenging the implementation of supply chain performance measurement system is, it is also necessary to know how familiar the participants are with measures when they manage their companies. To identify this, several questions and additional sub-questions (see appendix A and B) were asked.

The findings of the questions confirmed that only a small number of medium-sized companies measure their performance with figures. Only two of the questioned companies stated that they measure their internal performance with cost, time and quality figures. The companies 2 and 4 were only using the price as an indicator. The two consulting companies

mentioned that their experience shows that many companies use internal measure but are unaware of interrelations or lack knowledge of how to manage such measurement systems. Therefore the study draws a picture that internal measures exist, but have not experienced a widespread use in German medium-sized businesses.

An even more radical situation was demonstrated by another question about external measures. Five out of the six companies stated that they do not use external measures to control the supply chain or their suppliers and customers. Only company 1 is using cost, time and quality measures to control suppliers and customers.

The results of the study also indicate a phenomenon: the bigger the company is in size and turnover, the more likely it will be that they use performance measures to manage their operations. It was seen that the largest companies of the survey, 1 and 3, used measures to control their internal supply chain, while the smaller companies only used costs as a measurement. The external supply chain is only measured by the largest company 1 and only includes basic measures for suppliers and customers. Taking this phenomenon into consideration it will hardly jeopardize the success of supply chain performance measurement systems, since there is only little experience with the management of measures among German medium-sized businesses. The implementation of performance measurement systems will therefore also depend on how successfully the smaller supply chain participants can be convinced to participate.

Models to support the performance measurement of a supply chain

A common solution from scientists is the usage of models when implementing new ideas or approaches such as supply chain performance measurement. Therefore it is important to understand how models are accepted in practice and how they can be used.

A major issue of all the participants of the study was that scientific models are seldom able to include the complexity of reality. The lower educated participants showed particular resistance. Only company 4 believed that the balanced scorecard is a highly usable model, but at the same time doubted the subjective results. Therefore using models and suggesting them for implementation can be a cause of enormous conflicts between supply chain partners and within the hierarchies of the companies. To still use models as guidance, it is essential that the advantages of these models are communicated in practice, in order to achieve a high acceptance and to reduce the resistance towards change.

Therefore a scientific model can only be applied as general guidance when it is extended by the individual needs of the companies. Especially in the case of a whole supply chain, the application of individual needs is particularly difficult due to the different vertical and horizontal influences a supply chain is facing.

Willingness of suppliers and customers to participate in supply chain performance measurement systems

In order to implement a performance measurement system that includes the entire supply chain, it is important to know when suppliers and consumers are willing to participate in such a system.

The results of the study vary highly from willing to rather not willing to participate in a supply chain performance measurement system. Again, trust is essential for participation, as well as the fact that the suppliers need to see their advantages and disadvantages. The companies also need to be aware of workloads and utility of a performance measurement sys-

tem. Company 2 also mentioned that the larger a company, the more likely it will participate. It is also interesting that, for example, company 3, among others, believes that customers are only willing to participate in such measurement systems in exceptional cases. The answer might refer back to the structure of the automobile-spare parts branch and the position of company 3 as a distributor to the final customer. Their problem is that it is not predictable when a car is going to break down; the only requirement the customers of company 3 have is that the parts to repair a car are available in a very short time. Since this is the only requirement the customers do care about, the evaluation of other measures seems irrelevant to them. In general, it can be found that from the German medium-sized businesses point of view, they do not require material or services from a supply chain as a whole, they only see and think to the next supplier or customer and their company as a single entity.

Therefore it is essential that the supply chain participants see utility in a supply chain and a performance measurement system. It can be assumed that in most cases the participation of customers and suppliers in a supply chain performance measurement system depends highly on the advantages they can gain.

The most important characteristics of supply chain performance measurement

To further understand which characteristics are important for a supply chain performance measurement system, the participants of the study were asked to evaluate the following characteristics: strategic fit, development direction and speed, common culture, strategic interest, power distribution, integration, understanding the customer and the supply chain, commitment/trust, transparency, benefit sharing and communication.

The results of the study show that almost all of the characteristics are important for a supply chain performance measurement system. The most important characteristics for the companies seem to be communication, commitment/trust, transparency, strategic fit and integration. A little less important are development direction and speed, strategic interest and the understanding of customers and the supply chain. Still important matters are power distribution and benefit sharing, followed by a common culture.

Surprisingly none of the characteristics were evaluated as unimportant, demonstrating how complex it would be to implement and successfully run a supply chain performance measurement system by including all these important characteristics.

Problems of supply chain performance measurement

The last elements which were selected to be evaluated were the problem fields found in theory. They were selected to have a direct comparison with how these problems are seen in practice. Therefore several questions were used to evaluate the problems of supply chain performance measurement (see appendix A and B) in this study.

The most significant problems found in the study are trust, complex structures and cost focus. These problems are followed by interactions between suppliers and customers, flexibility and information sharing. According to the companies, gaining knowledge and utilization does not seem to be very difficult. In general, all characteristics are seen more or less as problematic for supply chain performance measurement. Especially for the complexity, sharing of information, learning and flexibility, more detailed questions have been asked and thereby show the following results:

Complexity

The six companies all agree that complexity is an enormous challenge for supply chain performance measurement. The main concern of the companies is that many different aspects need to be considered. It is essential to include supply chain participants to understand relations between them and to manage internal and external interfaces. Other problems mentioned are the involvement of humans causing errors, high workload for measurements, and the challenge to receive comparable results.

Information sharing

The majority of the companies said that they are very skeptical about the sharing of data. They found that sharing of sensitive data causes competitive disadvantage and that the information is used against them. They also stated that trust is the basis for sharing information. Exceptions were companies 5 and 6, which stated that sharing sensitive information is the basis for optimization and improving the supply chain performance. These statements lead to the consulting background, but they also said that according to their experience German companies, especially in the medium-sized businesses, are very anxious about sharing data.

Learning in supply chains

The companies agree that learning from others is very important to improve their performance. The problems they eventually connect with learning is that it is mainly done parallel to the daily work, the utilization is not measurable, knowledge is in the employees, not in the organizations, learning from partners is not much accepted, and that a learning culture needs to be lived in order to actually function. Therefore it can be stated that learning needs to be supported by the culture of the companies to achieve valuable results.

Flexibility

For 5 of the 6 companies reacting flexibly to environmental changes is essential for the success of performance measurement systems. They state that companies need to be able to flexibly switch suppliers and customers, that a system should react to environmental changes and can be extended accordingly to the demands. In comparison to flexibility, it is also argued by company 2 and partly by company 1 that for the measurement of performance it is important to have comparable data over a longer time period. Therefore they request a static system or that the changes in the supply chain performance measurement system should be carefully considered before they are realized.

In sum, the findings of the study show that supply chain performance measurement is very challenging, and it is especially interesting that the study results have very strong emphasis on communication, implying that the key to success is the detailed explanation of advantages and disadvantages of supply chain performance measurement systems. Furthermore, many different problems arose which need to be considered and which can jeopardize the success of supply chain performance measurement. Therefore the findings of the study indicate a wide variety of problems and challenges which need to be kept in mind for the implementation of supply chain performance measurement systems.

5.2 Summary of the empirical findings

To properly summarize the findings of the study, the same procedure as in the literature review is used. The found problems will be stated in the left column of a table and the resulting challenges for supply chain performance will be stated in the right column. To finally summarize the findings, a ranking of the most significant challenges found in the study will be presented at the end of this sub-chapter. The following table 5.1 illustrates the problems and challenges of supply chain performance measurement discovered in the study of this thesis.

Table 5.1: Practical problems and the arising challenges for supply chain performance measurement systems (Own Source)

Problems	Challenges for Performance Measurement
1. Definition of supply chain management • Different understanding of supply chain management • Different scopes of internal and external supply chains	• High need for sufficient communication and education on what supply chain management means • Communicating the advantages of supply chain performance measurement
2. Cost focus and the effect of the financial crisis • Cost savings are the main focus for every activity with external partners • Egoistic behavior and seeing the companies as an entity, not as a element of a supply chain • Trust, commitment and other criteria are seen as necessities • Processes are optimized only when cost savings are achievable • Social competences are only secondary • The financial crisis jeopardizes such criteria as trust and commitment and forces increased competition	• In order to implement a supply chain performance measurement system investments need to be made • Cost savings cannot be directly predicted, causing more difficult justification for investments • Ensuring team spirit throughout the participants of the supply chain to save costs together • Cost savings are the main objective, even though such criteria as trust and commitment need to be in place first to reach these savings • Continuous improvement is not emphasized very strongly since social competences such as learning from others are not evaluated as significant • Creating and developing a new atmosphere of trust after the financial crisis
3. Implementation challenges • Data consistency provided over the entire supply chain • Sufficient and clear communication • Coordination of flows from suppliers to customers	• Ensure data consistency over multiple links of the supply chain • Ensure that communication is clear and commonly understood by the participants • Work with many participants to coordinate any flows from supplier to customers
4. Expectations of a performance measurement system • Transparency • Cost reduction • Inventory management	• Fulfilling the expectations over the entire supply chain • Trade-offs between the expectations • To know all the expectations supply chain participants can have

• Control and optimization of processes • Risk reduction and continuous improvement.	• Communicate why certain expectations can not be fulfilled • Argue and present advantages and disadvantages according to the expectations to reach higher acceptance
5. Internal and external measures • Internal measures are used, but knowledge about them is often lacking • Internal measures are not as widespread as thought • External measures are hardly used to measure the performance of a supply chain	• The handling and use of measures to make management decisions is not widespread, making it difficult to justify a supply chain performance measurement system • Knowledge and belief in numbers in management is rather low, many decisions are made from personal experience • The larger the company, the more likely it is to use measures • External measures are almost never used indicating that the implementation of a performance measurement system is a new field of management
6. Models as supporting tools • Ability of models to capture the complexity of practice • Ability to adapt to specific situations • Participants do not see models as solutions to their problems	• Provide a supply chain performance measurement model which is adaptable to practical problems • Communicate and present the advantages of using models • Overcome the skeptical opinions of the participants to introduce a performance model on which the actual measurement system is built on • Use a model to present an understandable measurement system for the entire supply chain
7. Willingness of suppliers/customers to contribute • The willingness of suppliers/customers is only there when they gain advantages • The building of trust • Utility and workloads need to be clearly defined	• Communication of advantages and disadvantages to the suppliers and customers • Transparent presentation of the supply chain performance measurement system • Detailed description of the utilities and workloads, as well as costs, for the contributing companies
8. Important characteristics of performance measurement • Many important characteristics • Most important ones are strategic fit, integration, transparency and communication • The variety of characteristics show the complexity of supply chain performance measurement • Almost all of the characteristics	• Evaluation of which characteristics are important to the specific needs of a measurement system • Ensure that most of the characteristics are considered in a measurement system • Manage the complexity of each single characteristic • Ensure the practical implementation of the characteristics • Manage the trade-offs between the different

given for evaluation were evaluated as important	characteristics
9. Problems of performance measurement • Trust, complex structures and cost focus are the most important problems • Interaction between supplier and customers • Complexity causes many elements that need to be considered • Information sharing and especially the sharing of sensitive data is seen as problematic • Learning is done parallel to the daily work and not explicitly invested to improve the performance • Flexibility is necessary, but should not jeopardize measurement results	• Building up trust with a performance measurement system can only be secured over a long term time horizon by delivering accurate and valuable results over longer time periods • The continuous cost focus can endanger the implementation of a measurement system, since the investments need to be taken at first and might not pay off on short term basis • The interaction between many suppliers and customers increases the complexity and forces the companies to encounter many different aspects • The open sharing of information has to be the basis for supply chain performance measurement • Continuous learning needs to be supported and provided to improve measurement results • Reacting flexibly to environment changes and at the same time securing the measurement results is essential for success

The summary of the problems show that – similar as for the literature review – many different challenges can be found. The difference is that the challenges found aim for more specific issues which occur in practice. The variety of challenges also indicates that the idea of a supply chain performance measurement system, which includes the supply chain from a holistic point of view, has not entirely reached the German medium-sized businesses.

In order to further summarize the findings, the following list of most important challenges found in the study was developed. The list includes a ranking beginning with the most important challenge:

1. ***Communication:*** The most important challenge for a supply performance measurement system is communication. Initially and especially during the implementation phase everything depends on how advantages and disadvantages are communicated. Communication and the transparent presentation of a supply chain performance measurement system are the keys to success. Communication also establishes trust and supports other elements, such as commitment, requested by the supply chain participants. The problem with communication is that it often fails due to lack of skills and interest of the participants in a supply chain.

2. ***Strong cost focus:*** The study showed that almost all the decisions of the companies were taken from cost aspects. Whenever a company makes an investment, it wants to know directly what the expected utilities are and how long it takes to generate them. For a supply chain performance measurement system in particular, this is a tremendous challenge, since it can not be directly identified where and how much savings can be made.

3. ***Common language:*** Since communication is evaluated as the most important challenge, it is also important to speak the same professional language. For supply chain management in particular, the different understandings of supply chains can endanger the success of supply chain performance measurement systems. It is therefore necessary to ensure that all supply chain participants talk about the same thing when they work together.

4. ***Trust:*** An excellent and open communication will lead to trust, which also has enormous importance for successful relationships between the supply chain participants. These relationships are the basis for the implementation of a performance measurement system and need to function properly. Trust is seen as an essential element for working together in a team or supply chain.

5. ***Willingness to share sensitive data:*** Without sharing sensitive data and the willingness to do so on an extensive basis, a supply chain performance measurement system will not function. Sharing the information and passing it on to third parties is a key for improvement, but in many cases the companies refuse to do so because they fear disadvantages in negotiations with their suppliers and customers. Therefore it is again essential to clearly communicate between the involved parties.

6. ***Present advantages, disadvantages and utilization:*** Knowing the advantages and disadvantages, as well as the workload with the connected utilization, was a major concern for all the participants of the study. Therefore it is important to present and communicate these elements in a clear way in order to increase the willingness to actively contribute to and to participate in a performance measurement system.

7. ***Education and willingness to learn from others:*** Education and the willingness to constantly learn from other supply chain participants is essential to improve the performance of a supply chain. To ensure a common understanding and an improved performance of the supply chain it is necessary to implement a culture of learning in the supply chain.

8. ***Overcome resistance towards new approaches:*** A culture of learning can furthermore help to reduce the resistance of change and allow for easier implementation of new management approaches, such as supply chain performance measurement. It is very important that all the participants of the supply chain react flexibly to changes and are willing to adapt to new environmental settings. This does not only include managers in single firms of a supply chain, it especially includes those employees which would actually have to work with a performance measurement system on an operational level.

The important elements found in the study of supply chain performance measurement problems and challenges indicate that the implementation of such measurement system will face many challenges. The most relevant skill for a successful implementation is communication. Communication and detailed presentation of advantages and disadvantages are key to convince others to participate in a performance measurement system. Besides, many other challenges can be overcome with excellent communication, since it can, for example, facilitate trust, which then allows sharing of sensitive data. The key finding is that communication is the glue between the participants of supply chain performance measurement systems and needs to be maintained throughout the entire system to guarantee successful measurement results and performance improvements.

6 Analyses of supply chain performance measurement challenges

The following chapter analyzes the theoretical and practical findings of the thesis. Therefore the two lists of challenges are discussed and combined in a final list. This list also ensures the fulfilling of the last subpurpose of this thesis by providing the most important challenges for supply chain performance measurement found in this study.

After identifying the problems and challenges both from theoretical and practical points of view it is necessary to analyze the findings and to develop a final list of challenges that can be expected to occur when measuring the performance of a supply chain. The following table 6.1 presents the findings of the literature review and empirical study in a short overview.

Table 6.1: Theoretical and practical challenges of supply chain performance measurement (Own source)

Theoretical challenges	Practical challenges
1. Trust	**1.** Communication
2. Willingness to share information	**2.** Strong cost focus
3. Collaboration among supply chain participants	**3.** Common language
4. Transparency of processes and relationships	**4.** Trust
5. Understand the supply chain with effects and causes of action	**5.** Willingness to share sensitive data
6. Reduce complexity of the supply chain	**6.** Present advantages, disadvantages and utilization
7. Technology is a supporting tool	**7.** Education and willingness to learn
8. Implementation and maintaining costs	**8.** Overcome resistance towards new approaches

The comparison of the found challenges demonstrates many similarities, as well as some significant differences. Often the descriptions used aim for the same objectives and influence each other. For example, the fourth point of theoretical challenges "transparency of processes and relationships" is closely related to the practical challenge "present advantages, disadvantages and utilization", since a high transparency of processes is necessary to describe the advantages of supply chain performance measurement system in detail. By evaluating these interdependencies and the importance of each of the challenges the following final list was developed[3]:

1. ***Communication (P1/P3):***

   The challenge of communication was chosen as the most important for performance measurement, since it affects and can help to overcome most of the other challenges.

[3] The letters in the brackets show which theoretical and practical findings in table 6.1 have been combined together. Example: Trust (T1/P4) means theoretical finding 1 and practical finding 4 have be combined in this final challenge.

It is the glue between the participants of a supply chain in order to build up excellent relationships. Theory states that the connection of participants through communication in a supply chain across functional and organizational boundaries can provide them with relevant, accurate and actual information, reducing temporal and spatial distances, allowing better and coordinated decisions (Fawcett et al., 2007). Particularly problematic are the different understandings of supply chain management and the resulting interpretations (Larson, Poist, & Halldórsson, 2007). The findings in the study indicate similarities, for example, it was found that misunderstandings of supply chain management can be solved by communicating with a common professional language. Furthermore, it was seen that in order to make coordinated decisions, it is a necessary requirement to communicate the advantages and disadvantages of the implementation of a supply chain performance measurement system throughout the entire supply chain.

To conclude, an open communication within a supply chain supports the implementation of trust and helps to avoid misunderstandings among the supply chain participants as the basis for supply chain performance measurement systems.

2. Trust (T1/P4):

Anderson and Narus (1990) see trust as the belief of the company that another company will perform actions that result in positive actions for the company, as well as not take unexpected actions that would result in negative outcomes for the company. A lack of trust often hinders organizational learning and is therefore seen as a tremendous barrier in relationships (Kidd et al., 2003). The study as well demonstrated that to work closely and be able to overcome the multi-dimensional conflicts in a supply chain it is essential to facilitate trust between the involved participants. Trust is also identified as the characteristic which is necessary to convince others to participate in a supply chain performance measurement system. A special challenge for the generation of trust was found in such a negative economic event as the financial crisis, since most of the companies in the German medium-sized businesses stated that they see a rising mistrust between the companies and strong focus on individual companies.

Considering these theoretical and practical findings of trust, it has been chosen as the second most important challenge for supply chain performance measurement. Based on excellent communication, it is important to generate a high level of trust in order to work together and share information among supply chain participants.

3. Strong cost focus (T8/P2):

In theory it was stated in many cases that investments, for example, into information sharing technology, have been taken, but the results have not been satisfying (Jap & Mohr, 2002). Possible explanations are that investments in technologies have not been supported by investments in the organizational cultures, for example, to support the sharing of information (Fawcett et al., 2007). The study emphasized that almost all of the decisions taken by German medium-sized companies are made according to costs. Clearly, when the companies invest, they want to know what the expected utilities are and how long it takes to generate them. If the results of investments are not directly measurable, the companies often refuse to invest.

Therefore the strong cost focus has been chosen to be the third most important challenge, since in a supply chain performance measurement system the cost saving can in most cases not be predicted in advance. In order convince others to invest and participate it is necessary to overcome the first challenge and to communicate the trade-offs and advantages of a measurement system in the long run and explain how it supports the supply chain management.

4. ***Willingness to share information (T2/P5):***

A prerequisite for sharing information is that others are willing to share information, leading to a situation where each member has more information about others (Yu et al., 2001). On the one side of information sharing is the connectivity between supply chain partners supported by technologies, while on the other side there is the willingness of people to share information. Often people are unwilling to share information, because they fear that this might place their organization in a competitive disadvantage (Fawcett et al., 2007). The arguments found in theory are supported by the findings of the study. Most of the companies are rather skeptical about sharing data. It was widely believed that sharing information leads to competitive disadvantages and that this information is used against them in negotiations.

The challenge of willingness to share information was therefore ranked fourth, since the sharing of sensitive information is essential to improve the performance of a supply chain. If this is not achieved, a supply chain performance measurement can not be implemented and function.

5. ***Learning and collaboration among the supply chain participants (T3/P7):***

The opportunity to learn from others encourages continuous improvement and innovation. To create innovative behaviors, organizations should develop and support learning behaviors. Learning offers the opportunity to question and challenge existing processes (Hyland et al., 2003). To further improve the learning in supply chains, a close collaboration between the participants can be a solution. The most sophisticated form of collaboration occurs when a strategic alliance is formed between partnering firms. Strategic alliances enable buying and supplying firms to combine their individual strengths and work together to reduce non-value adding activities and to improve performance. In order for both parties to remain committed to this form of relationship, mutual benefit must exist. This is termed as developing "win-win" relationships (Whipple & Frankel, 2000). The study demonstrated that the companies see learning as important in improving the supply chain performance. The challenges they see is that learning has to be done parallel to the daily work, utilization is not measurable, knowledge is in the employees, not in the organizations, inability to learn from partners, and that a learning culture needs to be lived to achieve valuable results. A close collaboration is evaluated very skeptically by the German medium-sized companies; they do not see this as a justification to intensify learning and improvement. In general, it was found that the questioned companies see themselves as a single entity and not as a member of a network such as a supply chain.

The learning and collaboration among supply chain participants was chosen as the fifth challenge, because, after the previous challenges, it includes the most important element that is supposed to be achieved by a supply chain performance measurement system: the improvement of the supply chain. A learning culture and collaboration

among supply chain participants is essential to eventually improve the supply chain and achieve a better performance together.

6. ***Reduction of complexity (T6):***

In a dynamic environment such as a supply chain even simple dyadic relationships between supplier and customers have a tendency to exhibit operational complexity. The operational complexity of supplier-customer relations is associated with the uncertainty of information and material flows within and across organizations (Sivadasan et al., 2006). Therefore the complexity of most supply chains makes it difficult to understand how activities at multiple tiers are related and influence each other. It is challenging for performance measures that they must reflect the complexity and consider cross-company operations from original suppliers to the end customer (Lambert & Pohlen, 2001). The study shows that it is critical to reduce the complexity in order to understandably present the structure of a supply chain. It was suggested by the companies to limit the scope of the supply chain and to only include important elements of the supply chain to make it manageable. Furthermore, it was found that in many cases there are no guidelines in the form of models to effectively reduce the complexity. Additionally, many companies were not aware of this challenge. For example, when they implemented internal performance measures, they often only added new measures, instead of revising the previous measurement system and adding measures only where it is reasonable.

This challenge was chosen because it is very important for a supply chain performance measurement system to define the scope and to ensure the manageability. Only if the complexity of performance measurement systems is reduced to a reasonable level will it be possible to generate excellent measurement results that support continuous improvement in a supply chain. If this is not achieved, it will be impossible to properly manage the supply chain and to communicate the advantages and disadvantages of a supply chain performance measurement system.

7. ***Transparency of processes, advantages and disadvantages (T4/P6):***

Transparency refers to two-way exchange of information, that is, that the customer shares data with the supplier about its own operations, as well as requiring the supplier to share. The development from a simple provision of data to two-way sharing of sensitive information in the pursuit of a new value creation heightens the richness of the knowledge environment between customer and supplier and in the supply chain (Jeong & Phillips, 2001). In the study it was additionally found that there is much request from the participants before they participate in a supply chain performance measurement system to understand the advantages and disadvantages, as well as the workloads with the connected utilization. If this is not offered, most German medium-sized companies indicated that they would not be willing to support a supply chain performance measurement system at all.

This challenge was chosen because it is very important to convince other participants to contribute to a supply chain performance measurement system in order for it to function. Transparency helps to easily understand how processes work or how they influence the supply chain. Furthermore, the advantages and disadvantages can be presented in a more transparent way, making it easier to convince others to participate in a measurement system.

8. *Handling of new management approaches (T5/P8):*

Collaboration between internal and external partners, by considering the effects of their actions on the supply chain, is essential to create knowledge and information. The creation of knowledge happens when individuals with different backgrounds collaborate and share information. Therefore learning from other is extremely valuable to innovation and improvement of new performance measurement systems (Hyland et al., 2003). The study also demonstrated in many different ways that participants had a certain resistance against change. Some of the participants showed a general negative attitude against new approaches such as supply chain management, while others questioned the general use of such new approaches as supply chain performance measurement.

This challenge is significant for the success of a supply chain performance measurement system. The involved companies need to implement an organizational culture which easily adapts to change and supports the employees to do so. Only if the participants on all hierarchy levels of the companies in the supply chain accept new approaches and are continuously willing to learn, a supply chain performance measurement system will be a success.

9. *Technology as a supporting tool only (T7):*

It can be found that managers are seeking to improve operational and competitive performance by developing more efficient and effective information sharing capabilities. Most of the information sharing theories and practical approaches focus on the technological aspects of information sharing (Fawcett et al., 2007). The companies that took part in the study emphasized in many situations that a possible solution is always connected with IT-systems. There was even a request for more IT-support and mathematical solutions. It is also stated that it is crucial to understand that IT-systems can offer the opportunity to share information quickly and reliably, but the key is that the employees working with the system can handle it and accept working with it.

Even though this challenge has been previously mentioned, it still seems significant to name, since many companies still believe that technology can solve their problems and see it as more than only a supporting tool. IT- technology can not ensure the success of supply chain performance measurement systems; the key is that it is lived by the participants of the supply chain.

The final list of challenges indicates that there are many elements that need to be included for supply chain performance measurement. The fact that very few companies have any experience with measuring the performance of the supply chain makes it particularly difficult. The main tasks will be to communicate the reasons for supply chain performance measurement and to convince other supply chain participants to contribute.

In sum, supply chain performance measurement is a new field of research and has not been widely spread in German medium-sized enterprises. Therefore it is essential to further explore methods of how to measure the performance of a supply chain by considering the arising challenges.

7 Conclusion

The purpose of this thesis was to analyze existing supply chain performance measurement systems and identify problems and challenges of measuring the performance of the operations in a supply chain. To achieve this objective several sub-purposes have been presented and fulfilled.

The first sub-purpose concerned relevant supply chain performance measurement literature. Thereby the topic of the thesis was further delimited and the scope was defined. The chapter included a definition of supply chain performance measurement, a description of internal and external supply chains, different performance measurement systems and a description of applicable measures.

The second sub-purpose evaluated problems and challenges of supply chain performance measurement identified in theory. The chapter focused on supply chain information sharing, learning, relationships, complexity and flexibility. The theoretical findings were summarized and a final list of theory based challenges was developed.

The third sub-purpose concerned the identification of problems and challenges for supply chain performance measurement from a practical view. Therefore the used qualitative research method was described. The presentation of empirical findings was done similarly as in the theoretical part. In the first section the problems and challenges for supply chain performance measurement were presented. In the following second section the findings were then summarized and a list of practice based challenges was developed.

The last sub-purpose discussed the theoretical and practical challenges found in this thesis. Thereby the found challenges were combined and a final list of challenges for supply chain performance measurement was developed. The developed list included the nine following challenges:

1. **Communication**
2. **Trust**
3. **Strong cost focus**
4. **Willingness to share information**
5. **Learning and collaboration among the supply chain participants**
6. **Reduction of complexity**
7. **Transparency of processes, advantages and disadvantages**
8. **Handling of new management approaches**
9. **Technology as a supporting tool only**

With the development of this list the purpose and sub-purposes of the thesis to identify problems and challenges in the performance measurement of a supply chain were fulfilled.

It was critical for this study that it has only been carried out in a small number of companies, as well as in many different branches in only one country. Therefore the results – or in this case the challenges – might not be explicit enough to provide sufficient recommenda-

tions to companies and the individual characteristics of their branches. Another criticism of the study is that it only focused on medium-sized businesses which have rather seldom been involved with supply chain performance measurement, leading to the fact that the results of the study were mainly based on their thoughts and predictions about performance measurement and not on their actual experience.

For further research it would be an interesting approach to investigate how the results of the empirical study change in another environment. The research could be conducted in only one branch and therefore ensure that the found challenges match the branch and its characteristics. Additionally, it would be fascinating to know, for example, how companies see these challenges in an international environment and how the cultural differences influence the problems and challenges. To further extend the reliability it would also be helpful to conduct a quantitative study to verify the results by using a larger survey group. This way the relevance and ranking of the analyzed problems and challenges can be further improved.

Other necessary objects of research that are not directly connected to this study are guidelines or models for supply chain performance measurement. Without a guideline or a model it is almost impossible to communicate and implement a supply chain performance measurement system. Unfortunately only few up-to-date guidelines or models exist that can be properly adapted to supply chain performance measurement. The development of such a guideline or model will help to communicate something more tangible to the companies and to illustrate how to improve and adapt the supply chains of the individual companies.

The findings of this thesis can therefore be used as the basis of further research by offering a list of challenges which need to be kept in mind for a successful supply chain performance measurement. By conducting the research requests, the use of supply chain performance measurement systems can be further improved for the future.

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Appendix A: Interview guide for empirical research

„Supply chain performance measurement problems and challenges“

Interview guide

Interview guide for the evaluation of supply chain performance measurement problems and challenges

Hello, my name is Christoph Lindner and I am from the Jönköping International Business School. I am writing my master thesis on the topic „Supply chain performance measurement and the occurring problems and challenges“. For this reason I would like to ask you to take some time to answer the following interview guide questions.

Please answer the questions openly and honestly. If you have any questions, do not hesitate to ask. Your data will of course be kept confidential and will only be used for this empirical study.

General part

1. **What do you associate supply chain management with?**

_____

_____

_____

_____

2. **How much can supply chain management support you and your business in the future?**

1	2	3	4	5	6	7

1 = very significantly, 6 = very little, 7 = no comments

3. **What is your opinion on how well your company is managing its supply chain? Do you have a…**

- ☐ very good opinion
- ☐ good opinion
- ☐ not that good opinion
- ☐ bad opinion?
- ☐ no comments

4. **What do you think is particularly good when managing your part of the supply chain?**

_____

_____

_____

5. **What do you think is particularly bad when managing your part of the supply chain?**

_____
_____
_____

6. **„I take care of, support or work in supply chain optimization projects...“**

- ☐ regularly
- ☐ once in a while
- ☐ seldom
- ☐ never
- ☐ no comments

7. **How important do you think are the following characteristics when working with an important supplier or customer ?**

	1	2	3	4	5	6	7
Trust							
Commitment							
Costs (inventory, in/outbound freight, stock out)							
Quality (order fulfillment, complaints, material errors)							
Time (lead time, on-time delivery, cash-to-cash cycle)							
Personal sympathy							
Gaining of competences, sales (win-win)							
Reducing costs							
Creating more value (for customers/companies)							

1 = very important, 6 = unimportant, 7 = no comments

8. **Do you think the financial crisis will affect the characteristics of question 7? In what way will they be affected?**

_____
_____
_____

9. **What do you think could help to further improve your supply chain management?**

_____
_____
_____

Special part

Now I would like to ask you some questions considering supply chain performance measurement.

10. What are the biggest challenges in your opinion when installing a supply chain performance measurement system which includes the external supply chain?

1. _____
2. _____
3. _____
4. _____
5. _____

11. Why should such a supply chain performance measurement system be installed?

1. _____
2. _____
3. _____
4. _____
5. _____

12. Do you think measuring the performance of a supply chain can help you manage the supply chain ?

☐ Yes,why:_____
_____
_____

☐ No,why:_____
_____
_____

13. Would you separate performance measurement into internal and external supply chain performance measurement, or consider it a single system for the entire supply chain?

☐ Internal/external, why:_____
_____

☐ One system, why: _____
_____
_____

14. Do you have internal supply chain performance measures for your supply chain?

- ☐ Yes → continue with question 15
- ☐ No → continue with question 19, why not:_____
  _____

15. What kinds of measures do you use?

- ☐ Cost measures
- ☐ Quality measures
- ☐ Time measures
- ☐ Non-quantitative measures

16. Considering your system of internal supply chain performance measures, how well do you think it supports your management activities?

1	2	3	4	5	6	7

1 = very well, 6 = very poorly, 7 = no comments

17. What do you think is working particularly well?

_____
_____
_____

18. Where do you see your major problems?

_____
_____
_____

19. Do you have external performance measures for your supply chain?

- ☐ Yes → continue with question 20
- ☐ No → continue with question 24, why not:_____
  _____
  _____

20. What kinds of measures do you use?

- ☐ Cost measures
- ☐ Quality measures
- ☐ Time measures
- ☐ Non-quantitative measures

21. Considering your system of external supply chain performance measures, how well do think it supports your management activities?

1	2	3	4	5	6	7

1 = very well, 6 = very poorly, 7 = no comments

22. What do you think is working particularly well?

_____
_____
_____

23. Where do you see your major problems?

_____
_____
_____

24. Do you agree that measuring the external supply chain is important in order for a company to be competitive in the future?

1	2	3	4	5	6	7

1 = totally agree, 6 = totally disagree, 7 = no comments

Why do you think so?_____

25. What models for measuring the supply chain performance are you familiar with?

_____

☐ **None**

26. Do you believe that new models, such as the SCOR-model, or the extension of such existing models as the balanced-scorecard, can help you to measure your supply chain performance?

1	2	3	4	5	6	7

1 = totally agree, 6 = totally disagree, 7 = no comments

Why do you think so?_____

27. What kind of measures would you suggest when trying to measure the external supply chain? (If the answer to question 20 was yes, what other measures could be helpful?)

- ☐ Cost measures
- ☐ Quality measures
- ☐ Time measures
- ☐ Non-quantitative measures

28. What characteristics are very important to you for an excellent supply chain performance measurement system.

	1	2	3	4	5	6	7
Accuracy							
Visibility							
Facilitates trust							
Easy to understand							
Encourages appropriate behavior							
Measures only what is important							
Measures are quantitative							
Measures are defined and mutually unders-tood							
Measures are multidimensional							
Encompasses both in- and out-puts							

1 = very important, 6 = unimportant, 7 = no comments

29. Do you think your suppliers/customers would be willing to participate in a supply chain performance measurement project?

1	2	3	4	5	6	7

1 = entirely willing, 6 = not willing, 7 = no comments

Why do you think so?_____

30. What is necessary, from your point of view, to convince/support suppliers/customers to participate?

_____

_____

_____

31. How important do you think are the following characteristics for a successful supply chain performance measurement?

	1	2	3	4	5	6	7
Strategic fit (effective/responsive)							
Development direction and speed							
Common culture							
Strategic interest							
Power distribution							
Integration							
Understanding of the customer and the supply chain							
Commitment /Trust							
Transparency							
Benefit sharing							
Communication							

1 = very important, 6 = unimportant, 7 = no comments

32. Do you think measuring the performance in the supply chain is complex?

1	2	3	4	5	6	7

1 = totally agree, 6 = totally disagree, 7 = no comments

Why do you think so?_____

33. What problems do you see in the complexity in the supply chain?

_____

_____

_____

34. How can the complexity in supply chain performance measurement be overcome?

_____

_____

_____

35. Would you be willing to share sensitive data with a supplier/customer to improve the supply chain performance?

1	2	3	4	5	6	7

1 = entirely willing, 6 = not willing, 7 = no comments

Why do you think so?_____

36. What kind of problems do you see with data sharing in the supply chain?

_____
_____
_____

37. How can problems with data-sharing in supply chain performance measurement be overcome?

_____
_____

38. How important is it to learn from suppliers/customers to improve the supply chain performance?

1	2	3	4	5	6	7

1 = very important, 6 = unimportant, 7 = no comments

Why do you think so?_____

39. What kind of problems do you see with learning focused on supply chain performance measurement?

_____
_____
_____

40. How can the problems with learning in supply chain performance measurement be overcome?

_____
_____
_____

41. Reacting flexibly to environmental change is vital; do you think a performance measurement system should be able to adapt to changes quickly?

☐ Yes,why:_____
_____
_____

☐ No,why:_____
_____
_____

42. What kind of problems do you see with flexibility focused on supply chain performance measurement?

_____
_____
_____

43. How can the problems with flexibility in supply chain performance measurement be overcome?

_____
_____
_____

44. Do you see the following characteristics as problems in supply chain performance measurement?

	1	2	3	4	5	6	7
Interactions between Suppli-ers/Customers							
Trust							
Gaining of knowledge							
Information sharing							
Flexibility							
Complex structures							
Utilization							
Cost focus when deciding on implementation							

1 = enormous problem, 6 = no problem, 7 = no comments

45. Do you see other problems occurring when measuring the supply chain?

_____
_____
_____

Thanks for your participation!

Thank you very much for finding the time to participate in my questionnaire. The results will be kept confidential and will only be used for this master thesis, as mentioned in the beginning. I wish you the very best and a nice day.

Appendix B: Findings and analysis of the study

In the following appendix the findings of the study carried out in this thesis will be described and analyzed. Each question will be processed in two steps. In the first step, all the findings for each interview will be described, while in the second step the findings will be analyzed. In order to properly fulfill this, the companies and their interviews are numbered from 1 to 6.

1. **Mechanical engineering**
2. **Electrical engineering**
3. **Automobile spare-parts**
4. **Textile clothing**
5. **Consulting 1**
6. **Consulting 2** [4]

Using this procedure it will be possible to carefully describe and analyze all the findings of the interviews.

General part

1. What do you associate supply chain management with?

1. Connection of the single partners throughout the supply chain.
2. The delivery process from the supplier's-supplier to the final customer.
3. Securing the supply of goods for a business through organizational and management activities.
4. Goods transportation form the production to the customer.
5. Important function in a company, basis of the process chain.
6. Complete chain from production to final customer.

The findings in question 1 show that knowledge about supply chain management is widely spread in German medium-sized business. What is interesting in this finding is that the understanding of supply chain management differs. Companies 1 and 2 associate supply chain management with the complete supply chain from supplier's supplier to the final customer. In comparison, companies 4 and 6 reduce the supply chain management to manage the supply chain and transportation from production to the final customer, while company 3 has a more internally focused view on supply chain management, concentrating on the supply of goods. In contrast, company 5 emphasizes only that supply chain management is important to manage the processes.

[4] Consulting 1 and 2 are the same company. Since it is more convenient for the following description, they are company 5 and 6.

Analysis:

The different understanding of supply chain management in medium-sized businesses in Germany leads to conclusion that communicating between and even within companies can be very challenging. It becomes clear that there is no common language and knowledge concerning supply chain management.

2. How much can supply chain management support you and your business in the future?

1	2	3	4	5	6	7
16,6%	66,8%	16,6%				

1 = very significantly, 6 = very little, 7 = no comments

The findings of question 2 show that the companies see supply chain management as from very significant to rather significant, implying that they are aware of the importance. An aspect to point out is that the mechanical engineering company, which was the largest in this study, saw supply chain management as very significant, while the electrical engineering company, which is focused on installing electrical equipment, evaluated supply chain management only as rather significant.

Analysis:

Question 2 shows that the evaluation of how supply chain management can support a business is strongly dependent on how supply chain management is viewed internally by the companies. For the electrical company it seems to be odd that they knew what supply chain management is and then only saw it as rather significant in question 2. This can be seen as a result of internal conflicts between the interview partners who strongly disagreed about the importance of supply chain management. Therefore it becomes obvious that different knowledge about supply chain management is not only a problem externally, it is also internal. In general, question 2 revealed that supply chain management is seen as important for companies in the future, but with challenging internal and external problems with understanding of supply chain management that need to be solved.

3. What is your opinion of how well your company is managing its supply chain? Do you have a…

- ☐ very good opinion
- ☐ good opinion — 83,4%
- ☐ not that good opinion — 16,6%
- ☐ bad opinion?
- ☐ no comments

This question showed that the participants mainly have a good opinion of how their supply chain is managed. 5 companies had a good opinion and only one had a not so good opinion.

Analysis:

These findings refer back to the fact that all participants thought that their supply chain could gain some improvement, while at the same time they were quite pleased with the performance of the chain. In some cases, it might have been a tactical decision not to say that their supply chain works poorly, so downsizing their own work, since the participants are mostly involved in the supply chain management. Company 3 had not such a good opinion about their supply chain; this probably was an open answer, since the company is family owned and the participants were family members (free from hierarchy influences) seeking to improve their supply chain. In sum, question 3 implies that all participants see improvement potential in their supply chains, even though the general impression of their supply chains is rather good.

4. What do you think is particularly good when managing your part of the supply chain?

1. Communication between purchasing and other functions, supplier contacts and relationships, good IT support, logistic, purchasing and distribution processes.
2. Standardized papers, invoice processes, standardized purchasing processes, quality management, it is lived in the company's culture.
3. Connection between product demand and purchasing. Close interactions between purchase and sales department, leading to a high product availability.
4. Distribution within Germany, goods are available from China in a very short time through excellent third party logistic providers.
5. Good customer relationships, quality of the service.
6. Communication between different functions, results are transparent, leading to highly motivated employees.

The findings of question 4 show a high concentration on internal elements of the supply chain when naming good elements. Only for companies 1 and 4 it is found that external elements are named as functioning well in the supply chain.

Analysis:

Question 4 emphasizes that the companies are mainly focused on internal elements when they manage the supply chain. It can be assumed that they do not include other companies in their supply chain management, except in the supplier selection. This leads to the interpretation that many German medium-sized companies see themselves as single entities, optimizing their own processes and not the entire supply chains.

5. What do you think is particularly bad when managing your part of the supply chain?

1. Sales are not using all the available IT-tools, integration of supply chain partners with a common IT-tool.
2. Coordination between the departments, often the easiest way is selected.

3. Implementation of new goods and the associated development of a new supply chain to provide high availability. Coordination between demand and inventory of certain products is not functioning.
4. Sorting of goods in the warehouse.
5. Supply of materials and missing systematic working procedures.
6. Knowledge about supply chain management is not 100%, causing communication problems and misunderstandings.

Question 5 shows that all the companies have individual problems. There are several common elements though that concern coordination. The problems that seem to occur are mainly focused on internal coordination. The only company referring to external partners is company 1, seeing a problem in the external coordination with suppliers. Companies 5 and 6 emphasize a need for structure and knowledge to be improved, while 2, 3 and 4 focus on very specific problems.

Analysis:

As noticed in the previous question, it can be found that the companies focus mainly on their own company when improving the supply chain. Companies 5 and 6 refer to the need of better structured processes and the need of knowledge, showing that they found general solutions how to overcome problems in supply chains. These findings are of course related to the long term consulting experience of these participants. In general, it can be found that the companies rather focus on their own needs when solving problems.

6. „I take care of, support or work in supply chain optimization projects..."

- ☐ regularly 33,4 %
- ☐ once in a while 66,6 %
- ☐ seldom
- ☐ never
- ☐ no comments

This question is used to confirm that the participants work in supply chain projects and are therefore able to answer the interview guide. The findings can also support the fact, mentioned earlier in question 3, that the participants believe that their supply chain is functioning good since they are involved in the supply chain management.

7. How important do you think are the following characteristics when working with an important supplier or customer? (in percentage terms)

	1	2	3	4	5	6	7
Trust	17,7	83,3					
Commitment	17,7	83,3					
Costs (inventory, in/outbound freight, stock out)	33,3	33,3	17,7	17,7			
Quality (order fulfillment, complaints, material errors)	0,5	33,3	17,7				

Time (lead time, on-time delivery, cash-to-cash cycle)	17,7	66,6	17,7				
Personal sympathy		33,3	33,3	33,3			
Gaining of competences, sales (Win-win)		0,5	17,7	33,3			
Reducing costs	33,3	66,6					
Creating more value (for customers/companies)	33,3	0,5	17,7				

1 = very important, 6 = unimportant, 7 = no comments

The findings of question 7 show that trust, commitment and reducing costs vary from very important to important to the participants. Cost, quality, time and creating value range from very important to rather important, while personal sympathy and gaining of competences are only from important to rather unimportant.

Analysis:

The characteristics that are important can clearly be separated in three groups as described above. It becomes obvious that for a successful relationship with suppliers and customers trust, commitment and cost reduction are essential elements. As long as these elements are fulfilled, a relationship can function successfully. The other elements are also important since they can affect the first three elements, but they are secondary or third for successful relationships. Therefore it is necessary to establish trust, commitment and reach cost reduction in a supply chain management when including customers and suppliers.

8. Do you think the financial crisis will affect the characteristics of question 7? In what way will they be affected?

1. Yes, the trust in the market will be reduced, commitment will need to rise, other aspects will stay the same.
2. Yes, suppliers will aim for better relationships with the company, suppliers will be more likely to suffer.
3. Yes, reduced trust, reduced liquidity of companies, more securities through higher stocks and less availability of products.
4. Yes, reduced quality due to high price pressure, might also cause time problems.
5. Yes, price reduction, banks deny financing, risk sharing becomes more relevant, supplier or customer should finance products depending on the financial situation.
6. Yes, lower orders in many branches will cause difficulties. Trust will be lost in the market.

The findings of this question all confirm that the financial crisis will affect the characteristics of supply chain relationships. There are two main elements that the financial crises will affect negatively: the trust in relationships, since companies might not be able to pay their bills or cannot finance investments, and falling prices combined with more intense competition.

Analysis:

It is shown that the financial crisis will make the management of supply chains more difficult. Important elements of trust and commitment need to be built up again to install effective supply chain management. The tendency of some managers during the interviews was that at the moment a mentality of "save what you can save" arose. In that situation most companies focus on their own survival and not on that of the supply chain, making the supply chain management irrelevant.

9. What do think could help to further improve your supply chain management?

1. Understanding of partners with IT-support and mathematical models which are generally confirmed.
2. Continuous employee development and new ideas and solutions.
3. IT- analysis programs to calculate mathematical models for inventory and product availability.
4. Better communication between administration and warehouse.
5. More standards and systematic work.
6. Continuous improvement, teams to improve process on the basis of collaboration.

The companies named several elements to improve their supply chain management: IT-tools as support, mathematical models, continuous improvement and employee development, improved communication and coordination, and standards and systematic working processes.

Analysis:

The questioned companies are aware of many supply chain management problems and they are also aware of solutions. The focus of these solutions mainly considers internal aspects except for the suggestion of company 1, requesting an IT-support for partner understanding. The challenge arising from this internal focus is that the companies are unaware of the effects of their actions on the whole supply chain and how it can be managed.

In sum, the questions of the general part imply that the medium-sized businesses in Germany are aware of supply chain management, but that it has not reached a widespread operational level. Major challenges are employee education on supply chain management and transferring the thinking behind this management philosophy.

Special part

Now I would like to ask you some questions considering supply chain performance measurement.

10. What are the biggest challenges in your opinion when installing a supply chain performance measurement system which includes the external supply chain?

1. Data has to be consistent, available and analyzed the willingness to believe in numbers and manage according to them, less measures are sometimes more.
2. Interfaces, short distances and fast communication with all supply chain members.
3. Estimation of future demands for certain parts, supplier involvement.
4. Fast delivery of goods from Asia, inventory management.
5. Internal and external coordination of the processes.
6. Costs, time, quality and coordination.

The findings of question 10 emphasize a great variety of challenges when implementing a supply chain performance measurement system. Important findings were data consistency, referring to the fact that data is the basis and needs to be shared over the entire supply chain. Another important challenge found is the communication and coordination of flows. The participants are concerned of how information is shared and how goods are delivered. Furthermore, it is mentioned by company 1 that such a system needs to be lived throughout all the involved participants. Therefore it seems to be very important to successfully convince the supply chain participants to support and implement a measurement system.

Analysis:

The findings indicate that companies already see many different problems in the implementation of a supply chain performance measurement system. The problems found show that some companies are worried about communication patterns in such a system and how correct and valuable data can be transported throughout the complete supply chain. The answers of the question present that data management, communication and coordination of information and material flows, and the fact that a measurement system needs to be lived are keys to success.

11. Why should such a supply chain performance measurement system be installed?

1. Transparency, management support, quality improvement.
2. One contact person, less personnel, higher customer satisfaction.
3. Less inventory and high availability, less bound capital, risk reduction.
4. Optimal inventory, high quality delivery, less mistakes, goods delivery and control of finances.
5. Control of processes, benchmarks for measuring, figures for cost reduction.
6. Continuous improvement, realization of cost reduction potentials, lead time reduction, process optimization.

Question 11 illustrates many different reasons why a supply chain performance measurement system should be implemented. The most significant objectives the participants connected to a measurement system include transparency, cost reduction, inventory management, control and optimization of processes, risk reduction and continuous improvement.

Analysis:

The answers to this question clearly state what a performance measurement system should provide and what improvements it should achieve. An interesting aspect is that almost all companies expect cost reduction or are aiming for it. For the usage of supply chain performance measurement system, this can only be reached on a long term basis, since such a system needs to function properly before it can identify cost reduction potentials. This high expectation towards cost reduction can lead to disappointment and failure of such projects.

12. Do you think measuring the performance of a supply chain can help you manage the supply chain ?

1. Yes, processes become visualized through measures.
2. Yes, it helps to identify problems.
3. Yes, it improves the management of low inventory and high availability.
4. Yes, weaknesses and problems are found and can be optimized.
5. Yes, data can be collected to support management.
6. Yes, indicators can present what functions and what does not function.

All the participants indicate that a supply chain performance measurement system can provide them with valuable information about problems and where improvements can be achieved.

Analysis:

It is very interesting that all the participants agree that a supply chain performance measurement could improve the companies' processes. The question arising from this is why do the companies not have such systems to measure their performance?

13. Would you separate performance measurement into internal and external supply chain performance measurement, or consider it a single system for the entire supply chain?

1. One system; a holistic view of the supply chain is necessary.
2. One system; because the processes are not so complicated. (for the own company)
3. One system; customer satisfaction, just-in-time deliveries are possible, low inventory and high availability.
4. One system; control of the complete material flows.
5. One system; connection between internal and external supply chains is very close, therefore it is one system.
6. One system; internal and external supply chains affect each other.

Question 13 gives an idea about the reasons why companies face challenges in implementing supply chain measurement systems. They are all aware of the fact that in order to control the supply chain it needs to be viewed as one system consisting of all supply chain participants, internal and external supply chains.

Analysis:

This view from all the participants raises the problem of highly complex systems that are difficult to manage. The companies seem to be aware of their environment, but at the same time mainly intend to focus on their own matters. (See general part) This is an indicator that a supply chain is so complex for the companies that they do not see an opportunity to manage it. (This is a part of the answer to question "Why companies are not implementing a supply chain performance measurement system, even though they are aware of the advantages)

14. Do you have internal supply chain performance measures for your supply chain?

☐ Yes	→ continue with question 15	33,4 %
☐ No	→ continue with question 19	66,6 %

This question combines the answers of questions 14 -18

1. Use of cost, quality and time measures. Did not answer question 16-18 because of internal political reasons.
2. Only the price is accounted.
3. Use of cost, quality and time measures (inventory level, bound capital, inventory turnover, warehouse and customer complaints). Question 16 is between good and decent. Questions 17 -18 were not answered due internal political reasons.
4. Not using any measures, but they are in the development process. (price is a measure)
5. Could not answer this question because of the consulting background. Stated that companies often use a set of internal measures, but are often unaware of interrelations and effects of the measures.
6. Could not answer this question, because of the consulting background. Found that many companies are trying to develop measurement systems, but lack knowledge on how to manage them.

Only two companies questioned stated that they measure their performance with figures. Both companies confirmed that they measure cost, time and quality. The other two companies are only using price as an indicator. The two consulting companies mentioned that their experience shows that many companies use internal measures, but are unaware of interrelations or lack knowledge on how to manage such measurement systems.

Analysis:

The findings clearly state that most companies lack the ability to build up internal measurement systems which provide easily understandable measures that actually support the management activities. This is also stated by the fact that the two companies having measures did not know what particularly was supported by these measures or chose not to answer because of serious problems with the measures. Therefore it can be found that the internal measurement systems lack quality and need to be improved first, before the entire supply chain can be included.

19. Do you have external performance measures for your supply chain?

☐ Yes	→ continue with question 20	16,6 %
☐ No	→ continue with question 25	0,833 %

This question combines the answers of questions 20 -23

1. Use of cost, quality and time measures. Did not answer questions 16-18 because of internal political reasons.
2. Not used, only the price counts.
3. Generally no, only for unique situations.
4. Are not measured.
5. Could not answer this question because of the consulting background. Are seldom used in consulted companies.
6. Could not answer this question, because of the consulting background. Are seldom used in consulted companies.

It is observed that five out of the six companies state that they do not use external measures to control the supply chain or their suppliers and customers. Only company 1 is using cost, time and quality measures to control suppliers and customers.

Analysis:

The findings are evidence of the fact that none of the companies are actually controlling their supply chain beyond their own boundaries, other than performance measurement of suppliers and customers, but in these cases the measurement is limited just to the next supplier and customer and not beyond them. In sum, it can be stated that no holistic supply chain performance measurement is actually taking place.

24. Do you agree that measuring the external supply chain is important in order for a company to be competitive in the future?

1	2	3	4	5	6	7
66,6 %			**33,4 %**			

1 = totally agree, 6 = totally disagree, 7 = no comments

1. The only opportunity to stay competitive.
2. If there is no material, then there is no customer satisfaction.
3. It is not relevant in spare-parts retailing.
4. Internal processes are more important.
5. Relationship with the customers is very important, quality and the processes of the product can be controlled.
6. Processes need to be known to optimize them.

Companies 1, 2, 5 and 6 believe that the external supply chain is very important for competitiveness in the future. In contrast, companies 3 and 4 focus more on internal processes or do not see the potential in external supply chain.

Analysis:

The results of this question indicate two findings. First, some companies see the external supply chain as their future field for competitiveness where they should focus and develop. The second finding is that other companies are more focused on the improvement of internal processes or they do not see any relevance of the external supply chain to their company. In conclusion, this means that there are many different strategic intentions concerning supply chain management, causing enormous problems when cooperating with each other.

25. What models for measuring the supply chain performance are you familiar with?

1. Balanced-scorecard, SCOR-model and many others.
2. None.
3. Not really known.
4. None.
5. None.
6. None.

Only company 1 knew any models supporting the supply chain performance measurement. This can be explained by the fact that the questioned person had just received his PhD degree. Other than that nobody knew models supporting the supply chain performance measurement.

Analysis:

There was almost no knowledge of scientific models found during this survey. This also refers to the fact that some people working with supply chain management have never studied or are just not aware of this rather young management field.

26. Do you believe that new models, such as the SCOR-model, or the extension of such existing models as the balanced-scorecard, can help you to measure your supply chain performance?

1	2	3	4	5	6	7
	16,6 %	0,5 %	33,4 %			

1 = totally agree, 6 = totally disagree, 7 = no comments

1. Practice is too complex, models are too abstract.
2. Skeptical, models are too abstract, might help for some projects.
3. Not adaptable to practical matters.

4. The balanced-scorecard can support everything, but the question of reliability stays.
5. Skeptical whether a model can capture the entire supply chain.
6. Objectivity is not always provided, but it can help to visualize processes.

The major concern of the participants is whether a model is able to capture the complexity of practice and if it is adaptable to specific situations. The participants were quite skeptical whether such models are usable, except for company 4, which believed that the balanced scorecard is highly usable, but at the same time questioned the results.

Analysis:

The participants are very skeptical about the usage of any model. Models often receive resistance and are seen as academic work, unusable in practical environments. The challenge for a performance measurement system is therefore to be highly relevant for practical usage and to overcome the employees resistance.

27. What kind of measures would you suggest when trying to measure the external supply chain? (If the answer to question 20 was yes, what other measures could be helpful?)

1. Costs, quality and time.
2. Costs, quality and time.
3. Costs, quality and time.
4. Costs, quality and time.
5. Costs, quality and time. Qualitative measures are too subjective to evaluate.
6. Costs, quality and time.

All participants see cost, quality and time as the essential measurements. None wanted to measure qualitative measures because they are too subjective to evaluate, as company 5 stated.

Analysis:

Question 27 implies that all companies want to measure the traditional elements of cost, quality and time. Therefore a supply chain performance measurement system should concentrate on such measures and not include unwanted qualitative measures.

28. What characteristics are very important to you for a excellent supply chain performance measurement system. (in percentage terms)

	1	2	3	4	5	6	7
Accuracy	83,4	16,6					
Visibility	0,5	33,4				16,6	
Facilitates trust	16,8	33,3	33,3	16,6			
Easy to understand	66,7	33,3					

Encourages appropriate behavior	16,7	66,6		16,6			
Measures only what is important	66,7		33,3				
Measures are quantitative	83,4			16,6			
Measures are defined and mutually understood	66,7	33,3					
Measures are multidimensional	33,5	33,3		16,6		16,6	
Encompasses both in- and out-puts	66,7	33,3					

1 = very important, 6 = unimportant, 7 = no comments

The findings of question 28 mainly indicate that all the suggested characteristics are either very important or important for the participants. It is interesting that facilitating trust is not indicated as very important, it is spread from 1 to 4. This finding is rather odd, since previously the participants found trust to be very important. Other findings are that company 2 placed their evaluation for visibility and multi-dimensional measures at 6, rating these characteristics as unimportant. When asked why during the interview, they said that their processes are so simple that they do not need these characteristics.

Analysis:

The results state that the companies request high accuracy, visibility, easy understanding, encouragement of appropriate behavior, measuring only what is important, quantitative measures, defined, multidimensional and mutually understood and encompassment of both in- and out-puts. The odd element is that a supply chain measurement system should not necessarily facilitate trust. An explanation for this might be that the participants see trust more on a personal level which should be there beforehand between supply chain participants and is nothing that a measurement system can help to build up by numbers.

29. Do you think your suppliers/customers would be willing to participate in supply chain performance measurement project?

1	2	3	4	5	6	7
	33,3%	**33,3%**	**33,4%**			

1 = entirely willing, 6 = not willing, 7 = no comments

Why do you thinks so:

1. Lack of trust; transparence and openness is reduced.
2. The larger the company, the more likely it will participate.
3. Only exceptional customers, suppliers would be willing if they see advantages.
4. Workload and utility need to be compared. If the utility is higher, the partner will participate.
5. If the utility is visible and the workload manageable.

6. Communicating reasons and opportunities. Presentation as a support management tool.

The answers range from willing to rather not willing to participate in a supply chain performance measurement system. Again, trust is essential for participation, as well as the fact that the suppliers need to see their advantages and disadvantages. The companies also need to be aware of workloads and utility of a performance measurement system. Company 2 also mentioned that the larger a company, the more likely it will be to participate.

Analysis:

Participation in a supply chain performance measurement system is based on trust and utility for the participating company. The companies, in this case, suppliers and customers, clearly want to know what their advantages are and how it improves the performance. Only if this can be communicated, the companies will participate.

30. What is necessary, from your point of view, to convince/support suppliers/customers to participate?

1. Trust.
2. They either want to participate or they do not. (The size of the company is important)
3. Information about advantages; partners need to see the economic advantages.
4. Advantages for customers and suppliers need to be visible. The best way is to demonstrate in figures.
5. Information, utility and win-win.
6. Communicating the advantages and disadvantages of a supply chain performance measurement system.

In order to convince companies to participate, the companies named similar aspects as in question 29. Namely this were trust, communication of advantages and disadvantages, win-win situations and the size of a company.

Analysis:

For the analysis see question 29.

31. How important do you think are the following characteristics for successful supply chain performance measurement? (in percentage terms)

	1	2	3	4	5	6	7
Strategic fit (Effective/responsive)	66,6	16,6	16,6				
Development direction and speed	16,6	0,5	33,4				
Common culture	33,4		66,6				
Strategic interest	33,4	0,5	16,6				
Power distribution	16,8	33,3	33,3		16,6		

Integration	66,8	16,6		16,6			
Understanding of the customer and the supply chain	16,8	0,5	16,6			16,6	
Commitment /Trust	16,8	0,5	16,6			16,6	
Transparency	66,7	16,6	16,6				
Benefit sharing	33,4	33,3		33,3			
Communication	83,4		16,6				

1 = very important, 6 = unimportant, 7 = no comments

The most important characteristics for the companies seem to be communication, strategic fit, integration and transparency. A little less important are development direction and speed, strategic interest, commitment/trust and understanding of the customer and the supply chain. Important matters are power distribution and benefit sharing, followed by a common culture. The points given on the scale higher then four show individual opinions and can not be evaluated concerning any specific finding.

Analysis:

It is interesting that the companies mainly focused on terms that can be supported or solved by technical solutions, such as communication or transparency. They also feel that strategic fit is very important. The key point in the answers of this question is that they do not see social competences such as company culture or understanding of the customer/supply chain as the most important. This emphasizes that most of the companies have the tendency to expect technical solutions to solve their problems without investing in the social competences of their companies.

32. Do you think measuring the performance in the supply chain is complex?

1	2	3	4	5	6	7
83,4 %	**16,6 %**					

1 = totally agree, 6 = totally disagree, 7 = no comments

Taken into consideration in the following two questions.

33. What problems do you see in the complexity in the supply chain? (structural/organizational)

1. Complicated, not easy to understand relations within the chain, dynamic within short time periods.
2. The larger the structure or the supply chain, the more complex it is, a lot of work, ignoring the system if it is too complex (search for the easiest way).
3. Integration, many heterogenic organizations, internal and external interfaces are very complicated.

4. Very high workloads for the entire supply chain, very complex when starting, data security, humans are involved. The larger the supply chain, the easier is the loss of visibility and control.
5. Many things need to be included, structural and organizational elements from question 31 need to be evaluated.
6. Many things need to be included, high workload for measurement and comparability needs to be secured.

The six companies all agree that complexity is an enormous challenge for supply chain performance measurement. The main concern of the companies is that many different aspects need to be considered. It is essential to include supply chain participants, understand relations between them and to manage internal and external interfaces. Other problems mentioned are involvement of human errors, high workload for measurement and the challenge to receive comparable results.

Analysis:

All participants agreed that supply chain performance measurement is highly complex, stating that heterogenic organizations and the dynamic changes in the environment of a supply chain cause tremendous challenges in understanding and in control.

34. How can the complexity in supply chain performance measurement be overcome?

1. Clear structures and rules.
2. Transparency, reduction and focus on the important elements of a supply chain.
3. Stepwise implementation of easy and understandable instruments, integration from internal to external, transparence of suppliers and customers.
4. Transparency and better communication.
5. Focus on the important elements, concentrate on core-competences.
6. Standardization, simplification, transparency, the more structured, the easier it is to work.

Transparency, standardization and communication are the most named points. The companies value these elements as essential in managing the complexity of the supply chain.

Analysis:

The answer of this question confirms the findings from question 31 which also evaluated transparency and communication as the most important. Therefore it can be assumed that these characteristics are very important for a successful supply chain performance measurement system.

35. Would you be willing to share sensitive data with a supplier/customer to improve the supply chain performance?

1	2	3	4	5	6	7
16,6 %	16,6 %	0,5 %	16,6 %			

1 = entirely willing, 6 = not willing, 7 = no comments

Taken into consideration in the following two questions.

36. What kind of problems do you see with data sharing in the supply chain?

1. Company secrets, lack of trust with handling of data.
2. Company secrets, sharing can lead to disadvantages.
3. Threat of passing information, such as purchasing prices, to third parties.
4. Human behavior of being unwilling to pass information (it is power). No prices for goods can be passed. It is trust based. It can cause lose of customers, lead to price agreements and higher price pressure.
5. It is needed for a holistic approach of supply chain performance measurement based on trust. Losing know-how and sensitive data is problematic.
6. Requirement for optimization of processes, use of the data by the competitors, who knows the supply chain, knows how the company works.

The majority of the companies said that they are very skeptical about the sharing of data. They found that sharing of sensitive data causes competitive disadvantages and that the information is used against them. They also stated that trust is the basis for sharing information. Exceptions were companies 5 and 6 which stated that sharing sensitive information is the basis for optimization and improvement of the supply chain performance. These statements lead to the consulting background, but they also said that according to their experience, German companies, especially in the medium-sized businesses, are very anxious about sharing data.

Analysis:

Sharing sensitive data seems to be a major issue for the companies. They are not willing to share information on an open basis and almost refuse it. For supply chain performance measurement systems, sharing of information will be a major challenge that needs to be overcome.

37. How can problems with data-sharing in supply chain performance measurement be overcome?

1. Laws and rules, but they are often broken.
2. Absolute trust necessary, but it does not exist and therefore it is not done anymore.
3. Trust is necessary but seldom completely given, contracts and punishments for passing data can be used.

4. Through trust.
5. With contracts and trust.
6. Intensive trust, no security provided, the company is either willing to share or not.

The basis for information sharing is trust. Furthermore, contracts and agreements can help to secure sensitive information.

Analysis:

As found the in the previous question, trust is the basis for information sharing, but even with contracts it cannot be secured to 100%. Therefore the companies tend to refuse to share this information at all, since they fear loss of power and to suffer disadvantages in competition.

38. How important is it to learn from supplier/customer to improve the supply chain performance?

1	2	3	4	5	6	7
66,7 %	16,6 %	16,6 %				

1 = very important, 6 = unimportant, 7 = no comments

Taken into consideration in the following two questions.

39. What kind of problems do you see with learning focused on supply chain performance measurement?

1. Time, workload and utility.
2. Big companies can help with their experience and the others are too small.
3. Know-how transfer, informal relations of employees, rivalry of employees, people need to live such system of customer feedbacks or forecasting.
4. Knowledge is in employees, not in the organization, learning can always be done and improve the performance.
5. Lack of acceptance of partners' skills and the power distribution, who can and is willing to learn from whom.
6. Collection of experience, time problem, since it needs to be done parallel to work, everybody has the same knowledge, high education expenses.

The companies agree that learning from others is very important to improve their performance. The problems they eventually associate with learning is that it is mainly done parallel to daily work, the utilization is not measurable, knowledge is in the employees, not in the organizations, lack of consent to learn from partners and that a learning culture needs to be lived in order to actually function. Therefore it can be stated that learning needs to be supported by the company's culture to achieve valuable results.

Analysis:

Learning seems to be very problematic for the companies, it is an intangible asset and therefore does not receive too much attention. This is also found in question 31, which

states that social competences are not valued as much as technical assets. Therefore it can be said that learning is not as supported as it should be to allow companies to adapt to changes or implement a supply chain performance measurement system.

40. How can the problems with learning in supply chain performance measurement be overcome?

1. Investment in learning, the willingness to do so, sustainability of the supply chain.
2. Observation and learning, learning by doing (Best-practice).
3. Education seminars and information.
4. Employee binding and social aspects.
5. Openness, trust, close relationships, flat hierarchy and fair power distribution.
6. Standardized learning and controlling does not necessarily mean improvement, it can also mean blaming others, learning modules building up on each other.

To overcome the problems in learning, the companies suggested a broad variety of solutions. They range from seminars on learning by doing to employee binding and social offerings. Also very interesting is the comment that controlling does not only mean improvement, it can also encourage blaming others. This is a valuable statement since it can cause many problems when implementing a performance measurement system, maybe even leading to failure.

Analysis:

The key for learning is the willingness of the company to invest in learning. The companies are all aware of solutions of how to learn, but most of them are not directly investing in learning. The trade-off which needs to be settled is how much does the learning improve performance and how much does it cost to educate the employees. The basis for success when implementing a supply chain performance measurement system is that the employees learn and understand the need of such a system. If that is that not given, situations such as blaming of others occurs.

41. Reacting flexibly to environmental change is vital; do you think a performance measurement system should be able to adapt to changes quickly?

1. Yes, for structural changes, and No, since the forecast and measures need to be comparable over a long time. (Not every environmental change should be evaluated, only the important ones)
2. No, short term changes should not be considered. Data is not comparable otherwise.
3. Yes, environment of market, laws and requirements changes. Integrated system. Suppliers and customers disappear or change; this needs to be adapted in a supply chain performance system.
4. Yes, should be able to react quickly, changes and extensions should be possible.
5. Yes, basis for the functionality of the system. Short product life-cycles. Supplier change is not as flexible.

6. Yes, high flexibility and experience collection and sharing are requirements. Organizational freedom of decisions. Highly dependent on each participant's flexibility in the supply chain.

For 5 of the 6 companies, reacting flexibly to environmental changes is essential for the success of performance measurement systems. They name that companies need to be able to flexibly switch suppliers and customers, that a system needs to react to environmental changes and can be extended accordingly to the demands. In comparison to the flexibility, it is also argued by company 2 and partly by 1 that for the measurement of the performance it is important to have comparable data over a longer time period. Therefore they request a static system or that the changes in the supply chain performance measurement system should be carefully considered before they are realized.

Analysis:

The finding of this question emphasizes that a supply chain performance measurement system on the one hand needs to be highly flexible to adapt to environmental changes, while on the other hand it needs to provide comparable data about the performance of the supply chain on a long term time horizon. The challenge is therefore to balance flexibility and static elements in one system to achieve optimal measurement results.

42. What kind of problems do you see with flexibility focused on supply chain performance measurement?

Answers are given in question 41.

43. How can the problems with flexibility in supply chain performance measurement be overcome?

1. Not solvable, continuous changes.
2. Static system, only long term changes are evaluated.
3. Seminars and information.
4. Constant actualization and consideration of new procedures. Evaluation of effects and changes on the entire system.
5. Transparency of processes allows quick reaction to environmental changes.
6. Communication about why flexibility is necessary for the supply chain and its performance measurement system.

The companies could not suggest and identify common solutions on how to overcome flexibility problems. The suggestions range from a static system to transparency and communication. It is evident that there is no real solution found. Company 1 even states that there is no solution to manage flexibility.

Analysis:

According to these findings, problems of flexibility can not be solved, they can only be accepted. It is problematic that flexibility can always jeopardize performance measurement systems, since adaptation to changes is needed, while at the same time the results need to be comparable. This is an enormous challenge for supply chain performance measurement.

44. Do you see the following characteristics as problems in supply chain performance measurement? (in percentage terms)

	1	2	3	4	5	6	7
Interactions between Suppli-ers/Customers	0,5	16,6	33,4				
Trust	33,4	66,6					
Gaining knowledge		0,5	16,6	33,4			
Information sharing	16,6	0,5	16,6	16,6			
Flexibility	16,6	33,4	0,5				
Complex structures	33,4	0,5		16,6			
Utilization	16,6	33,4	33,4	16,6			
Cost focus when deciding on implementation	0,5	33,4	16,6	16,6			

1 = enormous problem, 6 = no problem, 7 = no comments

The most significant problems found by the companies were trust, complex structures and cost focus when deciding on implementation. These problems are followed by interactions between suppliers and customers, flexibility and information sharing. Not as problematic, according to the companies, are gaining knowledge and utilization. In general, all the characteristics are seen more or less as problems.

Analysis:

The findings of question 44 illustrate that almost all of the issues are seen as problematic for a supply chain performance measurement system. The companies see these characteristics as essential to overcome in order to successfully implement a supply chain performance measurement system. It is interesting that, similarly to previous questions, trust and costs issues are evaluated as the most challenging problems. In conclusion, this question demonstrates that supply chain performance measurement is facing a wide range of problems and challenges.

45. Do you see other problems occurring when measuring the supply chain?

1. Practical applicability and feasibility with the help of IT-systems with the right informational value.
2. None.
3. Know-how transfer and knowledge concentration in several employees.
4. Human failure, for example, when entering data into a system.
5. Not accepting a new system by the employees can disturb the processes, a system needs to be lived.
6. None.

The companies identified 4 additional problems when measuring the supply chain. The practical application with IT-systems, the knowledge-transfer between participants, the involvement of humans leading to failure and the ability of the employees to live such a measurement system.

Analysis:

The human element seems to be a major issue for the companies. The fear of human failure, not living a system and the knowledge concentration in few employees state that there is a high need to invest in these social competences when implementing a measurement system. Furthermore, the practical application in general and the support through IT-systems is questioned, indicating that a common IT-solution for the supply chain is far from reality. Since it is almost impossible to implement a performance measurement system without IT-support, tremendous challenges arise. Therefore it can be concluded that the development of an IT-system with high investments in the social competences of the involved employees is important for success.