Supply Chain Performance Measurement – A Case Study

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Abstract:

Today, organizations are confronted with numerous changes in the business environment, such as increasing levels of global competition, rising customer requirements, shrinking product lifecycles, and the fast pace of technological change. To meet these environmental changes, organizations need to expand outside their legal boundaries and form competitive networks. This includes the development of strategically aligned capabilities among all organizations that are part of their value-adding networks. Increased networking with suppliers, sales partners, and customers requires active management to guarantee optimization of the entire supply chain. Supply chain management (SCM) has therefore evolved into a strategic factor of differentiation and competitiveness in many business segments. However, many companies have not succeeded in maximizing their supply chain's potential. The lacking implementation of the SCM concept in practice is one common reason. Another widespread reason is the deficiency of performance measures and metrics to fully integrate the supply chain. Performance measurement and metrics play an important role in setting objectives, evaluating performance, and determining future courses of action. In this case study, an electrical industry enterprise will be considered. The company offers a wide spectrum of products, systems, solutions, software and services. To create transparency, identify performance gaps, and come up with improvements to close these gaps, this contribution aims to answer the following questions:
How can supply chain performance be measured in general?
What is an appropriate approach to meet the requirements of the considered company's daily operations to create transparency?
What is the enterprise's performance? What are the recommendations for actions to overcome performance gaps?

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1 Introduction

Today, organizations are confronted with numerous changes in the business environment, such as increasing levels of global competition, rising customer requirements, shrinking product lifecycles, and the fast pace of technological change.[1] To meet these environmental changes, organizations need to expand outside their legal boundaries and form competitive networks. This includes the development of strategically aligned capabilities among all organizations that are part of its value-adding networks. Increased networking with suppliers, sales partners, and customers requires active management to guarantee the optimization of the entire supply chain.[2] Supply chain management (SCM) has therefore evolved into a strategic factor of differentiation and competitiveness in many business segments.[3] However, many companies have not succeeded in maximizing their supply chain's potential.[4] The lacking implementation of the SCM concept in practice is one common reason.[5] Another widespread reason is the deficiency of performance measures and metrics to fully integrate the supply chain.[6] Performance measurement and metrics play an important role in setting objectives, evaluating performance, and determining future courses of action. Therefore, it is doubtful whether managers have actual and specific information about their deficits related to SCM performance and the ability to make the right decisions to overcome these gaps.[7] Due to the increasing level of complexity, supply chain visibility is becoming an increasingly important criterion in the long-term competitiveness of the supply chain.[8] It ensures accurate and fast delivery of relevant information and thus represents a critical basis for decision making.[9] The more accurate the information shared within a supply chain network, the higher the transparency.[10] According to Enslow (2006), a lack of critical supply chain process visibility is the top concern of most companies for maintaining their supply chain operations.[11] Companies are therefore prioritizing visibility programs to enhance customer satisfaction and operational efficiency.

In this case study, an electrical industry enterprise will be considered. The company offers a wide spectrum of products, systems, solutions, software and sevices. In order to create transparency, identify performance gaps, and come up with improvements to close these gaps, this contribution aims to answer the following questions:

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1 Cf. Lockamy III/McCormack (2004), p. 272; Arndt (2008), pp. 8–26; Handfield/Bechtel (2002), pp. 368-369.
2 Cf. Corsten/Gabriel (2004), p. 4.
3 Cf. Staberhofer/Rohrhofer (2007), pp. 37-38.
4 Cf. Gunasekaran et al. (2004), p. 335.
5 Cf. Jording/Sucky (2016), p. 99.
6 Cf. Gunasekaran et al. (2004), p. 335.
7 Cf. Gunasekaran et al. (2004), p. 333; Jording/Sucky (2016), p. 99.
8 Cf. Bartlett et al. (2007), p. 294.
9 Cf. Chan (2003), p. 540.
10 Cf. Svensson (2004), p. 743.
11 Cf. Enslow (2006), pp. 1-2.

- How can supply chain performance be measured in general?
- What is an appropriate approach to meet the requirements taken from the considered company's daily operations to create transparency?
- Which performance metrics exist in the field of SCM and which are most suitable for measuring the company's performance?
- What is the enterprise's performance? What are the recommendations for actions to overcome performance gaps?

This paper is therefore organized as follows. Chapter 2 presents maturity models as a method of measuring SCM performance. The examination of different maturity models helps identify an approach that meets the requirements of the practical example. Chapter 2 also provides an overview of existing performance measurements and metrics in the context of SCM. Chapter 3 demonstrates the approach and the results of the performance study for the examined company. This includes the performance analysis as well as the recommendations for action. Chapter 4 summarizes the findings and arrives at a conclusion regarding the importance of supply chain performance measurement and the creation of transparency.

2 Supply Chain Performance Measurement

In this chapter, we describe how SCM performance can be measured and why companies should address SCM and its performance measurement. In the first instance, this requires an explanation of the term and importance of SCM. Subsequently, maturity models are introduced as a method of measuring SCM performance. The introduction includes the characterization of maturity models in general, the definition of SCM maturity models in particular, and the analysis of existing SCM maturity models in the literature. The analysis is based on the literature review of Jording and Sucky (2016) and intends to find an approach that meets the requirements of the practical example as described in the introduction. Finally, chapter 2 explains the crucial aspects of effective performance measurement and provides an overview of performance metrics in the context of SCM.

2.1 Supply Chain Management

A supply chain can be defined as a network of several business entities collectively responsible for product or service-related value creation, linked by a flow of goods, information, and funds.[12] Ideally, the supply chain includes all business processes cutting across all organizations, from the initial supplier to the ultimate point of consumption.[13] Then, supply chain management describes the integrated, coordinated

[12] Cf. Asdecker (2014), p. 37; Swaminathan et al. (1998), p. 607; Tsay et al. (1999), p. 301; Sucky (2004), p. 18.

[13] Cf. Cooper et al. (1997), p. 5; Asdecker (2014), pp. 37-38.

planning, implementing, and controlling of value creation networks, comprising several business entities that are linked by a flow of goods, information, and funds.[14] Cost reduction and the continuous improvement of competitiveness and customer service are the main objectives of SCM.[15]

The considered company defines supply chain management for itself as integrated, process-oriented planning, controlling, execution and monitoring of the processes of the value chain—within and across companies—to fulfill customer orders and sustainably improve performance and costs. The enterprise refers to the Supply Chain Operations Reference (SCOR) Model, developed by the Supply Chain Council, an independent, not-for-profit, global corporation.[16] The SCOR Model is a cross-functional framework for evaluating and improving enterprise-wide supply chain performance. It is structured in four levels and focuses on the six supply chain processes: plan, source, make, deliver, return, and enable. This framework enables the considered company to model their processes and benchmark their performance against other supply chains.[17] Then, the company can develop a roadmap to improve their performance vis-à-vis the benchmarks.

The high level of effort necessary for the development of an efficient SCM as well as the uncertainty and risk connected with this concept raise the question of why SCM is seen as a key to success.[18] Would it not be easier to minimize the efforts for communication, coordination, and exchange of information between companies in order to save time and work? Would it not be beneficial for companies to focus on themselves in order to reduce complexity? According to practical and scientific studies, the potential of SCM is significant. Studies show a reduction of inventory (up to 60 %), shorter lead times (up to 50 %), and improved forecasting accuracy (up to 80 %).[19] Eisenbarth (2003), for instance, conducted a survey with first-tier automotive suppliers. The results show that approximately 70 % of the participants attach high importance to SCM.[20] Approximately 90 % state that SCM will be especially important in the future.[21] However, these findings do not correspond to the level of practical SCM implementations.[22] A common way to illustrate this progress is the use of maturity models, which classify companies into different stages depending on their realization of SCM implementation. The "Global Survey of Supply Chain Progress" uses a five-stage maturity model:[23] The "Five Levels of Supply Chain Evolu-

14 Cf. Asdecker (2014), p. 39.
15 Cf. Cooper et al. (1997), p. 3; Heusler (2004), pp. 17-18.; Kotzab (2000), p. 33.
16 Cf. Stewart (1997), pp. 62–66; Stephens (2001), pp. 471–473; Bolstorff/Rosenbaum (2003), pp. 2–8; Holmberg (2000), pp. 862-863; Reyes/Giachetti (2010), p. 416.
17 Cf. Reyes/Giachetti (2010), p. 416; Bolstorff/Rosenbaum (2003), pp. 2–8.
18 Cf. Staberhofer/Rohrhofer (2007), p. 29.
19 Cf. Beckmann (2004), pp.15–17; Staberhofer/Rohrhofer (2007), p. 29.
20 Cf. Eisenbarth (2003), p. 198.
21 Cf. Eisenbarth (2003), p. 198, Mayer et al. (2009), p. 26.
22 Cf. Jording/Sucky (2016), p. 98.
23 Cf. Poirier/Quinn (2006), pp. 19–24; Jording/Sucky (2016), p. 98.

tion" begins with the basic level of enterprise integration (level 1) and ends with the highest level of full network connectivity (level 5). It is shown that 57 % of the participating companies are assigned to stage one or two. Although companies assign high importance to SCM, the mentioned survey reveals a lack of implementation, i.e., a gap between aspiration and reality.[24] Therefore, it is doubtful whether managers have up-to-date and specific information about their deficits related to SCM and the ability to prioritize actions necessary to overcome this gap. Maturity models provide a common way to assess the implementation of concepts or to identify gaps.

2.2 Maturity Models to Measure Supply Chain Performance

Essentially, maturity models are intended to describe the typical behavior exhibited by a company at a number of levels of "maturity".[25] This allows companies to codify what might be considered good practice (and, conversely, bad practice). In addition, there are some intermediate or transitional stages. The concept applies to a range of activities, including quality management, software development, supplier relationships, and many more, both as a means of assessment and as part of a framework for improvement. One of the earliest maturity approaches was Crosby's Quality Management Maturity Grid (QMMG).[26] For this reason, most of the following approaches have their roots in the field of quality management. The QMMG expects companies to evolve through five levels of maturity before ascending to quality management excellence: uncertainty, awakening, enlightenment, wisdom and certainty. At each level, the performance of a number of key activities is described. For this purpose, the approach provides a descriptive text for the characteristic traits of performance for each level. The Capability Maturity Model (CMM) for Software, developed by the Software Engineering Institute at Carnegie Mellon, is perhaps the best-known derivative from this line of work.[27] "The Capability Maturity Model for Software provides software organizations with guidance on how to gain control of their processes for developing and maintaining software and how to evolve toward a culture of software engineering and management excellence."[28] The CMM for software provides a framework consisting of five maturity levels that define the extent to which a specific process is defined, managed, measured, controlled, and effective.[29] The fundamental assumption of this approach is that quality can be cultivated through control.[30] Therefore, companies at higher maturity levels are better managed, have less risk, and are more likely to deliver a quality product that meets the

[24] Cf. Jording/Sucky (2016), p. 99.
[25] Cf. Fraser et al. (2002), p. 244.
[26] Cf. Fraser et al. (2002), pp. 244-245.
[27] Cf. Fraser et al. (2002), p. 244; Reyes/Giachetti (2010), p. 416.
[28] Paulk et al. (1993), p. 5.
[29] Cf. Paulk et al. (1993), pp. 4–7.
[30] Cf. Klimko (2001), p. 271; Reyes/Giachetti (2010), p. 416.

budget and schedule. The software CMM inspired the development of other frameworks, such as the CMM for systems engineering (SE-CMM) and the CMM for integrated product and process development (IPD-CMM).[31] The most recent attempt to consolidate the multiple models is the integrated CMM (CMM-I), which has motivated the development of similar frameworks in other disciplines.[32] "Although a number of different types of maturity models have been proposed […], they share the common property of defining a number of dimensions or process areas at several discrete stages of levels of maturity, with a description of characteristics performance at various levels of granularity."[33] Therefore, various components are the same or similar in each model:[34]

- A number of maturity levels (typically 3-6) to describe the development of a single entity[35] in a simplified way
- A descriptor for each level (such as initial, repeatable, defined) to organize the levels sequentially, from an initial level up to an ending level of perfection
- A generic explanation or summary of the characteristics of each level as a whole
- A number of dimensions or process areas, which in turn consist of a number of elements or activities
- A description of each activity that the entity has to achieve on that level.

During development, the entity progresses from some initial state to some more advanced state.[36] "Some do it faster than others and with fewer detours, but fast or slow, every company that gets to world class must evolve through theses stages to get there."[37] Therefore, no stages can be left out. In assessing performance (i.e., maturity), a distinction is made between two types of models:[38] On the one hand, there are models in which different activities may be scored at different levels. On the other hand, there are models in which maturity levels are "inclusive", where a cumulative number of activities must all be performed. In practice, however, maturity models are not primarily used as absolute measures of performance but rather as part of an improvement process.[39] In this regard, the purpose of using a maturity model is to identify a gap that can be closed by subsequent improvement actions.

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31 Cf. Fraser et al. (2002), p. 245.
32 Cf. Reyes/Giachetti (2010), p. 416; Fraser et al. (2002), p. 245.
33 Fraser et al. (2002), p. 246.
34 Cf. Fraser et al. (2002), p. 246; Klimko (2001), p. 271.
35 This entity can be anything of interest like a human being, an organizational function etc.
36 Cf. Klimko (2001), p. 271.
37 Shapiro (1996), p. 147.
38 Cf. Fraser et al. (2002), p. 246.
39 Cf. Fraser et al. (2002), p. 248.

2.2.1 Overview of SCM Maturity Models

Many of the aforementioned approaches and ideas of maturity have been adapted to supply chains and their management.[40] To analyze the characteristics of maturity models in the field of SCM, Jording and Sucky (2016) developed a design-based characterization of SCM maturity models. The goal of their work is to provide the reader with a purpose-driven design-based catalog that serves as a guideline for a more efficient construction of maturity models.[41] For this reason, the authors performed a literature review to analyze existing maturity models based on five different core attributes:

- General attributes: all aspects related to the development of the model
- Conceptual attributes: all aspects that describe the formal content of the stages
- Operationalization attributes: all aspects that describe the evolution process
- Retention attributes: all aspects that describe the change process
- Survey attributes: all aspects related to the evaluation of the model itself

The analysis of these models and their shortcomings reveal quality attributes of SCM maturity models, which then provide the basis of the purpose-driven catalog.[42] This catalog specifies the essential building blocks of SCM maturity models. For the purpose of this paper, the literature review helped us preselect SCM maturity models and find an appropriate approach that meets the requirements of the practical example described in the introduction.

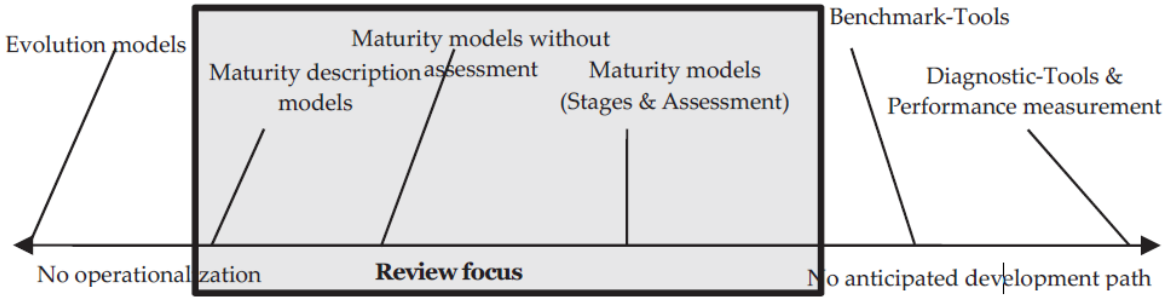

Figure 1: Maturity Model Differentiation.[43]

Based on the components of the maturity models described above, the authors developed a definition of SCM maturity models necessary for the literature review process: "A maturity model can be defined as a construction-based model which consists of an anticipated, limited development path, separated into stages with defined characteristics and dimensions. It has one or more objectives related to the stage evaluation, gap identification and transformation. If a model of this kind fo-

[40] Cf. Reyes/Giachetti (2010), p. 416.
[41] Cf. Jording/Sucky (2016), p. 99.
[42] Cf. Jording/Sucky (2016), p. 99.
[43] Source: Jording/Sucky (2016), p. 105.

cuses [on] intercorporate collaboration, customer focus, management of flow of goods and/or management of information flow, it is called a SCM maturity model."[44] The examination of the numerous models identified in the literature review reveals that those models differ between the anticipated evolutionary content and the operationalization of the stages.[45] As depicted in Figure 1, some models prioritize the evolutionary content, whereas others prioritize a complex operationalization without having an anticipated stage-driven process. The three maturity models, "Maturity description models", "Maturity models without assessment" and "Maturity models (Stages & Assessment)", represent the review focus. Maturity description models and maturity models without assessment both lack a substantial method of assessing maturity, but they illustrate an anticipated development process. The authors summarized these two categories under the notion of "general maturity models". Maturity models providing an anticipated development process and a related assessment method represent "specific maturity models". For detailed information regarding the literature review, see Jording and Sucky (2016).

2.2.2 Applicability of Selected Maturity Models to the Case Study

Following the literature review by Jording and Sucky (2016), eight general and eight specific maturity models are identified, which have to be examined in order to find an appropriate approach and framework for the practical example.

2.2.2.1 Applicability of General Maturity Models to the Case Study

The SCM focus area of the general maturity models most importantly narrows down the choice of an appropriate model. The selection of appropriate maturity models takes place according to the requirements of the case study, as described in the introduction. Therefore, models with unsuitable focus areas are excluded. Ultimately, only two general maturity models are worth considering: the "Global Supply Chain Progress Framework" and the "Supply Chain Visibility Roadmap". However, neither general maturity model turned out to be applicable to the practical example to the same extent. For the considered general maturity models, the number of stages varies between three and five, but both have in common that collaborative aspects gain in significance with a rising maturity level.[46] The models can be criticized for their insufficient documentation quality and absence of substantial assessment of maturity. For this reason, none of the general maturity models are suitable for the practical example in terms of SCM performance measurement. However, the Supply Chain Visibility Roadmap provides an appropriate project approach for the practical

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44 Jording/Sucky (2016), p. 104.
45 Cf. Jording/Sucky (2016), pp. 104-105.
46 Cf. Jording/Sucky (2016), pp. 105–107.

example. Steps one and three of the roadmap especially serve as a valuable template since they describe what needs to be considered when defining the strategy and the rollout plan of such a project. Therefore, only the "Supply Chain Visibility Roadmap" provides a helpful approach for the investigated company, which is why this model is presented here.

Supply Chain Visibility Roadmap

The goal of this approach is to identify the necessary steps for a successful visibility program that improves supply chain productivity, responsiveness, and reliability.[47] Companies must evolve through three levels of maturity when seeking operational improvement and financial value from visibility technology. In the first level (Shipment Tracking), the system provides shipment tracking to locate the product. This information improves customer satisfaction and helps internal operations planning. In the second level (Supply Chain Disruption Management), disruption management is notified proactively if shipments deviate from planned milestones and assists in problem resolution.[48] This information improves the on-time delivery performance and lowers expediting costs. The greatest financial value comes in the third level (Supply Chain Improvement), when visibility information helps identify and eliminate root causes of delays. Effectiveness at this level has a positive impact on lead time, inventory investment, and freight cost. The successful implementation of such a supply chain visibility technology requires five critical steps, described in the Roadmap for Supply Chain Visibility: First, it is important to devise a visibility strategy. Since visibility develops over time, the strategy should focus on the highest problem areas first and then expand from there. The creation of an "as is" assessment of key metrics, targeted for improvement, is part of the strategy process. Key metrics should include both cross-functional and department-based metrics, such as cycle times, on-time delivery performance, or safety stock levels. The definition of the visibility strategy also includes the identification of responsibilities for the improvement of each metric and the establishment of a cross-functional team with an executive sponsor. Second, the company has to select a visibility technology that meets their requirements.[49] There are different visibility technologies available. These can be classified into three categories: internally developed systems, systems provided by logistics providers and systems from commercial technology vendors. The most important aspect of a visibility project is the creation of a rollout plan, described in step three.[50] The project team has to determine which areas of the supply chain to concentrate on first. This requires the identification of small, simple projects. Depending on the company, this can mean concentrating on certain regions,

47 Cf. Enslow (2006), p. I.
48 Cf. Enslow (2006), pp. 11-13.
49 Cf. Enslow (2006), pp. 13–16.
50 Cf. Enslow (2006), pp. 17–20.

shipments for key customers, or certain product lines, perhaps those with the highest value or time sensitivity. Assessing the availability of quality status data is another consideration for determining the scope. Therefore, it is beneficial to start with the smallest data set possible that still drives value. "Successful pilot programs often focus on areas in which better visibility will lead to significant improvements in lead times and on-time delivery performance […]."[51] The fourth step deals with the improvement of disruption management. Many commercial visibility systems now include functionality to not only serve as a problem detector but also to provide resolution insights and support. If necessary, these features help decide what actions should be taken if the actual status deviates from the planned status. As a result, resolution functionality can help enforce corporate policies for expediting, rerouting, reallocating inventory, etc.[52] This has positive effects on customer service capabilities and delivery performance. Driving structural supply chain improvement, however, requires analytical discipline, as described in step five. Using visibility data to measure actual lead times across the supply chain network is one quick opportunity to update the inventory and customer service system with these times. Identifying bottlenecks and recurring points of variability, analyzing their underlying causes, and taking corrective actions, on the other hand, helps companies achieve the highest value from visibility technology.

The conceptual background of the model describes the maturity of supply chain transparency with a special focus on the flow of goods[53]. It therefore addresses the topics relevant for the practical example: first, the goal of this approach is to create transparency throughout the entire supply chain to increase customer satisfaction and improve the supply chain performance sustainably. Second, on-time delivery performance and lead time represent two very important parameters for measuring and improving supply chain performance. Third, the Roadmap to Supply Chain Visibility provides an appropriate project approach for the practical example, although it describes the necessary steps to successfully implement a visibility technology. Steps one and three especially serve as valuable templates.

2.2.2.2 Applicability of Specific Maturity Models to the Case Study

The eight specific maturity models—identified by Jording and Sucky (2016)—focus on a specific content, similar to the general maturity models. According to the SCM focus, two of the models focus on process maturity. Since process maturity seems to be the appropriate SCM focus in this case study, the following two models are worth considering: "Supply Chain Management (SCM) Process Maturity Model" and "Supply Chain Capability Maturity Model", named S(CM)2. These specific maturity

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51 Enslow (2006), p. 18.
52 Cf. Enslow (2006), pp. 20-21.
53 Cf. Jording/Sucky (2016), p. 107.

models focus on more-collaborative aspects at higher stages as well.[54] For the "SCM Process Maturity Model", the SCOR Model serves as the basis for conceptualizing. However, the S(CM)2 also divides its processes into several supply chain competency areas. In both models, the assessment of maturity takes place via self-assessment by answering a questionnaire. Moreover, the "SCM Process Maturity Model" and the S(CM)2 also have the capability to identify gaps and provide a roadmap to overcome those gaps. After the examination of the specific maturity models, it turned out that the "SCM Process Maturity Model" and the S(CM)2 provide especially relevant frameworks for this case study. For this reason, the two models are presented in the following.

SCM Process Maturity Model

The SCM Process Maturity Model shows the progression of activities toward effective SCM and process maturity based on five stages.[55] Each of the stages contains characteristics associated with process maturity. These characteristics include predictability, capability, control, effectiveness, and efficiency. Due to its process orientation and wide adoption by the supply chain academic and practitioner communities, the SCOR model serves as the basis to conceptualize the SCM Process Maturity Model. The five stages describe the process maturity of four areas: plan, source, make and deliver. In Stage 1 (Ad hoc), the supply chain and its processes are unstructured without any process measures in place. Functional cooperation is low, and the process performance is unpredictable. As a result, customer satisfaction is low. In Stage 2 (Defined), basic SCM processes are defined and documented, and process performance is more predictable.[56] The improvement of functional cooperation requires considerable effort. Targets are defined but still missed most of the time. Customer satisfaction has therefore improved but remains low. Stage 3 (Linked) represents the breakthrough, as broad SCM jobs and structures are put in place, and intracompany functions, vendors and customers are cooperating. Process performance is more predictable, and defined targets are often achieved. Increased customer satisfaction begins to show market improvement. In Stage 4 (Integrated), organizational structures and jobs are based on SCM procedures, and traditional functions begin to disappear. Cooperation between the company, its vendors, and suppliers takes place on a process level. Advanced collaboration with customers and suppliers helps process performance become highly predictable. Targets are reliably achieved, SCM costs are dramatically reduced, and customer satisfaction becomes a competitive advantage. In the fifth stage (Extended), individual companies are no longer just competing against each other but against entire supply chains. These supply chains represent a horizontal, customer-focused, collaborative culture that shares common

[54] Cf. Jording/Sucky (2016), p. 109.
[55] Cf. Lockamy III/McCormack (2004), p. 275.
[56] Cf. Lockamy III/McCormack (2004), pp. 276-278.

processes and goals, as well as joint investments in improving the system. In order to investigate the relationship between SCM process maturity and overall SCM performance, the authors created a survey instrument.[57] Their investigation revealed significant relationships. Performance measured by each area of the SCOR Model is the measurement of performance most related to SCM process maturity. An explanation for this result is that the four areas of the SCOR Model provide a clear process context. Delivery performance and order lead times are also significantly correlated with SCM process maturity. Both describe process measures that clearly reflect process performance.

Even though the authors conclude that their measures of business process maturity might be too high-level to reveal correlations with business performance, their research illustrates an important aspect relevant for the practical example:[58] Direct process performance measures such as lead times are related to SCM maturity.

S(CM)2

The S(CM)2 consists of three dimensions: supply chain views, lifecycle maturity levels, and abstraction levels.[59] To achieve the defined enterprise goals, a company needs to successfully manage the following seven supply chain views:

- Supply chain management and logistics: functions, processes, activities, and tasks related to the integration, collaboration and development of the suppliers
- Production systems: functions, processes, activities, and tasks regarding the transformation of the product or service
- Inventory management: actions related to inventory management and control
- Customer relationship management: actions regarding meeting the customer's needs
- Human resource management: actions related to the enterprise's employees, their integration into the company, and the work environment
- Information systems and technology management: actions linked to the development and implementation of information systems and the technology management process
- Performance measurement systems to measure the enterprise's performance regarding processes, functions, and employees

[57] Cf. Lockamy III/McCormack (2004), pp. 276–278.
[58] Cf. Reyes/Giachetti (2010), p. 416; Lockamy III/McCormack (2004), p. 278.
[59] Cf. Reyes/Giachetti (2010), p. 418-419.

Level	Level name	Description
1	Undefined	Describes a competency area for which the enterprise has no documentation or standardization. The processes are *ad hoc*, dependent on the person doing the activity, and reactive to the environment
2	Defined	Describes a competency area for which the enterprise has defined the process and procedures. The competency areas are isolated and there is little formal efforts to integrate the many processes
3	Manageable	Describes a competency area for which the enterprise has defined established procedures that they measure and manage to those measurements. Moreover, the enterprise has taken action to integrate and coordinate the internal processes and systems of the enterprise
4	Collaborative	Describes a competency area for which the enterprise has established procedures to collaborate with suppliers and customers
5	Leading	Describes a competency area for which the enterprise has established procedures to collaborate with suppliers and customers, it measures these practices, and regularly obtains feedback to improve these practices

Table 1: Maturity Levels of the Supply Chain Maturity Model.[60]

For detailed information regarding the supply chain views, see Reyes and Giachetti (2010). Each of the seven competency areas develops through five supply chain maturity levels, illustrated in Table 1. All enterprises are assumed to begin for each view at the first level and develop from there.[61] Based on the current maturity levels for each view, the model provides actions that need to be addressed to reach the proceeding levels.

The S(CM)2 is designed to evaluate the maturity level of a company's supply chain practices for different views. Theses seven supply chain views address topics relevant for the practical example. Furthermore, the model helps identify possible actions to improve the processes and define an appropriate roadmap. This model provides a beneficial framework, since it indicates, similar to the SCM Process Maturity Model, which process maturity refers to several different viewpoints. Furthermore, it is the first model that considers a performance measurement system, which is a central aspect in this case study.

2.3 Performance Measurement and Metrics in SCM

In practice, maturity models are not primarily used as absolute measures of performance but rather as part of an improvement process.[62] Furthermore, the maturity levels of an enterprise can differ depending on the different model views or process areas.[63] Consequently, there are two ways of measuring SCM performance based on a company's maturity level: on the one hand, by assessing a company's overall maturity level based on a framework that describes an anticipated development path; on the other hand, by assessing the company's maturity levels for different supply chain views or process areas.

The goal of the practical example is to enhance supply chain processes and expand knowledge concerning customer expectations and market trends. This includes the

60 Source: Reyes/Giachetti (2010), p. 419.
61 Cf. Reyes/Giachetti (2010), p. 418.
62 Cf. Fraser et al. (2002), p. 248.
63 Cf. Reyes/Giachetti (2010), p. 418.

creation of transparency from both an internal and external point of view. The creation of transparency from an internal point of view requires performance metrics that describe the current SCM performance of these processes appropriately. The creation of transparency from an external point of view requires the feedback of the customer to understand their expectations and how they perceive the company's SCM performance.

The considered maturity models contain valuable concepts and solutions to structure and address those topics. The Supply Chain Visibility Roadmap provides an appropriate project approach, especially by describing the necessary steps of defining a visibility strategy and creating the rollout plan. According to the Visibility Roadmap, the following elements are important when defining a strategy that aims to create transparency:[64]

- Focusing on the main problem areas first and then expanding from there
- Creating "as is" assessment of key metrics, targeted for improvement
- Including both cross-functional and department-based metrics
- Establishing a cross-functional team with an executive sponsor

When creating the rollout-plan, the Visibility Roadmap recommends:[65]

- Determining which areas of the supply chain to concentrate on first
- Identifying small, simple projects
- Assessing the availability of quality status data
- Starting with the smallest data set possible that still drives value

The specific maturity models use different supply chain views to analyze the process performance of each viewpoint. This is especially important, since the practical example considers processes that are cross-functional. The SCM Process Maturity Model uses the SCOR Model as a conceptual basis to describe the process maturity of the supply chain activities plan, source, make, and deliver. Since the regarded company's definition of SCM is based on the SCOR processes, the SCOR Model hereinafter also represents the conceptual framework for measuring the SCM performance. However, this mainly represents the internal perspective on SCM performance. It is also important to consider other viewpoints, such as those presented in the S(CM)2: customer relationship management, for instance, assesses performance in terms of meeting the customers' expectations. According to the SCM definition, all SCM activities focus on the needs and expectations of customers.[66] Therefore, the customer's viewpoint is indispensable to finding out about how SCM performance is perceived and how they measure their supplier's SCM performance.

Performance measurement systems represent an important viewpoint, since they determine the performance metrics to measure the enterprise's performance regarding processes, functions, and employees. Some of the maturity models considered al-

64 Cf. Enslow (2006), pp. 12-13.
65 Cf. Enslow (2006), pp. 17–20.
66 Cf. Staberhofer/Rohrhofer (2007), p. 39.

ready emphasize the importance of direct process performance measures, such as delivery performance and lead times.[67] This chapter aims to analyze the importance of performance measures and metrics in each of the four basic supply chain processes (plan, source, make, and deliver).

The following four aspects are crucial for effective performance measurement and improvement. First, measurement goals must represent organizational goals. This allows measuring the achievement of those targets and evaluating the effectiveness of the strategy employed. Second, selected metrics should reflect a balance between financial and non-financial measures. Financial performance measurements are important for strategic decisions and external reporting, whereas non-financial measures support the day-to-day control of manufacturing and distribution operations. Third, metrics should be related to strategic, tactical, and operational levels of decision making and control. The decisions of top-level management are based on the strategic level and, thus, mainly on financial measures. The tactical-level measures deal with the allocation of resources and the achievement of the results specified at the strategic level. Operational-level measurements and metrics assess the results of the decisions of low-level managers in order to achieve the tactical objectives. Finally, performance assessment can be better addressed by using a few performance measures that are critical to success and truly capture the essence of organizational performance.

Gunasekaran et al. (2004) reviewed the literature on SCM performance measurements and metrics in the context of the following activities/processes: (1) plan, (2) source, (3) make/assemble, and (4) delivery/customer.[68] Furthermore, the authors developed a survey to study SCM performance measures and metrics that are used in the environment of those four activities/processes. The purpose of the literature review was to identify metrics for the individual activity/process, whereas the purpose of the study was to weight these metrics according to their importance. The performance metrics identified in the literature review serve as the basis for the importance rating survey. The authors used three categories to prioritize the metrics (highly important, moderately important, and less important). The following subchapters especially focus on the highly and, to a certain extent, moderately important metrics of each activity area. For more-detailed information about all metrics, see Gunasekaran et al. (2004).

Planning Performance Evaluation Metrics

The survey distinguishes between strategic planning and order planning. According to the survey, the level of customer-perceived value of the product is highly important.[69] This clearly indicates that customer satisfaction is of the utmost im-

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67 Cf. Lockamy III/McCormack (2004), p. 278.
68 Cf. Gunasekaran et al. (2004), pp. 335–340.
69 Cf. Gunasekaran et al. (2004), pp. 340-341.

portance in increasing competiveness. The measures considered within the moderately important category include three financial and three non-financial measures, which reflect the importance of a balance between financial and non-financial measures in strategic planning. Variances against budget represent the highest-rated financial metric, whereas order lead time represents the highest-rated non-financial metric. At the order planning level, the customer query time is highly important, whereas the product development cycle time is moderately important. Both metrics are related to meeting customer needs by performing in a timely fashion, which again emphasizes the importance of customer service. At the bottom line, customer satisfaction and service is most important at the planning level.

Sourcing Performance Evaluation Metrics

The sourcing process includes purchasing and supplier management activities.[70] In their literature review, the authors identified six metrics related to the sourcing process. The participants of the survey clearly rated supplier delivery performance as highly important. Supplier lead time against industry norm and supplier pricing against market are two of the moderately important metrics. Most notable is that firms regard delivery performance as more important than price.

Production Performance Evaluation Metrics

The importance rating survey identified three metrics as highly important for the production performance evaluation:[71] percentage of defects, cost per operation hour, and capacity utilization. The first metric measures product quality, whereas the latter two are fundamentally measures of efficiency regarding the utilization of resources. Efficiency of operations translates into lower costs per unit to manufactured products/provided services. The range of products and services is the only moderately important measure. In short, product quality and manufacturing efficiency seem to be more important when evaluating production performance.

Delivery Performance Evaluation Metrics

Similarly to the production performance metrics, there are three delivery performance metrics that are highly important.[72] The first two measures, quality of delivered goods and on-time delivery of goods, have nearly the same rating. Flexibility of service systems to meet customer needs represents the third highly important metric. The authors assume that these three metrics influence the perceived customer value of the product. The following sentence describes the overall goal of the delivery activities, basically summarizing the highly important delivery performance evaluation metrics. “Providing the customer with a quality product in a timely fashion, and

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70 Cf. Gunasekaran et al. (2004), p. 342.
71 Cf. Gunasekaran et al. (2004), pp. 342-344.
72 Cf. Gunasekaran et al. (2004), pp. 343-345.

maintaining customer satisfaction with a service system designed to flexibly respond to customer needs are key in producing value for the customer".[73]

Gunasekaran et al. (2004) aimed to create a framework to promote a better understanding of the importance of SCM performance measures and metrics that helps organizations in developing a performance measurement program for SCM.[74] The framework, presented in Table 2, considers the four major supply chain activities (plan, source, make/assemble, and deliver), as well as the three management levels (strategic, tactical, and operational). The measures are therefore grouped in cells at the intersection of these two axes, listed in order of importance. Since some measures are appropriate at more than one management level, they appear in more than one cell. It seems that customer satisfaction is paramount in importance in increasing competitiveness, especially for the planning and delivery activities: each first-mentioned metric, at least on the tactical or strategic level, in some way deals with meeting the customers' needs. Companies can use this framework to identify the supply chain activity to be measured, the appropriate metric, and the level of management to which the measure should be applied. However, not all supply chains are identical, and the company will certainly have individual performance measurement needs that reflect the unique operations of their business. In terms of the practical example, it is necessary to first devise a strategy and create a rollout plan to determine which areas of the supply chain to focus on. This allows for the selection of performance measures reflecting the operations of the respective supply chain areas.

[73] Gunasekaran et al. (2004), p. 343.
[74] Cf. Gunasekaran et al. (2004), pp. 344-345.

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

Table 2: Supply Chain Performance Metrics Framework.[75]

3 Supply Chain Performance within an Electrical Industry Enterprise

The company in this case-study offers a wide spectrum of products, systems, solutions, software and services. The current situation and challenges result in the need for action: first, improvement of transparency regarding logistics and SCM performance is paramount. Furthermore, the company needs to be aware of the latest expectations and trends from the market it is operating in with regards to logistics and SCM performance. Finally, in order to identify best practices and gaps, a comparison of the current performance, customer expectations, and market trends is required. The performance component represents the internal point of view and aims to create transparency by analyzing the logistics and SCM performance using appropriate performance metrics.

According to the Visibility Roadmap, it is crucial to establish a cross-functional team with defined responsibilities.[76] For this reason, in the practical example, the study used a cross-functional approach. For the visibility strategy, as well as for the rollout plan, it is important to focus on the main problem areas first and then expand from there.[77] Consequently, the project team, which was driving the study, had to determine which areas of the supply chain to concentrate on first. The objectives

[75] Source: Gunasekaran et al. (2004), p. 345.
[76] Cf. Enslow (2006), pp. 12-13.
[77] Cf. Enslow (2006), pp. 12 and 17.

include the enhancement of supply chain processes by improving lead times and being a more reliable supplier. This clearly emphasizes the delivery perspective of SCM and thus determines the supply chain focus area. Delivery performance directly impacts customer satisfaction.[78] As a result, it is the key to supply chain excellence. Customer satisfaction is one of the main goals of SCM, which is why measuring and improving delivery performance is always desirable in order to increase competitiveness.

According to the Visibility Roadmap, it is important to create an "as is" assessment of key metrics targeted for improvement.[79] The objectives of the company already determine one cross-functional metric, lead time, to increase transparency along the supply chain processes. Reducing lead times is one way of improving delivery performance and customer satisfaction, especially because there is continuing pressure from the marketplace to shorten lead times.[80] For this reason, the objective of this study was to measure the SCM performance by analyzing the lead times: on the one hand, to identify average lead times and deviations from this lead time; on the other hand, to compare the actual lead times with those requested by the customer. The Visibility Roadmap suggests starting with the smallest data set possible that still drives value.[81] In this case, the timeframe from order entry to delivery at the customer site represented the smallest data set possible that still drives value. Deviations from the overall average and requested lead time then required a detailed investigation to find possible bottlenecks.

3.1 The Company's Supply Network

The supply chain depicted in Figure 2 describes the simplified processes up through delivery to customer via various sales channels, either of raw materials being transformed into final products or of final products being purchased directly from contract manufacturers. The supply chain contains four levels: supply, manufacturing or purchasing, distribution, and customers. Each level of the supply chain comprises numerous facilities. There are a variety of external suppliers that are not part of this analysis and are therefore illustrated in a simplified manner. The manufacturing or purchasing level in Figure 2, described as make or purchase, comprises basically seven facilities: A, B, C, and D represent national plants, while E and F represent international plants. Furthermore, the company has a large international DC and some contract manufacturers. The third level contains the national DCs, in this case, G and H. Finally, there are customers who obtain their products through different sales channels. In this case, the study focuses on five sales channels.

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78 Cf. Stewart (1995), p. 41; Gunasekaran et al. (2004), p. 337.
79 Cf. Enslow (2006), p. 12.
80 Cf. Stewart (1995), p. 41.
81 Cf. Enslow (2006), pp. 18-19.

Five customer types are in scope, representing 92 % of the total volume. Distributors represent the major customer type. The retail business is separated into retail and online retailing. Although online retailing represents only a small percentage of the total business, the company attaches great importance to it, since it is the enterprise's fastest-growing branch. Besides exports, original equipment manufacturers (OEMs) embody the fifth customer type. The remaining eight percent of the business volume is depicted as "Others".

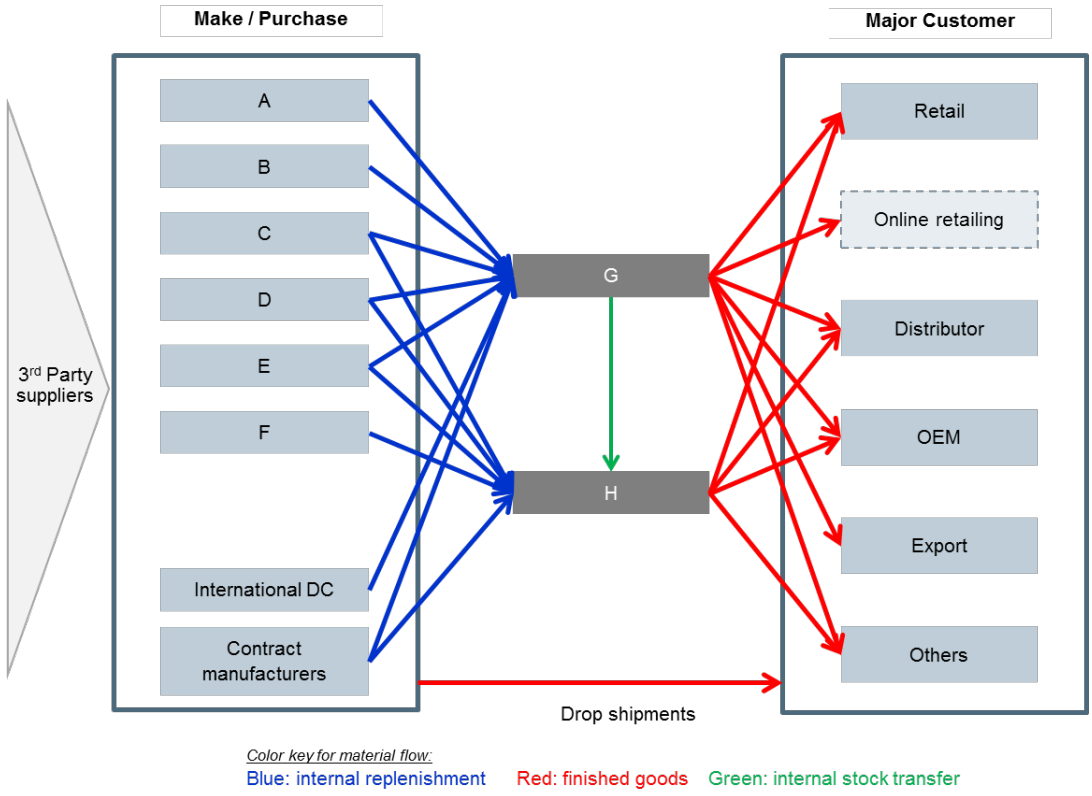

Figure 2: The Company's Supply Chain Network

According to the legend at the bottom of Figure 2, there are three types of standard material flows. Internal replenishment describes the process of refilling the DC's shelves with finished goods, basically from the plants. A sales order causes the delivery of a finished good from either a DC or directly from the plant to the customer.

3.2 Lead Time Analysis

The sequence of presenting the results of the lead time analysis is the same for all customer channels: a graph visualizes the actual (blue line) and requested (red line) lead times by displaying the days on the x-axis and the percentage of the total volume on the y-axis. Furthermore, two vertical bars mark the actual average (brown solid line) and average requested lead time (green dotted line). The average numbers represent fiscal year 2015.

Results for Distributors

The lead time analysis for Distributors yielded the results depicted in Figure 3. It shows a higher volume requested for a dispatch within one and two days than was actually performed. The volume for orders requested with a lead time longer than two days drops sharply, whereas the actual volume decreases more slowly.

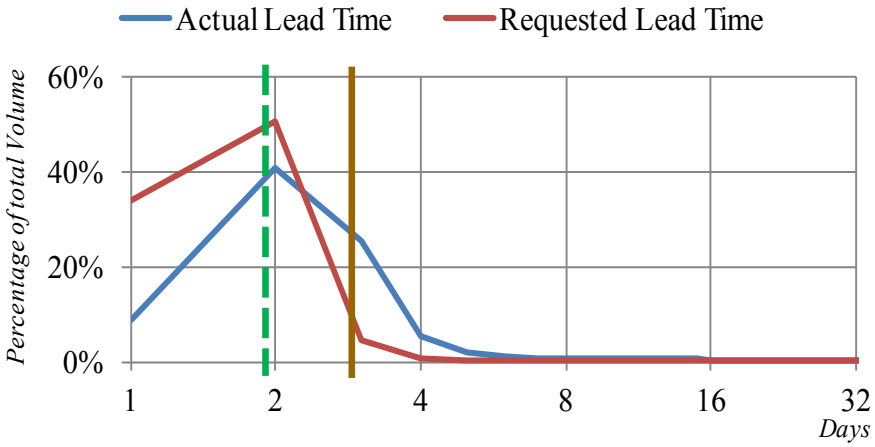

Figure 3: Lead Time Analysis for Distributor

This indicates that the DCs are making up for those shipments requested within two days. On average, customers request a lead time of 1.9 days, while the company performs within 3.2 days. The project team evaluates those results as a significant gap between customer expectation and own performance. For the replenishment of the distributor's shelves, those differences in lead time might not be critical. Delayed deliveries to a job site, however, are critical. Currently, the DCs cannot distinguish between shipments going to the customer site or replenishing the Distributor's shelves.

Results for OEMs

Figure 4 describes the results of the lead time analysis for OEMs. Most of the order volume is requested within one or two days, although the volume already decreases heavily between one and two days. After two days, the volume drops from approximately 25 % to roughly 2 %, where it levels out with some smaller oscillations later on.

The actual volume increases continuously until it reaches its peak at nearly three days and a volume of 28 %. Subsequently, the actual volume decreases almost in parallel to the red line. The graph indicates again that the DCs are making up for the shipments requested for a delivery within two days by dispatching them one or two days later. The comparison of the average lead times shows a similar picture. On average, the customer requests a lead time of 3.5 days, whereas the DCs perform, on average, within 5.1 days—a delta of 1.6 days.

Figure 4: Lead Time Analysis for OEM

The project team understands the results as a significant gap between customer expectation and own performance. The huge differences between the lead times for Distributors and OEMs are especially conspicuous. From a logistics perspective, the lead times should be very similar. Therefore, the next steps are to analyze the different lead times for Distributors and OEMs.

Results for traditional Retail

Contrary to Distributors and OEMs, the requested and actual performances for Retail are nearly identical. According to Figure 5, both the blue and red lines reach their peak at approximately three days and a volume of 60 %. The course of the two lines before and after reaching the peak is similar as well.

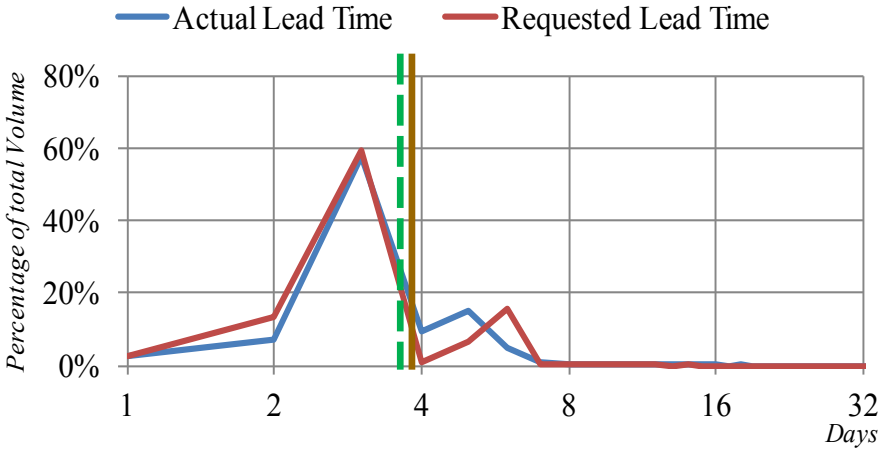

Figure 5: Lead Time Analysis for Retail Classic

Thus, the average actual (3.9 days) and average requested lead times (3.8 days) are nearly identical. Since the current performance matches the customer's expectations, the project team evaluates the current status as uncritical. Nevertheless, the company needs to expand awareness of market trends in order to remain stable for the future.

Results for online retailing

Online retailing is special, since it requires a fast lead time, as depicted in Figure 6. While the highest volume is requested within one day, there is no volume requested for shipments within two days. Eventually, there is a demand for shipments within 4 days. However, the DCs ship most of their volume between one and three days.

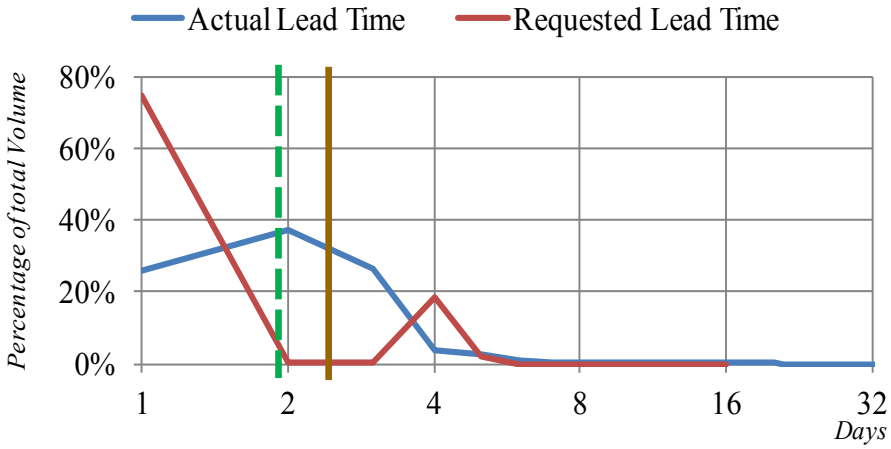

Figure 6: Lead Time Analysis for Retail Alternative

On average, the customer expects a shipment of 1.9 days, whereas the DCs perform, on average, in 2.4 days. Currently, there is an agreement upon lead time of three days with most of the retailers for the online business. Nevertheless, the analysis shows that the customer requests a shorter lead time if possible. For that reason, the project team evaluates the results as an area of concern, not necessarily because of the current status but because of potential market trends that might cause a reduction of lead time.

3.3 Definition of Actions

The main focus in this study is performance. This chapter presented the company's SCM performance by analyzing the requested and actual lead times from order entry until the product is ready to ship. This analysis gave a first impression of how the enterprise is performing from an internal point of view. As a result of the study, the following three actions have been defined:

Lead time improvement for shelf products out of the DCs
It has to be examined whether the DCs are able to meet a 24 hour pick/pack time for all customers and what are the costs associated with this. This requires a detailed analysis of the lead times and system setup in order management per business/customer.

Value proposition for different shipping modes out of the DCs to meet specific customer demands

To provide the customer with additional services, the action aims to define different options for expedited shipments of goods out of the DCs to specific customers.

Additional performance measurement of the Supply Chain to add customer view

Delivery compliance and customer-specific performance criteria, like the number of shipments and the fill rate, have to be integrated into the company's performance measurement with the intention of incorporating the customer's perspective.

The first action especially focuses on the improvement of delivery performance in terms of lead times and on-time performance. According to the framework of Gunasekaran et al. (2004), however, these metrics are limited to the operational level.[82] The value proposition for different shipping modes out of the DCs aims to improve the flexibility of service systems to meet customer needs. This represents the most important metric within the context of delivery activities on both the tactical and strategic levels. The first two actions, therefore, affect metrics from all three abstraction levels (operational, tactical and strategic) in the context of delivery performance, which is the driver of customer satisfaction and the first key to supply chain excellence.[83] The last action strives to incorporate the customer's perspective by including customer-specific performance criteria in the company's performance measurement reports. Using the same performance measurement standards is paramount to focus all activities on the needs and expectations of the customers.

4 Conclusion

Maturity models have been introduced as a common way to assess the implementation of concepts, measure SCM performance, and identify gaps. The examination of different SCM maturity models helped find an approach that meets the requirements of the practical example. The Supply Chain Visibility Roadmap provides an appropriate project approach, especially by describing the necessary steps of defining a visibility strategy and creating the rollout plan. According to this general maturity model, it is especially important to focus on one supply chain area first and expand from there.[84] The specific maturity models considered all use different supply chain views to analyze the performance from each viewpoint. The SCM Process Maturity Model uses the SCOR Model as a conceptual basis to describe the process maturity of the supply chain activities plan, source, make, and deliver. Since the company's definition of SCM is based on the SCOR processes, the SCOR Model represented the conceptual framework for measuring the SCM performance. However, in practice, maturity models are not primarily used as absolute measures of performance

[82] Cf. Gunasekaran et al. (2004), p. 345.
[83] Cf. Stewart (1995), p. 41.
[84] Cf. Enslow (2006), pp. 17–20.

but rather as part of an improvement process.[85] The measurement of performance requires respective measures and metrics. The inability of performance measures and metrics to fully integrate the supply chain is a widespread reason why companies have not succeeded in maximizing their supply chain's potential.[86] For that reason, this contribution examined performance metrics within the context of SCOR activities. The selection of appropriate metrics and the definition of the project approach required the determination of a supply chain focus area for the practical example. The study is part of a strategic program that aims to enhance the supply chain processes by improving lead times and becoming a more reliable supplier. This requires the creation of transparency to identify performance gaps and develop improvement ideas to close these gaps. The program already determined a cross-functional metric, i.e., lead time, to increase transparency along the supply chain processes.

The contribution presented the approach and results of the study. The performance assessment from an internal point of view already indicated some potential bottlenecks in terms of lead times. The study highlighted the importance of supply chain performance measurement in order to create visibility and therefore to generate the basis for correct decision-making in order to overcome performance gaps.

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[85] Cf. Fraser et al. (2002), p. 248.
[86] Cf. Gunasekaran et al. (2004), p. 335.

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