

**INCREASING SUPPLY
NETWORK TRANSPARENCY:
STRUCTURE MODEL,
MAPPING PROCEDURE AND
PERFORMANCE IMPACT**

ANTONIA KAPPEL

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AND PERFORMANCE IMPACT

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DISSERTATION

*to obtain
the degree of doctor at the University of Twente,
on the authority of the rector magnificus,
prof.dr. T.T.M. Palstra
on account of the decision of the graduation committee,
to be publicly defended
on Thursday, 19th of December 2019, at 14.45 hours*

by

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Printed by CCC Druck und Medien GmbH
Cover by ZUMO GmbH

ISBN: 978-90-365-4910-3
DOI: 10.3990/1.9789036549103
URL: <https://doi.org/10.3990/1.9789036549103>

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Acknowledgments

„Every mountain top is within reach
if you just keep climbing.“

Barry Finlay

In the beginning, achieving a doctorate degree seemed like an invincible mountain to me. Shining from a far distance, yet awakening my sporting ambition. I decided to take this challenge without knowing if I would make it to the top. Reflecting on this decision today, I did not regret it. Although the hike was sometimes tough, the weather kept changing continuously and there were many rocks on the way, I learned some helpful lessons. Perseverance, keeping focus and trust in your own strengths turned out to be very important skills for life. This experience contributed significantly to my personal and professional development.

Now I am very excited to present to you this doctoral thesis as the outcome of my academic work during the last years. The dissertation was inspired and influenced by many people that I encountered during my hike. I would like to take the opportunity to thank the most important ones who helped me climbing up this mountain.

First of all, I would like to mention my supervisor Prof. Dr. habil. Holger Schiele. Dear Holger, thank you for countless fruitful exchanges on my research topic and methodologies. I always learned a lot from your honest and constructive advice and it truly took my academic work to the next level. Your excellent coaching enabled me to build up quantitative research skills, while I was starting this project as a practitioner with education in applied sciences. You pushed me to make the best of my capabilities. Inviting us PhD students to annual research retreats to receive intense feedback from you and your assistant professors Aldis, Erwin, Matthias and Petra improved both my research knowledge and the unique spirit of our UT team. Moreover, I will keep the traditional Christmas dinners in your home in good memory, with innovative themes such as “Christmas in space”. Thank you and your family for your hospitality and impressive cooking skills.

Secondly, I would like to express my thanks to Prof. Dr. Wolfgang Buchholz as my co-supervisor and daily mentor at the Institute of Process Management and Digital Transformation in Münster. Dear Wolfgang, no matter if discussing research, giving lectures, supervising student projects or traveling to conferences together - working with you always was great fun. I could profit a lot from your large experience in conceptual and qualitative research and your excellent contacts to industry. You gave me the necessary freedom to perform my research while I could always rely on your loyalty and belief in my skills. Motivating me in the right moments was just as helpful as calming me down in stressful situations. I know an equivalent for the German term “doctoral father” does not exist in English, but it would probably best express the role you played during the last years.

Next to my supervisors, I would also like to thank the members of my graduation committee: Prof. Dr. P. de Weerd-Nederhof, Prof. Dr. J. Henseler, Prof. Dr. K. Hamza, Prof. Dr. T. Johnsen and Prof. Dr. M. Essig. It is a great honor for me that you are part of my committee and show

your interest in my research topic. I appreciated your valuable comments on my doctoral thesis, which helped me to improve its quality. Now traveling long distances to join my defense cannot be taken for granted. Thank you for making the official ceremony to become part of the scientific community a special moment that I will never forget.

Particular thanks go to my employer setting excellent conditions for this journey. Leading the purchasing project “Supply Network Mapping” in an industrial company enabled me to use my insights from practice directly in theory and vice versa. In this context, I would like to mention my project sponsor Ulrich Timcke as well as my former boss Ronald Hammacher, supporting me during project execution. In addition to them, I would like to highlight my second project sponsor and new boss Rüdiger Mohr who was a very important promotor of this project. Not many PhD students have the chance to conduct applied research in this way. I am very grateful for this unique opportunity.

Furthermore, I would like to list the other research fellows accompanying me on the hike: Janina, Bitá, Ines, Madelon, Remco, Klaas, Juliano, Thomas, Franz, Tobias and my two paranymphs Frederik and Vincent from Twente – as well as Holger, Andreas, Eika, Patrick, Colin, Constantina, Sebastian, Micha and Catja from Münster. While climbing different stages and enjoying good times together, I am glad that some of you became close friends of mine. Looking forward, several of you already completed their academic journey, while others are still on different heights of their mountains. Good luck to all of you in completing your projects - just keep climbing, I am sure you will make it!

Special thanks go to my family – above all my mother Edith and my brother Benedikt. Thank you very much for your patience, understanding and unconditional support in the last years. You helped me keeping my motivation and recharging my batteries when energy was low. I could always count on you. This thesis is dedicated to you.

Last but not least, I am very grateful to have my longtime friends Marina, Daniela, Laura, Anne and Vanessa from my hometown Wiedenbrück; the “Stuttgart Crew” Jule, Johanna, Martina, Kathrin, Eva, Bene and Konrad; and my dear friends Tatiana and Josiane in Münster. On my journey towards the top of the mountain, you always kept celebrating small stage victories with me and encouraging me when muscles were aching.

All of you have been part of this exciting hike and joined me climbing it to the summit cross. Thanks a lot. Without you, this project would have been impossible.

Münster, December 2019

Antonia Kappel

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List of Abbreviations

AVE	Average Variance Extracted
CA / α	Cronbach's Alpha
CP	Cost Saving Performance
CR	Composite Reliability
DP	Delivery Performance
DS	Direct Sourcing
H	Hypothesis
HTMT	Heterotrait-Monotrait ratio of correlations
IMP	Industrial Marketing and Purchasing
KPI	Key Performance Indicator
MA	Mapping
MGA	Multi-Group Analysis
OEM	Original Equipment Manufacturer
PLS	Partial Least Squares
PLSc	consistent Partial Least Squares
PSM	Purchasing and Supply Management
Q	Question
ρ_A	Dijkstra-Henseler's rho
ρ_c	Jöreskog's rho
RfQ	Request for Quotation
RM	Risk Management
RP	Responsible Practice
RQ	Research Question
SC	Supply Chain
SCM	Supply Chain Management
SEM	Structural Equation Modeling
SET	Social Exchange Theory
SNM	Supply Network Mapping
SP	Sustainability Performance
SPSS	Statistical Package for the Social Sciences
SRMR	Standardized Root Mean Square Residual
TCE	Transaction Cost Economics
VB	Volume Bundling
VI	Vertical Information Quality
VIF	Variance Inflation Factor
VMI	Vendor Managed Inventory
VOS	Visualization of Similarities
WoS	Web of Science

Chapter 1: Thesis Background and Research Structure

1.1 State of research and research questions: Need to investigate the transparency on supply network structure, mapping procedure and transparency benefits

In today's world, the general quest for supply chain transparency is increasing (Marshall, McCarthy, McGrath, & Harrigan, 2016) and has extended beyond corporate boundaries in supply chains (Mol, 2015). High demand for learning where products are coming from exists on both business-to-consumer and business-to-business markets. On business-to-consumer markets, consumers require detailed information about where and how the food or the clothes that they buy have been produced (Kraft, Valdés, & Zheng, 2018). Current trends and movements such as "slow food" or "conscious clothing collections" express this increasing consumer awareness for a local, sustainable and ethically correct production of their goods.

The manufacturers try to match these consumer requirements by marking the exact origins on the products or by publishing voluntarily the codes of conduct concluded with their suppliers (Toffel, Short, & Ouellet, 2015). Hence, consumers can track and trace their eggs or T-shirts back to the farm in the nearby village or the garment factory in Bangladesh (DiMase, Collier, Carlson, Gray, & Linkov, 2016; Doorey, 2011; Egels-Zandén, Hulthén, & Wulff, 2015). Modern information and communication technologies such as radio frequency identification facilitate the tracking and tracing process resulting in a higher supply chain transparency (Marshall et al., 2016).

On business-to-business markets, companies need extensive information on the organizations that might influence their market position and on the relationships between these organizations. In this context, previous researchers in Supplier Relationship Management have already investigated the dynamics in buyer-supplier relationships. However, in order to get a full picture, buyers need to consider not only their own relationships with their direct suppliers, but also the relationships of these suppliers with third parties. These supplier relationships with third parties might have an impact on the market position of the buying firm (Nalebuff & Brandenburger, 1997). Current literature has already examined several triadic constellations in buyer-supplier relationships, such as buyer-supplier-supplier or supplier-buyer-buyer (T. Y. Choi, Wu, Ellram, & Koka, 2002). In this dissertation, we will explore new triadic constellations and investigate the relationships of the suppliers with sub-suppliers and with other customers from the buyer's point of view in order to contribute to the supply chain transparency literature.

Supply chain transparency is commonly defined as the "disclosure of information" about the supply chain (Doorey, 2011; Mol, 2015). It is an important challenge in today's buyer-supplier relationships (Kashmanian, 2017). To create a transparent supply chain, a company needs to gain visibility into its own supply chain first (Kraft et al., 2018). Secondly, it needs to decide which information it would like to disclose to its customers (New & Brown, 2011). Hence, supply chain visibility can be defined as "the extent to which a company has information about [...] its supply chain", while the disclosure is "a company's decision regarding what

information to communicate to consumers” (Kraft et al., 2018). Therefore, supply chain transparency is an outcome of supply chain visibility (Egels-Zandén et al., 2015).

Consumers increasingly want to know where and how the products which they purchase were made (Kassahun et al., 2014). Previous research has shown that they value a great supply chain visibility in the upstream supply chain, e.g. regarding a company’s social responsibility practices. The higher the level of this visibility is, the more satisfied the consumers are (Kraft et al., 2018). In this context, the regulatory pressure for companies to disclose supply chain information increases. Recent examples are the Restriction of Hazardous Substances Directive and the Registration, Evaluation, Authorisation, and Restriction of Chemicals regulation in Europe or the 2010 Dodd-Frank Wall Street Reform and Consumer Protection Act and the California Transparency in Supply Chains Act of 2010 in the USA (Marshall et al., 2016). However, consumers perceive a voluntary disclosure of information more positively than this mandatory disclosure (Kalkanci, Ang, & Plambeck, 2016).

Nevertheless, gaining a high supply chain visibility requires a significant investment of time and resources (Doorey, 2011; Marshall et al., 2016). Moreover, determining how transparent the companies want to make their supply chains exactly is difficult and needs a deep understanding of customer requirements. For instance, Marshall et al. propose a supply chain transparency matrix where companies can select the degree of transparency they want on one axis (Marshall et al., 2016).

There are several barriers to supply chain transparency (Marshall et al., 2016). Most OEMs today concentrate on their core competences. This trend leads to the fact that a large value-added share is outsourced to suppliers. The companies only know their 1st-tier suppliers, as the labor in their supply chains is divided (Theuvsen, 2004). It is presumed that less than 33% of the value creation is still done by original equipment manufacturers, while mostly sub-suppliers carry out the remaining two-thirds of value-adding activities (Altmayer & Stölzle, 2016). Hence, most buying firms do not have sufficient information about the lower tiers in their supply structure, because they carry out system or modular sourcing (Trimble & O’Kane, 2008). For this reason, monitoring and managing all suppliers and their competencies within a supply chain get more and more important. An optimized value chain is a high competitive advantage (Heß, 2010).

Moreover, the number of suppliers is decreasing as only half of the suppliers existing in 2002 can still cope with the increasing requirements, e.g., in fast-moving technologies such as electronics or powertrain. This fact leads to a strong consolidation of suppliers to so-called mega suppliers and to a significant change in the supplier-manufacturer relationship to a trustful partnership at eye level (Semmler & Mahler, 2007). The need for resources in terms of investment and employees at the supplier’s end is rising and with this development also the responsibility to control the success and stability of common projects. As the balance of power between both actors is changing in favor of the supplier, the manufacturer needs to win as much visibility as possible about his value creation.

The pressure to disclose supply chain information also comes from the frequent occurrence of risks in the supply chains (Marshall et al., 2016). Not only can a financial instability of the suppliers cause risks, but also natural disasters, raw material shortages and further risks. In this context one goal of the dissertation, therefore, is to explore how visibility on the supply network can be created and increased. Although high supply network visibility and the application of dedicated tools like Supply Network Mapping will not be able to prevent these risks, they can at least enable companies to react faster after the risk occurrence.

Nevertheless, many companies only have limited supply chain visibility. A recent study by The Sustainability Consortium has figured out that 81% of the 1,700 participating companies lack full visibility into the social responsibility practices of their supply chains (The Sustainability Consortium, 2016). Another 2013 survey of Australian fashion companies revealed that 93% of the companies surveyed do not know where their raw materials come from (Nimbalkar, Cremen, & Wrinkle, 2013). Moreover, many companies have a poor understanding of their capabilities for capturing and reporting supply chain information. Hence, the assessment of these capabilities is the second axis of the supply chain transparency matrix by Marshall et al. (Marshall et al., 2016).

In order to create the desired visibility on supply chains, companies started to develop appropriate tools like Supply Chain Mapping. “Strategic supply chain mapping focuses on how goods, information and money flow in both the upstream and downstream directions and through a firm. All processes may be included.” (J. T. Gardner & Cooper, 2003), p. 45. The mapping is a helpful tool to identify and visualize the supply chain structure (Altmayer & Stölzle, 2016).

The current state of literature only covers the mapping of linear supply chains (J. T. Gardner & Cooper, 2003). However, the existing Supply Chain Mapping approach is no longer sufficient for this task as it only addresses the linear, vertical supply chain, but competing supply chains rather look like overlapping networks (Lambert, 2008). Due to significant changes on the supplier market, it has become evident to map whole networks as companies need to be assessed regarding their network partners and relationships in value networks. This research gap is illustrated in figure 1:

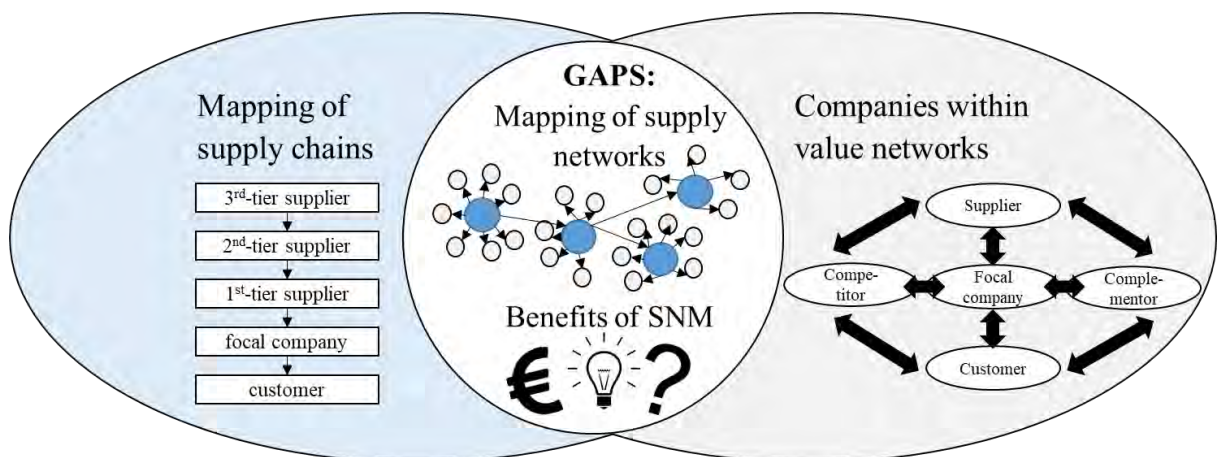


Figure 1: Research gaps

There is a positive belief in the potential of supply chain transparency and previous researchers agree that transparency conceptually makes sense (Egels-Zandén et al., 2015). It is regarded as desirable (Augustine, 2012) and as connected to desirable characteristics such as accountability (Dublink, Graafland, & van Liedekerke, 2008), legitimacy (Kell, 2012) and trust (Augustine, 2012). However, only a few empirical studies have examined how to establish supply chain transparency in practice yet, so that more empirical research is definitely needed (Egels-Zandén et al., 2015). In this dissertation, we add empirical research based on a large survey with purchasers.

The current supply chain transparency literature focuses on the disclosure of information to consumers (Hainmueller, Hiscox, & Sequeira, 2015; Marshall et al., 2016), while supply chain visibility is understudied (Kraft et al., 2018). Consequently, our research focuses on the visibility dimension. We address this gap by identifying which information companies really need and where they can get it.

A similar finding obtained during the literature study is that the subject is called Supply Chain Mapping, while there is hardly any information on mapping responsibilities, objectives, information sources, requirements, process steps, determinants, obstacles or further details of the procedure. Instead, the outcome of these papers are images with map structures. This finding leads to the conclusion that a differentiation between the map structure and the mapping procedure needs to be set up. Therefore, the second research goal refers to the Supply Network Mapping procedure.

Although prior research has already pointed out that supply chain transparency is of growing importance for the buying firm (Kashmanian, 2017), current literature still lacks evidence about the real benefits of mapping. Almost all studied papers are conceptual research or case studies, while there is no large empirical study so far that would analyze if the tool really leads to success. Concrete cost and benefit figures are missing in the papers published so far. Hence, our research will assess the cost savings and non-monetary benefits achieved by the mapping. This third research gap is also illustrated in figure 1.

In order to address the research gaps, the three main arising research questions are:

- **RQ1:** How can transparency on supply network **structure** be created?
- **RQ2:** Which **procedure** can operationalize supply network transparency and mapping?
- **RQ3:** How can supply network transparency and mapping lead to purchasing **benefits**?

In order to answer the first research question, our research goal is to set up a holistic Supply Network Map Structure Model that covers all relevant actors and the relationships between them. The structure of this model needs to be standardized and suitable for the application on different products and commodities. A company's supply network plays a key role in explaining supply chain transparency outcomes. Transparency is no longer a firm internal affair but extends across firm boundaries in the supply network (Egels-Zandén et al., 2015).

At the same time, this model needs to be operationalized. Therefore, the second target of the research is to deduce the steps and helpful recommendations for the mapping procedure. For RQ2, we identify the necessary information on supply chains and the corresponding information source. Moreover, we conduct case study research and identify targeted sourcing levers to be applied in addition to Supply Network Mapping.

The third research question relates to purchasing success. The target is to evaluate the benefits that can be achieved through Supply Network Mapping. Hence, we test the impact of supply chain transparency, Supply Network Mapping and the additional sourcing levers on the purchasing performance.

Finally, yet importantly, there is a lack of a broader allocation of the transparency issue from Supply Chain Management to Organizational Theory. This theoretical embedding is plausible and useful, as Organizational Theory studies organizations and how they are affected by external forces. Hence, it matches the motivation of the buying firm to gather visibility about its supplier relationships. Organizational Theory is often used to explain why firms exist or what makes firms successful. Moreover, the theoretical frameworks in Organizational Theory have implications for managerial decision-making. Such decisions are necessary in the context of supply chain transparency and Supply Network Mapping with regards to the choice and target-oriented application of the various sourcing levers, as well.

Consequently, the next section introduces the framework of our research and highlights its background in Organizational Theory.

1.2 Theoretical background in Social Exchange Theory and Transaction Cost Economics

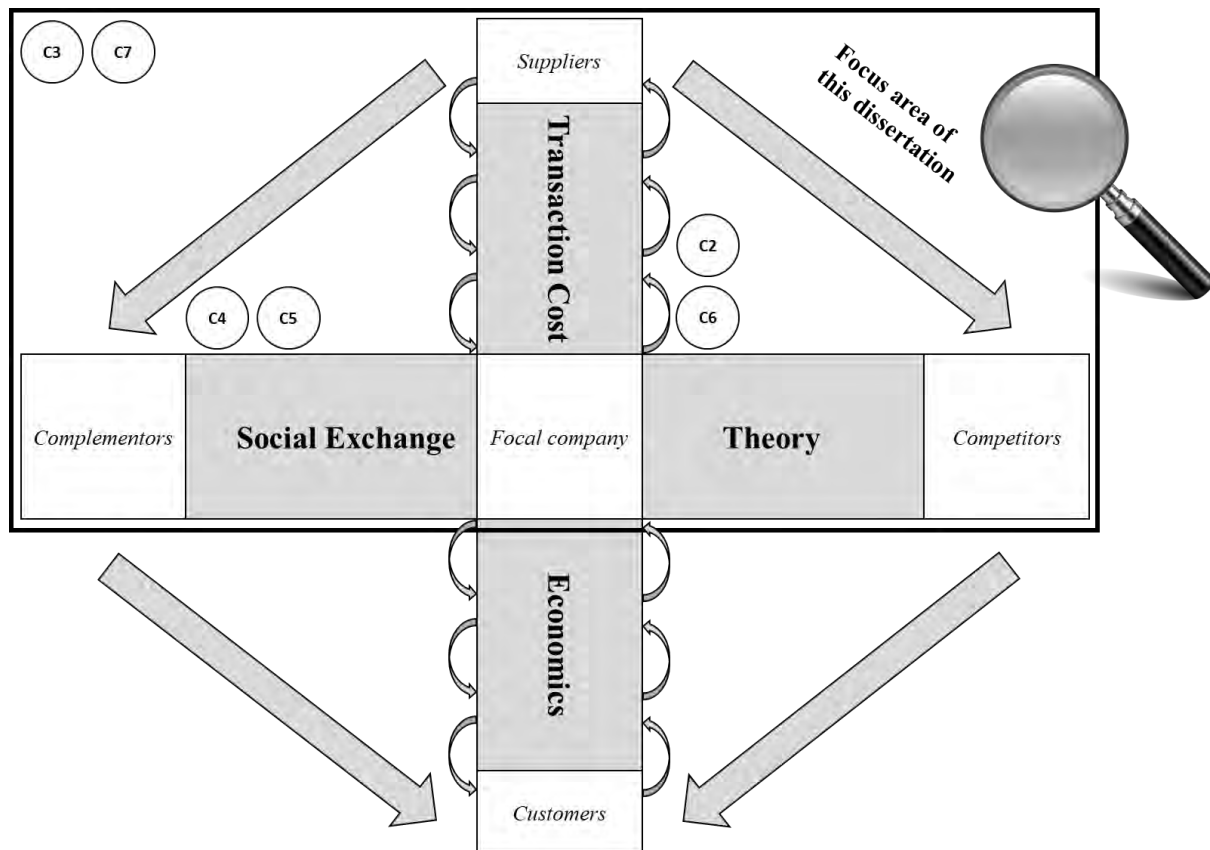


Figure 2: Research framework and theoretical background

Our research framework presented in figure 2 is inspired by the position of a focal company within its network of suppliers, customers, complementors and competitors (Nalebuff & Brandenburger, 1997). Inside this network, we consider two axes: a horizontal axis with the focal company, its complementors and competitors and a vertical axis with the focal company, its suppliers and customers.

Lambe et al. recommend that research of relational business-to-business exchange needs to use both the Social Exchange Theory (SET) and Transaction Cost Economics (TCE) whenever possible to fully explain exchange governance (Lambe, Wittmann, & Spekman, 2001). Consequently, we embed the horizontal axis of our research framework in the SET because we regard the social exchange relations across this axis as the basic unit of our analysis (Emerson, 1976). Social exchange is defined as a process with two-sided transactions and mutual rewards (Emerson, 1976), which is based on mutual attractiveness (Blau, 1964).

The preferred customer literature transfers this theory to buyer-supplier relationships and their mutual attractiveness. On the one hand, a high supplier attractiveness strongly influences the supplier awarding decision. However, if the supplier performance and attractiveness decrease, the customer might select a different supplier. On the other hand, a high customer attractiveness can motivate the supplier to start or maintain a relationship with a certain customer, while its loss might cause termination from the supplier side. The supplier does not want to spend more time in one relationship while being in another one could be potentially more beneficial. Chapters 4 and 5 deal with the horizontal axis in the context of the SET. Our main research interest on the horizontal axis is to gather information, which helps to assess the attractiveness of a focal company for its suppliers in comparison to its competitors.

The vertical axis of our research framework covers the upstream supply structure and the downstream sales structure with all its tiers. This axis is embedded in the TCE to explain the process of value creation. According to this theory, every transfer of goods between the actors in the vertical supply chain has to be paid (Williamson, 1981, 1985). The goal of the focal company is to minimize its sum of production and transaction costs (Williamson, 1979). Hence, it can change tiers in both directions or even eliminate them if they are not value-adding. If tiers are eliminated, the transactions between them will lapse, as well. Consequently, the elimination of transactions across the vertical supply chain is a transaction cost-related decision (Tsang, 2006). Companies take transaction cost considerations into account when deciding on a governance mode for their value-creating processes. On the one hand, suppliers can climb up this vertical supply chain by increasing their capabilities (Wan & Wu, 2015). On the other hand, the focal company can step it down by cooperating directly with lower-tier partners and by transferring power to the highly skilled system or component suppliers. The curved arrows in figure 2 illustrate these movements across the vertical supply chain. Chapter 6 deals with the vertical axis in the context of the TCE.

The storyline of this dissertation is aligned with the two axes of our research framework. Consequently, chapter 3 presents the whole Supply Network Map structure in both directions. While chapters 2 and 6 focus on the vertical axis of the Supply Network Map structure, chapters 4 and 5 are about the horizontal model axis. Finally, chapter 7 combines both axes again.

Chapter 2 is a literature review on Supply Chain Mapping. Consequently, it covers the whole vertical supply chain across all supplier tiers, the focal company and all customer tiers. As Supply Network Mapping is a term that has been introduced within this dissertation for the first time in literature, the literature review cannot be extended to the horizontal dimension of the model yet. Nevertheless, first signs that a network view is necessary are there; for instance, as many of the analyzed articles use the term “netchains”.

For the conceptual development of the Supply Network Map Structure Model in chapter 3, not only the vertical supply chain but also the complementors and the competitors introduced in the Value Net by Nalebuff and Brandenburger have been taken into account (Nalebuff & Brandenburger, 1997). That is why the new model offers a holistic overview of the focal company within its environment, as represented by the two model axes.

Chapters 4 and 5 contain the empirical verification of the horizontal model axis, while chapter 6 treats the empirical verification of the vertical model axis. Chapters 4 and 5 analyze which information sources lead to knowledge across this horizontal model axis, while chapter 6 investigates how the information quality across the vertical supply chain affects the purchasing performance. Finally, chapter 7 contrasts the horizontal with the vertical model axis. This chapter examines when companies with a high horizontal or vertical information quality apply Supply Network Mapping.

The bold frame and the magnifier in figure 2 accentuate the focus area of this dissertation. It focuses on the upstream supply network, including all relationships between the focal company, its suppliers, sub-suppliers, competitors and complementors. These relationships are analyzed under aspects, which are relevant for Purchasing and Supply Management (PSM). Consequently, the downstream supply network covering the sales structure with all deliveries across various dealer levels until the final end-customer is out of the scope of this dissertation. Nevertheless, we encourage future researchers to search for similarities and synergies between these two sides of the supply network.

After explaining the research framework and theoretical background, the next section focuses on the research methodology in this dissertation.

1.3 Research methodology: Mixed-methods research design with a conceptual and empirical research phase

The research methodology in this dissertation is divided into a conceptual and empirical research phase, as presented in figure 3. Both phases provide different advantages to our research. Conceptual research relies on previously conducted studies. Developing a conceptual framework helps us to hypothesize the relationships and to improve the understanding of the dynamics of the situation of the focal company (Sekaran & Bougie, 2016). Empirical research is based on new observations. Although empirical research has its burdens, such as the required data access, time and possibly cost, it leads to new knowledge and evidence (Gagnon, 1982).

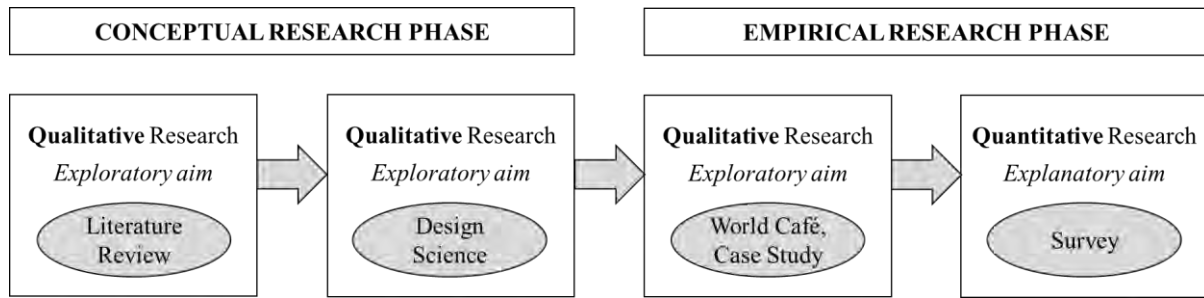


Figure 3: Research methodology

We use a mixed-methods research design, which is an emerging field (Tashakkori & Teddlie, 2011; Timans, Wouters, & Heilbron, 2019). Combining qualitative and quantitative research provides a better understanding of the research problem (Johnson, Onwuegbuzie, & Turner, 2007). As Supply Network Mapping is still a very new research topic, qualitative research is mandatory before proceeding to quantitative assessments. Qualitative research is very suitable for initial in-depth assessments of new or rarely explored topics (Lamnek, 2005). However, it is limited in its generalizability to the broader population (Yin, 2018). Hence, quantitative research is necessary in addition to the qualitative methods.

In the first qualitative stage of our research design, a structured literature review is carried out according to Denyer and Tranfield (Denyer & Tranfield, 2009) and Cooper (H. M. Cooper, 1982). The literature review helps us to identify the current state of the research as well as the structure of the research field “Supply Chain Mapping”. For this aim, the selected articles are examined according to their literature contribution and the terminology that has been used for the map, its actors and tiers, as well as the mapping process. As the outcome of Supply Chain Maps by traditional keyword search is quite low (Carvalho, Cruz-Machado, & Tavares, 2012), the search has been enlarged to related research streams like product modularization, supply chain visibility and supply chain complexity. Consequently, it is interesting to visualize the structure of the research field with its different streams also in a term map in the course of bibliometric mapping (van Eck, Waltman, Noyons, & Buter, 2010). The literature review is supplemented by bibliometric analysis methods to add objectivity and quantitative rigor to the qualitative analysis and to decrease researcher bias (van Raan, 1996; Zupic & Cater, 2015).

The literature review reveals that almost all papers that have been analyzed during the structural literature review are conceptual research or case studies. Hence, the biggest identified gap for future research is that there is no large empirical study so far that analyzes how the Supply Network Mapping procedure works in practice and if the tool leads to purchasing success. This research gap is the reason for our later empirical research phase.

In a second conceptual, qualitative research stage, the Supply Network Map Structure Model is created. We choose this approach to investigate the requirements and objectives of Supply Network Mapping (Bortz & Döring, 2006; Flick, 2007). For data collection, semi-structured interviews with experts from topic related departments in an agricultural machinery company are realized as well as interviews with other agricultural enterprises to obtain additional input. Furthermore, brainstorming sessions with purchasers of product-related material are carried

out. According to design science, the model is conceptualized in several iterations with various model stakeholders. Following this methodology, the results of one interview or brainstorming session serve as an input for the next interview or brainstorming session (Johannesson & Perjons, 2014).

Concerning the second research objective, we use the World Café method created by Brown and Isaacs to gather data in the same agricultural machinery company (Brown, Isaacs, & Community, 2005). The advantages of this method lie in its high output attainable in a short period of time, high stability and reliability of data and a reduced bias (Fouché & Light, 2010; Kidd & Parshall, 2000). The World Café is followed by the Gioia method to structure this qualitative data (Gioia, 2012). Both methods are needed to determine the indicators for quantitative research, which follows in the next quantitative stage of our research design.

Moreover, we carry out a long-term case study for 3.5 years in the same company. A case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between phenomenon and context are not evident (Yin, 1981b). Case study research provides powerful methods to enhance knowledge in the field of management (Halinen & Tornroos, 2005; Larsson, 1993; Stake, 2006; E. J. Wilson & Vlosky, 1997). The focus of a case study is to examine why decisions were taken, how they were implemented, and with what result (Schramm, 1971). Hence, case study research helps to build new theories (Eisenhardt, 1989) or to refine existing ones (Siggelkow, 2007). In the case of this dissertation, the case study is carried out in order to explore business cases of a successful Supply Network Mapping application. The researchers investigate how data for the tool is gathered, which sourcing levers are applied in addition to the mapping and if there is an impact on the purchasing performance.

In the last quantitative stage of our mixed-methods research approach, we apply statistics on a data set gathered from 624 purchasers during a survey. The first research method selected to examine the mapping benefits of research objective 3 is partial least squares structural equation modeling (PLS-SEM) in SmartPLS 3.2.8 by Ringle, Wende and Becker (Ringle, Wende, & Becker, 2015) and in ADANCO 2.1.1 by Henseler and Dijkstra (Henseler & Dijkstra, 2015). The structural equation modeling method is applied to assess the unobservable latent variables and the causal relationships between them in our research model. Hence, we use it to explain the performance impact of transparency and Supply Network Mapping.

The second research method chosen to approach research objective 3 and to compare differences between cost and innovation leaders is partial least squares multi-group analysis (PLS-MGA). The benefit of this method lies in assessing whether the paths between constructs are significantly different from each other for different data groups (Sarstedt, Henseler, & Ringle, 2011).

After describing the research methods, the next section gives an overview of the outline and the contributions of this dissertation.

1.4 Research outline and contributions: Exploring transparency on supply network structure, mapping procedure and transparency benefits in eight chapters

The subject of this dissertation is Supply Network Mapping. In this context, the main research objectives are to explore the following aspects:

RQ1: Transparency on supply network **structure**

RQ2: **Procedure** for transparency and mapping

RQ3: Transparency and mapping **benefits**.

These overarching research questions have been answered in multiple steps (see figure 4):

1	Chapter 1: Thesis Background and Research Structure			
2	Chapter 2: Supply Chain Mapping: A structured literature review and a bibliometric analysis	Aim: To explore the SC map structure and mapping procedure	Approach: Literature review incl. bibliometric analysis	Data basis: 71 research papers
3	Chapter 3: Coping with rising Supply Chain Complexity: Conceptualizing a Supply Network Map Structure Model to address that challenge	To develop a Supply Network Map Structure Model	Conceptual research / Design science	13 semi-structured interviews
4	Chapter 4: Supplier relationships with competing customers: How can purchasers find out who is the preferred customer?	To collect info sources, knowledge and contingency factors	World café + Gioia method	14 participants
5	Chapter 5: Knowing your supplier relationships with other customers: People or media as key sources of information?	To analyze the impact of info sources to assess the customer status	PLS-SEM	Survey with 624 purchasers + Long-term case study
6	Chapter 6: Cost savings through supply chain transparency: A transaction cost view	To test for the performance effects of supply chain transparency	Case study + PLS-SEM	
7	Chapter 7: Cost versus Innovation Leaders: Performance effects of Supply Network Mapping	To explore when cost and innovation leaders apply SNM	PLS-MGA	
8	Chapter 8: Summary of the main research findings			

Figure 4: Research design and structure

Chapter 2 carries out a structured literature review, including a bibliometric analysis, based on 71 selected research papers. This chapter aims to explore the supply chain map structure and mapping procedure. Concerning the map structure, the results of this chapter cover the geometry and unit of analysis in supply chain maps. The second main finding of this chapter is a generalized draft of the mapping procedure, including the object to be mapped, data

collection, mapping execution, analysis and improvements. Hence, this chapter contributes to the first and second research questions.

Chapter 3 is conceptual research and develops a Supply Network Map Structure Model. The model is conceptualized with the help of design science based on 13 semi-structured interviews. It gives shape and framework to the actors and links in supply networks. Hence, it contributes to the first research objective concerning the structure of a Supply Network Map.

Chapter 4 contributes to the second research question dealing with the Supply Network Mapping procedure. It covers the information sources, desired supplier relationship knowledge and contingency factors for the need for transparency. The most desired information are the prices for other customers and the delivered customer plants. Purchasers regard the supplier and supplier factory visits as the most promising information sources. Volatile times with increasing supply risks and a decreasing supplier performance require a high supply network transparency. These results are collected during a World café with 14 purchasers. In a second step, this qualitative data is structured with the help of the Gioia method.

Chapter 5 adds to this research objective by determining the most important information sources, which lead to supplier relationship knowledge. These information sources can help the focal company to assess its customer status. We figure out that people and events are more helpful information sources than media. These information sources best explain the variance in the customer attractiveness knowledge. Chapters 5 to 7 are based on the same data set “Supply Network Mapping”, which was gathered during a large empirical survey with 624 purchasers. As the methodological approach, chapter 5 applies Partial Least Squares Structural Equation Modelling on this sample in order to examine the effect of various information sources on the supplier relationship knowledge.

Chapters 6 and 7 are related to the last research objective concerning the benefits of Supply Network Mapping. Chapter 6 tests for the performance effects of supply chain transparency. This study investigates the impact of information quality, supply chain mapping and targeted sourcing levers on the cost-saving, sustainability and delivery performance. We show that supply chain mapping is used as an input for volume bundling, direct sourcing, responsible practices and risk management, which indeed have a positive impact on the purchasing performance. The study is not only based on the above mentioned data set, but also on a long-term case study with various application cases of Supply Network Mapping. Focusing on cost savings, the research is embedded in the theory of transaction cost economics.

Finally, chapter 7 splits the above mentioned sample into purchasers working for employers who pursue a cost leadership strategy and those who follow a differentiation strategy by product innovation. By contrasting these two sub-samples in a Partial Least Squares Multi-Group Analysis, we figure out that cost leaders use SNM if they know their supplier relationships with sub-suppliers, while product differentiators need it for supplier relationships with other customers. Firms with cost leadership strategies directly benefit from vertical information about their sub-suppliers for the cost-saving performance but do not from applying mapping tools. Firms pursuing innovation leadership strategies, on the other hand, benefit most from horizontal

information quality about other customers for innovation performance. For them, the application of Supply Network Mapping further enhances the performance effect.

To sum the major contributions up mainly chapters 2 and 3 deal with transparency on the supply network structure, which is the first research objective. While chapter 2 analyzes the geometry and unit of analysis in supply chain maps, chapter 3 transfers these insights to network level and introduces a new holistic Supply Network Map Structure Model. Secondly, nearly all chapters provide new findings regarding the procedure for transparency and mapping: Chapter 2 proposes a generalized draft of this procedure. Chapters 4 and 5 highlight the desired supplier relationship knowledge, most important information sources and contingency factors for the need for transparency. Chapter 6 investigates sourcing levers in addition to the mapping and applies the mapping on various business cases during a long-term case study. Finally, chapter 7 presents two use cases for Supply Network Mapping: cost and innovation leaders. Regarding the third research objective purchasing benefits, chapters 6 and 7 evaluate the impact on cost-saving, innovation, sustainability and delivery performance.

Chapter 2: Supply Chain Mapping: A structured literature review and a bibliometric analysis

Abstract

Focal companies only have limited knowledge about the complex relationships in their environment. In order to manage these relationships, practitioners need appropriate tools such as Supply Chain Mapping. However, in current literature, there is no established standard for the structure of supply chain maps and the mapping procedure. Moreover, a consistent terminology to describe these maps is missing. Hence, we conduct a structured literature review of 71 selected articles published from 1992 to 2017 across various research streams to close these research gaps. The literature review is supplemented by bibliometric analysis methods to add quantitative rigor to the qualitative analysis.

The study reveals that most maps are structural and show chains or netchains, covering both the supply and distribution side with an average length of five and an average width of four tiers. The unit of analysis in most of the maps is a general company or commodity. Another important outcome of the study is a generalized draft of the supply chain mapping procedure, including the identification of the mapping object, data collection, mapping execution, analysis phase and deduction of improvements. Moreover, the broad range of identified topics, objectives and research streams underlines the universal applicability of the method.

Keywords

Bibliometric analysis; structured literature review; supply chain mapping; supply chain visibility; supply chain structure; supply chain complexity

2.1 Introduction: Supply chain mapping tool lacking mapping conventions and instructions for the mapping procedure

Several incidents have highlighted recently how important it is for companies to be aware of their supply chain and its vulnerabilities. Not only are firms endangered by natural catastrophes, as Fukushima has shown in 2011 since Japan is an important production site for bearing manufacturers, but also do they need to establish alternative supply sources in order to prevent supply chain disruptions occurred in the case of VW for its gearbox and seat supply chains in 2015. These are some of the triggering events that will be examined in our first research question on the motives for supply chain mapping.

In order to fight the challenges mentioned above, companies need appropriate concepts and tools like supply chain mapping. “Strategic supply chain mapping focuses on how goods, information and money flow in both the upstream and downstream directions and through a firm. All processes may be included.” (J. T. Gardner & Cooper, 2003), p. 45. In this context, there is quite often overlap with the definition of value stream mapping. Our understanding that we take as a basis for this paper is that supply chain maps must contain inter-company links between several supply chain members and may contain intra-company links within one company. That is why, pure value stream maps in single companies are excluded in our review; however, the chosen supply chain maps may contain operations information within the focal company and its suppliers and distributors.

Although Gardner and Cooper have already emphasized the need to map supply chains in 2003 and Farris in 2010, both authors have concluded that no conventions on how to map the supply structures properly exist yet. They recommend future research to develop mapping approaches and conventions for the use in supply chain management (Farris, 2010; J. T. Gardner & Cooper, 2003). This paper takes up this suggestion by reviewing the status quo and deducing recommendations for a supply chain mapping notation.

Gardner has made a first step towards mapping conventions through establishing a framework of map attributes. These attributes are classified into geometric, perspective and implementation issues and contain features like the length and the width of supply chain maps. In our study, we will analyze the structure of the available supply chain maps regarding these attributes in order to answer our second research question.

Another issue mentioned by Farris and Gardner is the difficulty of determining the right degree of information to be displayed in the maps. On the one hand, the maps need to be detailed enough for a successful operational supply chain management, but on the other hand, they need to be applicable to the strategic management level. In order to solve this economic problem, Farris suggests economic macro maps as they lead to a valuable output at a low effort and might, later on, be drilled down to enter into the details (Farris, 2010). However, additional research is necessary on the suitable unit of analysis and will be covered, as well, by the second research question.

In terms of the supply chain mapping procedure, Farris has mainly dealt with the information sources. However, our paper also covers the mapping terminology, responsibilities and

procedure steps. Further aspects like mapping obstacles, effort or benefits might be the subject to a future research agenda. The mapping procedure will be subject to our third research question.

2.2 Methodology

2.2.1 Following the five stages of structured literature reviews by Denyer and Tranfield

We followed the five stages for literature reviews suggested by Denyer and Tranfield (Denyer & Tranfield, 2009) or comparably by Cooper (H. M. Cooper, 1982). According to these researchers, a systematic review starts with the formulation of the research questions. Table 1 provides an overview of the research questions that will be explored in this paper:

Question no.	Research question
RQ 1	<i>What is the matter of supply chain mapping and for whom does it matter?</i>
RQ 1.1	What are the topics associated with supply chain mapping?
RQ 1.2	Which are the objectives of supply chain mapping?
RQ 1.3	Which research streams does supply chain mapping concern?
RQ 2	<i>Which structure do supply chain maps have?</i>
RQ 2.1	How does the geometry of the supply chain maps look like?
RQ 2.2	Which perspective is used in the supply chain maps?
RQ 2.3	How high is the information density displayed in the supply chain maps?
RQ 3	<i>Which procedure does supply chain mapping follow?</i>
RQ 3.1	Which is the common term for the procedure and who is responsible for it?
RQ 3.2	Which information sources can be used for mapping?
RQ 3.3	Which action steps are part of the mapping procedure?

Table 1: Overview of research questions

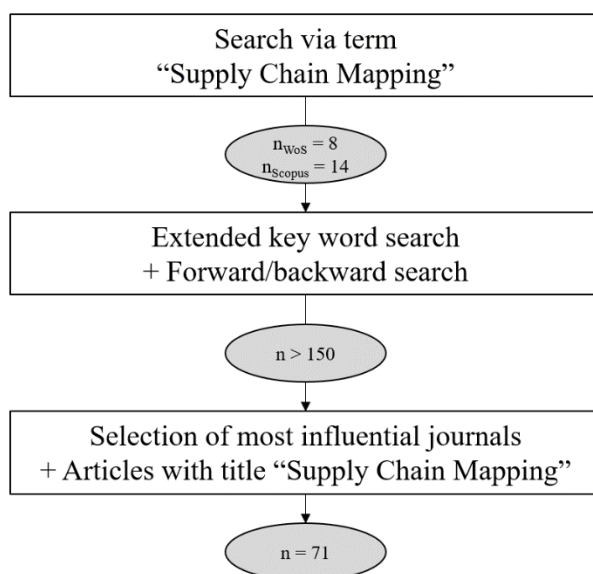


Figure 5: Literature selection procedure

The second step is locating the articles for the review, followed by their selection in step 3. This search starts with an investigation of citation databases using search strings, grouping keywords and applying search conventions (Denyer & Tranfield, 2009). This paper is based on the Thomson Reuters Web of Science (WoS) as a database frequently used in management and organization. In order to enlarge the range of articles for this rather new research field, the Elsevier Scopus database has been screened for articles about supply chain mapping in addition to the WoS.

The literature search demonstrated in figure 5 has been started by the term “Supply Chain Mapping”. However, the outcome of research papers using this search key is quite low

(Carvalho et al., 2012). We had eight hits only in WoS and 14 in Scopus under this term. Related parameters like “supply” AND “mapping” did not lead to valuable results, as these papers are mostly about value stream or process mapping in a supply chain context. At the same time, every manufacturing firm has a supply chain, so we made the reasonable assumption that more supply chain maps must have been published. Hence, in a second step, we extended the keyword search to further topic-related terms such as modular and multi-tier supply chain, supply chain visibility, supply chain complexity and sub-supplier management in order to identify more articles. These papers have been added to the selection for the review about supply chain mapping if they depict any supply chain maps. This search took place in line with a backward and forward reference searching. In the backward reference searching process, we examined the articles listed in the references, while in a forward reference searching process, they used WoS and Scopus to find articles that cite the initial article. Finally, the outcome was more than 150 publications, including conference listings, books and publications in various languages that enhanced the understanding of the topic.

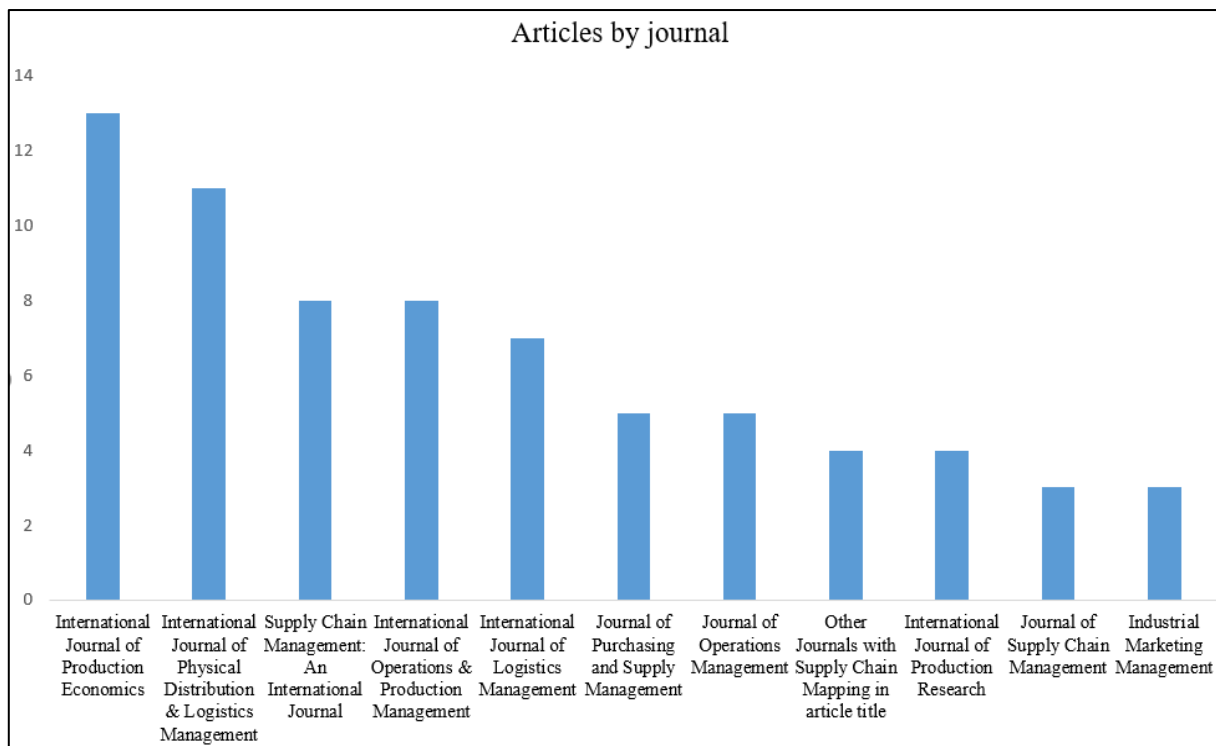


Figure 6: Ranking of articles by journal

However, this selection had to be narrowed down again to the relevant international journals illustrated in figure 6 to increase the validity of the results. Not only, these journals limit the range of articles to a manageable size for our study, but also they have a high rating and impact factor and represent well the research field of supply chain mapping (Zupic & Cater, 2015). In the end, only ten journals are included in the literature review. Among the most impactful journals in the field of supply chain mapping is the International Journal of Production Economics with 13 articles followed by the International Journal of Physical Distribution & Logistics Management with eleven papers. Moreover, four additional articles from other journals are accepted, as they contain the term supply chain mapping in the article title and thus

need to be mandatorily included in the selected literature in order to avoid content-related losses. This selection leads to a final data set of 71 articles for the literature review.

The selected publication timeframe is 1992 to 2017. Figure 7 shows a stable publication rate until 2006 and more articles from 2007 to 2015 with a peak in 2013. This curve shape shows that the importance of supply chain mapping is rising. While the publications in the nineties rather cover conceptual research, the later articles are about network structures or the mapping application explored in case studies. A full list of these papers is provided in the appendix.

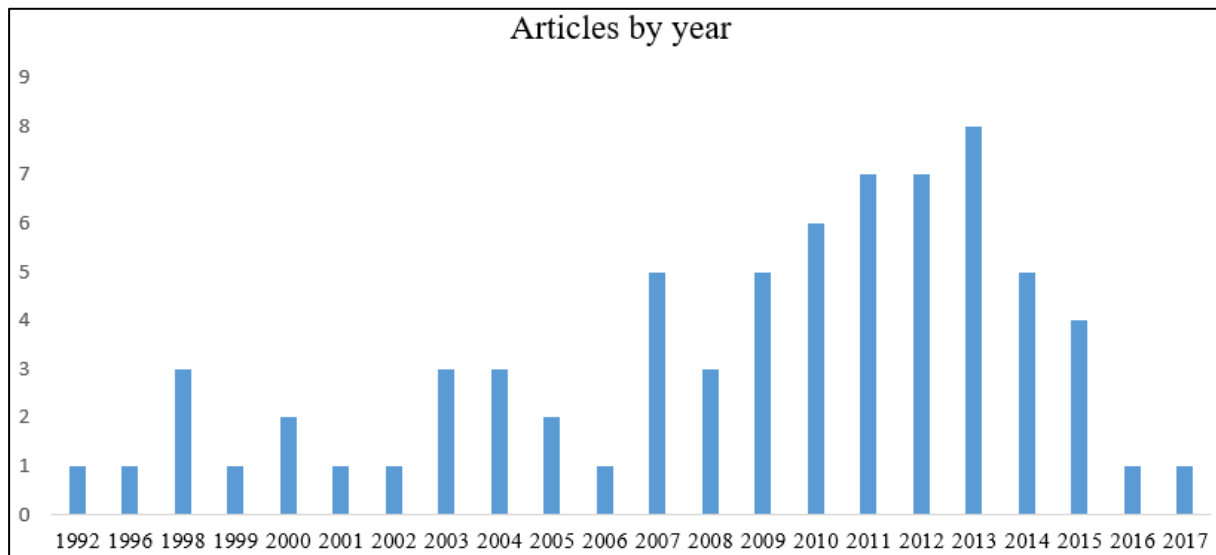


Figure 7: Ranking of articles by year

The fourth step, according to Denyer and Tranfield, is data analysis and synthesis. Coding and entering the articles in a database was done by two independent researchers and discussed with several supply chain experts to avoid misinterpretations. This methodical approach distinguishes this structured review from narrative reviews and helps to reduce bias and increase transparency (Tranfield, Denyer, & Smart, 2003). Afterward, the data is synthesized both qualitatively and quantitatively in order to answer the research questions. In the fifth step of reporting the results, the review contains both concept-centric and author-centric approaches (Webster & Watson, 2002), depending on the accordance between the different authors. The results can be interpreted and thus have generalizability (Rousseau, Manning, & Denyer, 2008), which helps to strive towards the lacking supply chain mapping convention.

2.2.2 Adding quantitative rigor to the qualitative review through a bibliometric analysis

In addition to the structured literature review, a quantitative bibliometric method is used. This approach is particularly interesting, as articles of different research fields have been selected so that relations can be visualized. According to research question 1.2, a co-word analysis is applied in order to add further research on the topics associated with the literature on supply chain mapping and their connections to each other. The co-word analysis examines the content of the articles and connects words whenever they appear in the same keyword list. This analysis technique leads to an image of the cognitive structure of supply chain mapping with all the topics and their links to each other (Zupic & Cater, 2015).

Moreover, our article will examine the different research streams in the intellectual structure of supply chain mapping. The intellectual structure describes the structure of the knowledge base consisting of the articles mostly cited by the current research and refers to supply chain mapping's research traditions, its disciplinary composition, influential research topics, and the pattern of its interrelationships (Shafique, 2013). These articles are the foundations for the current research on supply chain mapping containing related theories and important early publications. Consequently, the co-citation analysis has been selected as an appropriate research technique as it shows the central and bridging researchers in the reference lists of all 71 articles in our data set and aggregates them to clusters of the different research streams (Zupic & Cater, 2015). The closer two authors are in the network visualization, the more often they are cited together in a third, newer publication.

When conducting the bibliometric analysis, first, the relevant bibliometric information needs to be converted to a .txt format. Once all articles are available as .txt files, the information has to be cleaned to eliminate the different spelling of keywords, as shown in table 2. As a rule of thumb, plural forms for firms, models or systems are adjusted to singular forms, unless the singular form content-wisely is wrong. Moreover, terms expressing the same content are unified (e.g. case study research and case study) and a different spelling is modified to the commonly used version like adjusting supply-chain management to supply chain management.

Original keywords	Modified keywords
adaptive systems, adaptive systems perspective, complex adaptive systems	adaptive system
automotive, automotive industry	automotive industry
case study, case studies, case study research	case study
complexity, supply chain complexity	supply chain complexity
firm, firms	firm
green, green supply chain management	green supply chain management
integration, supply chain integration	supply chain integration
model, models	model
networks, network	network
risk management, supply chain risk management	risk management
social network, social network analysis	social network
supply chain, supply chains	supply chain
supply chain management, supply-chain management, chain management	supply chain management
supply networks, supply network	supply network
system, systems	system

Table 2: Adjustment of keyword spelling

As the spelling of the keywords has to be adjusted, also the author's information in the cited reference lists has to be cleaned. Table 3 shows that in the case of the authors, this is mainly an issue of the different spelling of double first names. Since WoS uses the double letter version, the authors are coded in this way. Consequently, Cooper M is adjusted to Cooper MC.

Original authors	Modified authors
Barney J, Barney JB	Barney JB
Bozarth C, Bozarth CC	Bozarth CC
Burt R, Burt RS	Burt RS
Chen F, Chen FR	Chen FR
Christopher M, Christopher MG	Christopher MG
Cooper M, Cooper MC	Cooper MC
Ellram L, Ellram LM	Ellram LM
Harland C, Harland CM	Harland CM
Lambert DM, Lambert Douglas M	Lambert DM
Yin R, Yin RK	Yin RK

Table 3: Adjustment of author spelling

The gathered data has to be exported to software being able to process it. In this context, the freeware VOSviewer, version 1.6.5, developed by Nees Jan van Eck and Ludo Waltman, has been chosen as the favorable product due to its convenient functionality regarding the various graphical representation options of the maps (van Eck & Waltman, 2010). VOS is an abbreviation for visualization of similarities. The input for VOSviewer is a similarity matrix based on the association strength. The similarity between two items is calculated by counting how often these items co-occur and by dividing this number through the product of the total number of occurrences of these items (van Eck & Waltman, 2010). VOS aims at minimizing a weighted sum of the squared distances between all pairs of items. Finally, the application of the VOS technique leads to better visualization of the underlying dataset than maps constructed by the help of multidimensional scaling (van Eck, Waltman, Dekker, & van den Berg, 2010). VOSviewer only works with distance-based maps meaning that the distance between two items stands for the strength of the relation between these items. The more similar two items are, the closer they need to be located to each other (van Eck & Waltman, 2010). We chose a fractional counting method, as recommended by van Eck and Waltman (van Eck & Waltman, 2014).

Further available software for a bibliometric analysis is, e.g., SciMat or Bibexcel. SciMat has a good user interface and data processing module (Cobo, López-Herrera, Herrera-Viedma, & Herrera, 2012), but lacks satisfying data export opportunities (Zupic & Cater, 2015). Bibexcel provides good export options (Persson, Danell, & Wiborg Schneider, 2009), yet the visualization in the tool is not satisfying (Cobo, López-Herrera, Herrera-Viedma, & Herrera, 2011).

The bibliometric method provides several advantages: It increases objectivity and rigor but decreases researcher bias (Zupic & Cater, 2015). Therefore, the bibliometric analysis complements the structured literature review and enhances the quality of its results.

2.3 Findings

2.3.1 Focus on supply chain relationship management, integration and risk management

RQ 1.1: Topics associated with supply chain mapping

In order to investigate the topics associated with supply chain mapping, a co-occurrence map is created. The map's unit of analysis is all keywords given by the authors and WoS.

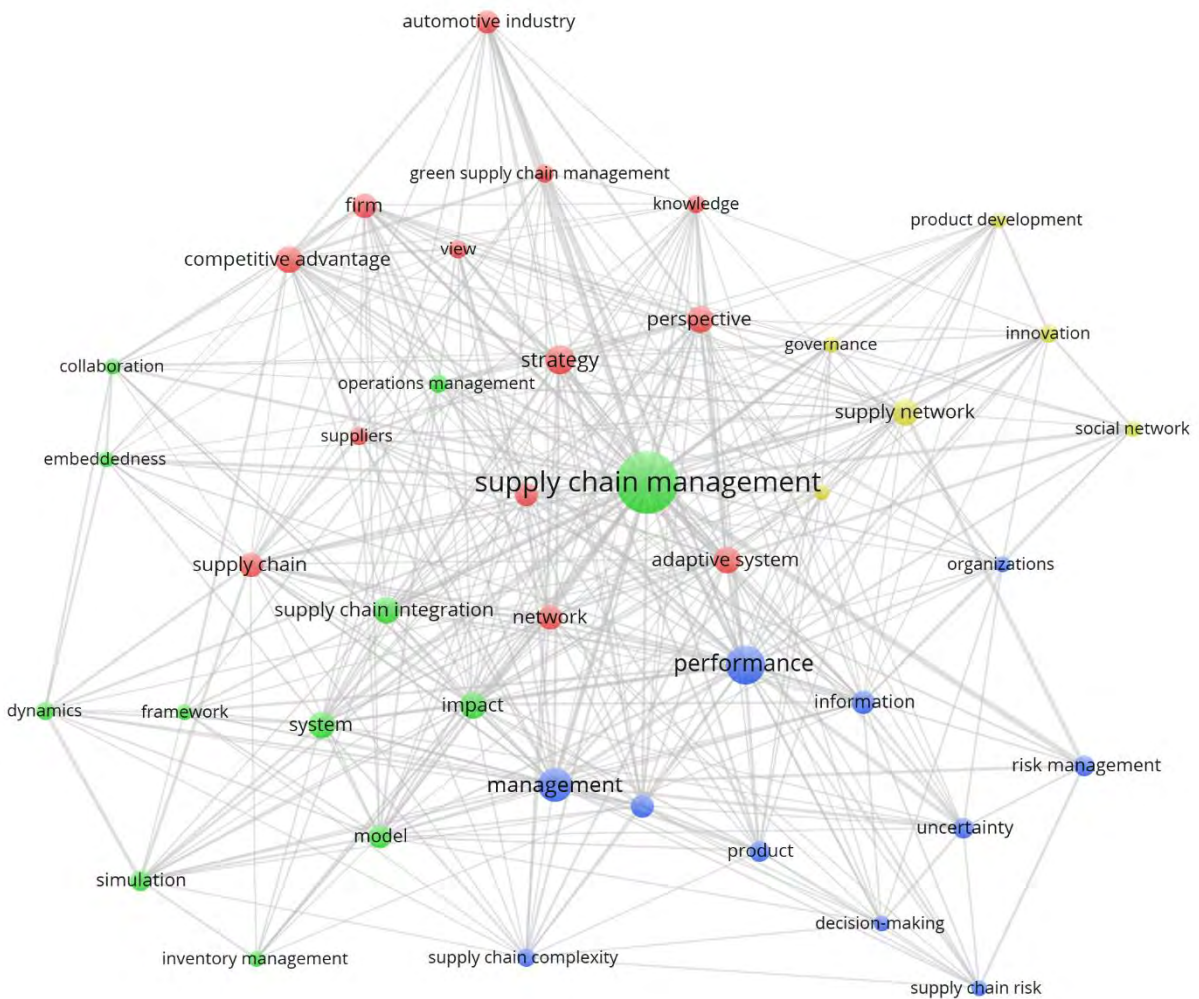


Figure 8: Co-occurrence map of keywords

For the creation of the map, a threshold has to be fixed, defining how many occurrences a keyword must have. In order to choose a suitable threshold, a sensitivity analysis has been carried out. The default setting proposed by VOSviewer is five minimum occurrences. However, a test has shown that only 23 keywords would meet this threshold, which does not give a broad overview of the topics associated with supply chain mapping. At the same time, these 23 keywords would still be in five different clusters, which some supply chain experts who were asked to review the proposed clusters did not regard as very significant. In two iterative steps, the threshold has therefore been decreased to three occurrences, still ensuring a minimum significance of these terms. After the data cleaning process, 42 out of the 371 items meet this threshold.

When interpreting the co-occurrence map in figure 8, the keywords are mainly distributed into four distinctive quadrants building four different clusters presented in table 4 with the respective subjects of the clusters. These clusters were regarded as helpful by the supply chain experts. The only term belonging to the green cluster but being located close to the red cluster is supply chain management. This exception can be explained by the fact that the management of the supply chain is both necessary to implement the supply chain strategy (red cluster) and to guide supply chain integration (green cluster) and will, therefore, be indicated by the authors of both topics. The keywords illustrated in the co-occurrence map show 407 lines between their nodes.

Cluster 1 (red)	Cluster 2 (green)	Cluster 3 (blue)	Cluster 4 (yellow)
<i>SC Strategy & SC Structure</i>	<i>SC Integration & SC Analysis Methods</i>	<i>SC Complexity & Risk Management</i>	<i>SC Operations & Social Network</i>
adaptive system automotive industry case study competitive advantage firm green supply chain mgt. knowledge network perspective strategy suppliers supply chain view	collaboration dynamics embeddedness framework impact inventory management model operations management simulation supply chain integration supply chain mgt. system	decision-making design information management organizations performance product risk management supply chain complexity supply chain risk uncertainty	governance innovation logistics product development social network supply network
13 items	12 items	11 items	6 items

Table 4: Keyword clusters

The largest red cluster contains 13 items and affects supply chain strategy and supply chain structure. The strategy subject covers next to the term strategy three issues that the management needs to deal with: how to achieve a competitive advantage, how to become an adaptive system being able to cope with environmental changes and how to integrate environmental thinking into supply chain management (green supply chain management). The structural issue is reflected in several words describing the supply structure (supply chain, network), the perspective of the illustration (perspective, view) and the related actors (firm, suppliers). Such a structure can be observed, e.g., in the automotive industry, by the help of a case study that creates visibility/knowledge, explaining why these three words are included in the same cluster.

Supply chain mapping is a helpful tool to visualize the supply chain structure and, therefore, a valuable decision-making aid for strategic managers.

Supply chain integration and supply chain analysis methods are the subject of the second, green cluster, including twelve keywords. Supply chain integration covers supply chain collaboration, dynamics, embeddedness, integration and management, while supply chain analysis methods are any frameworks, models and simulations. The subject of their analysis can be the impact of supply chain changes on inventory management, operations management and the system in general. Supply chain mapping is often used as a tool before modeling and simulation in optimization projects in order to gain supply chain transparency first.

Colored in blue, the eleven items in the third cluster belong to the domain of supply chain complexity and risk management. Various drivers such as a complex supply chain design, many involved organizations, high performance requirements or a complex product architecture can cause this supply chain complexity. This high complexity, combined with an information deficit, can lead to a high supply chain uncertainty and supply chain risks. This challenge can be met only with reasonable risk management and decision-making process. Risk management is one of the most common application fields of supply chain mapping.

The smallest cluster with six items, marked in yellow, still comprises two subjects, as well: supply chain operations and social network. While the social network term is very important but occurs rather isolated both in this cluster and at the right edge of the co-citation map, the remaining five terms are linked closely to each other. Supply chain operations concern the governance of several operations, starting from the innovation process, continuing with the product development and ending with the external logistics needed for distribution through the whole supply network. A holistic supply chain mapping approach of, e.g., a product line, may support the governance of the concerned operations.

In order to sum up the keyword analysis, the clusters have shown that supply chain mapping can be applied in many different contexts. It can help to improve the strategic as well as operational supply chain management.

RQ 1.2: Objectives of supply chain mapping

The keywords analyzed above regarding the topics associated with supply chain mapping give first implications also for the mapping objectives. However, this list of targets can be extended by a qualitative analysis of the articles in table 5.

Apart from the supply chain integration analysis being with 16 counts on the first place (cluster 2), followed by the risk assessment subject on the second place (cluster 3), another mapping goal occurring in several articles is with ten counts the implementation of green supply chain management (Fabbe-Costes, Helen Walker, Roussat, Taylor, & Taylor, 2014; Fabbe-Costes, Jonsson, Roussat, & Colin, 2011; Grimm, Hofstetter, & Sarkis, 2014; Koh, Gunasekaran, & Tseng, 2012) on the third rank. Moreover, the table delivers the following additional mapping targets: Supply chain mapping needs to lead to a high visibility (Barratt & Barratt, 2011; Barratt & Oke, 2007; Jin, Fawcett, & Fawcett, 2013; Tse & Tan, 2012) that can help to create a common

understanding of the supply chain (J. T. Gardner & Cooper, 2003) and the consumer needs (Zokaei & Hines, 2007). Once this understanding is created, the map can serve as a communication tool and distribute information (J. T. Gardner & Cooper, 2003; Miyake, Silveira Torres, & Favaro, 2010). Presuming a sufficient data analysis (Ellram, Tate, & Carter, 2007), a supply chain map can also serve controlling and measurement purposes (Allesina, Azzi, Battini, & Regattieri, 2010). Further researchers and practitioners appreciate the support of supply chain maps for supply chain categorization (Lamming, Johnsen, Zheng, & Harland, 2000) and comparisons (Braziotis, Bourlakis, Rogers, & Tannock, 2013) in order to detect either differences (MacCarthy, Singh Srail, & Jayarathne, 2013) or similarities and redundancies (Berry & Towill, 1992; Stewart, Glenn Richey, Kolluru, & Smith, 2009). Furthermore, practitioners make use of supply chain maps in order to react to trends and structural changes by creating future state supply chain maps (Allesina et al., 2010; Kumar, Srail, Pattinson, & Gregory, 2013; Zokaei & Hines, 2007). Additional objectives are e.g. the analysis of optimization potential (Lambert & Pohlen, 2001), the evaluation of constraints (Oglethorpe & Heron, 2013) or the highlighting of value creation (Doran, 2005). Other maps rather contribute to theory (Borgatti & Li, 2009; Hearnshaw & Wilson, 2013).

Mapping objective	No. of articles	Authors
SC integration & relationship mgt. analysis	16	Capaldo and Giannocco, Corsaro et al., Doran et al., Farris, Galaskiewicz, Gardner and Cooper, Hultman et al., Jin et al., Lambert and Schwietermann, Lambert and Cooper, Lambert and Pohlen, Lambert et al., Lau et al., Ojasalo, Raj Sinha et al., Sha et al.
Risk management & resilience assessment	12	Doran et al., Grimm et al., Harland et al. (b), Lambert and Schwietermann, Norrman and Jansson, Rao and Goldsby, Stewart et al., Tse and Tan, Tummala et al., Wang et al., Wilding (a), Wilding (b)
SC sustainability & green SCM implementation	10	Dadhich et al., Fabbe-Costes (a), Fabbe-Costes (b), Grimm et al., Koh et al., Lambert and Schwietermann, Miemczyk et al., Nasir et al., Sohal and Perry, Tachizawa and Wong
SC visibility & understanding creation	8	Barratt and Oke, Barratt and Barratt, Caridi et al., Dadhich et al., Gardner and Cooper, Jin et al., Tse and Tan, Zokaei and Hines
Future state SC presentation & SC redesign	6	Allesina et al., Berry and Naim, Gardner and Cooper, Kumar et al., Miyake et al., Zokaei and Hines
SC optimization potential analysis	5	Lambert and Pohlen, Lin et al., Ojasalo, Rigot-Muller et al., Zokaei and Hines
Inventory replenishment process illustration	5	Creazza et al., Jin et al., Miyake et al., Shockley and Fetter, Viswanathan et al.

SC categorization & comparison	5	Berry and Towill, Braziotis et al., Lamming et al., MacCarthy et al., Stewart et al.
SC dynamics & responsiveness evaluation	4	Catalan and Kotzab, Gardner and Cooper, Mizgier et al., Thomé et al.
SC management improvement identification	4	Ellram et al., Gardner and Cooper, Mena et al., Tummala et al.
SC measurement & capability assessment	3	Allesina et al., Ellram, Singh Srai and Gregory
Material flow visualization	3	Harland (a), Marufuzzam and Deif, Nasir et al.
SC strategy tool support	3	Gardner and Cooper, Harland (a), Tummala et al.
SC alignment examination	3	Doran and Giannakis, Lambert and Pohlen, Lyons and Ma'aram
SC structure investigation	3	Choi and Hong, Kim et al., Smith et al.
SC complexity evaluation	3	Bode and Wagner, Sohal and Perry, Stewart et al.
SC constraints evaluation	2	Oglethorpe and Heron, Thomé et al.
Communication tool	2	Gardner and Cooper, Miyake et al.
SC operations illustration	2	Dubois and Fredriksson, Hultman et al.
Value creation highlighting	2	Doran, Lambert and Schwietermann
SC theory contribution	2	Borgatti and Li, Hearnshaw and Wilson

Table 5: Objectives of supply chain mapping

RQ 1.3: Research streams concerned by supply chain mapping

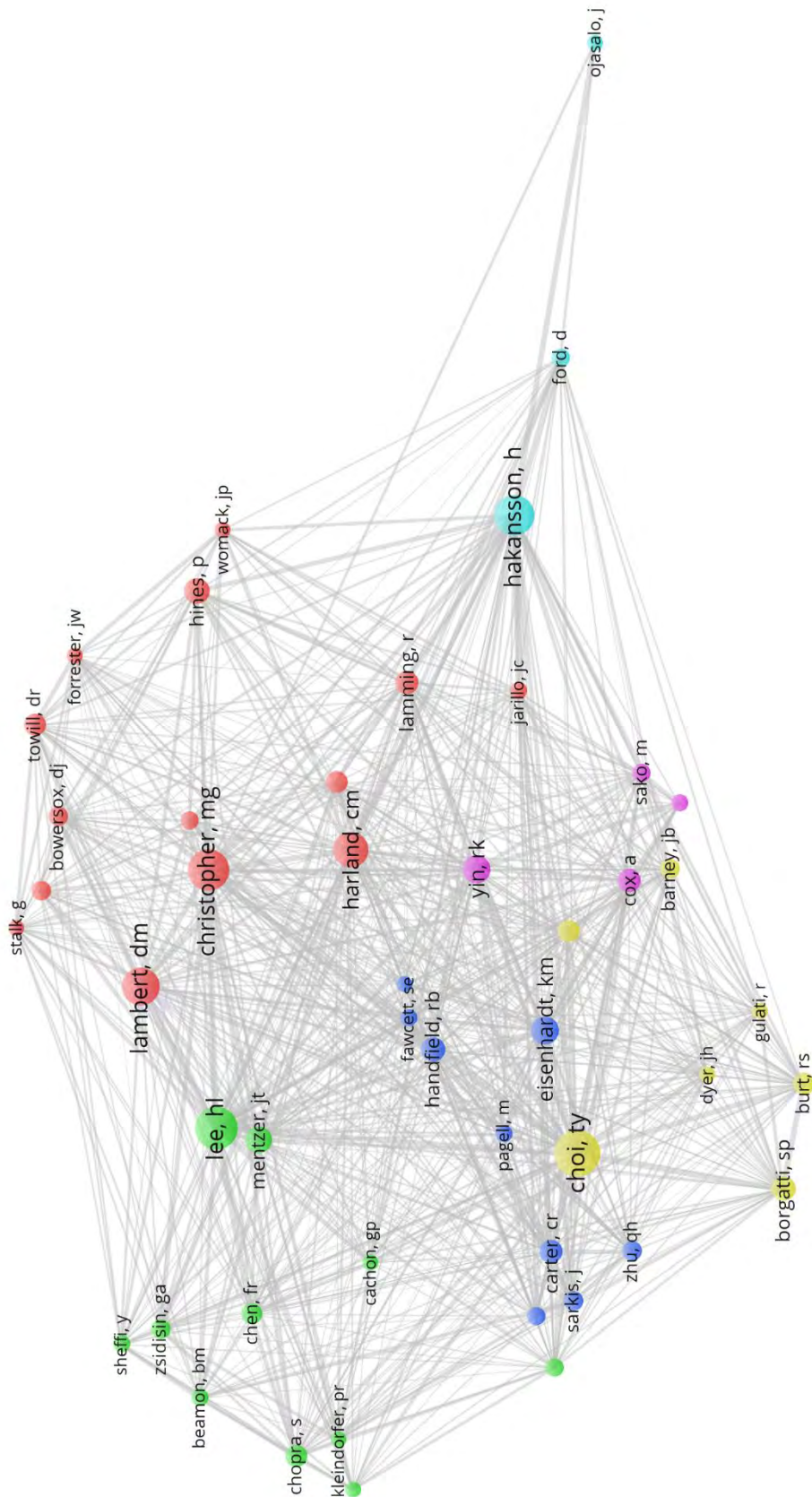


Figure 9: Co-citation map of authors

The threshold for the co-citation map of authors needs to be higher than for the co-occurrence map of keywords, as the total number of references is higher than the number of keywords being usually limited to about three to five per article. However, the default settings of twenty occurrences proposed by VOSviewer turn out to be again too high for the selected number of 71 examined articles: Although the outcome is two separate clusters, only eight out of the 2550 authors listed in the reference list meet this threshold. Consequently, the sensitivity analysis has been started a big step lower at ten occurrences and has been reduced in two more iterations. Again some supply chain experts gave their input about the validity of the clusters until a reasonable result could be gathered at a threshold of eight and 48 remaining authors.

The authors presented in the co-citation map in figure 9 are sorted into six different clusters depicting 816 links between their nodes. In table 6, the number of items ranks the clusters in decreasing order:

Cluster 1 (red)	Cluster 2 (green)	Cluster 3 (blue)	Cluster 4 (yellow)	Cluster 5 (purple)	Cluster 6 (turquoise)
<i>PSM Literature</i>	<i>Risk Mgt. Literature</i>	<i>Strategic Mgt. & SCM Literature</i>	<i>Social Network Literature</i>	<i>Case Study Literature</i>	<i>IMP Group Literature</i>
Bowersox, DJ Christopher, MG Cooper, MC Ellram, LM Forrester, JW Harland, CM Hines, P Jarillo, JC Lambert, DM Lamming, R Porter, ME Stalk, G Towill, DR Womack, JP	Beamon, BM Cachon, GP Chen, FR Chopra, S Kleindorfer, PR Lee, HL Mentzer, JT Pathak, SD Sheffi, Y Wagner, SM Zsidisin, GA	Barratt, M Carter, CR Eisenhardt, KM Fawcett, SE Handfield, RB Pagell, M Sarkis, J Vachon, S Zhu, QH	Barney, JB Borgatti, SP Burt, RS Choi, TY Dyer, JH Gulati, R Williamson, OE	Cox, A Doran, D Sako, M Yin, RK	Ford, D Hakansson, H Ojasalo, J
14 items	11 items	9 items	7 items	4 items	3 items

Table 6: Author clusters

Being the largest cluster with 14 items, the red cluster comprises authors of the purchasing and supply management (PSM) literature. Many of these researchers are known for their general, impactful publications on supply chains like Christopher (Christopher, 1998), Cooper (M. C. Cooper, Lambert, & Pagh, 1997), Ellram (Ellram et al., 2007), Lambert (Lambert & Cooper,

2000) and Stalk (Stalk & Hout, 1990), while other authors like Harland (C. Harland, Brenchley, & Walker, 2003), Jarillo (Jarillo, 1993), and Lamming (Lamming et al., 2000) concentrate their work on supply networks and Porter (Porter, 1980) on industrial clusters. Further authors treat more specific subjects in the field of PSM literature as Bowersox regarding logistical management (Bowersox & Closs, 1996), Forrester (Forrester, 1958) and Towill (Towill, 1996) focusing on dynamics modelling and Hines (Hines, Holweg, & Rich, 2004) and Womack (Womack & Jones, 1996) writing about lean management. When tracing the roots of supply chain mapping, due to the first cluster, it seems that PSM literature has a huge impact on this concept.

The second author cluster relating to the concept of supply chain mapping contains eleven authors who are publishing in the field of risk management and is colored in green. Risk management being a broad research field starts with the measurement of the supply chain (Beamon & Chen, 2010) and continues with an analysis of the supply network complexity (S.D. Pathak, Day, Nair, Sawaya, & Kristal, 2007), supply chain resilience (Sheffi & Rice, 2005) and supply chain vulnerability (Wagner & Bode, 2006). This leads to an assessment of the supply chain disruption risk (Cachon & Fisher, 2000; Chopra & Sodhi, 2004; Kleindorfer & Saad, 2005; H. L. Lee, So, & Tang, 2000), that can hopefully be handled by an adopted supply chain risk management (Mentzer et al., 2001; Zsidisin, Panelli, & Upton, 2000). As mentioned already for the third keyword cluster, supply chain mapping needs to be part of a holistic supply chain risk management process. This author cluster highlights that supply chain mapping also originates to a huge extent from the supply chain risk difficulty.

The blue cluster provides a combination of strategic management and supply chain management (SCM) literature. Eisenhardt, who is known for his work on strategic decision-making and alliance formation, represents the strategic management side (Eisenhardt & Schoonhoven, 1996). This subject builds the link to the supply chain management side, as strategic decision-making processes are also required for supply chain integration, leading to the SCM authors Barratt (Barratt, 2004), Fawcett (Fawcett & Magnan, 2002) and Handfield (R. Handfield, Sroufe, & Walton, 2005). Especially new research streams like sustainable supply chain management need a strategic decision framework as examined by the remaining authors in this cluster Carter (C. R. Carter, Crum, & Liane Easton, 2011), Pagell (Pagell & Wu, 2009), Sarkis (Sarkis, 2012), Vachon (Vachon & Mao, 2008) and Zhu (Zhu, Sarkis, & Lai, 2008). The fact that many co-cited references are from strategic and supply chain management literature shows that there is a necessity to integrate supply chain mapping into the strategic decision-making framework.

Social network literature is the common denominator for the authors in the fourth cluster presented in yellow: Borgatti (Borgatti & Li, 2009), Burt (Burt, 1997), Dyer (Dyer & Nobeoka, 2000) and Gulati (Gulati, Nohria, & Zaheer, 2000) commit themselves to social network analysis. Barney mainly focuses on competitive advantage in his work (Barney, 1991). Choi makes an exception as he is examining the structure of supply networks in his case studies at Honda, Acura and DaimlerChrysler (T. Y. Choi & Hong, 2002). The co-citation map shows that, on the one hand, he is examining the centralization and decentralization tendencies in these

supply networks, which relates to social network design, but on the other hand, he also analyzes their complexity, which again relates to the third keyword cluster risk management. Consequently, the author node of Choi builds a link between the yellow and the green cluster. The yellow cluster is good advice for supply chain mapping execution. As references from social network literature are there, it is certainly helpful to achieve an input from this research stream for the visualization in the supply chain maps.

The fifth cluster in purple deals with case study literature, a research strategy often applied for supply chain mapping and impacted significantly by Yin (Yin, 1994). In our literature review, most publications concerned focus on the execution of case studies, as in modular supply chains described by Doran (Doran, 2005) and Sako (Sako, 2002). As supply chain mapping consequently has turned out to be a valuable analysis tool within case studies apart from the well-examined automotive industry, its spread might be enhanced by implementing it also in other sectors. Furthermore, Cox examines the buyer and supplier power in dedicated cases (Cox, 2004).

Finally, the last cluster mapped in turquoise lists authors of the Industrial Marketing and Purchasing (IMP) Group. These authors carry out their research on the interactions between companies and networks in various issues, e.g., purchasing. A very influential and well-quoted author in this cluster is Hakansson (H. Hakansson & Ford, 2002), as also indicated by the size of his author node. Usually, there are more than the three authors listed in the turquoise cluster in the IMP group. However, in this group of researchers, many authors cooperate with other co-authors and publish common papers. VOSviewer, though, considers only the first authors for its co-citation maps. Consequently, some authors do not meet the threshold of eight citations, as has been verified in the case of Gadde, for instance. The IMP cluster provides insight into the analysis of supply network interactions with the help of supply chain mapping. This finding might lead to the recommendation that in future supply chain maps, more often, the links between the actors can be chosen as a focus of the analysis, instead of the actors, as this approach has already led to well-quotable results.

2.3.2 Most supply chain maps are structural maps and share a similar geometry

RQ 2.1: Geometry of the supply chain maps

Figure 10 shows that out of 71 articles, 59 representing 83% include an illustration of the supply chain map, while the remaining 12 articles corresponding to 17% only deal with the mapping procedure. Although there are many mapping and risk management software tools on the market, all maps are manually created. The only authors mentioning mapping tools are Gardner (J. T. Gardner & Cooper, 2003), referring to mapquest (<https://www.mapquest.com>) and Farris (Farris, 2010), listing bing maps (<https://www.bing.com/maps>) and google maps (<https://www.google.com/maps>) next to mapquest. All of these tools are for geographic mapping. The article about forest supply chain mapping (M. Smith, Fannin, & Vlosky, 2009) includes geographic maps, as well, downloaded from the internet or copied from a book.

The following part of the literature review concerns the terms for the structure in the supply chain maps. For this text section, all results only concern the 59 articles that include map illustrations. The horizontal words in the legend in figure 11 correspond to the terminology used by the authors of the examined articles, while the vertical words would be accurate according to the following notation that we propose: A chain includes several nodes in the map length, but the map width is always one, so there is just one actor for one tier of the map. A netchain or chain network consists of one single focal point, but of several alternative actors on the supply or distribution side. Finally, a network comprises not only several suppliers or customers but also several competing or collaborating focal companies.

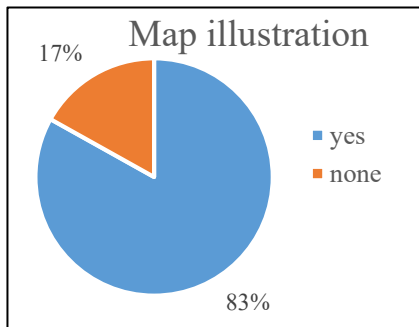


Figure 10: Map illustrations in articles

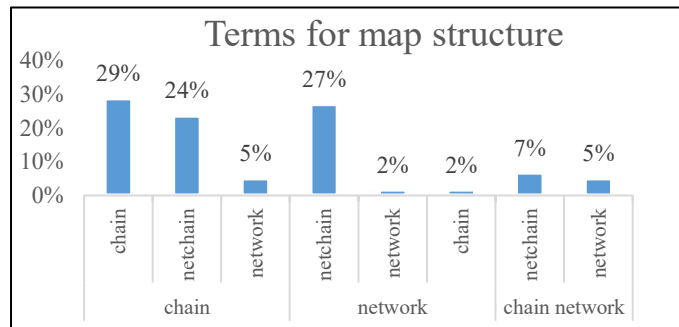


Figure 11: Terms for structure in maps

Consequently, figure 11 shows that there is a rather arbitrary use of terminology. While 58% of the articles state to be about supply chain mapping, this would only be true for 29% of the articles according to our notation. In fact, 24% of these articles cover netchains and 5% even cover networks. Interesting enough, out of the articles concerning the mapping of networks, only 2% cover real networks with several focal firms, but the majority of 27% actually treat netchains and the remaining 2% even chains. At least the last 12% that are supposed to be about chain networks all show a certain degree of complexity in the maps, but only 7% are chain networks, while 5% could be classified into the networks. This discrepancy shows that there is a need to establish a notation for supply chain mapping. With our terminology proposed above, we try to contribute to theory in this aspect.

An aspect still missing regarding the terminology, are the terms for the map rank. As displayed in figure 12, the term used in more than half of the articles is tier, followed by echelon with 14% in the second place and both terms occurring together in three percent of the articles. A quarter of the articles does not name the rank, as sometimes they are called part manufacturer, component supplier and OEM, or a designation of the rank is missing. Other synonyms such as layer or stage are rarely used. In addition to these results, we also counted the ranks depicted in both directions of the maps in each article. If netchains, for instance, have shown a different number of nodes for different streams like three to five, the average number of four actors has been taken into account. Very high exceptions, as in the article of Singh, mentioning more than 500 suppliers on tier-3 level (Singh Srani & Gregory, 2008), have been excluded. Corresponding to the definitions introduced by Gardner (J. T. Gardner & Cooper, 2003), the result is an average supply chain map length of five ranks and an average supply chain map width of four tiers.

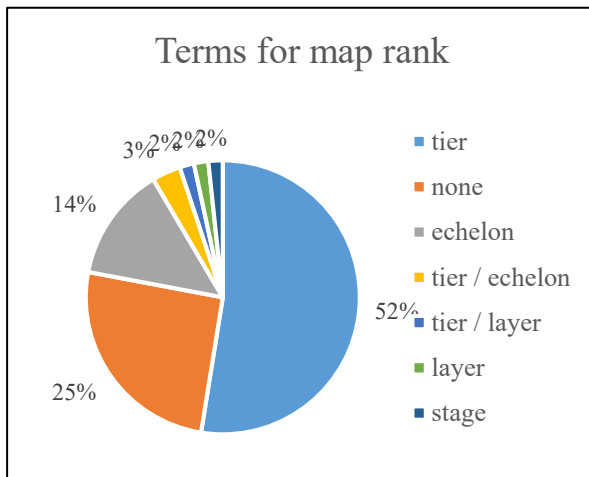


Figure 12: Terms for rank in supply chain maps

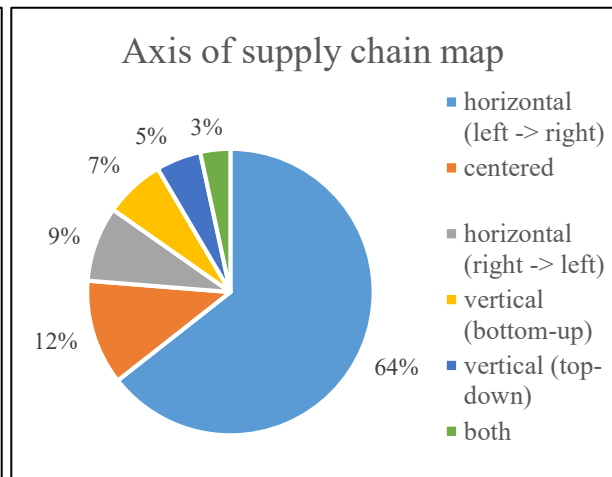


Figure 13: Axis of supply chain maps

The axis used for supply chain maps shows that there is no standard, either. With 64% in the pie chart in figure 13, most supply chains or netchains are presented from left to right on the horizontal direction following the reading flow of the addressees. Another 12% of the articles contain centered representations without an explicit direction. This kind of visualization is often used in ego networks in the social network literature (Borgatti & Li, 2009) or supply networks (Creazza, Dallari, & Rossi, 2012). In the third place are horizontal ways of mapping with 9%, which start on the right side and end on the left side. Only 12% of the authors adapt to the literature regarding the vertical axis of supply chains (T. Y. Choi & Hong, 2002) and map the supply chains either bottom-up (7%) or top-down (5%). Finally, the remaining 3% mix both axes to point out different directions of influence on the supply chain members.

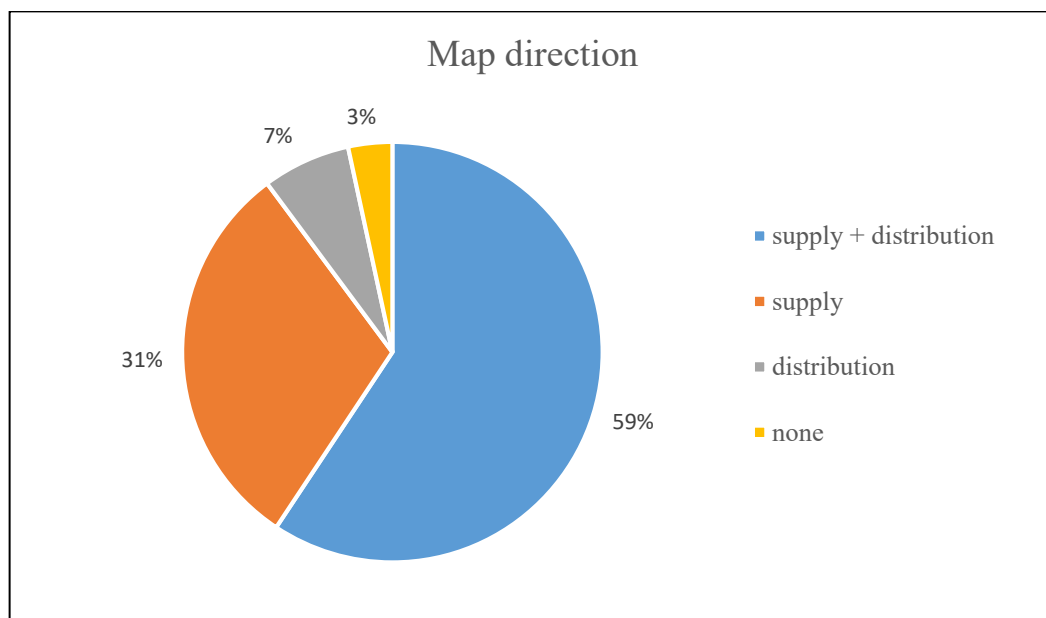


Figure 14: Direction of supply chain maps

The next research question deals with the map direction. Figure 14 emphasizes that supply chain mapping is not only restricted to the supplier side. Although roughly one-third of the maps only focus on the multi-tier supplier structure, the most common application of supply chain maps with 59% is both the supply and the distribution direction. 7% of the articles even show only

the distribution process, because, for the aim of synchronizing inventory replenishment, it is important to analyze the ordering patterns of the different echelons (Viswanathan, Widiarta, & Piplani, 2007). The remaining 3% give no indication to which side of the supply network they refer.

Continuing with an evaluation of the map spatiality, only the three articles already mentioned regarding the mapping software tools are about geographic supply chain mapping. The remaining 95%, as illustrated in figure 15, refer to structural supply chain mapping. This clear distribution shows, on the one hand, that research on geographic supply chain mapping might be extended, as it is useful for reaching mapping objectives. Moreover, the use of support by mapping software tools needs to be further examined for structural supply chain mapping. An exchange with practitioners has confirmed that these tools are already in use by the companies, but these firms are not in favor of publishing these cases because of the high data sensitivity linked to internal and external risks (J. T. Gardner & Cooper, 2003).

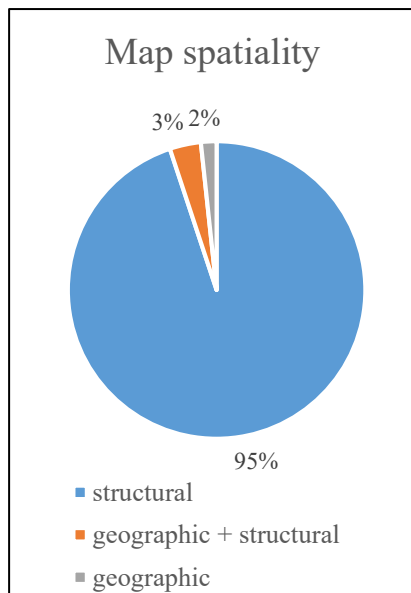


Figure 15: Spatiality in supply chain maps

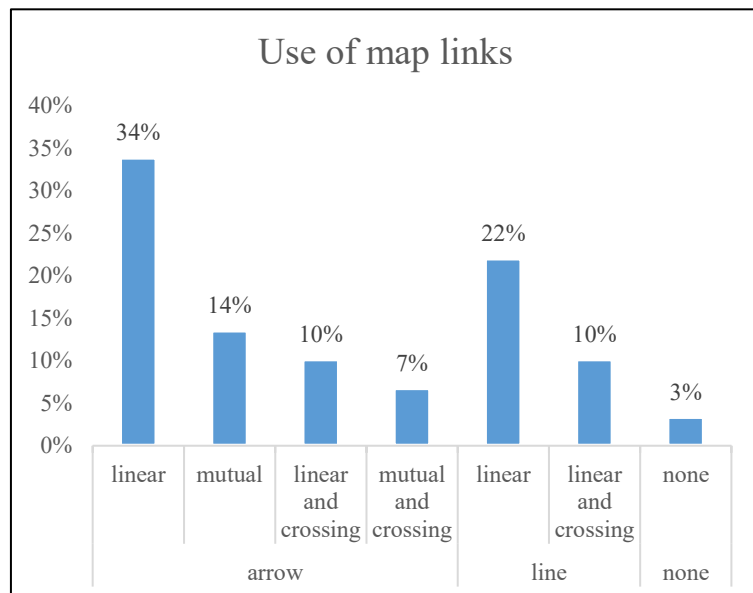


Figure 16: Use of links in supply chain maps

Links usually connect the nodes in a supply chain map. In 64% of the examined articles, we found arrows indicating the direction of the respective material, financial or information flow. Moreover, 32% of the authors used lines showing at least which actors are connected on the map. Finally, two illustrations only show the nodes on the map without the corresponding links. In addition to these results, figure 16 gives insight into the complexity of the maps. Concerning the arrows, 34% represent linear flows and another 10% show linear but also crossing links that can be found in netchains or networks. A similar distribution applies concerning the lines, of which 22% pass linearly and again 10% linearly and crossing. One particularity exists relating to the arrows: 14% of these arrows are drawn mutually and another 7% mutually and crossing. This fact gives important implications for supply chain integration and relationship management as several links exist in a mutual direction.

However, from a practitioner's point of view, it is not only interesting to know if there is a relation between several actors but also to which extent it exists. Therefore, we have also verified in which maps the links are quantified. Out of the 71 articles, we have found such

quantifications only in seven papers showing that it is not so common yet to show this information in maps. An assumption is that access to the required information is restricted in most cases. Table 7 points out that if the link is quantified, the quantification refers most frequently either to the material flow, indicating the number of goods shipped, or to the number of business units at one level in order to demonstrate the supply chain complexity by keeping the illustration simple at the same time. Examples in this context are the articles by Allesina (Allesina et al., 2010) measuring the steel transfer in tons/year displayed in a separate transfer matrix and the article by Miyake (Miyake et al., 2010) giving the number of gears, forged parts, assembly cubes, etc. that are needed in a transmission supply chain in an additional table. Articles underlining the number of business units have been published by Creazza relating to the delivery points of the tire manufacturer Pirelli (Creazza et al., 2012) and by Berry (Berry & Naim, 1996) about the number of business units in a P.C. supply chain. Other opportunities to quantify relationship information concern the percentage of suppliers or customers indicated by the arrow size (M. Smith et al., 2009), the financial flow in terms of the percentage of total sales revenue for selling or of total purchase spend for buying (Farris, 2010) or a visibility index that assesses the quantity and the quality of the shared information (Caridi, Crippa, Perego, Sianesi, & Tumino, 2010).

Author	Link quantification
Allesina et al.	goods transfer (steel in tons/yr.)
Berry and Naim	no. of units
Caridi et al.	visibility index
Creazza et al.	no. of delivery points
Farris	financial flow (% of total sales revenue for selling, % of total purchase spend for buying)
Miyake et al.	no. of SKUs (in a table)
Smith et al.	% of suppliers/customers (indicated by arrow size)

Table 7: Quantification of links in supply chain maps

RQ 2.2: Perspective in the supply chain maps

Out of the 59 maps, not all visualize specific industries. As presented in figure 17, 39% are general maps, followed by case studies in the automotive, electronics, food, construction and clothing industry. A reason for the high interest in supply chain mapping in these sectors might be, that there are on the one hand products with high complexity and modularity like in the automotive or construction industry, and on the other hand industries being regulated by strict directives such as the food or clothing industry. Apart from these frequently visualized industries, single application cases could also be found in further industries such as the telecommunications, aerospace or furniture industry.

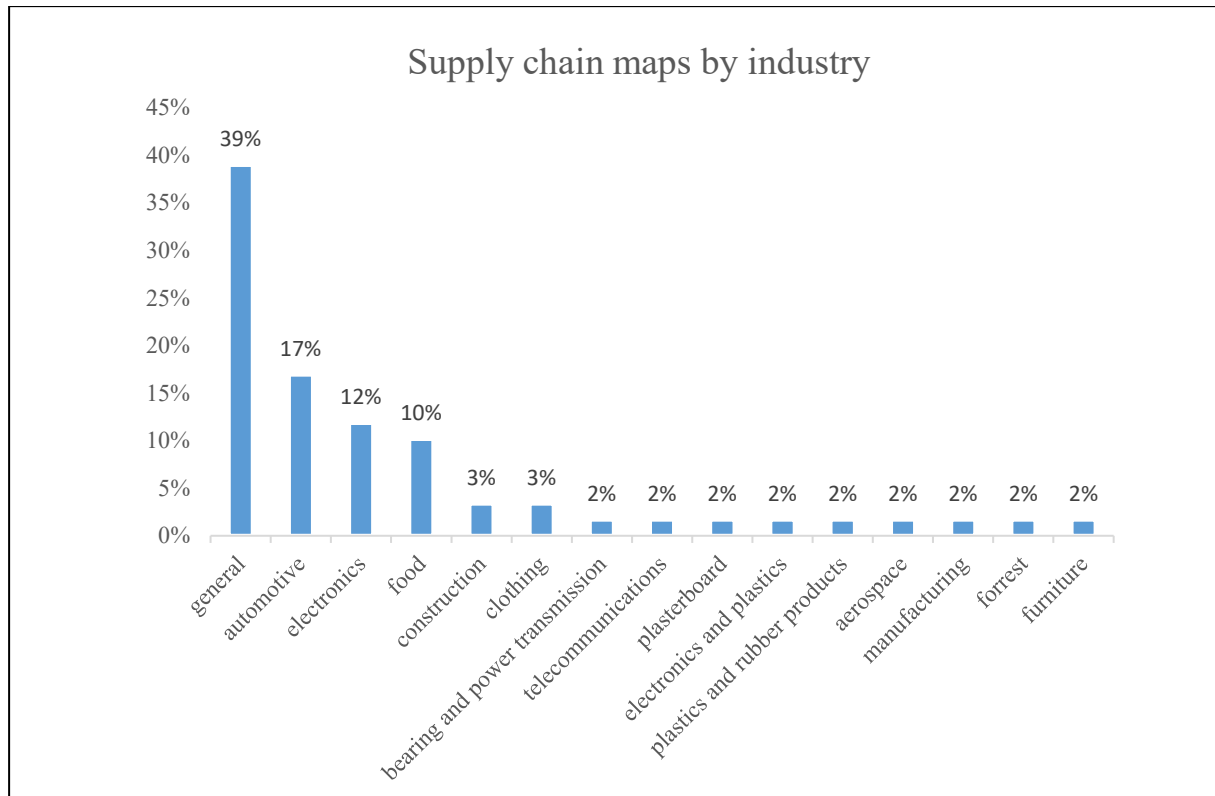


Figure 17: Supply chain maps by industry

The next interesting research question to be answered concerns the unit of analysis in a supply chain map. Both Gardner and Farris already mention the dilemma to include enough information in a supply chain map to manage the supply chain by still keeping it useful for strategic purposes. As the authors do quite often not explicitly mention the unit of analysis in the articles investigated, sometimes assumptions have to be made to deduce the unit of analysis from the supply chain map. Figure 18 shows various application fields, all being frequently used. 41% of the articles cover the supply chain of a whole company like the supply chain network structure in the article by Lambert, Cooper and Pagh, covering all members of the focal company's supply chain (Lambert, Cooper, & Pagh, 1998). With 37%, nearly as many articles analyze the supply structure of a commodity group. Examples for commodity group maps are the supply chain network of t-shirts (Marufuzzaman & Deif, 2010), a beer supply chain (Mena, Humphries, & Choi, 2013) or the supply chain for TFT-LCD manufacturing (Sha, Chen, & Chen, 2008). The commodity maps listed according to frequency are followed by industry maps being in third place with 17% of the articles. Maps depicting this unit of analysis are also called macro maps identifying the overall structure of the supply chain at industry level like the 326 plastics and rubber products industry supply chain macro map (Farris, 2010) or contain the industry focus in the map names, e.g. the North American bearing and power transmission equipment industry supply chain (Shockley & Fetter, 2015) or the major Australian cereals industry supply chain channels (Sohal & Perry, 2006). Finally, there are also three articles examining concrete products as the units of analysis: the Honda Accord (T. Y. Choi & Hong, 2002; Y. Kim, Choi, Yan, & Dooley, 2011) and the PAX wardrobe system (Hultman, Johnsen, Johnsen, & Hertz, 2012). Although the number of articles targeting a single product is low, this

analysis possibility offers the opportunity to become more concrete than on industry level and to show more details.

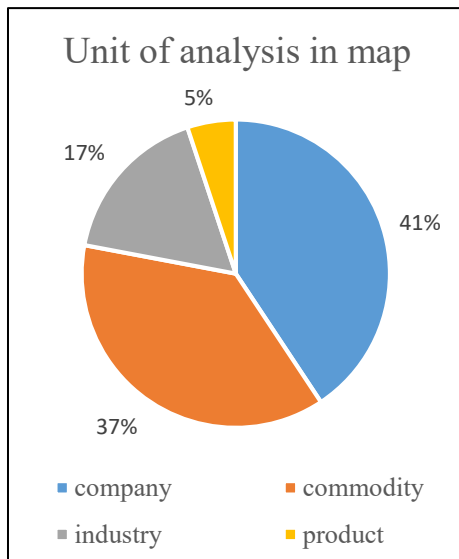


Figure 18: Unit of analysis in supply chain maps

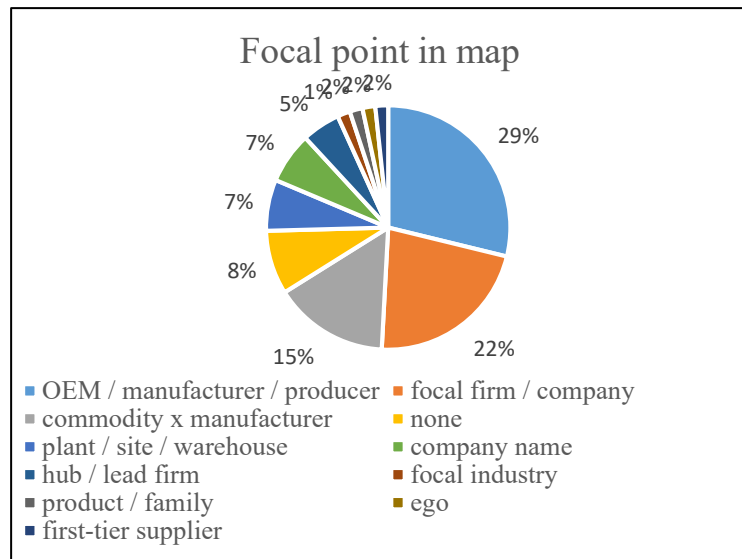


Figure 19: Focal point in supply chain maps

The unit of analysis is linked to the focal point in a supply chain map. Half of the articles displayed in the pie chart in figure 19 either visualize the OEM/manufacturer or producer understood as synonyms in the center of the maps or, more generally, the focal firm or company. This finding fits the fact that the company is the most illustrated unit of analysis. Either the third quarter consists of the manufacturers of a certain commodity or there are nodes in the middle of the maps without a designation. Besides, Ericsson maps his supply chain structure on the commodity level after a serious sub-supplier accident and is the only article choosing the product/family as the focal point (Norrman & Jansson, 2004). Farris, with his macro map on plastics and rubber products, chooses the focal industry as the focal point. An exception makes Johnsen, who puts EuroPart as a first-tier supplier in the middle of the map (Johnsen & Ford, 2005).

RQ 2.3: Information density displayed in supply chain maps

Finally, supply chain maps offer also the possibility to display additional information as listed in table 8. Apart from the quantification information regarding the links that has been analyzed above, most of this information concerns the supply chain operations aligned to the SCOR model, e.g. in the clothing industry (MacCarthy et al., 2013), the construction sector (Nasir, Genovese, Acquaye, Koh, & Yamoah, 2017) or an aerospace supply chain (Raj Sinha, Whitman, & Malzahn, 2004). Other information that can be integrated into a supply chain map might be the information flow as in the supply network of hi-tech products (C. Harland et al., 2003), the indirect inputs in a plasterboard supply chain (Dadhich, Genovese, Kumar, & Acquaye, 2015), opportunities for cost reduction or new technical standards (Ojasalo, 2004) or sourcing responsibilities (T. Y. Choi & Hong, 2002).

Additional information displayed	Author
Car models concerned	Dubois and Fredriksson
Characteristics of link (indirect communication, transport,...)	Mena
Complexity directions	Bode and Wagner
Effects of the directives WEEE and ROHS on the supply chain	Koh et al.
Information flow, lead times	Viswanathan et al.
Information flow, agents, international borders	Harland et al.
Information flow, perceived competitive relationships (by the first-tier supplier)	Johnsen and Ford
Intra-company transports, utilities and indirect inputs	Dadhich et al.
Investigated sites	Berry and Naim
Magnitude of relationship	Farris
Material & order flow	Berry and Towill
No. of delivery points	Creazza et al.
No. of plants, regionalality	Singh Srai and Gregory
No. of SKUs (in a table)	Miyake et al.
No. of suppliers & customers by region	Smith et al.
Non-managed process links, non-members of the focal company's supply chain	Lambert and Cooper
Non-managed process links, non-members of the focal company's supply chain	Lambert et al.
Operations	MacCarthy, Marufuzzaman, Nasir, Raj Sinha, Sha
Opportunities for the focal company	Ojasalo
Order flow	Shockley and Fetter
Primary + secondary stakeholders, imported goods (tn)	Kumar et al.
Serial and parallel interactions	Wilding
Sourcing responsibility	Choi and Hong
Structure / process / information complexity	Lin et al.
Subcomponent details	Thomé et al.
Transitive triadic clusters	Hearnshaw and Wilson
Value-added (%)	Doran
Visibility	Barratt and Barratt, Caridi et al.

Table 8: Additional information displayed in supply chain maps

2.3.3 Deducing a generalized draft for the procedure of supply chain mapping

RQ 3.1: Supply chain mapping terminology and responsibility

Moving from the structure of the supply chain map to the supply chain mapping procedure, we investigate this procedure first according to its terminology, as well. Figure 20 points out that

nearly half of the authors describe the procedure towards achieving a supply chain map as mapping. About one-third of the articles only show the map as the output, but do not suggest a word for the mapping procedure. Other common words are showing, scanning or illustrating that can be regarded as synonyms. Furthermore, phrases like devising or creating a map underline the desired outcome of the procedure.

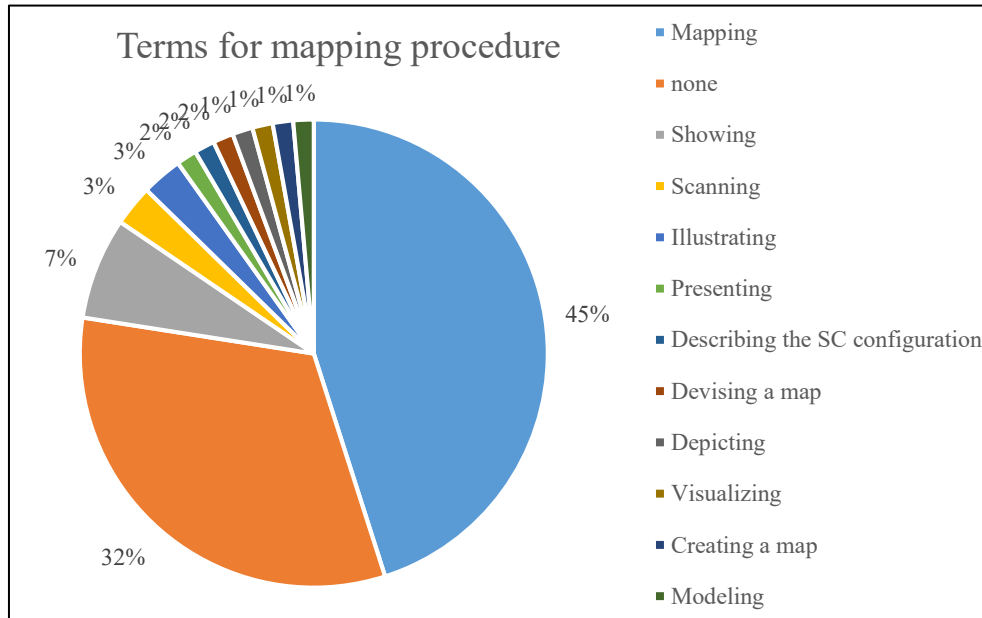


Figure 20: Terms for supply chain mapping procedure

Although most articles give a hint on the mapping objectives, hardly any authors explain the mapping responsibilities. From the respective context, it can be deduced that the authors of the respective articles have created the maps in nearly all cases. Only exceptional articles mention the involvement of the focal company (Dadhich et al., 2015; Grimm et al., 2014; Lamming et al., 2000) or students (Farris, 2010) or even a dedicated project team of supply chain members (Zokaei & Hines, 2007).

RQ 3.2: Information sources for supply chain mapping

Regarding the information sources to create the maps, the information provided by the articles is also low, as about one-third of the articles do not provide any information, as presented in table 9. Interviews, a survey or the cases themselves are mentioned as the most frequent information sources in case studies. These sources can be extended by workshops (Oglethorpe & Heron, 2013) or focus group discussions (Fabbe-Costes et al., 2014), field work days (Zokaei & Hines, 2007), observation (Doran & Giannakis, 2011), company documents (Norrman & Jansson, 2004) or visits (Lin, Zhou, Shi, & Ma, 2009; Shockley & Fetter, 2015). Finally, one can contact the following supply chain members to disclose information: customers, suppliers, competitors, experts or trade associations. Moreover, there are informative events like exhibitions and conferences as well as documents such as industry forecasts, scientific reports, annual reports, newspapers, professional magazines, trademark registrations, patents, the internet and others (Kumar et al., 2013; Ojasalo, 2004). Furthermore, MBA students can be a valuable information source (Farris, 2010). In particular cases, the Ecoinvent database has been consulted (Dadhich et al., 2015; Nasir et al., 2017) and the Louisiana Forest Products

Development Center has provided a list of all forest supply chain members in Louisiana (M. Smith et al., 2009).

Mapping information source	No. of articles	% of articles
None	24	34%
Interviews	12	17%
Case study	11	15%
Literature review	6	8%
Interviews + survey	2	3%
Interviews, workshops, questionnaire	1	1%
MBA students and graduating logistics undergraduates	1	1%
Louisiana Forest Products Development Centre	1	1%
Application initiatives identified in the Brazilian industry	1	1%
Interviews, supplementary documents	1	1%
Plant visits, documentation posted on official web sites, interviews	1	1%
Data collection protocol, interviews, Ecoinvent database	1	1%
Industrial reports, literature reviews and case studies	1	1%
Ecoinvent database + interviews	1	1%
Survey	1	1%
Four field workdays	1	1%
Supplier selection according to value creation activities	1	1%
Interviews, company documents, observation	1	1%
Customers, suppliers, competitors, experts, forecasts, exhibitions,...	1	1%
Interviews, company visits	1	1%
Interviews, focus group discussion, literature	1	1%
Total no. of articles	71	100%

Table 9: Information sources for supply chain mapping

RQ 3.3: Supply chain mapping procedure steps

Finally, we examined the mapping procedure. About 15% of the authors reveal information about the different procedure steps, as displayed in table 10:

Author	Mapping procedure
Dadhich et al.	<ol style="list-style-type: none"> 1. Data collection 2. Data analysis (emission calculation) 3. Supply chain mapping
Farris	<ol style="list-style-type: none"> 1. Start with high-level macro map 2. Determine focus area 3. Seek to determine necessary data (if no primary data, use secondary sources)

Harland (b)	<ol style="list-style-type: none"> 1. Definition of key elements 2. Mapping stage 3. Presenting the maps at many global meetings
Lambert and Pohlen	<ol style="list-style-type: none"> 1. Map the supply chain 2. Analyze each link 3. Find improvement potential and realign SC processes
Lau et al.	<ol style="list-style-type: none"> 1. Data collection 2. Data analysis 3. Describing SC configurations
Norrman and Jansson	<ol style="list-style-type: none"> 1. Mapping the supply chain 2. Evaluation of risk probability 3. Taking risk management actions
Ojasalo	<ol style="list-style-type: none"> 1. Identifying a key network 2. Strategies for managing actors of the key network 3. Developing and applying operational methods for managing key network actors
Singh Srail and Gregory	<ol style="list-style-type: none"> 1. Identifying business units for assessment 2. Mapping supply network configuration 3. Mapping supply network capability 4. Deducing future network configuration
Smith et al.	<ol style="list-style-type: none"> 1. Survey 2. Condensation into four geographic regions for further analysis 3. Categorization of results 4. Mapping of results
Thomé et al.	<ol style="list-style-type: none"> 1. Data gathering 2. Visualization 3. Analysis 4. Cross case analysis for similarities and discrepancies detection
Zokaei and Hines	<ol style="list-style-type: none"> 1. Learning mapping technique 2. Data collection 3. Evaluation of current state SC map 4. Action plan for moving towards the future state SC map

Table 10: Steps in supply chain mapping procedure

After having compared these steps, we can identify similarities and create a generalized draft of the supply chain mapping procedure, which is illustrated in figure 21:

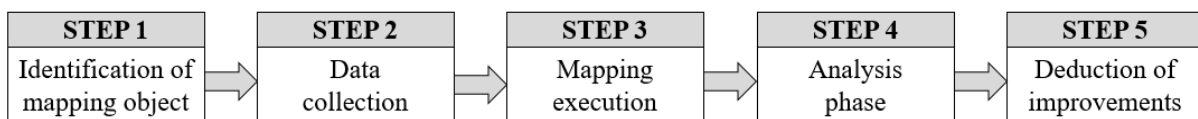


Figure 21: Generalized draft of the supply chain mapping procedure

The procedure starts with the identification of the mapping object (Farris, 2010; Ojasalo, 2004; Singh Srail & Gregory, 2008) followed by the data collection phase (Dadhich et al., 2015; Lau,

Yam, Tang, & Sun, 2010; M. Smith et al., 2009; Thomé, Scavarda, Pires, Ceryno, & Klingebiel, 2014; Zokaei & Hines, 2007). The next step is the mapping execution, which is mentioned by nearly all listed authors as the core of the procedure. The completion of the map leads to an analysis phase. Aspects for this evaluation can be the risk probability (Norrman & Jansson, 2004), the interactions between the supply chain members at each link (Lambert & Pohlen, 2001) or the current state of the map in general (Zokaei & Hines, 2007). This activity results into the deduction of improvement potential such as operational management measures (Ojasalo, 2004), the realization of the desired future network configuration (Lau et al., 2010; Singh Srai & Gregory, 2008; Zokaei & Hines, 2007) linked to the realignment of supply chain processes (Lambert & Pohlen, 2001) and the implementation of risk management levers (Norrman & Jansson, 2004).

2.4 Conclusion and Future Research

2.4.1 Contributing to a standardized supply chain mapping terminology and delivering mapping instructions for practitioners

The structured literature review offers a profound analysis of the literature on the concept of supply chain mapping published between 1992 and 2017. In order to answer the first research question, both a qualitative review and a bibliometric co-word analysis have shown that supply chain mapping is used for a broad range of purposes, thereof mostly for the analysis of supply chain relationship management and integration and risk management. This analysis of the objectives contributes to both theory and practice. In current literature, single case studies of companies using supply chain mapping have been published, but there was no synthesized overview of the application cases of supply chain mapping. The analyzed objectives will also arouse the interest of practitioners, who now have reasons why they need to add this method to their toolbox.

In our second research question, the structure of supply chain maps has been investigated in detail. We found out that many supply chain maps share a similar geometry: Most maps are structural and show chains or netchains, covering both the supply and distribution side with an average length of five and an average width of four tiers. Most of them have a general company or commodity as the unit of analysis, but some have a relation to one sector, thereof mostly to the automotive, electronics or food industry. Hence, these results mainly contribute to theory because they deliver valuable conventions on how to map the supply structures properly, as inquired by Gardner and Cooper (J. T. Gardner & Cooper, 2003) and Farris (Farris, 2010) and also contribute to a standardized supply chain mapping terminology.

The highest managerial implications of our study concern the third research question dealing with the supply chain mapping procedure. While practitioners can find many supply chain maps in the media, there are hardly any instructions on how to create them. By synthesizing the analyzed articles, a generalized draft for the mapping procedure has been deduced. The procedure comprises the following steps: identification of the mapping object, data collection, mapping execution, analysis phase and deduction of improvements. Hence, practitioners learn that they need to select a small part of their supply network before the mapping because the

mapping of their whole supply network most probably is unfeasible. They also need to check first if they have access to the necessary information, which is the precondition for the mapping.

2.4.2 Analyzed conceptual and case study papers showing a high need for future empirical research

An important quality criterion of structured literature reviews is the replicability of the review. The hurdle regarding the fulfillment of this criterion lies in the selection of the articles. As the number of articles that can be found under the search term of supply chain mapping is very low (Carvalho et al., 2012), articles of other research fields have been added that depict supply chain maps, as well. Nevertheless, another researcher who might have left out one research field or added another one might come to different results up to then. However, the replicability of the results significantly increases again through the explicit terms that have been used in the qualitative literature review to analyze the articles. Moreover, also, the bibliometric method leads to reproducible results and hence ameliorates the quality of the literature review significantly. Structured reviews are a subjective method to evaluate literature. The bibliometric method has helped to add a quantitative rigor and a monitoring device to this qualitative research approach (van Raan, 1996).

Almost all papers that have been analyzed during the structural literature review are conceptual research or case studies. Hence, the biggest identified gap for future research is that there is no large empirical study so far that analyzes if the tool really leads to success. Concrete cost and benefit figures are missing in the papers published so far. Hence, future research activities need to assess the savings and non-monetary benefits achieved by the realization of supply chain redesigns or risk improvement measures triggered by supply chain mapping activities. It will be interesting to examine if a good supply chain knowledge and a high data quality itself are already sufficient or if the application of the supply chain mapping tool is really worth its effort.

Additional research is also needed regarding the necessary sources of the information, which is displayed on the map. In many papers, the mapping took place based on interviews. However, future researchers need to examine which people can provide the most helpful supply chain knowledge in such interviews in order to improve the efficiency of the data gathering step in the supply chain mapping procedure.

Furthermore, research on geographic supply chain mapping needs to be extended. Currently, most articles deal with structural supply chain mapping, even though geographic supply chain mapping certainly has its relevance in the context of global sourcing. A future research agenda in this context needs to cover not only the geometric spatiality of the maps but also the opportunities offered by mapping software. In this context, not only the tools already mentioned by Gardner and Cooper and Farris might be deeper explored, but also innovative products on the market that offer additional functionalities, for instance, in the context of supply risk management software.

Chapter 3: Coping with rising Supply Chain Complexity: Conceptualizing a Supply Network Map Structure Model to address that challenge

Abstract

The complexity in supply networks is increasing and influences the competitive position of the focal company. Traditional approaches like supply chain mapping only show the focal company's relationships with suppliers and customers along the vertical supply chain but are not capable of mapping any horizontal buyer-supplier relationships with other companies. Hence, this paper introduces a new Supply Network Map Structure Model that extends the multi-tier view towards suppliers and customers along the vertical supply chain also to the complementors and competitors across the horizontal supply chain. Thus, the model enables the development of the existing Supply Chain Mapping theory further into a holistic Supply Network Mapping method. The model has been conceptualized with the help of 13 semi-structured interviews and is based on relevant models from the strategic management and the purchasing and supply management (PSM) literature. According to design science, it has been refined in several iterations.

Keywords

Supply network; Supply chain mapping; Supply chain complexity; Conceptual research; Theory development; Semi-structured interviews; Design Science

3.1 Introduction: Supply chain visibility, complexity and necessary tools

3.1.1 Better visibility needed due to supply risks, supply market trends and legal obligations

If companies aim to maximize their profits, they can either try to increase revenue by raising sales prices or by achieving higher sales volumes or they can try to lower their purchasing costs. An important pre-condition for the companies in this context - especially from the purchasing perspective - is to have high visibility about the inbound supplier structure and the interrelated buyer-supplier relationships (Barratt & Barratt, 2011; Barratt & Oke, 2007; Jin et al., 2013; Tse & Tan, 2012). Influential authors of the Industrial Marketing and Purchasing (IMP) Group, such as Hakansson (H. Hakansson & Ford, 2002), have researched these complex interactions between companies and networks in various contexts, e.g., in purchasing, since the 1980s.

High visibility is desirable for optimizing supplier relations, but also mandatory to react to the occurrence of risk events such as the tsunami in Japan in 2011 or the major fire at the production facility of the German filter supplier Hydac in 2015, which caused damage costing many millions of euros. Risk management rises in significance as supply chain vulnerability grows due to the increasing integration of actors into supply chains and networks. This development leads to dynamics that might damage all of these actors simultaneously. Such integration trends include the alignment of business models and strategies, processes and IT integration approaches as well as a trend to reducing buffer stocks (Norrman & Jansson, 2004; Spahr & Schäfer, 2014).

Most industrial firms currently concentrate on their core competences. It is assumed that the low value-creation share of 38% of OEMs in the automotive industry in 2017 will even further decrease to 35% until 2030 (Wyman & VDA, 2018). The affected companies only have sufficient information about their 1st-tier suppliers, because they carry out system or modular sourcing, but they usually know little about the lower tiers in their supply chains (Trimble & O’Kane, 2008).

Moreover, there is a trend towards the globalization of the value-creating processes in the supply network, which allows manufacturers to profit from the cost advantages in low-cost countries but does reduce transparency. Furthermore, as a result of this development, manufacturers need to cope with the volatility of the various sourcing market currencies (Semmler & Mahler, 2007).

Another important driver why the focal firm needs to improve the transparency across its supply network are increasing legal obligations concerning supply chain transparency: The taxation law of the European Union requires certification of preferential origin and is obligatory for all WTO members as a part of the GATT agreement. The certificate must indicate the country of origin; if several countries are involved, the country of the last substantial material transformation is decisive (European Commission, 2019).

3.1.2 A great variety of suppliers and other causes increasing the supply chain complexity

Supply chain complexity is increasing significantly (Hamta, Akbarpour Shirazi, Behdad, & Fatemi Ghomi, 2015) and managers need to respond to this severe challenge (Cagliano, Carlin, & Rafele, 2009; Turner, Aitken, & Bozarth, 2018). The growing complexity results from several causes: globalization, customization, innovation, product complexity, flexibility, sustainability, volatile markets and unpredictable demands (Kavilal, Prasanna Venkatesan, & Harsh Kumar, 2017; Sun & Rose, 2015). The supply chain complexity drivers denote the number and variety of suppliers, customers, products, processes and uncertainties, which are highly interdependent (Kavilal et al., 2017). The growing supply chain complexity may result in negative consequences on cost, customer service and reputation. Organizational aspects of complexity are often reflected in process-related or structural deficits, bottlenecks, information gaps or further obstacles. Uncertainty in material planning due to supply chain complexity can lead to inaccurate forecasts that will result in overstocks caused by bullwhip effects (Blecker, Kersten, & Meyer, 2005) or in late deliveries (Wilding, 1998).

Furthermore, Choi and Hong differentiate between horizontal, vertical and spatial characteristics of upstream supply chain complexity (T. Y. Choi & Hong, 2002). Horizontal complexity is characterized by the number of suppliers in each tier, while vertical complexity is characterized by the number of tiers and spatial complexity is finally specified by the extent of the dispersion among members within the network. The three complexity drivers intensify the effects of the other two complexity drivers mutually. Complexity usually consists of a static element concerning the variety of supply chain actors and behavior as well as a dynamic aspect regarding the interactions between these actors (Bode & Wagner, 2015). An industrial network is the combination of the vertical and horizontal direction, including indirect relationships (Miemczyk, Johnsen, & Macquet, 2012).

3.1.3 Suitable tools required to cope with low visibility and rising supply chain complexity

As inbound risks and supply chain complexity increase while the overview of value creation architectures declines, purchasing managers need suitable tools to achieve visibility about the actors in their supply network and their relationships with each other in order to help make strategic sourcing decisions. The existing Supply Chain Mapping approach is no longer sufficient for this task as it only addresses the linear, vertical supply chain, but competing supply chains rather look like overlapping networks (Bellamy & Basole, 2013; T. Y. Choi & Wu, 2009; Lambert, 2008). Consequently, the research goal of this paper is to design a Supply Network Map Structure Model to support the strategic sourcing process according to the following research questions:

- ***RQ1:*** *What are the requirements for and objectives of a Supply Network Map Structure Model from the focal company perspective?*
- ***RQ2:*** *Which structure, actors and directions of relationships are needed to meet these requirements?*

This introduction will be followed by an overview of existing models in strategic management as well as PSM literature to guide model conceptualization. In the first step, the existing models are analyzed before defining the term Supply Network Mapping and explaining the relevant attributes of Supply Network Maps. In the following part of this paper, the exploratory research approach is described. After explaining the methodology, requirements and objectives of the Supply Network Map, we present our findings, which are relevant for the model conceptualization. The main body of the paper is based on the theoretical and exploratorily gained findings and explains all the elements of the Supply Network Map Structure Model in detail: supply network structure, supply network actors and supply network directions. Finally, the paper ends with conclusions, including the theoretical contributions, managerial implications, as well as the limitations and the need for future research.

3.2 Theoretical foundations: Relevant strategic management and PSM models

Strategic management and PSM literature examine a focal firm within its environment. Hence, we decided to search in both disciplines for relevant structural models in preparation for the Supply Network Map Structure Model to be conceptualized. Figure 22 provides an overview of the existing models, which have been identified as influential for the new Supply Network Map Structure Model, sorted by discipline and publication chronology:

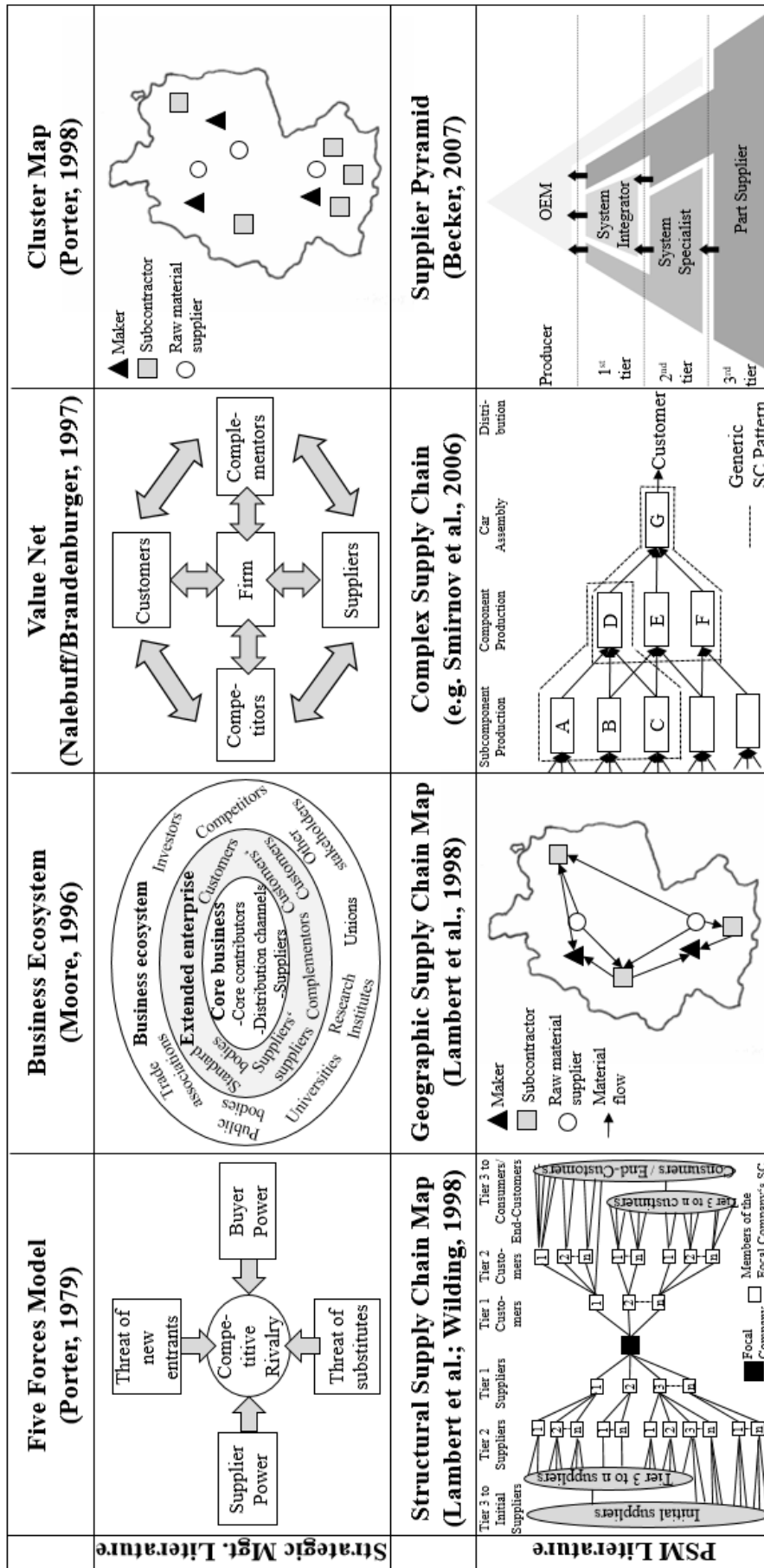


Figure 22: Relevant models for structure model conceptualization

3.2.1 Relevant models in strategic management literature covering other actors

In strategic management literature, the Five Forces Model by Porter (1979), the Business Ecosystem by Moore (1996) and the Value Net by Nalebuff and Brandenburger (1997) took a structural approach to investigate actors in the environment of the focal company influencing the firm's business. As this environment is characterized by a high degree of transparency and continuously evolving relationships between the actors, the ecosystem stream of strategy knowledge is relevant (Jarzabkowski & Wilson, 2006). In contrast to these structural analyzes, the Cluster Map by Porter (1998) is a geographic approach to investigating local concentrations of makers, subcontractors and raw material suppliers within a certain industry in a defined area.

The overlap of these four strategic models lies in the focal company and its direct suppliers. Moreover, these strategic models show customers and competitors as important actors. While competitors directly influence the focal firm's business in the Five Forces Model and the Value Net, they only appear on the periphery on the third layer of the focal company in the Business Ecosystem. Cooperation with competitors without violating compliance regulations might, in certain business cases, lead to a "coopetitive advantage" (Nalebuff & Brandenburger, 1997; Sroka, 2013).

Complementors are another important group of actors in the Value Net and the extended enterprise on the second layer of the Business Ecosystem. They are regarded as the mirror image of competitors (Brandenburger & Nalebuff, 2011). Complementary products are connected with the product delivered by the focal company and make the offering more attractive to the customer, whereas products of competitors make it less valuable and less unique to the customer. Subcontractors are considered in the Cluster Map and the extended enterprise of the Business Ecosystem as well as customers' customers who are included in the ecosystem but appear on the same layer as the other actors.

In the new Supply Network Map Structure Model, stakeholder interests play an important role. As the structure model is conceptualized for application in strategic purchasing, all actors who are part of complex networks to plan, source, make and deliver products need to be involved (Millar, 2015). This analysis leads to the conclusion that the new model needs to fully cover the scope of the Value Net and the Cluster Map. The threat of new entrants and new substitutes, according to the Five Forces Model, are subordinated to the group of competitors in the model conceptualization phase as new or substituting products enhance the rivalry between the focal company and its competitors (Porter, 1979). As the following regulatory and enabling forces in the Business Ecosystems are not directly related to the above mentioned product sourcing and delivery, they are neglected in the new model, but might be added if needed in response to stakeholders' demand in future as in a later self-renewal evolutionary stage of the ecosystem (Moore, 1996): contributors, trade associations, standard and public bodies, universities, research institutes, trade unions, stakeholders and investors.

3.2.2 Relevant models in PSM literature showing multi-tier interactions

The authors of the PSM literature like Harland (C. Harland et al., 2003), Jarillo (Jarillo, 1993), and Lamming (Lamming et al., 2000) concentrate their work on supply networks. Hence in PSM literature, we identified again three structural models presented in the overview in figure 22 as influential for the design of the new Supply Network Map Structure Model: the Structural Supply Chain Map (Lambert et al., 1998), the Complex Supply Chain (Smirnov, Shilov, & Kashevnik, 2006), the Supplier Pyramid (Becker, 2007) and the Geographic Supply Chain Map (Lambert et al., 1998). While the models from the strategic management literature have mainly been taken into account to help select the relevant actors to form the nodes in the new Supply Network Map Structure Model, the PSM models have primarily been considered concerning the links between these actors. When analyzing these models, a remarkable finding is that these relations reach across many tiers. Up to three levels are included in the Structural Supply Chain Map, with each tier being a new branch point for multiple links. Other authors such as Wilding with his Supply Chain Complexity Triangle (Wilding, 1998) as well as Kaufmann and Germer with their Supply Chain Map (Kaufmann & Germer, 2001) suggest models with very similar structures compared to the Structural Supply Chain Map. While the above mentioned models show relationships being complex but parallel, other complex Supply Chain Maps allow complex overlapping links. Within these illustrations of complex supply chains, small simplified units consisting of a producer and his 1st-tier suppliers can be highlighted and serve as configuration patterns (Smirnov et al., 2006), as illustrated in figure 22.

An additional important insight is provided by a modified version of the conventional Supplier Pyramid. In this pyramid, suppliers are sorted according to their degree of value creation (Becker, 2007). The shape not only describes the closeness to the OEM at the top of the pyramid but also the number of suppliers at each level of the pyramid. Starting at the bottom of the pyramid, part suppliers manufacture standard parts and hardly perform any research and development or provide any assembly service. At the next level, suppliers deliver modules and possess high technological competence but do not execute much assembly work, either. Finally, at the 1st-tier level, suppliers deliver assembled systems or components and have high technological and logistics competencies, so that the OEMs collaborate with them via modular or system sourcing (Appelfeller & Buchholz, 2011). The recent version of the Supplier Pyramid by Becker (2007) shows that deliveries do not only take place directly between an actor and its direct higher or lower tier, but that single or several tiers can also be skipped and so direct relationships between part suppliers and OEMs, for instance, can be established (Präuer, 2003). This behavior is also referred to as climbing up the supply chain from a supplier's perspective or as stepping down it from the focal company's point of view (Wan & Wu, 2015). As suppliers have realized that the lower they are classified in the supplier pyramid, the easier they are to replace, they now strive to extend their product scope and to system integration (Wolf, Herbert, & Zipse, 2010).

3.2.3 Supply Network Maps having a more complex geometry than Supply Chain Maps

The supply network is more complex than the vertical supply chain. Therefore, a definition for the mapping approach needs to emphasize the focus on the new processes and dependencies resulting from this complexity. Moreover, complementors and competitors will need to be added to the mapping approach following the literature review. Consequently, we derive the following definition of the purpose of the new Supply Network Mapping approach from the Supply Chain Mapping definition: “Strategic Supply Network Mapping focuses on goods, money and information flows and the corresponding processes and dependencies into all directions of a company’s environment: upwards towards the suppliers, downwards towards the customers, to the left towards the complementors and to the right towards the competitors.”

Supply Network Maps are characterized by several features that are classified into the main attributes of geometry, perspective and implementation. We adapted these attributes from chain to network scope in table 11, based on the attributes for Supply Chain Maps defined by Gardner and Cooper (J. T. Gardner & Cooper, 2003):

Main attribute	Sub-attribute	Definition	KPIs / characteristics
GEOMETRY	Tiers	Sequential actors leading to the initial supplier / final customer, most distant complementor / competitor	# tiers # layers
	> Direction	Coverage up or down / left or right	supplier-orientation / customer-orientation complementor-orientation / competitor-orientation
	> Length	Tiers / layers in each direction	# tiers up / # tiers down # layers left / # layers right
	Width	Interchangeable actors within a tier or layer	# tier-x suppliers / # tier-x customers # layer-x complementors / # layer-x competitors
	Spatiality	Geographical representation	yes / no
PERSPECTIVE	Focal point	Company or industry	company / industry
	Scope	Scope of the perspective	see below
	> Product breadth	Breadth of product coverage	commodity group / product / component
	> SC perspective	Inclusion of SCM processes	yes / no
	> Process view depth	Extent to which the map incorporates processes	# processes
	> Cycle view	Inclusion of return channels and other feedback loops	yes / no
IMPLEMENTATION	Information density	Amount of information in the visual display	high / low
	Link to database	Link to preexisting corporate or supply chain database	yes / no
	Delivery mode	Communication medium towards the users	paper / electronic / web

Table 11: Supply Network Map attributes

Geometry describes the shape of the map. The tiers on the vertical axis, as well as the layers on the horizontal axis, are determined by direction and length. Direction means the upwards supplier-orientation, the downwards customer-orientation, the complementor-orientation to the left or the competitor-orientation to the right. Concerning the length in each direction, the number of tiers or levels can be calculated. The width is characterized by the number of interchangeable actors within one tier or layer (Pawellek, 2012). Nevertheless, this understanding differs from the definition given by Gardner and Cooper, who regard the degree

of specificity within a tier as the map's width. Finally, the element of spatiality distinguishes between structural and geographical maps.

The most important decision in terms of the perspective for a Supply Network Map is to choose the focal point: this is the heart of the map and may either be a single company or a whole industry, depending on the relations that will be shown on the map. Moreover, the scope of the map needs to be narrowed down to an adequate product breadth, supply chain perspective, process view depth and cycle view. The product breadth ranges from a single component to a whole commodity to a whole end-customer product right up to the whole product portfolio of one focal company. For model implementation, it is important to define a suitable object to be mapped, implying a certain pattern within the supply network structure. If a whole system of a focal company were mapped, the complexity would be very high and visualization could hardly provide a precise overview. Furthermore, the investment of time and resources would be very high (Doorey, 2011; Marshall et al., 2016) and probably not all the necessary information would be available. Therefore, it is necessary to choose a subsystem that will be mapped, such as a single commodity group (Heimbrock, 2001). Sometimes, an object cannot be decoupled easily from the rest of the network due to multiple relations and dependencies. As a result, it is mandatory that any partial entities can be integrated into the whole network again (Jehle, 2005). Moreover, a map must incorporate the relevant perspective, including processes such as procurement, manufacturing, packaging and distribution. Such processes can be mapped in varying depths. Another attribute of supply chain maps is whether the cycle view with return channels and feedback loops are part of the map.

Finally, the implementation of the map is crucial for its acceptance and use within a company. Thus, the information density may vary from high to low, depending on the amount of information that is shown on a visual display. If a link to a database such as Microsoft Access exists, this may allow real-time data processing. Finally, the creator of a map can choose a suitable delivery mode depending on the user's preference, such as paper, e-mail or the Internet.

The literature review and subsequent deduction of a definition and attributes for Supply Network Maps have enabled us to get a first idea of the required structure of the model to be conceptualized. However, it is important to explore the requirements and objectives of the buyers who will carry out Supply Network Mapping and use our model in strategic purchasing. Therefore, an additional exploratory empirical research approach defined below is required.

3.3 Research methodology: Model requirements and objectives identified through exploratory research

3.3.1 An exploratory empirical research approach to create and refine the model

Qualitative research is a suitable methodology to examine rarely explored questions and objects (Lamnek, 2005). As the approach is used to reveal reasons lying beyond the surface, the exploratory empirical research approach is an appropriate way for investigating the

requirements and objectives of Supply Network Mapping that are not yet visible to a purchasing organization (Bortz & Döring, 2006; Flick, 2007).

For data collection, we carry out semi-structured interviews with agricultural professionals from relevant departments of a focal agricultural machinery manufacturer and other firms in the same industry, because a complex, multi-tier network including various actors is characteristic of the agricultural machinery sector. This type of interview allows variation in the use of questions in order to involve a participant deeply into the study. Each interview has been linked to the purpose of the study to try to uncover the requirements and objectives of Supply Network Mapping (Galletta, 2013).

The sample size for these qualitative interviews is typically small. All in all, 13 interviews – twelve physical sessions and one webinar - with 16 people were conducted over half a year, including eleven employees of the focal firm and five people from companies in the same industry and software providers. The order of the interviewees was chosen according to the most promising research progress (Galletta, 2013). That is why the interviews started with the Heads of Corporate Purchasing and Spare Parts Purchasing as well as the Global Sourcing coordinator in order to achieve a broad understanding of the underlying objectives as quickly as possible. Interviews with employees who are responsible for more specific areas such as product management, customs and foreign trade, product cost optimization and logistics purchasing were carried out later. In addition to this, brainstorming sessions with several purchasers of product-related material were conducted to capture the model requirements for an application in their daily work.

According to design science, the model has been conceptualized in several iterations with various model stakeholders. Following this methodology, the results of one interview or brainstorming session serve as an input for the next interview or brainstorming session (Johannesson & Perjons, 2014). Based on the stakeholders' requirements, a first draft of the Supply Network Map Structure Model was created. Different commodities were selected for a test case to verify if the created model is suitable for the application. Following the application experience, the model was again refined in several iterations.

3.3.2 Model requirements and objectives being important for model conceptualization

Several model requirements have been decisive for the creation of the Supply Network Map Structure Model. The purchasers of product-related material highlighted during their brainstorming sessions that the model needs to lead to good market transparency for tenders, renegotiations and cost optimization projects. Moreover, the model shall be able to provide a geographic view by comparing local with global sourcing scenarios or by illustrating alternative purchasing options. Margin structures in the assembly of a component need to be visualizable by the structural view of the model. Further results concern the actors in the supply network. Not only has the upstream vertical supplier network to be mapped, but also the various layers of complementors and competitors in order to lead to benchmarking findings.

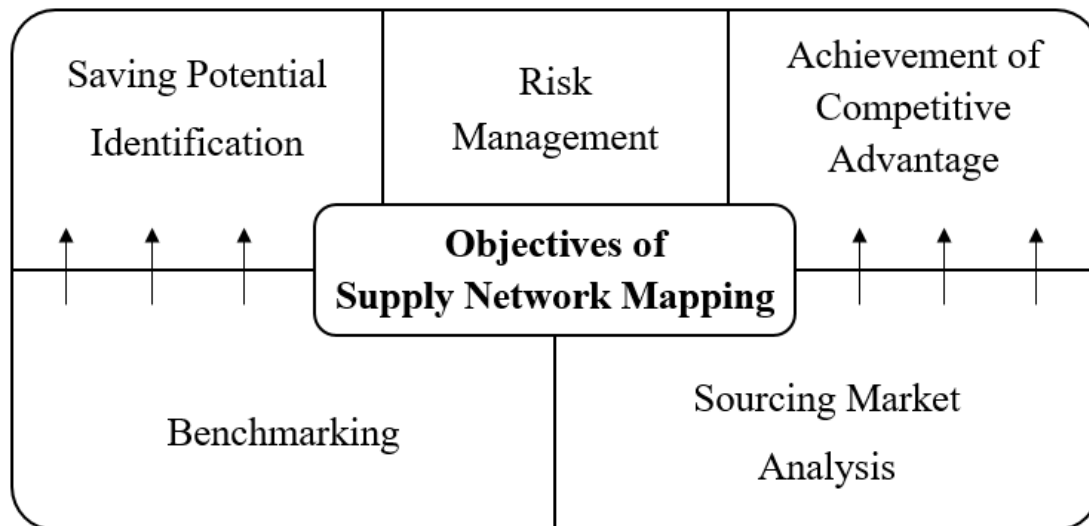


Figure 23: Objectives of Supply Network Mapping

Supply Network Mapping can be a promising tool for achieving the three main objectives arising from the expert interviews and brainstorming: Saving Potential Identification, Risk Management and the Achievement of Competitive Advantage. These objectives are supported by Sourcing Market Analysis and Benchmarking, both contributing as a foundation to the achievement of the main goals, as shown in figure 23.

A component can be split up into its single parts to identify cost-saving potential. The OEM can negotiate the volume on 2nd-tier parts directly with module suppliers in order to achieve lower prices. He can even switch to the 2nd-tier supplier to source the volume directly from him if it makes sense from a total cost of ownership perspective. The second objective is the management of external, uncontrollable risks. Although these risks are difficult to quantify, the occurrence probability and the severity of such risks, such as a natural disaster in Japan, can still be predicted and monitored by calculating suitable risk KPIs (Borghesi & Gaudenzi, 2013). As the third objective, it is important to analyze the potential for the achievement of a competitive advantage, which is also subject to the important related literature stream of social network analysis (Barney, 1991). Competitive advantage can be achieved by being a preferred customer of shared 1st-tier suppliers (Pulles, Schiele, Veldman, & Hüttinger, 2016; Schiele, Calvi, & Gibbert, 2012). The sourcing market analysis is a subordinate target to support the three main targets above. The country of origin, where a part has been manufactured, plays an important role for the supplier's sales price in the context of both structural and geographic Supply Network Mapping and is of a high interest for the customer in times of an increasing consumer awareness for a local, sustainable and ethically correct production of the goods that they consume (Kraft et al., 2018). The targets of benchmarking as a further subordinate objective of Supply Network Mapping include: to evaluate the competitors' successes and to improve the knowledge improvement on his existing and future suppliers, competitors, customers and complementors in line with a strengthening of the own market position (Büsch, 2013).

3.4 Model conceptualization: Capturing the structure, actors and relationships in a company's environment

3.4.1 Supply Network Map Structure Model visualizing a company's environment

The Supply Network Map Structure is based on the structural mapping for the upstream purchasing network through all supplier tiers and the downstream distribution network passing through all customer tiers (Gudehus & Kotzab, 2009). We supplemented this vertical order by the same horizontal triple-layer structure towards the competitors and complementors. There is no n^{th} -layer competitor or complementor, as there is no initial source of competition or complementarity.

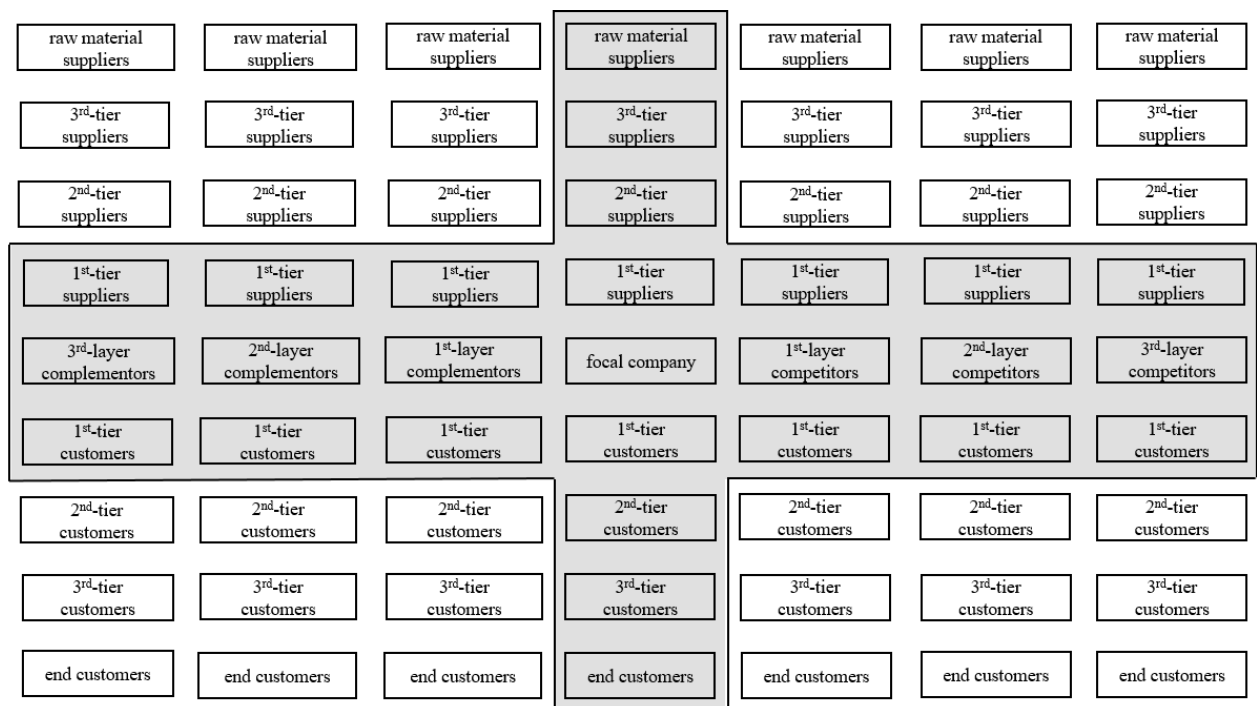


Figure 24: Supply Network Map Structure Model

In order to create the model in figure 24, the following abstraction and idealization of the real company environment were carried out (Jebeile & Kennedy, 2015): The vertical supply chain is no longer than four tiers consisting of 1st-, 2nd-, 3rd-tier and raw material suppliers. All boxes have the same distance between them, not representing the real geographic distance; each box signifies one type of actor rather than the real number of actors and every actor only plays one role within the supply network. Due to this idealization, the following business cases are left out of consideration: the focal company can be both OEM and supplier, joint ventures between the focal company and competitors, suppliers with creditor and debtor accounts and suppliers who also act as complementors or competitors.

To turn the supply network structure into the Supply Network Map Structure Model, we draw a zone in the form of a cross shape into the model. This cross marks the target zone of transparency achievement for the focal company because reaching 100% visibility and knowledge about all actors in the supply network requires too much effort (Doorey, 2011; Marshall et al., 2016). The focal company needs to know in detail the tiers within its own supply

chain. In contrast to the upstream supplier network, this knowledge usually exists on the customer side as the company is actively choosing and influencing this structure. Furthermore, the company needs to be aware of the competitor's 1st-tier supplier and customer structure. On the complementor side, the transparency about customers will already be there because both companies have a mutual interest in increasing their sales together. On the supplier side, research is advisable on 1st-tier suppliers if the products share common parts, which will mainly be true for 1st-layer complementary products.

3.4.2 Suppliers, customers, competitors and complementors and their relations

Figures 25-27 will illustrate the relationships in a company's environment by arrows, not limited to physical flows. The idea behind the new Supply Network Map Structure Model is that a company needs to supervise any relationships into all four directions within the supply network: towards suppliers, competitors, customers and complementors. The following four definitions highlight the basic idea of relationship management.

Supplier Relationship Management is described as the IT-based design of strategic and operative procurement processes and supplier management in line with the overall procurement strategy (Appelfeller & Buchholz, 2011). As a mirror image to the supply side, Customer Relationship Management is presented as "the initiation, enhancement and maintenance of mutually beneficial customer and partner long-term relationships through business intelligence-generated strategies" (Baran, Galka, & Strunk, 2008), p. 10. Armin Günther has characterized the term Complementor Relationship Management as the ideal integration of the focal company and its complementors concerning product ranges and resources (Günther, 2015). Finally, we introduce the new term Competitor Relationship Management in this paper to complete the management of interactions towards all actors chosen as relevant in the supply network, although it might appear self-contradictory at first sight. Competitor Relationship Management represents the IT-based collection of knowledge about competitors concerning their supplier and customer relations that leads to a mutually beneficial alignment of activities between the focal company and its competitors.

All these four types of relationship management are summarized in table 12. Moreover, we suggest definitions for all the actors in a supply network. Definitions for the various layers of complementors and competitors are proposed in this paper for the first time.

Chapter 3: Coping with rising Supply Chain Complexity: Conceptualizing a Supply Network Map Structure Model to address that challenge

<i>Suppliers</i> Supplier Relationship Management (SRM)	<i>Customers</i> Customer Relationship Management (CRM)	<i>Complementors</i> Complementor Relationship Management (CoRM)	<i>Competitors</i> Competitor Relationship Management (CompeRM)
1st-tier suppliers = system suppliers	1st-tier customers = distributors, importers	1st-layer complementors = vendors of end-product-related products that cannot exist without the end-product	1st-layer competitors = end-product competitors
2nd-tier suppliers = module suppliers	2nd-tier customers = contract dealers	2nd-layer complementors = vendors of end-product-related products that complement the end-product	2nd-layer competitors = single end-product / market competitors
3rd-tier suppliers = part suppliers	3rd-tier customers = independent dealers	3rd-layer complementors = vendors of customer-related products	3rd-layer competitors = single part / spare part competitors
raw material suppliers = steel suppliers, rubber suppliers,...	end-customers = agricultural contractors, farmers	no equivalent	no equivalent

Table 12: Supply Network Map actors

Starting with Supplier Relationship Management, according to the supplier pyramid by Becker, system suppliers are regarded as 1st-tier, module suppliers as 2nd-tier and part suppliers as 3rd-tier suppliers (Becker, 2007). Raw material suppliers represent the nth-tier in this order and deliver primary material, such as steel.

The relevant customer tiers can be clarified by analyzing a focal company's sales structure: The distribution channel via subsidiary distributors or importers in foreign countries is regarded as the 1st-tier customer level. One level lower, contract dealers can be listed who distribute products on behalf of the focal company. As the counterpart to contract dealers, independent dealers who sell products of several brands enlarge the sales capacity of the focal company. Finally, the goods are sold via dealers to the end customers in the supply network.

Regarding complementors, the paper distinguishes between the subject and the extent of complementarity. While complementary products of 1st- and 2nd- layer complementors are tied to the products of the focal company, complementors are classified on the 3rd layer if their products are related to the customers of the focal company. Concerning the extent of complementarity, products of 1st-layer complementors cannot exist without the product of the focal company, whereas 2nd-layer products only complement the other product. 3rd-layer complementors provide products fitting to the interests and needs of the customers of the focal company in order to offer them a complete product range.

Finally, the various layers of competitors need to be defined based on the subject and the extent of competition regarding the product portfolio (Hefti, Rawitzer, & Cometta, 2014). 1st- and 2nd-layer vendors compete concerning end-products, whereas 3rd-layer competitors try to gain market share for spare parts. 1st- and 3rd-layer competitors are in competition with the focal company over nearly the whole product range. However, 2nd-layer competitors either only serve selected markets or only have a few competing products for product quality and/or pricing reasons.

3.4.3 Mapping of a company's relationships being necessary in three directions

Vertical Supply Network Mapping: Analyzing value creation in the vertical supply chain

Vertical Supply Network Mapping according to the wording used by Choi and Hong (T. Y. Choi & Hong, 2002) is the first of the three directions to be presented. This type of mapping focuses on the length of the vertical supply chain of the focal company and is visualized by the vertical arrows in figure 25. This direction prompts the core question: How many tiers does the vertical supply chain include upstream in the chain?

However, the goal of Vertical Supply Network Mapping is not only to determine the number of tiers but also to gather as much information as possible on countries, value creation by the various suppliers and supplier names. As mentioned in previous paragraphs, the target of the focal company needs to be to achieve at least transparency within the zone marked by the cross shape, which includes the whole vertical upstream supply chain.

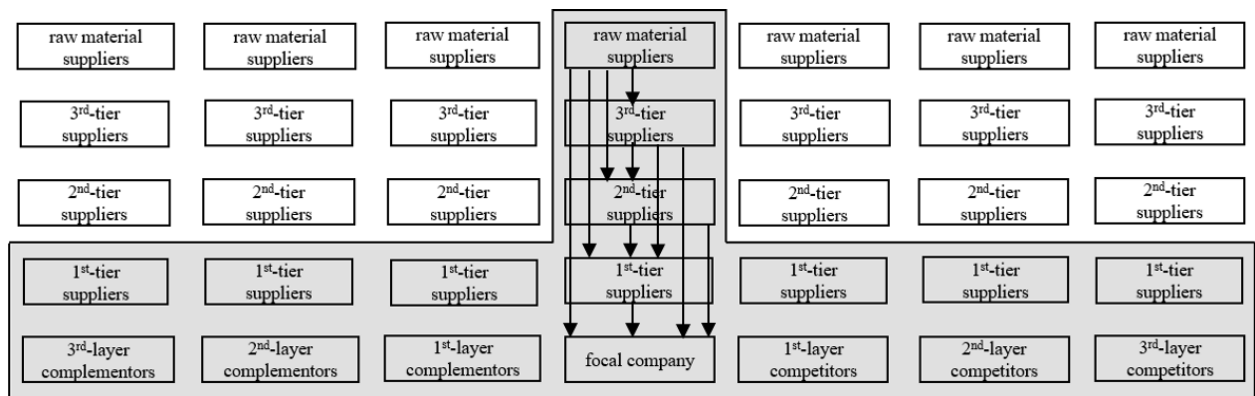


Figure 25: Vertical Supply Network Mapping

As the identification of cost-saving potential is one of the main objectives of Supply Network Mapping, vertical mapping can help to ease the direct negotiation of indirect volume by the focal company. The indirect volume describes modules or parts that are delivered by 1st-tier suppliers to the focal company or needed for their assembly process of systems but have been manufactured by lower-tier suppliers. Hence, the purchasers may take charge of the direct negotiations with 2nd- or 3rd-suppliers without having direct contracts or delivery agreements with them. In this case, the purchasers step down the supply chain towards lower-tier suppliers (Wan & Wu, 2015). Once the purchasers of the focal company have made their price agreements with these lower-tier suppliers, they communicate their prices to the 1st-tier suppliers who can then place their orders by referring to these price agreements. As an alternative to this approach, the purchasers of the focal company can also offer to their 1st-tier suppliers to bundle their volumes in order to negotiate better prices from sub-suppliers, termed Chain Sourcing (Schulte in den Bäumen, 2009).

Another aspect in the context of Vertical Supply Network Mapping is the strategic supplier classification, segmenting suppliers into preferred, alternative, restricted and phased-out suppliers or comparable classes (Appelfeller & Buchholz, 2011; Helmold & Terry, 2016). Usually, such classifications only consider the direct spend volume and suppliers are developed or phased out based on the result. However, in order to evaluate the actual total volume, the

classification would have to be enlarged to the 2nd- and 3rd-tier levels, because if a supplier is phased out by the focal company but continues as a sub-supplier of 1st-tier suppliers, the supplier does not disappear from the focal company's supply network.

In the context of risk management, the vertical mapping needs to reach beyond 1st-tier supplier risks and risk management needs to be expanded to the sub-suppliers. However, the transparency that the focal company may achieve on the sub-supplier structure is limited, especially for financial monitoring. Therefore, in the future, 1st-tier suppliers will have to be involved in strategic risk management with sub-suppliers.

Horizontal Supply Network Mapping: Capturing the number of interchangeable actors

Horizontal Supply Network Mapping according to the wording used by Choi and Hong (T. Y. Choi & Hong, 2002) explores the number of interchangeable actors within one tier or layer, termed supply network width. Consequently, the main objective of Horizontal Supply Network Mapping is market analysis. The core question arising from this mapping relating to horizontal supply chain complexity is: How many suppliers are there in every tier of the supply chain?

Horizontal relationships are deemed “more informal and invisible” (Bengtsson & Kock, 1999). Usually, there is no horizontal flow of goods, money or information. The actors just co-exist. Co-existence describes a rather passive state without explicit interaction between the parties but still potential dependencies (Bengtsson & Kock, 1999).

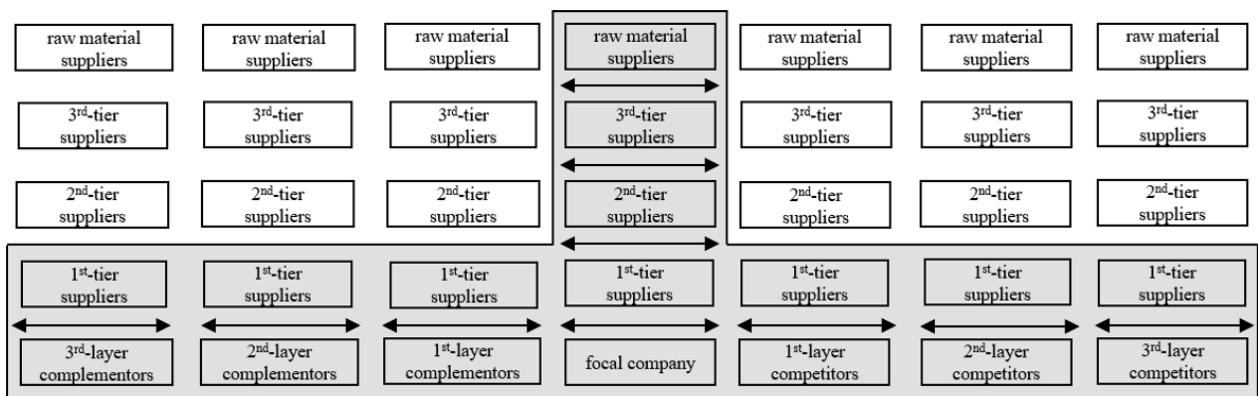


Figure 26: Horizontal Supply Network Mapping

Nevertheless, horizontal relationships are just as important as vertical relationships. They are an indicator of respective market power. According to the taxonomy of supply networks by Harland et al., focal companies can actively manage their supply networks if they have a high supply network influence and only cope with the networks if they have a low supply network influence (C. M. Harland, Lamming, Zheng, & Johnsen, 2001).

The width describes the number of interchangeable actors, which influences the supply risk according to the Kraljic Matrix (Kraljic, 1983). Thus, the width is very low in the case of a monopolist who manufactures complex components that are protected by intellectual property rights and very high in the case of standard material suppliers. The number of interchangeable actors also affects the overall supply network complexity. If all competitors and complementors use the same 1st-tier supplier for a certain component, there is just one vertical flow of goods

and the pressure to increase the satisfaction of this one supplier in order to improve the own customer status is very high for the buyers. A preferred customer status would lead to beneficial treatment and, thus, to competitive advantage (Vos, Schiele, & Hüttinger, 2016). However, if there are many interchangeable suppliers, what if-scenarios can be simulated. The effects can be measured in purchase prices and logistics costs. With the help of a suitable IT tool, the simulation can be done quickly and various paths can be illustrated, that are linked to several Supply Network Mapping scorecards with KPIs for the various objectives.

The findings for the suppliers also hold true for the focal firm. The more complementors and competitors that exist, the more important it is to look into the whole supply network and all dependencies within it. In contrast to this, focal companies that do not have any competitors can concentrate only on their supply chain. However, totally stopping to observe their competitive environment can be harmful, as new entrants can emerge quickly, according to Porter (Porter, 1979).

Hybrid Supply Network Mapping: Unveiling the suppliers of competitors and complementors

Finally, Hybrid Supply Network Mapping combines horizontal and vertical mapping. The perspective towards competitors or complementors is the horizontal aspect of the term, whereas the emphasis on sub-suppliers represents the vertical element.

Referring to the cross shape representing transparency in the Supply Network Map Structure Model, Hybrid Supply Network Mapping will help to find out: who are the 1st-tier suppliers of the complementors and competitors? Out of the mapping objectives, hybrid mapping contains mainly a benchmarking view to support the achievement of competitive advantage.

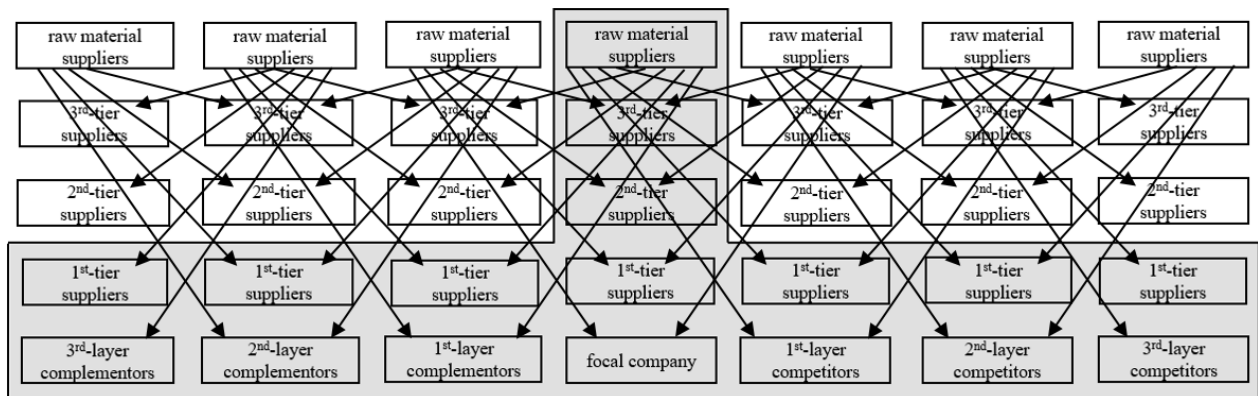


Figure 27: Hybrid Supply Network Mapping

The arrows in figure 27 show that the complexity of Hybrid Supply Network Mapping reaches far beyond the cross shape. On the one hand, suppliers at all levels of the vertical sub-supplier structure might also supply to competitors or complementors. On the other hand, suppliers at all levels of the competitors' or complementors' sub-supplier structure might also supply to sub-suppliers or the focal company directly. If a supplier is supplying a competitor or a complementor with high-quality products, this supplier might also be an attractive partner for the focal company.

If the focal company and 1st- or 2nd-layer complementors or competitors share the same supplier base at one or more of the above levels, several activities can be recommended to the purchasers of the focal company:

- Projects involving shared suppliers and complementors or competitors can be monitored to profit from price decreases during increasing project volumes.
- In particular cases, it can make sense to bundle purchasing volumes with complementors (Cooperative Sourcing) or competitors (Coopetition Sourcing) in order to achieve better prices (Schulte in den Bäumen, 2009).
- The monitoring of the business that shared suppliers make with other customers can also help to improve the risk management system: If the suppliers' capacity is restricted, supply chain disruptions can be anticipated.
- Confidentiality agreements need to be closed or intensified with shared suppliers in order to protect the intellectual property of the focal company from its competitors.

If suppliers also supply 3rd-layer competitors with parts, this will typically not be appreciated by the focal company. That is why purchasers usually consider this aspect in audits before making their supplier choices and why they will strive for exclusivity agreements.

Finally, the focal company and 1st-layer or 2nd-layer complementors or competitors might not yet have common suppliers. In that case, hybrid mapping enables market research, including the performance of potential new suppliers in their relationships with other customers.

3.5 Conclusions: Supply Network Mapping contributing to literature and helping purchasing managers

3.5.1 Considering the complex relationships in a company's environment

Supply Network Maps show the material, information and money flows in all directions of a focal company's environment: towards suppliers, customers, competitors and complementors. They can either show the structural or the geographical view of the relations. Supply Network Mapping can support the decision-making process of strategic purchasers in the following main areas: identifying cost-saving potential, risk management and achieving competitive advantage.

The result of this paper is a new Supply Network Map Structure Model. The model is based on the relevant actors that appear in several well-known strategic management models and combining these with the analysis of multi-tier network links from relevant PSM models. The core of the new Supply Network Map Structure Model is a cross shape that implies that a focal company needs to gain visibility about all actors with a direct link to this company: the whole vertical supply chain as well as all complementors and competitors with their 1st-tier suppliers and customers. Concerning flows and interactions in the network, vertical, horizontal and hybrid directions of Supply Network Mapping have been identified with the help of semi-structured interviews and the application of the model in various test cases.

3.5.2 Closing a gap between PSM and strategic management literature

This research contributes to both strategic management and PSM literature. It is closing a gap between these disciplines by adopting the analysis of the multi-tier interactions regarding suppliers and customers, which is known from supply chain maps, complex supply chains and the supplier pyramid as discussed in the PSM literature (Becker, 2007; Lambert et al., 1998; Smirnov et al., 2006) to integrate further actors like competitors, complementors, subcontractors and customers' customers as discussed in the strategic management literature (Moore, 1996; Nalebuff & Brandenburger, 1997; Porter, 1979, 1998). In terms of the PSM literature, this transfer leads to a network-like understanding of the focal company's environment, fitting well into the continuously evolving roles and relationships in an ecosystem instead of the antecedent linear chain interpretation (Jarzabkowski & Wilson, 2006). Competition between several companies' supply chains is a scenario often described in the literature but rarely illustrated in a structural model approach until now (Lambert, 2008). Considering the strategic management literature, a visualization of actor relationships via multi-tier links is a new, valuable addition. Using the example of competitors, it would be very helpful not only to group all competitors into one node in the business ecosystem or value net but also to map all links to other actors in order to analyze the subject and the extent of the competition. Moreover, in the geographic sense, it would be of great interest to analyze whether all actors located closely to each other in a regional cluster really have intensive relationships with each other.

Caused by the extension to competitors' and complementors' supply chains, many complex overlapping interactions result that will take research on current buyer-supplier-supplier triads and possibly new supply network patterns to a higher level and require further analysis. Such new triad constellations are among others: buyer-competitor-supplier, buyer-complementor-supplier, buyer-competitor-customer, buyer-complementor-customer, competitor-supplier-2nd-tier-supplier, complementor-supplier-2nd-tier-supplier, competitor-customer-2nd-tier-customer and complementor-customer-2nd-tier-customer. The new term Supply Network Map that we introduced in this paper is linked to this evolution from chain-like structures towards network-like structures' visualization. In terms of spatiality, the model can be used both structurally and geographically. These two approaches reflect the existing literature on Supply Chain Mapping and take this field further on the network level.

3.5.3 Supply Network Map Structure Model as a tool to facilitate strategic purchasing

The Supply Network Map Structure Model gives shape and framework to the actors and links of supply networks and can consequently be considered as a tool to facilitate strategic purchasing decisions and processes. As a result, the model leads to more transparency about a focal company's network.

The model has been conceptualized from the requirements of an agricultural machinery company. However, its suitability for other industries can be assumed due to the basic structure of the model. Taking a look into the three economic sectors, the Supply Network Map Structure Model covers the food supply network in the primary sector, where, e.g., fishermen may act as

raw material suppliers to a focal food producer. Furthermore, the model is suitable for businesses in the secondary craft sector, such as carpentries, and in the industrial sector, such as road vehicle manufacturers, because these businesses execute purchasing and selling activities and are involved in value creation. The model might also be transferable to the tertiary services sector in the future. For that sector, the bottom part of the supply network will be of particular interest because it is focused on customer-orientation.

Following the three directions of Supply Network Mapping, the model contributes to the achievement of all five Supply Network Mapping objectives. While Vertical Supply Network Mapping aims at the identification of cost-saving potential and risk management, Horizontal Supply Network Mapping focuses on market analysis assisting Hybrid Supply Network Mapping that can help to achieve competitive advantage supported by new benchmarking findings. However, these are only the most significant objectives for each of the directions, but there are also weaker relations, such as those between Hybrid Supply Network Mapping and risk management. Regarding the timeframe, the model cannot only help to realize medium- and long-term improvements through its strategic use but also support the identification of short-term cost savings in its operative application.

3.5.4 Further testing of the model in various business contexts required

Our paper proposes a new Supply Network Map Structure Model to achieve a holistic structural understanding of a focal company within its complex environment. However, the Supply Network Map Structure Model presented in this research is an abstraction and idealization of the real company environment, which is often considered to be a misrepresentation of its target system (Jebeile & Kennedy, 2015). The model contains a triple-tier structure into all directions and a congruent cross shape marking the zone of transparency. This basic shape might be refined according to the requirements of strategic purchasers of various commodities. Furthermore, an investigation of the actors on the vertical model axis and their continuously evolving roles and relationships in an ecosystem might require to modify the shape. Consequently, the current structure will probably be further developed towards both larger and smaller basic structures with thicker and thinner cross shapes.

Regarding the directions of Supply Network Mapping, only the upstream part of the supply network has yet been explored in detail. However, the customers of the various supply network tiers have also been defined, so that future research on the downstream part of the supply network can be carried out by sales experts. Once the Supply Network Mapping application is extended to the downstream supply network, experience needs to be gained concerning the model application in sales. A follow-up study could take place concerning correlations between the upstream and the downstream part of the supply network. Such research might contain the influence of supplier deliveries to 3rd-layer competitors on end-consumer sales for the focal company or the consumer demand for complementary products depending on the alignment between complementors and the focal company.

The scope of this paper concerning the commodities to be mapped is limited to product-related material covering components, modules and single parts, while non-product related material

and services were excluded from this research. Therefore, future researchers are encouraged to investigate the structure of the supply networks and the applicability of the Supply Network Map Structure Model for non-product related material and services. Moreover, the model might also be tested for other logistical applications, such as stock control at all levels in the supply network and the transport optimization in operations research.

An important result of this study is that it is important to define a suitable object to be mapped, implying a certain pattern within the supply network structure. If a whole system of a focal company were manually mapped, the complexity would be very high and visualization could hardly provide a precise overview. Therefore, it is necessary to choose a subsystem, such as a single commodity (Heimbrock, 2001). Nevertheless, we are aware that the real advancement in Supply Network Mapping will happen with the help of Big Data analysis. If supply network information could be gathered and processed automatically, it would be possible to map the whole supply network of focal companies. This paper can be regarded as the conceptual basis for this approach and future researchers are encouraged to further explore the antecedents, usage and effect of Big Data in Supply Network Mapping.

Moreover, success factors for information gathering and, finally, Supply Network Mapping success need to be further investigated and are expected to lead to important theoretical and managerial implications. Despite the general model applicability, costs and benefits analysis are a major limitation of the Supply Network Mapping opportunities and need to be evaluated for every application. A linear relationship between the supply network's complexity in terms of the net's length, width and dependencies and the benefit through the mapping work is assumed. The more complex and dynamic a supply network is, the more stressed it is (Kaufmann & Germer, 2001) and the more optimization potential exists.

Finally, the procedure of how to create a supply network map in a concrete business case remains unattended in this paper. This broad research field remains to be investigated and includes the mapping responsibilities, information sources, requirements, procedural steps, determinants and obstacles. Publications in the field of Supply Chain Mapping and related research streams, such as supply chain complexity or vertical integration, often do not distinguish clearly between a Supply Network Map as the output of the mapping activity and the Supply Network Mapping procedure that is necessary in order to achieve such visualization.

Chapter 3: Coping with rising Supply Chain Complexity: Conceptualizing a Supply Network Map
Structure Model to address that challenge

Chapter 4: Supplier relationships with competing customers: How can purchasers find out who is the preferred customer?

Abstract

Focal companies are embedded in complex supply networks consisting of various suppliers, customers, competitors and complementors. The activities of these actors influence the competitive position of the focal companies. Some customers achieve preferred customer status and gain preferential treatment, while others remain standard customers and get less privileged services. Hence, focal companies have to achieve transparency about the relationships of their suppliers towards their competitors and complementors in order to map them and to analyze their impact.

Current literature lacks a holistic approach to capture these relationships. Which information do focal companies need, when do they need it and how can they find it? Building on Social Exchange Theory, we use a World Café method with purchasers for data gathering, followed by a Gioia method for data structuring in order to answer these research questions. The results show that the purchasers are most interested in the prices that their suppliers offer to their competitors. They believe that the suppliers can disclose most of the interesting information and that high transparency is needed in volatile times with increasing supply risks. These results can help focal companies to assess their own customer status compared to other customers.

Keywords

Social Exchange Theory; Preferred Customer Status; Supply Chain Mapping; Supply Chain Transparency; Supplier Relationship Management; World Café Method; Gioia Method

4.1 Introduction: Competing customers must assess their own customer status

Increasingly, business-to-business markets are characterized by supplier oligopolies. Introducing tier structures and concentrating on a few strategic relationships has often resulted in a reduction of the number of competing suppliers. In such a situation, the problem may arise that suppliers do not treat all customers equally, which would also not make any sense from a resource optimization perspective. Some customers enjoy preferred customer status, while others are treated as standard customers. The ones who achieve a preferred status derive greater benefits from suppliers' resources and capabilities and thus gain a competitive advantage (Schiele et al., 2012). In order to understand their situation, firms need an even better self-awareness of their attractiveness towards their suppliers. They need to assess whether they are sufficiently attractive to initially motivate a supplier to start a business relationship with them and in the long term to maintain it by satisfying the supplier. A customer is perceived as attractive by a supplier if the supplier in question has a positive expectation towards the relationship with this customer (Schiele et al., 2012). Consequently, firms need more supply chain transparency as compared to previous times, where large numbers of suppliers were present.

Supply chain transparency is commonly known as the disclosure of information on involved actors (Doorey, 2011). The actors considered in this research are suppliers, customers, competitors and complementors, according to the Value Net (Nalebuff & Brandenburger, 1997). Competitors and complementors will be summarized as other customers in the further course of the paper. Previous empirical research among purchasers has shown that the vendors' relationships' transparency as perceived by the buyers contributes to the overall success of a business relationship (Eggert & Helm, 2003). However, the current literature lacks a standard on the required knowledge about the relationships. Only proposals, which information to gather, exist, such as the suppliers' names and sustainability conditions (Egels-Zandén et al., 2015).

Building on Social Exchange Theory (SET), the analysis of the suppliers' relationships leads to a deep business knowledge about the supply network. This knowledge is useful for focal companies and can confer a competitive advantage on them. Furthermore, an investigation of the suppliers' relationships with competing customers might help to improve negotiation positions or to mitigate strategic risks (Hoffmann, Schiele, & Krabbendam, 2013). On the other hand, research on the complementors' relationships can help to increase sales. Therefore, both actors and their relationships might create value for the focal firm. As these relationships concern several companies next to each other on the same level, we regard this as the horizontal perspective of the supply network as defined by Choi and Hong (T. Y. Choi & Hong, 2002).

In this paper, we will introduce the World Café Method as a suitable exploratory-qualitative research method to examine the knowledge of a focal company's purchasers concerning the relationships of its suppliers with other customers. This method will be complemented by the Gioia Method, which is used to structure the qualitative findings to subordinate constructs. Important findings are that purchasers are most interested in the prices that their suppliers offer to their competitors. They believe that the suppliers can disclose most of the interesting information and that high transparency is needed in volatile times with increasing supply risks.

4.2 Theoretical Background: Social Exchange Theory explaining supplier satisfaction

Social Exchange Theory (SET) studies social behavior in the exchange of activities between at least two people (Homans, 1958). This social exchange is defined as a process with two-sided transactions and mutual rewards (Emerson, 1976). It is based on mutual attractiveness as the basis for exchange relationships and covers diverse relationship issues between the actors (Blau, 1964). We regard these exchange relationships as the basic unit of our analysis (Emerson, 1976).

Lambe et al. have carried out a review on the use of SET and suggest that future research needs to examine how the business and social outcomes of exchange are affected by interactions outside of the exchange relationship (Lambe et al., 2001). Current empirical research has often underscored the relevance of the existence of alternative relationships (Ping, 1994). Hence, in our paper, we try to close this research gap by collecting information about the interactions outside of the own relationship because this information will affect one's own business. It influences the success of the own relationships because it gets easier to prevent the own relationships from failure based on the gathered information.

The SET can be transferred to buyer-supplier relationships in the context of preferred customer literature (Schiele et al., 2012). SET suggests that purchasers feel positively or negatively about their exchange relationships with suppliers because of three factors (Thibaut & Kelley, 1959):

The first factor mentioned by Thibaut and Kelley are the expectations regarding the costs and benefits of an exchange relationship (Thibaut & Kelley, 1959), reflecting customer attractiveness. Attractiveness is an important SET construct (Tanskanen, 2015). The self-awareness of one's attractiveness may increase reward power in a buyer-supplier-relationship (Molm, 1990). Mutual attractiveness is important to improve value creation and value transfer in buyer-supplier-relationships (Sundtoft Hald, Córdón, & Vollmann, 2009). Important attributes of attractiveness are the expected value, trust and dependency (Sundtoft Hald et al., 2009).

On the one hand, a high supplier attractiveness strongly influences the supplier awarding decision and can lead to the initiation of a relationship (Schiele et al., 2012). However, if the supplier performance and attractiveness decrease, the customer might select a different supplier. On the other hand, a high customer attractiveness can motivate the supplier to start or maintain a relationship with a certain customer, while its loss might cause termination from the supplier side. The attributes of buyer attractiveness are rather unique and manifested only in one or two different buyer-supplier-relationships (Tanskanen, 2015). According to Baxter, a very important determinant for the preferred customer status is the financial customer attractiveness (Baxter, 2012). Furthermore, social exchange leads to non-materialistic benefits, such as social approval and respect (Blau, 1968). The supplier does not want to spend more time in one relationship while being in another one could be potentially more beneficial.

The second factor, according to Thibaut and Kelley, is the comparison of the expectations to the attained outcomes (Thibaut & Kelley, 1959). The discrepancy between the expectations and the actual outcome determines the level of satisfaction (D. T. Wilson, 1995). Satisfaction is

achieved if the quality of the outcomes meets or exceeds the expectations (Schiele et al., 2012). In current literature, there is a substantial number of publications operationalizing the SET. Many of them use the variable of satisfaction in business-to-business exchanges to operationalize the success of the exchange relationships. Satisfaction serves as a measure of a firm's view of the outcomes of the relationship (Lambe et al., 2001).

Supplier satisfaction is the buyer's ability to fulfill the expectations of the supplier (Schiele et al., 2012). It is influenced by growth opportunities, reliability and profitability of the relationship (Vos et al., 2016). Moreover, Ellis, Henke and Kull state that early supplier involvement and relational reliability positively affect supplier satisfaction (Ellis, Henke, & Kull, 2012). A high customer attractiveness is an antecedent of supplier satisfaction and can motivate the supplier to invest his limited resources in the common business with this customer (Baxter, 2012).

The third factor listed by Thibaut and Kelley is the comparison of the current relationships with potential benefits from alternative relationships (Thibaut & Kelley, 1959). The consideration of alternatives is an important extension of the classical satisfaction literature (Essig & Amann, 2009; Ghijsen, Semeijn, & Ernstson, 2010). It requires a shift from dyadic-level to network-level analysis (Lambert, 2008; Schiele et al., 2012), which we offer in our research. Thibaut and Kelley state that actors will use not only absolute but also relative criteria to evaluate the outcome of an exchange relationship (Thibaut & Kelley, 1959).

The decision of the supplier to award the preferred status or a regular status to the customer or to discontinue supplying the customer is influenced by the availability of alternatives (Schiele et al., 2012). Business-to-business markets currently face high competition for resources (Pulles, Schiele, et al., 2016). In many industries, the number and the capacity of the suppliers are limited and can cause bottlenecks in the supply. Especially in expanding or even booming phases of the business cycle, the situation is very serious and the suppliers cannot saturate all the existing demand. Thus, suppliers can choose between a broad range of potential alternative customers and decide themselves whom they would like to deliver. Furthermore, customers can benefit from preferential treatment regarding product quality, support in the sourcing process, delivery and prices (Nollet, Rebolledo, & Popel, 2012) as well as the supplier's willingness to share new technology with this customer (Ellis et al., 2012). These ways of preferential treatment again increase customer attractiveness and satisfaction (Bemelmans, Voordijk, Vos, & Dewulf, 2015).

This development on the markets also leads to changes in the market power: In the past, suppliers fought hard to gain the orders of their customers (Schiele et al., 2012). Most purchasing organizations had a list of preferred suppliers due to competitive pricing and convincing supplier performance. The supply market consisted of a broad range of interchangeable small to mid-size suppliers, whereas the manufacturing companies had a high manufacturing depth and owned most of the intellectual property on innovations. Nowadays, the customers cannot take the fulfillment of their demands for granted anymore due to an oligopolistic market structure (Schiele et al., 2012). The number of suppliers has significantly reduced to a remaining set of big, consolidated and powerful enterprises with high innovation

power and thus a very good negotiation position. Hence, the customers need to struggle hard in order to become the preferred customers of their suppliers and to obtain preferential resource allocation (Pulles, Schiele, et al., 2016; Schiele et al., 2012).

Consequently, it is very important for the focal companies to be aware of the relevant actors in their supply network and to map how the relationships between them are. The purchasers need to figure out the characteristics of their suppliers' business with other customers. They do not only try to learn more about the products and projects of their suppliers with other customers but also about the collaboration between both parties. In order to create the desired transparency on supply chains, companies started to develop appropriate tools like supply chain mapping.

Supply chain maps can have a structural or geographic shape (Lambert et al., 1998; Wilding, 1998). They visualize the material, financial and information flow into all directions of the supply chain and through a firm (J. T. Gardner & Cooper, 2003). The maps can show complex, overlapping links, if some actors on a higher level have relationships with various actors on a lower level of the supply chain (Smirnov et al., 2006). Nevertheless, supply chain maps only focus on the vertical multi-tier supply chain. They present all sub-suppliers on the supply side and all trade levels on the sales side (Lambert et al., 1998; Wilding, 1998). This paper tries to take supply chain transparency a step ahead towards supply network transparency. By integrating a horizontal dimension in addition to the vertical supply chain as defined by Choi and Hong (T. Y. Choi & Hong, 2002), it considers the whole overlapping network of competing supply chains (Lambert, 2008). According to the value net by Nalebuff and Brandenburger, the important actors in the horizontal dimension are the competitors and complementors of the focal company, as both influence its strategic position on the market (Nalebuff & Brandenburger, 1997).

Once the purchasers know who has a preferred and who has a neglected status for their suppliers, they can define or review their preferred customer strategy and adapt their supplier relationship management. For this purpose, they can reflect on the reasons for their own (un)attractiveness and try to improve the supplier satisfaction in order to maintain their preferred customer status or to be upgraded to a preferred status (Schiele et al., 2012). The buyers can adjust their supplier classification and focus on those suppliers who treat them as preferred customers. They might stop the collaboration with suppliers who have a trustful relationship with their competitors or intensify projects with suppliers who closely work together with their complementors. Moreover, they can develop another strategy for the suppliers who treat them preferentially and try to reduce purchasing costs or to achieve other advantages from them.

As far as we know, no broad investigation on the information gathering about the relationships between the suppliers and competing customers exists yet. That is why we concentrate on the purchasers' transparency about supplier relationships with other customers. Contributing to SET and preferred customer theory, the aim is to investigate the following research question:

RQ: *How can purchasers assess their own customer status in comparison with other customers?*

4.3 Research Design

4.3.1 *World Café Method: Efficient exploratory method to gain qualitative data*

The World Café is an exploratory-qualitative research method that has been created by Brown and Isaacs (Brown et al., 2005). Small focus groups discuss on selected subjects in a café-like atmosphere (Prewitt, 2011; Wibeck, Dahlgren, & Öberg, 2007). Seven core design principles constitute the basis of the World Café method, such as exploring questions that matter or connecting diverse perspectives (Brown et al., 2005; Fouché & Light, 2010; Lorenzetti, Azulai, & Walsh, 2016; Tan & Brown, 2005). The advantages of the method lie in its high output attainable in a short period of time compared to other qualitative research methods such as longitudinal case studies or interviews. In contrast to interviews, an exchange among the participants is possible and desired. Due to the iterative process of the World Café method, high stability and reliability of data are ensured (Kidd & Parshall, 2000). Varying group constellations enable to achieve rich data and to reduce bias (Fouché & Light, 2010).

Our research aims to create a deep and collective understanding of how to assess customer status with the help of a small group of purchasers. That is why a single case study is suitable to explore the problem instead of a multiple case study analyzing the similarities and differences across various cases. We apply the method in an agricultural machinery company, as this firm faces a complex, multi-tier supply network including various suppliers, competitors and complementors and does not carry out a holistic approach to achieve transparency on it yet. In order to form a representative sample of the product-related material purchasing team in this company, five divisions are involved in the World Café session, thereof three manufacturing facilities buying production material, the aftersales division ordering spare parts as well as corporate purchasing. The heads of purchasing select 14 purchasers, so that at least three buyers and the moderator take part in the discussions at each table.

Important criteria for the selection of the participants are a heterogeneous experience and portfolio among the group. The heterogeneous portfolio enables us to examine whether the need for transparency depends on the commodity. Represented commodities are assemblies, axles, bearings, belts, cabins, chains, drivelines, electrics, electronics, gearboxes, hydraulics, machined parts, metal sheets, OEM parts, plastics, power train, pulleys, rims, rubber, service provider parts, special tools, tires and weldments. An average participant of the World Café has worked for the agricultural machinery company for 13.6 years - thereof 11.5 years in strategic purchasing at this manufacturer – and is responsible for 44 suppliers. With regards to the professional level, nine strategic purchasers, one lead buyer, one head of purchasing as well as three purchasers in corporate functions form the group. The purchasers in the corporate functions are responsible for contract management, product cost optimization and product-related material. Only two participants have taken part in a World Café session previously.

At different stations, the purchasers answer the following questions and change groups after each round. According to the World Café design principles, questions have to be powerful and appreciative (Brown et al., 2005; Alexander Schieffer, David Isaacs, & Bo Gyllenpalm, 2004).

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Questions 1 and 2 are discussed on separate tables regarding competitors and complementors but lead to similar results, which are presented together in the findings sector.

Q1: *What would you like to know about your supplier relationships with other customers?*

Q2: *How do you find out information about these relationships?*

Q3: *When do you need a high knowledge about these relationships?*

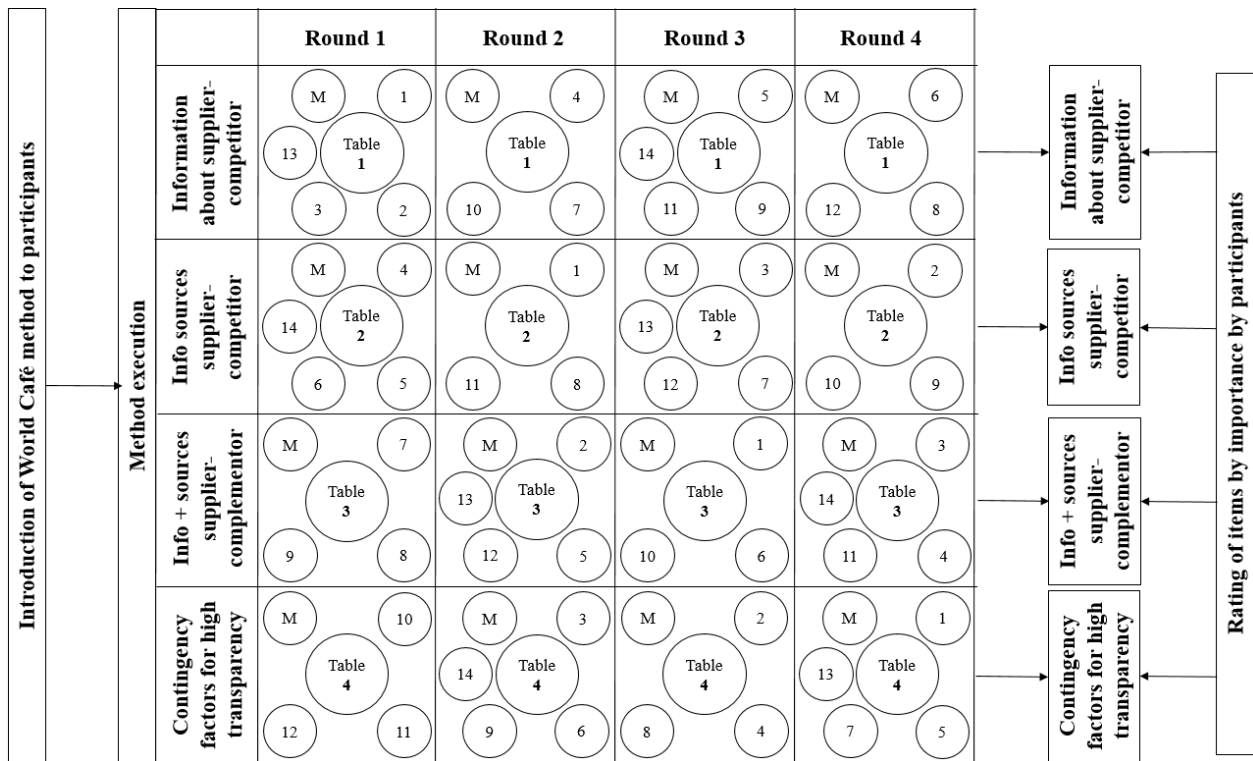


Figure 28: World Café design and application

The numbers in the World Café design in figure 28 illustrate how the participants mix when rotating between the tables in order to maximize knowledge exchange (Chang & Chen, 2015; Prewitt, 2011). The table constellations are announced by the café convenor for each round to ensure that there are new constellations every time and that the participants of the different company division mix. In the beginning, each participant draws a number and then changes the tables accordingly. As figure 28 demonstrates, the same participants do not meet each other in the same discussion group more than twice. While the participants move, the moderators remain on their tables. They take notes, make sure that discussions stick to the subject and that every participant can contribute to them. Finally, they sum up the findings for the new group (Hüttinger, Schiele, & Schröer, 2014; Alexander Schieffer, David Isaacs, & Bo Gyllenpalm, 2004). Movable walls and paper sheets are used for documentation (Pumpe & Vallée, 2016). When noting down the answers, it is very important to use another pen with a different color for every new round in order to track the progress.

The discussion rounds are recorded so that no important suggestions are lost due to the tension in lively debates. All audio files are transcribed after the World Café session. These transcripts

allow writing a clear definition for every suggested answer listed in the glossary in the appendix. The definitions avoid misunderstandings of the keywords on the paper sheets and provide additional explanation. Therefore, they also help to detect overlaps in the answers and to condense them to one single answer.

Four rounds take place each lasting 20-30 minutes so that a two-hours-time span for the method execution is sufficient (Jorgenson & Steier, 2013). Experience has shown that usually, the first session needs to be the longest and is therefore scheduled with 30 minutes. Most participants have not taken part in a World Café before and they need to get familiar with the questions, colleagues and moderators first. Moreover, there is often a natural resistance to get started with creative techniques. Furthermore, the participants can still mention any aspect that they regard as important, whereas the scope of discussions narrows down from round to round. The second and third rounds serve mainly to ensure that all ideas are covered and are thus five minutes shorter. The last round aims at filling the gaps and takes about 20 minutes.

At the end of the World Café session, the participants are requested to fix stickers next to the answers according to the significance of the suggested aspects (Pulles, Schiele, et al., 2016) in order to provide a ranking of the answers collected in the World Café. Another hour is necessary for the evaluation and the closing session. Each participant gets stickers in different colors for different questions. Six stickers are distributed per question, multiplied by the 14 participants, resulting in a voting of 84 points per question. As there are many answers, all possible ways are allowed for the rating, such as giving all six points to one answer or splitting them up to several answers. Once all stickers are on the paper sheets, the moderators start counting the points per answer. They sort the answers in descending order by the number of received answers in order to figure out the most important answers for the group. This order can be seen in the rankings (figures 30, 32 and 34), which are presented in the findings section. Finally, the moderators present the top responses as the findings to the World Café's participants.

4.3.2 Gioia Method: Structuring and analyzing the qualitative data

In order to enhance the qualitative rigor of this inductive research, the World Café is complemented by the Gioia Method. This method is a holistic approach to inductive concept development. The huge advantage of this method is that it clusters the answers given by the participants of the World Café and creates a structure of this qualitative data. This data structure facilitates the integration of the World Café results in the focal company's supplier strategy and supplier relationship management. Although the Gioia Method was developed based on semi-structured interviews, it is just as fitting for the World Café with focus groups, as both methods serve to obtain retrospective and real-time accounts by those people experiencing the phenomenon of theoretical interest (Gioia, 2012).

The analysis of the qualitative data, according to the Gioia Method, starts with the creation of 1st-order categories by seeking redundancies or high similarities between answers of the focus group. Although the number of categories needs to be manageable, the effort to merge different categories is still low at this stage. In the next step, we condense several categories to 2nd-order

themes on a more abstract, theoretical level explaining the observed phenomena. At the end of the analysis, we aggregate these themes again to higher dimensions (Gioia, 2012).

In order to build the 2nd-order themes and aggregate dimensions for our research, the posters of the discussion rounds with the purchasers, as well as the attached glossary, are a big help in order to understand the broader context behind single noted down answers. They give the first indication for the clustering of the answers. A graphic representation for every question in the findings section shows the data structure of 1st-order categories, 2nd-order themes and aggregate dimensions. The dimensions help to generalize from this case study to other manufacturing companies, as the collected insights on the desired knowledge, information sources and contingency factors on supplier relationships are also relevant to other industries.

4.4 Findings: Desired knowledge, information sources and contingency factors

The results section describes the data structure according to the Gioia Method, followed by the rating of the answers coming from the World Café approach for each question. This structure allows presenting the findings in a logical sequence, although chronologically, the results in the World Café were collected first. For the first two questions, most answers regarding the supplier relationships with complementors were the same as already mentioned for the competitors. However, some answers were only given for complementors. These answers are marked by a star (*) in the data structure figures 29 and 31. They give additional insights, how the relationship of the focal company with complementors differs from the relationship with competitors. The answers marked by the star (*) can be looked up in the attached glossary, but are not included in the rating figures 30 and 32.

4.4.1 Prices for other customers and delivered competitor plants as most desired knowledge

As illustrated in figure 29, the purchasers are interested in the business that suppliers make with other customers. This business can be expressed best by its commercial facts: Which products are in the delivery scope of the supplier? At which price level? And how much turnover does the supplier make with other customers? Besides this financial perspective, also more background on the business partners is interesting for the purchasers: Are the suppliers unknown for the focal company and consequently new, potential suppliers? Do they deliver directly to the aftermarket of other customers? Over time, each party in the social exchange relationship compares the social and economic outcomes from the interactions with business partners to those that are available from exchange alternatives, which determines their dependency on the exchange relationship (Lambe et al., 2001).

Moreover, the purchasers of the focal company would like to find out how other customers deal with suppliers whom they both have in common: How do they handle and manage these suppliers? Supplier assessment-related answers given in the World Café are the supplier classification, evaluation and audit results. Concerning the management of the suppliers, the purchasers would like to know which targets they set for suppliers, how they award projects to suppliers and how they optimize their processes.

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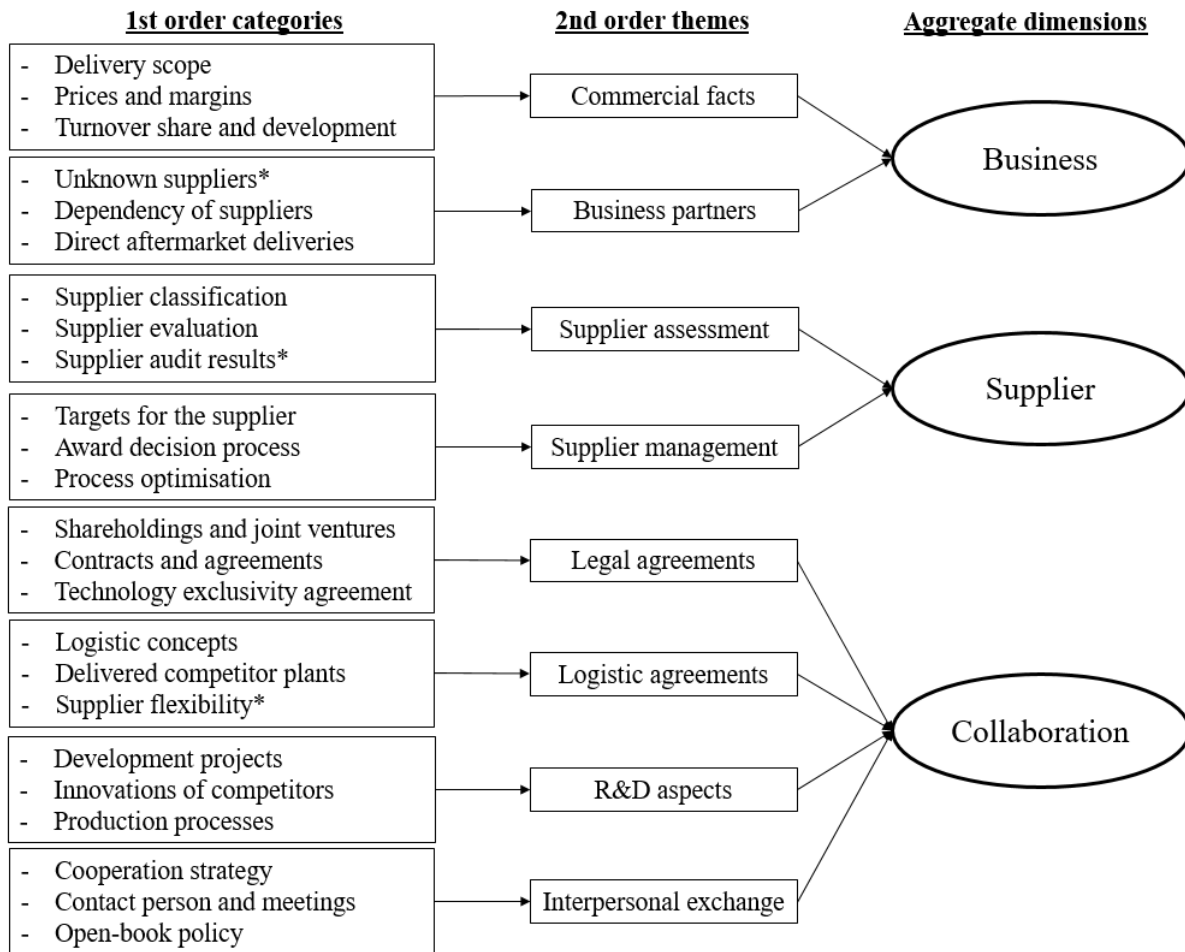


Figure 29: Data structure of desired relationship knowledge

Finally, the buyers would like to discover how the collaboration works between the suppliers and other customers. They would like to figure out which contracts, agreements and norms exist between their suppliers and other customers. Social exchange is significantly governed by norms (Blau, 1964; Homans, 1958). They increase the efficiency of interactions and reduce the degree of uncertainty (Lambe et al., 2001).

Furthermore, they are interested in the innovations developed by their common R&D staff. Social exchanges often occur in complex exchange systems with several people characterized by competition for scarce resources (Coleman, 1994). The best product innovation can only be offered to one customer. Next to innovation, scarce resources also concern production capacities, preferential pricing or logistic concepts. A supplier's relationship with another customer mediates the buyer's relationship with this supplier.

Last but not least, the purchasers would like to explore the interpersonal exchange: How is the cooperation strategy? How often do they meet? Does the supplier offer an open-book policy for them? In this context, trust in the other party is important (Lambe et al., 2001). If a supplier is a cooperation partner, the customer shares important and sensitive information with him. Hence, customers are interested in the cooperation strategy of their suppliers with other customers, because they want to figure out if they can trust them with regards to, e.g., sharing intellectual property information. The core issues discussed by the SET include questions of

relationship initiation, termination and continuation (Kelley & Thibaut, 1978). According to the SET, purchasers might stop the relationship with suppliers who closely collaborate with their competitors or intensify projects with suppliers who closely work together with their complementors.

As figure 30 shows, the most desired information mentioned in the World Café are the prices and margins that the supplier grants the competitor. The purchasers placed 15 stickers on this top response. According to SET, being in a relationship is associated with costs (Lambe et al., 2001). Hence, the purchasers want to evaluate the costs and potential rewards of their own relationships with these suppliers. If the rewards of the interactions exceed the costs, the interactions are likely to occur or continue (Homans, 1961). In order to be able to compare exchange relationships with existing alternatives, Thibaut and Kelley developed the concepts of comparison level and comparison level of alternatives (Thibaut & Kelley, 1959). A purchaser considers his suppliers' prices and margins in comparison to what he feels is warranted (comparison level). However, if an alternative supplier can provide better prices and lower margins, the buyer will switch his supplier (comparison level of alternatives) (Lambe et al., 2001). The prices were rated as very important regarding supplier-complementor relationships, as well. However, the aim to figure out this information for the complementors is not the same as for competitors, as it might make sense for complementors to align their prices to each other and to raise or lower them by mutual consent. The managers of an airline would like to know when destination resorts lower their room rates, as the demand for flights will rise. This management of the complement's relationships describe Yoffie and Kwak as "knowing your friends" (Yoffie & Kwak, 2006).

Another important financial KPI being assessed with 8 points is the turnover share and development that the supplier makes with the competitor. SET suggests that trust-building between two parties may start with relatively small or minor transactions (Lambe et al., 2001). If the number of interactions and the size of the transactions increase, the trust increases, as well (Houston & Gassenheimer, 1987). That is why purchasers are also interested in the turnover share and development of their suppliers with other customers.

However, not only financial facts are highly important to the purchasers, but also other parameters describing the supplier-competitor business, e.g., if the supplier delivers directly to the competitor's aftermarket (8 points) or if he supplies to his global plants (13 points): Do the supplier and the competitor go local-for-local? If he were willing to implement the corresponding structural and processual changes with other customers, maybe he would agree on the same strategy with the focal company.

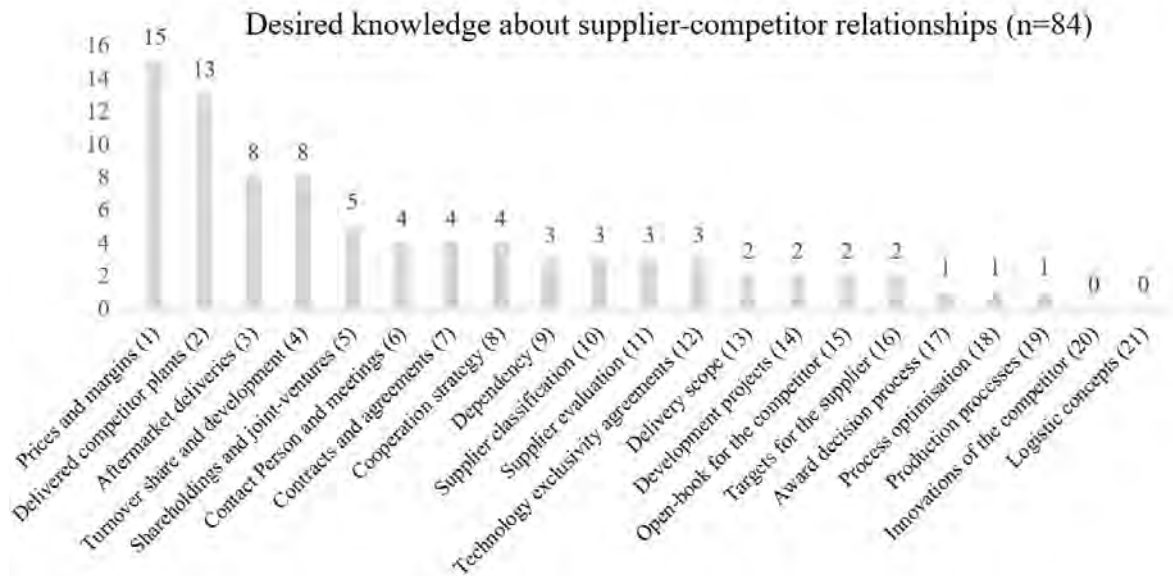


Figure 30: Rating of desired relationship knowledge

The desired relationship knowledge presented in this paper contributes to the current literature examining the different dimensions of customer attractiveness and supplier satisfaction (Pulles, Schiele, et al., 2016). Some mentioned answers correspond to the outcome of the World Café presented by Pulles et al. and thus render the findings of these authors more robust. Other aspects are new and complement the outcome of the previous World Café by valuable additions.

More precisely, the purchasers in our research mention the same following dimensions of customer attractiveness as in the World Café of Pulles et al.: turnover share (corresponding to the purchasing volume of the buyer), top-management interest (derived from the contact person and frequency of meetings), firm/cooperation strategy, exclusivity agreements, supplier development projects and the open-book providing suppliers access to advanced knowledge (Pulles, Schiele, et al., 2016). New additional dimensions of customer attractiveness from our research are: location of plants, shareholdings and joint ventures, contracts and agreements, process optimization and logistic concepts.

Concerning the dimensions of supplier satisfaction, purchasers in both cases mention: prices and margins, the turnover development (equivalent to the growing purchasing volumes), the supplier evaluation (corresponding to supplier rating), joint developments and innovations as well as shared targets (Pulles, Schiele, et al., 2016). However, some interesting, new answers from our research can be added to the dimensions of supplier satisfaction: dependency of the customers on the suppliers, supplier classification, delivery scope and the award decision process.

4.4.2 *Supplier factory visits and suppliers as the most promising information sources*

Potential information sources for the supplier relationships with other customers can be differentiated into media/events and people, as demonstrated in figure 31. Media does not only cover print media in the form of specialized press but also internet search engines and internet-based RfQ platforms. Concerning complementors, the following documents are worth reading:

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industrial reports (Kumar et al., 2013), industry forecasts, scientific reports, annual reports, newspapers, professional magazines, trademark registrations and patents (Ojasalo, 2004). Events are usually organized by fair organizers and associations. However, sometimes activities take just place on the market and thereby inform third parties about relationships.

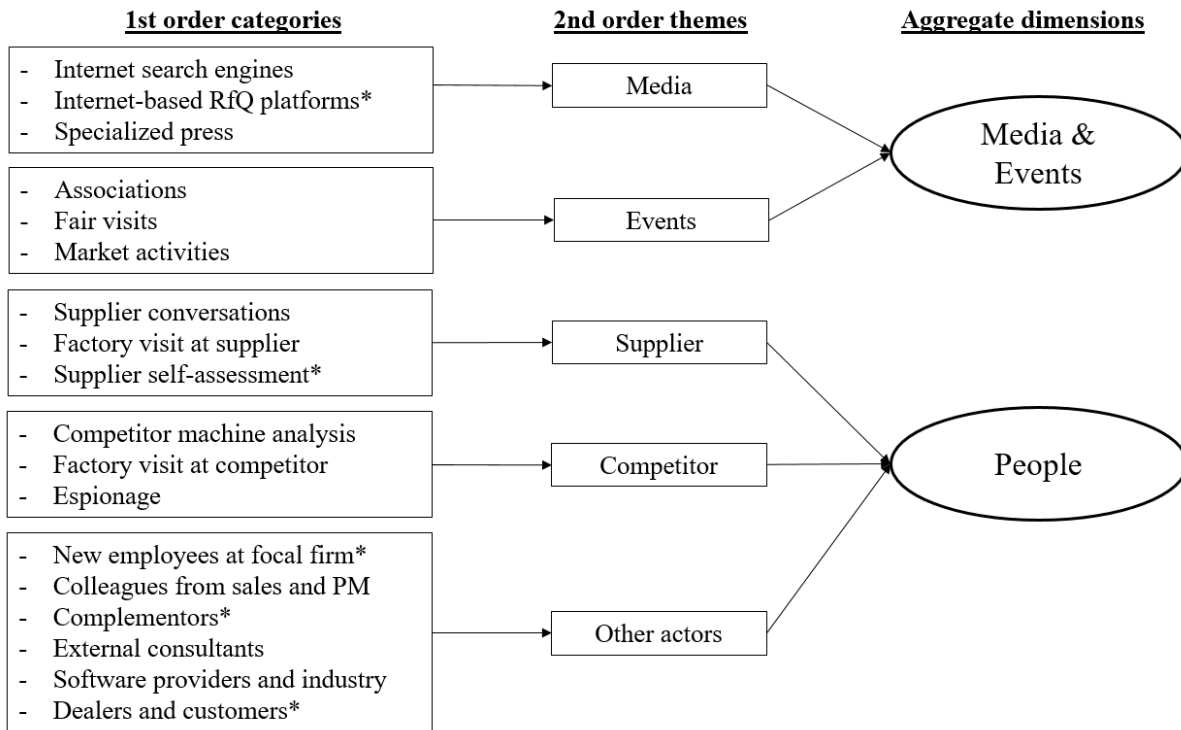


Figure 31: Data structure of information sources

Several people in a company’s environment reveal the desired information: The most obvious of these information sources is the supplier himself, who either speaks frankly with his contacts of the focal company or who gives information unintentionally during visits at his plant or because he has to do so in self-assessments for the application for new customers. The competitor tends to be more restrictive with his data, yet sometimes his plants may also be visited or one of his products can be analyzed. Espionage is another theoretical way but illegal and therefore excluded for further considerations. Furthermore, it is regarded as helpful to talk to colleagues from other departments or to new colleagues about the suppliers. Complementors, external consultants, software providers and dealers are further promising sources of supplier relationship information.

Rated by 16 points each in figure 32, the purchasers regard both factory visits at the supplier and conversations with the supplier (Ojasalo, 2004) as the most promising information sources regarding relationships with competitors. For relationships with complementors, the score is even higher, as the information policy is obviously more open regarding complementors being considered as “friends” of the focal company (Yoffie & Kwak, 2006). Several contact persons at the supplier might disclose the required information: the sales contact, back-office employees, the project leader or the responsible engineer.

With eleven points on the second rank, the purchasers regard the exchange with colleagues as highly important. Networking helps to achieve information and team meetings also provide an

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important platform to exchange with colleagues. The technical approach via a competitor machine analysis is evaluated just as important by the purchasers with eleven points, too.

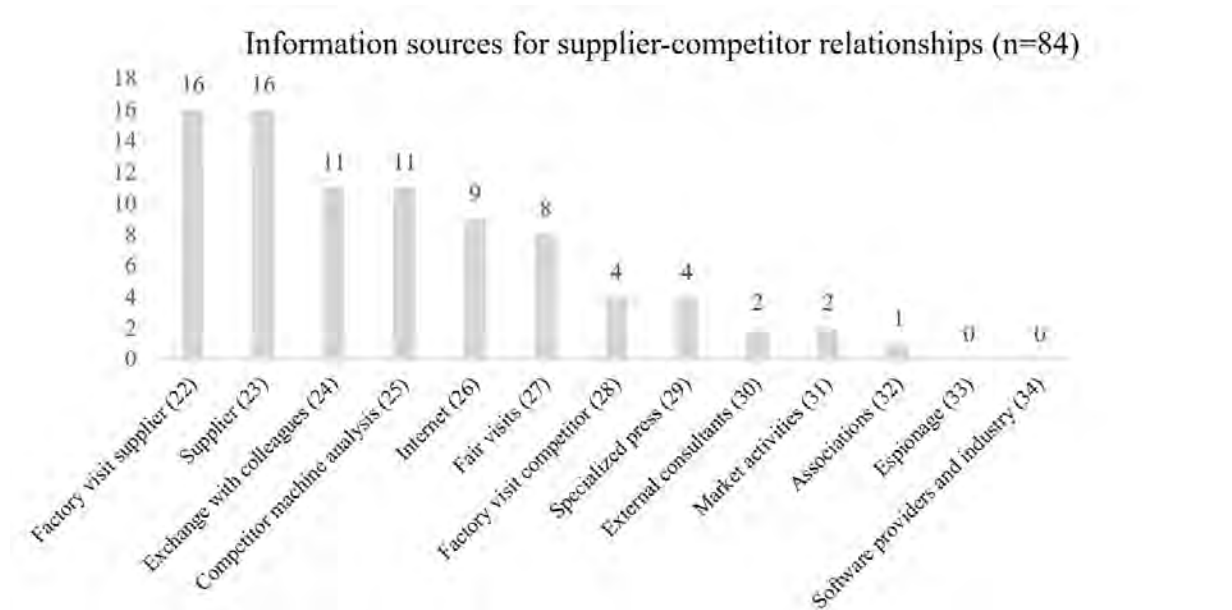


Figure 32: Rating of information sources

4.4.3 Volatile times with increasing risks requiring a high supply network transparency

The contingency factors can be clustered in general conditions, changes and particular occasions as demonstrated in figure 33:

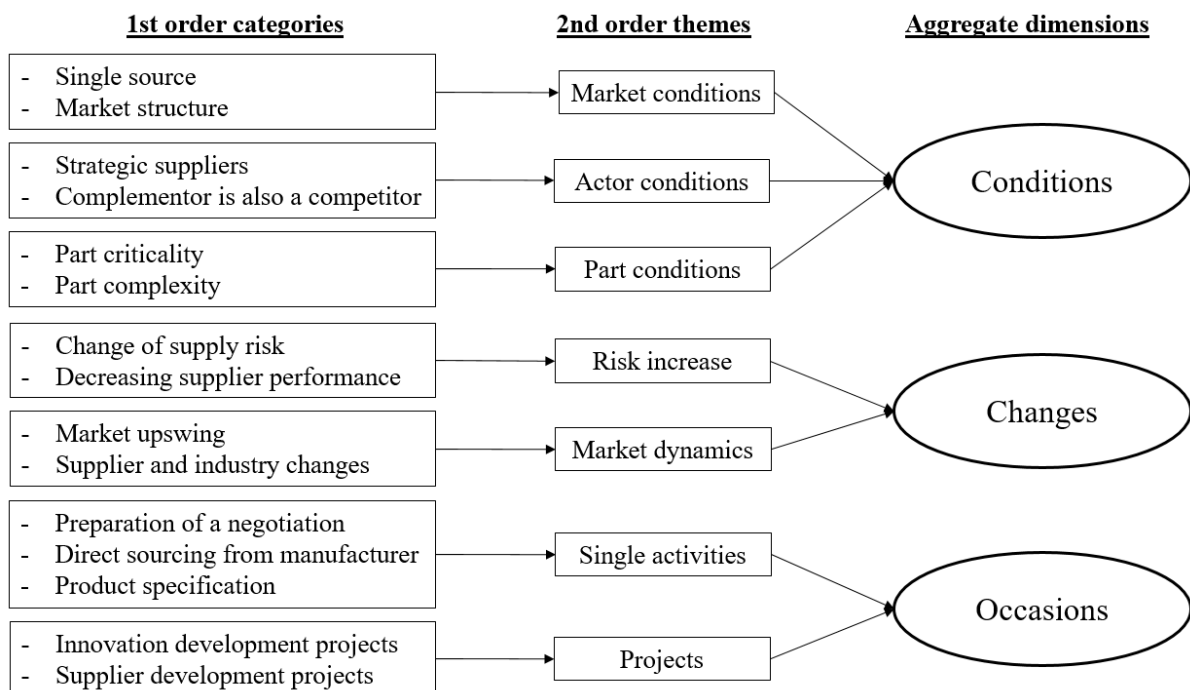


Figure 33: Data structure of contingency factors

The conditions cover the market with his structure and potential alternative sources. The purchasers give seven points to this answer during the World Café. If the focal company is a monopolist, it does not have to bother about relationships that might potentially improve or

endanger its situation. However, especially for small and medium-sized enterprises that are not market leaders, it is extremely important to capture their suppliers' relationships. On the one hand for pricing reasons, but on the other hand also to ensure that there are enough resources planned for the own orders and to secure a beneficial strategic negotiation position even without being the preferred customer (Pulles, Schiele, et al., 2016; Schiele et al., 2012). If the supplier is a monopolist or an oligopolist, the market structure requires high transparency, too, because there are only a few suppliers available for sourcing.

Further conditions are the actors like strategic suppliers or complementors if they are also competitors at the same time, as well as the part regarding its criticality and complexity. In contrast to parameters requiring a high need for transparency, a low part criticality (six votes) and a low part complexity (four votes) do not justify a high effort to search for information. According to the understanding of this World Café's participants, the part criticality signifies the percentage share of the part of the final product. Hence, A-parts like the gearbox or the engine for vehicles endanger the shipment of the final product to the customer in contrast to attachment parts. The technical complexity of a part differentiates assemblies from simple or standard parts.

Apart from these static conditions, also dynamic factors play an important role in a high need for supplier relationship knowledge. Changes can concern the disruption risk, which increases (Norrman & Jansson, 2004), or the supplier performance, which decreases. Both changes are classified as threatening by the purchasers, as the supply risk on the top rank achieves eighteen points and the decreasing supplier performance still achieves twelve points (see figure 34). According to the purchaser discussions, a high supply risk can be suspected if parts are tool-specific, in case of supplier insolvency or due to changes in the supplying company's property.

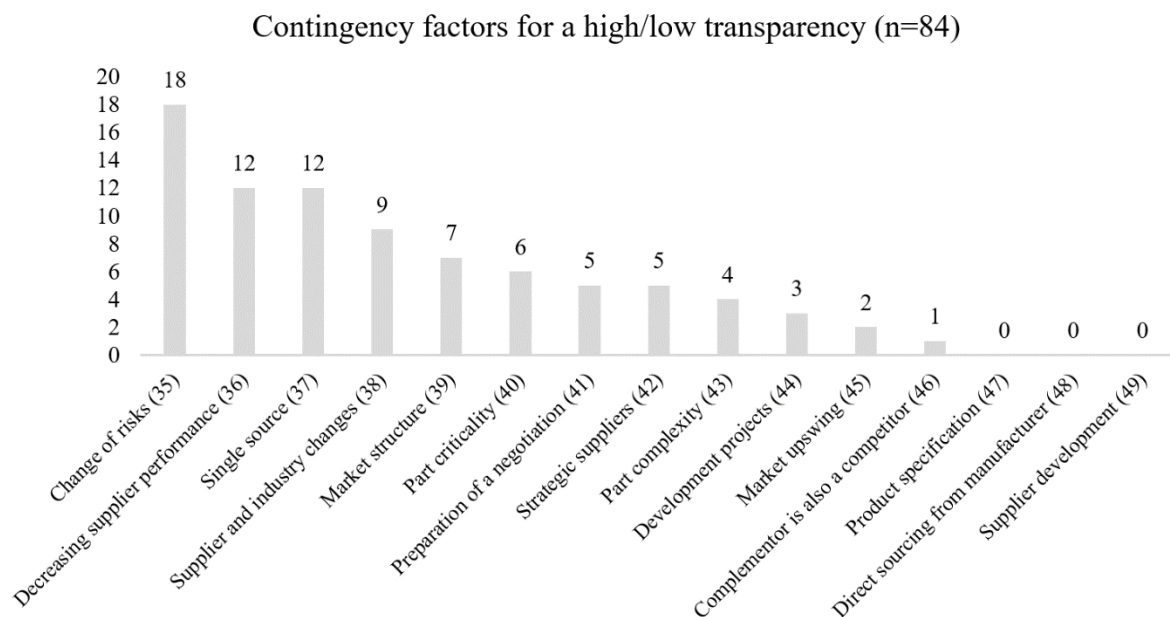


Figure 34: Rating of contingency factors

Apart from risk changes, there are also changes in the market like an upswing or significant changes for the suppliers or even the whole industry. Such trends include e-mobility drive

technology, the signature of a contract to extend a business relationship or a change in the supplier's strategy and still achieve nine points by the purchasers during the World Café.

Particular occasions lead to a high need for transparency, as well. Quite often, the purchasers have to prepare a negotiation, want to source a part directly from its original manufacturer or need to specify the product before its launch. Apart from these single activities, a high supplier relationship transparency also makes sense in regular innovation and supplier development projects, as these close partnerships are based on mutual trust, according to the SET (Lambe et al., 2001).

4.5 Conclusion and Future Research

4.5.1 Contributing to preferred customer and supply chain mapping literature as well as to the work of strategic purchasers

According to a review on the use of SET, future research needs to examine the interactions outside of the own exchange relationships (Lambe et al., 2001; Ping, 1994). In particular, strategic purchasers of a focal company have the interest to figure out how their suppliers are related to their competitors and complementors. For this purpose, we asked 14 purchasers to participate in a World Café and clustered their answers according to the Gioia Method. Our research leads to the following main theoretical contributions:

Building on SET, this article explains which knowledge about the relationships of their suppliers with other customers can help purchasers. It investigates when and how purchasers can find out how their suppliers work together with other customers. Consequently, the results contribute to both SET and the assessment of customer attractiveness, supplier satisfaction and the preferred customer status in the preferred customer literature. In particular, this research investigates the different dimensions of customer attractiveness and supplier satisfaction. By increasing the robustness of these dimensions, purchasers can improve their self-awareness of their own customer attractiveness (Molm, 1990). An increased attractiveness better matches the suppliers' expectations and increases their satisfaction. A standardized procedure to gather information enables companies to react faster. They can assess their status as perceived by the suppliers and in the next step, actively influence it to become a preferred customer. These insights contribute to the literature on the benefits of preferential treatment.

The current literature on supply chain mapping presents the supply chain maps as an output but neglects the procedure of how to create them. This research contributes to the procedure of supply chain mapping. It examines the information gathering phase, which is an initial step before an object can be mapped. It suggests which information needs to be collected and where it can be found. Furthermore, the current literature focuses on the mapping of vertical supply chains. This article investigates the horizontal mapping of supplier relationships with competitors and complementors according to the wording used by Choi and Hong (T. Y. Choi & Hong, 2002). The authors explain when it is important to know and map these relationships. Combining both directions enables the mapping of complex supply networks. While most supply chain mapping literature focuses on the mapping of nodes, this article proposes characteristics of supply chain linkages to be examined. It also gives ideas on how these

connections can be quantified. This approach differentiates the current research from pure market research on suppliers.

Moreover, this research also contributes to the work of strategic purchasers. They now have a checklist of the most important information that they need to collect for a successful supplier relationship management. This information covers knowledge about the suppliers themselves, the business of their suppliers with other customers, and the collaboration between both parties. Prices and margins achieve the highest interest. Moreover, purchasers profit from a collection of information sources covering media that they can read, events where they can go or people whom they may contact in order to gather the desired information. Among the sample of 14 purchasers, they even know that these buyers regard factory visits at their suppliers and information disclosed by their suppliers as most helpful. Furthermore, the purchasers know in which general situations and particular occasions this knowledge is important. Especially volatile times with increasing supply risks require a high supply network transparency. Hence, the buyers can create an early-alert-system of severe changes that require a sudden increase in supplier relationship transparency.

Finally, the new knowledge can help purchasers to check and revise their supplier strategies. A well suitable supplier relationship management can again lead to a competitive advantage compared to other customers who do not have as much transparency about the relationships of their suppliers as the focal company. It helps the purchasers to assess their own customer status and to switch it from a neglected to a preferred status eventually.

4.5.2 Limited generalizability of the World Café Method requiring an explanatory follow-up survey

The World Café has been applied to a single agricultural machinery company. The single case study may bias the results because the opinions of the participants may be determined by the market structure in which this company operates. Even though the generalizability of the results to other industries can be assumed, it requires a subsequent cross-sectional study across, e.g., the automotive, electronics, food, construction and textile industry in order to strengthen the sample. Such an extension of the single case research design would certainly lead to additions regarding the required information or potential information sources and might lead to further, sector-specific contingency factors concerning the need for transparency on the supplier relationships.

Moreover, all participants in the World Café have come from the purchasing department. However, there are far more services in a company that are in a strategic collaboration with suppliers such as the research and development, material planning or product management department. The opinions of these departments on the required information about suppliers' relationships might lead to helpful additional aspects.

Even if the participants of this World Café have been purchasers with different portfolios, not all product-related commodities of the company have been represented. Maybe additional interviews with the purchasers of the remaining commodities might lead to further required information, information sources and contingency factors for the need for transparency.

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Furthermore, an explanatory follow-up survey with a larger sample of purchasers from different industries is required to make the evidence generated from this research stronger and more reliable. This study needs to test the impact of different information sources on supplier relationship knowledge and to explore the effect of supplier relationship knowledge on purchasing performance. This paper has figured out which information is desirable, how it can be gathered and when it is needed. Based on these findings, it is important to examine further which activities purchasers carry out if they have this transparency and how successful they are with these activities. These results will create an additional contribution to decision-making literature.

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Chapter 5: Knowing your supplier relationships with other customers: People or media as key sources of information?

Abstract

Few buying firms perceive to have good and complete knowledge about their suppliers. However, in particular in industrial markets often characterized by oligopolies, it becomes increasingly important for buyers to understand how their suppliers look at them and how their suppliers allocate priorities among their customers. In order to enable the assessment of the own customer status, this paper analyzes the impact of several information sources on the customer attractiveness, supplier satisfaction and preferred customer status knowledge on supplier relationships with other customers.

Testing these hypotheses on a sample of 624 purchasers, we show that people and also events, which are visited by many people, provide more relevant information on the company's strategic positioning than media. The finding on the importance of personal contacts implies that also in the fourth industrial revolution (I4.0), strategic purchasers cannot be replaced by media analyzing artificial intelligence systems. The suppliers themselves, but also competitors and other actors like consultants, are very important information sources for the purchasers. Moreover, these sources can disclose relevant information about the attractiveness of other customers and satisfaction of their suppliers with other customers, while the status of other customers remains a blind spot for the purchasers of the focal company. Following our findings, purchasers can better anticipate the customer treatment that they can expect from their suppliers and adjust their supplier relationship management.

Keywords

Social Exchange Theory; Preferred Customer Status; Competitive Advantage; Supply Chain Transparency; Supplier Relationship Management; Structural Equation Modeling

5.1 Introduction: Important knowledge on the own customer status being hard to figure out

5.1.1 Awareness of the own customer status becoming crucial for the company success

The competition for resources by the customers in business-to-business markets is increasing (Pulles, Schiele, et al., 2016; Schiele et al., 2012). In many industries, the number and the capacity of the suppliers are limited and can cause bottlenecks in the supply. Recent examples of supply shortages caused by supplier Prevent not delivering VW with engine parts (Iwersen, Murphy, & Buchenau, 2018) or Bosch not supplying steering systems to BMW (McGee, 2017) have shown that these constraints can hit even large manufacturers seriously. Especially in expanding or booming phases of the business cycle, the situation is very serious and the suppliers cannot saturate all the existing demand. Natural disasters and further risks in a globalized world render purchasing activities even more difficult.

This development on the markets also leads to changes in the market power: In the past, suppliers fought hard to gain the orders of their customers (Schiele et al., 2012). The supply market consisted of a broad range of interchangeable small to mid-size suppliers, whereas the manufacturing companies had a high manufacturing depth and owned most of the intellectual property on innovations. Nowadays, the customers often cannot take the fulfillment of their demands for granted anymore due to an oligopolistic market structure (Schiele et al., 2012). Prominent examples of supplier oligopolies are the operating systems for smartphones, Apple iOS and Google Android (Kramer, 2018). In many industries, the number of suppliers has significantly reduced to a remaining set of big, consolidated enterprises with high innovation power and thus a very good negotiation position.

Due to these developments in the markets, the purchasers need more information about the suppliers and their relationships with other customers, because the suppliers may not treat all customers equally. Instead, some customers enjoy preferred customer status, while others are treated as standard customers. Hence, the customers need to struggle hard in order to become the preferred customers of their suppliers (Pulles, Schiele, et al., 2016; Schiele et al., 2012). It is becoming increasingly important for companies to be a preferred customer and to have satisfied suppliers, as purchasers with highly satisfied suppliers receive a better status and ultimately better treatment than their competitors (Vos et al., 2016). They derive greater benefits from suppliers' resources and capabilities and thus gain competitive advantage (Schiele, Calvi, & Gibbert, 2012; Pulles et al., 2016; Schiele et al., 2012). Furthermore, the preferential treatment can be beneficial for product quality, support in the sourcing process, delivery and prices (Nollet et al., 2012) as well as the supplier's willingness to share new technology with this customer (Ellis et al., 2012). These ways of preferential treatment by the suppliers again increase customer satisfaction (Bemelmans et al., 2015).

5.1.2 1.2 Difficulty of assessing the own customer attractiveness

There is a gap in the literature regarding the assessment of the own customer attractiveness and resulting customer status. Prior literature has broadly examined how to achieve information about suppliers, e.g., in the context of the supplier selection problem. Purchasers can gather the necessary information directly from suppliers during conversations or supplier site visits (Purdy & Safayeni, 2000) or from consultants (Hada, Grewal, & Lilien, 2013). To achieve information about the actors in networks, Ojasalo suggests competitors, experts, industry forecasts, exhibitions, conferences, trade associations, scientific reports, annual reports, newspapers, professional magazines, trademark registrations, patents and the internet as further potential information sources (Ojasalo, 2004). Moreover, in triads consisting of different customers and suppliers, reference customers (Huntley, 2006; Jaakkola & Aarikka-Stenroos, 2019; Salminen & Möller, 2006), who may be selected by suppliers (Hada et al., 2013; Salminen, 2001), can provide information about the supplier performance. Suppliers may offer reference visits, reference lists, brochures of customer cases, success stories and communicate about references on trade fairs or via the internet (Helm & Salminen, 2010). Even though this enhances the knowledge of suppliers, the current literature has not sufficiently investigated the supplier relationships with different customers and the resulting consequences on their customer status.

Hence, most of the companies are not aware of their own customer status. They cannot assess their own strategic positioning compared to their competitors properly – especially before having experienced the preferential treatment by their suppliers. Moreover, they do not have full transparency on the supplier relationships with other customers, either, as they do not have access to their price lists, quality inspection reports, on-time-delivery measurements, or other confidential information. Supply chain transparency is ranked as the fourth most underestimated emerging research theme, according to a study by Wieland et al. (Wieland, Handfield, & Durach, 2016). Nevertheless, appropriate measurement instruments for supply chain transparency are still lacking (T. R. Morgan, Richey Jr, & Ellinger, 2018).

The most obvious way to achieve information on the own customer status would be to ask the suppliers directly if the own company is their preferred customer or not. However, the treatment of different customers and future development with them is part of their strategy. Unlike the results of supplier evaluations, the results of customer evaluations are usually not communicated to the customers and are not the result of a systematic procedure. Hence, the only solution for the companies is to self-assess their own status in order to understand their situation. They need to evaluate if they are sufficiently attractive to initially motivate a supplier to start a business relationship with them and in the long term to get and maintain a preferred customer status by satisfying the supplier. For this assessment, the purchasers need proper information sources.

Therefore, in this paper, we investigate the following research question:

RQ: *Which information sources can provide most knowledge on customer attractiveness, supplier satisfaction and preferred customer status in the supplier relationships with other customers?*

Gathering this particular knowledge is based on achieving supply chain transparency, which is commonly known as the disclosure of information on involved actors (Doorey, 2011). The actors considered in this research are suppliers, customers, competitors and complementors, according to the Value Net (Nalebuff & Brandenburger, 1997). Competitors and complementors will be summarized as “other customers” of a particular supplier in the further course of the paper according to the wording used by Farris (Farris, 2010).

In this paper, we introduce the usage of different information sources and the knowledge on the customer attractiveness, supplier satisfaction and preferred customer status in the supplier relationships with other customers as the constructs building the framework of our research. We use the structural equation modeling method to assess these unobservable latent variables. This method helps us also to investigate the causal relationships between the variables. We apply the method based on a data set that we gathered during a survey with 624 participating buyers. After having presented our findings, we will mention the contributions of our study and the potential fields of future research.

5.2 Theoretical Background: Information sources for social exchange

5.2.1 Types of information sources: Media, events and people

Supply chain transparency is a potential outcome of information-sharing activities (Barratt & Oke, 2007). Information sharing in a supply chain context refers to the extent to which information is available to the members of a supply chain (Hsu, Kannan, Tan, & Keong Leong, 2008). Effective information sharing between the members of a supply chain enhances visibility and reduces uncertainty (Brennan & Turnbull, 1999; R. Handfield & Bechtel, 2002). The ability to access important information across the supply chain can also provide further benefits: If additional supply chain information becomes available, the companies can take advantage of this increased visibility to modify existing actions or to plan future operations (Hsu et al., 2008). They can generate competitively advantageous positions in the global marketplace (Ho, Ghauri, & Larimo, 2017). Knowledge is an important factor in strengthening the competitiveness of multinational companies (Park, 2008).

The question is, which sources of information business professionals can access in order to gain transparency in their supply network? To answer this question, we suggest three different types of information sources: media, events and people.

Depending on the nature of the information needed, we assume that analog and digital media are information sources that are used by purchasers (Amelia S. Carr & Kaynak, 2007; Larson & Kulchitsky, 2000). In our study, we differentiate between analog media, which contains different print media as well as the television, and digital media, which sums up different Internet-based information sources. Secondary stakeholders have increased their ability to gather and share information through the help of the Internet (Jurgens, Berthon, Edelman, & Pitt, 2016). The general public, communities and activist groups who are present in the social media, belong to these secondary stakeholders. Unlike suppliers, customers and other primary

stakeholders in the Value Net, they have no direct connection with the companies and represent a large group of people with diverse interests (Gardberg & Newburry, 2013; Zietsma & Winn, 2008). We consider these secondary stakeholders in our digital media construct.

Furthermore, there is a positive impact of the networking capability for the management of existing supplier relationships in order to improve the company's overall performance (Mitrega, Forkmann, Zaefarian, & Henneberg, 2017). On the other hand, those companies which do not strive for networking and which do not exchange knowledge limit their knowledge base in the long term (Pittaway, Robertson, Munir, Denyer, & Neely, 2004). Hence, we integrate events, where purchasers can exchange information, as another exogenous construct to our research frame, because we assume that they lead to the desired knowledge within the supply network.

Prior research has shown that advanced communication technologies do not replace face-to-face communication (Wognum, Fisscher, & Weenink, 2002). Following these insights, we regard the supply chain members as one potential group of information sources. In accordance with the Value Net (Nalebuff & Brandenburger, 1997) building the framework of our research, we take the information by the suppliers and the competitors as one latent variable each. We summarize the information by customers, complementors and further supply chain members in the third construct "info by other actors".

5.2.2 Social Exchange Theory explaining the reasons for preferred customership

Our hypotheses are embedded in the context of the social exchange theory (SET), which deals with social behavior in the exchange of activities between at least two people (Homans, 1958). This social exchange is defined as a process with two-sided transactions and mutual rewards (Emerson, 1976). It is based on mutual attractiveness as the basis for exchange relationships and covers diverse relationship issues between the actors (Blau, 1964). We regard these exchange relationships as the basic unit of our analysis (Emerson, 1976).

The SET can be transferred to buyer-supplier relationships and the attractiveness of both suppliers and their customers. On the one hand, a good supplier ranking due to a high supplier attractiveness motivates a buyer in his awarding decision for a certain supplier. However, if the supplier performance and therefore, his attractiveness decreases, the customer might select a different supplier.

On the other hand, a high customer attractiveness can motivate the supplier to initiate or maintain a relationship with a certain customer, according to the cycle of preferred customership (Schiele et al., 2012), illustrated in figure 35. Once being in this relationship, he constantly evaluates whether he is satisfied or not. If his satisfaction is high, he will grant this customer preferential treatment, while he will rather treat him as a regular customer or even stop the relationship with him, in case he is not satisfied (Schiele et al., 2012).

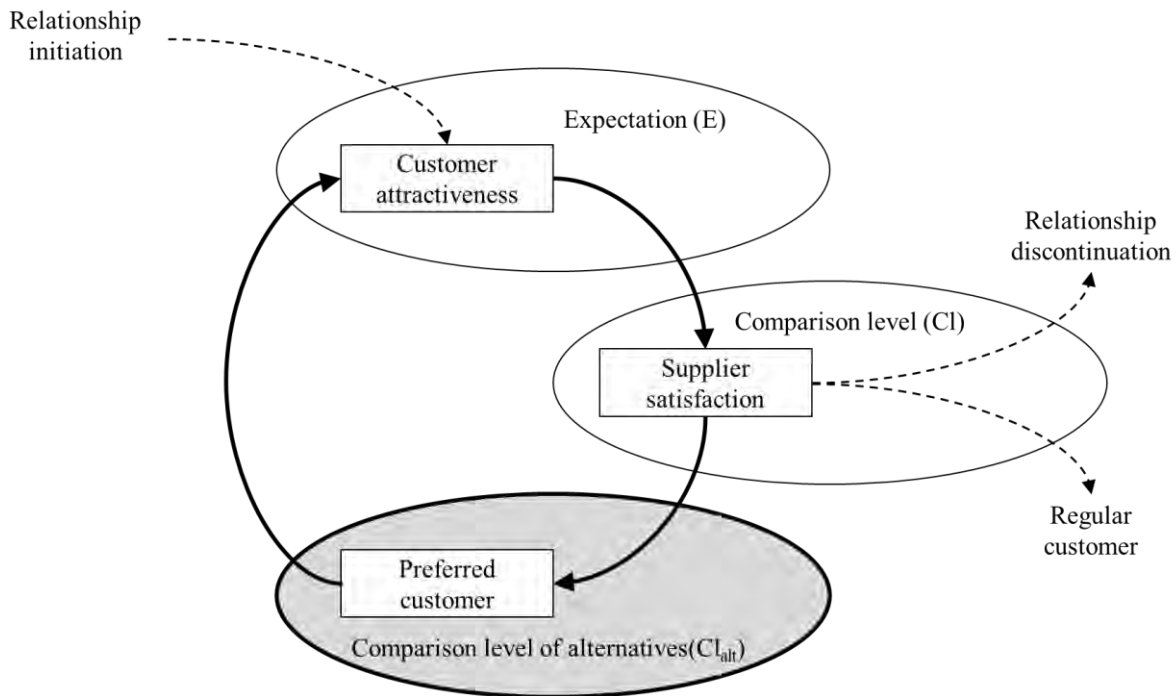


Figure 35: Research focus in the cycle of preferred customership

Lambe et al. have carried out a review on the use of SET and suggest that future research needs to examine how the business and social outcomes of exchange are affected by interactions outside of the own exchange relationship (Lambe et al., 2001). Current empirical research has often underscored the relevance of the existence of alternative relationships (Ping, 1994). Hence, in our paper, we focus on this research gap, which is illustrated by the grey ellipse in figure 35. In order to fill this gap, we measure the knowledge on supplier relationships with other customers. Moreover, we test which information sources have the highest impact on this knowledge of alternative relationships.

SET suggests that actors feel positively or negatively about their exchange relationships because of three factors (Thibaut & Kelley, 1959). The three dependent variables in our research model correspond to the three elements of the cycle of preferred customership, reflecting the three factors of the SET (Schiele et al., 2012):

- 1.) Expectations regarding the costs and benefits of an exchange relationship ($\hat{=}$ customer attractiveness),
- 2.) Comparison of the expectations with the outcomes of the relationships ($\hat{=}$ supplier satisfaction),
- 3.) Comparison of the current relationships with potential benefits from other relationships ($\hat{=}$ preferred customer status).

5.2.3 Expectations regarding an exchange relationship reflecting customer attractiveness

The first factor mentioned by Thibaut and Kelley are the expectations regarding the costs and benefits of an exchange relationship (Thibaut & Kelley, 1959), reflecting customer attractiveness. Attractiveness is an important SET construct (Tanskanen, 2015). The self-awareness of one's attractiveness may increase reward power in a buyer-supplier-relationship (Molm, 1990). Mutual attractiveness is important to improve value creation and value transfer in buyer-supplier-relationships (Sundtoft Hald et al., 2009). Important attributes of attractiveness are the expected value, trust and dependency (Sundtoft Hald et al., 2009).

Companies need to search for information to assess their own attractiveness towards their suppliers. SET proposes that the relationships that the suppliers choose to create and maintain are the ones that maximize their benefits and minimize their costs. The potential costs of a relationship are regarded as negative, while the benefits are seen as positive. The key to the benefits is the other party's attractiveness. The attributes of buyer attractiveness are rather unique and manifested only in one or two different buyer-supplier-relationships (Tanskanen, 2015). Therefore, we will use an exploratory qualitative research method to determine the relevant measures of customer attractiveness as well as the potential information sources in our research.

We set the knowledge on this attractiveness of other customers as the first endogenous variable in our structural model. According to Baxter, a very important determinant for the preferred customer status is the financial customer attractiveness (Baxter, 2012). We believe that the media will rather not publish such confidential information as well as details regarding contractual agreements or the cooperation strategy. Instead, we assume that exhibitions, conferences and events might be a suitable platform to learn about the attractiveness of different actors in the supply network (Ojasalo, 2004), leading to H1c. Moreover, suppliers need to be able to provide information about the attractiveness that motivated them to initiate and maintain a relationship with a certain customer (H1d). Finally, competitors will also have certain criteria why they believe that business with them may attract suppliers (H1d). Nevertheless, we will also measure the potential impact of the remaining identified information sources:

H1: (a) Digital and (b) analog media usage, (c) event visits, as well as the information by (d) suppliers, (e) competitors and (f) other actors, are positively related to customer attractiveness knowledge (keeping all other variables equal).

5.2.4 Comparison of the expectations with the outcomes determining supplier satisfaction

The second factor, according to Thibaut and Kelley, is the comparison of the expectations to the attained outcomes (Thibaut & Kelley, 1959). The discrepancy between the expectations and the actual outcome determines the level of satisfaction (D. T. Wilson, 1995). Satisfaction is achieved if the quality of the outcomes meets or exceeds the expectations (Schiele et al., 2012). In current literature, there is a substantial number of publications operationalizing the SET. Many of them use the variable of satisfaction in business-to-business exchanges to

operationalize the success of the exchange relationships. Satisfaction serves as a measure of a firm's view of the outcomes of the relationship (Lambe et al., 2001).

Supplier satisfaction is the buyer's ability to fulfill the expectations of the supplier (Schiele et al., 2012). It is influenced by growth opportunities, reliability and profitability of the relationship (Vos et al., 2016). Moreover, Ellis, Henke and Kull state that early supplier involvement and relational reliability positively affect supplier satisfaction (Ellis et al., 2012). A high customer attractiveness is an antecedent of supplier satisfaction and can motivate the supplier to invest his limited resources in the common business with this customer (Baxter, 2012).

Supplier satisfaction expresses thus a supplier's feeling of fairness about buyer's incentives and supplier's contributions within an industrial buyer-seller relationship (Essig & Amann, 2009). We presume that the supplier will communicate this feeling both if he is treated fairly or unfairly (H2d). Breaching relational obligations in B2B relationships has negative consequences on fairness perception and may cause emotional responses (Blessley, Mir, Zacharia, & Aloysius, 2018). Hence, he will not be afraid to communicate this information also in public via the Internet (H2a), press or TV (H2b) or on events (H2c). As our research focuses on the knowledge of supplier relationships with other customers, we hypothesize that competitors will be an important information source regarding the satisfaction of their own suppliers (H2e). Additionally, other actors, like internal colleagues from other departments and complementors being in direct contact with the suppliers as well as external consultants via market research, are capable to provide information on their satisfaction (H2f).

H2: (a) Digital and (b) analog media usage, (c) event visits as well as the information by (d) suppliers, (e) competitors and (f) other actors are positively related to supplier satisfaction knowledge (keeping all other variables equal).

5.2.5 Comparison with alternative relationships to decide about the preferred customer status

The third factor listed by Thibaut and Kelley is the comparison of the current relationships with potential benefits from alternative relationships (Thibaut & Kelley, 1959). The suppliers will compare their satisfaction in each ongoing relationship with different customers. This consideration of alternatives is an important extension of the classical satisfaction literature (Essig & Amann, 2009; Ghijssen et al., 2010). It requires a shift from dyadic-level to network-level analysis (Lambert, 2008; Schiele et al., 2012), which we expand in our research. Thibaut and Kelley state that actors will use not only absolute but also relative criteria to evaluate the outcome of an exchange relationship (Thibaut & Kelley, 1959).

The core issues discussed by the SET include questions of relationship initiation, termination and continuation (Kelley & Thibaut, 1978). The decision of the supplier to award the preferred status or a regular status to the customer or to discontinue supplying the customer is influenced by the availability of alternatives (Schiele et al., 2012). Business-to-business markets currently

face high competition for resources (Pulles, Schiele, et al., 2016). Thus, suppliers can choose between a broad range of potential alternative customers and decide themselves whom they would like to deliver. Hence, the customers need to struggle hard in order to become the preferred customers of their suppliers and to obtain preferential resource allocation (Pulles, Schiele, et al., 2016; Schiele et al., 2012).

Purchasers have a high interest in figuring out their status as customers because it can help them to anticipate the behavior of their suppliers (Vos et al., 2016). Once they know if they are the suppliers' preferred customers or not, they can also anticipate and evaluate future treatment by their suppliers. Preferred customers can benefit from preferential treatment regarding product quality, support in the sourcing process, delivery and prices (Nollet et al., 2012) as well as the supplier's willingness to share new technology with this customer (Ellis et al., 2012). These ways of preferential treatment again increase customer attractiveness and satisfaction (Bemelmans et al., 2015), depicted by the cycle of preferred customership in figure 35.

In the previous hypothesis, we have stated that it is important to use information sources in order to determine supplier satisfaction. However, supplier satisfaction is an antecedent to preferred customer status and preferential treatment, but not an absolute value. Whether a customer receives preferential treatment or not also depends on the alternatives available to the supplier. Hence, we believe that the supplier himself will be the best information source to provide any knowledge about the preferred customer status, as he is the only one knowing his alternatives and his relative intended level of resource allocation (Baxter, 2012), leading us to H3d. Additionally, we would like to test to which degree the remaining six identified information sources may also provide preferred customer status knowledge:

H3: (a) Digital and (b) analog media usage, (c) event visits, as well as the information by (d) suppliers, (e) competitors and (f) other actors, are positively related to preferred customer status knowledge (keeping all other variables equal).

The three hypotheses are illustrated in our research model in figure 36. We will test the impact of various information sources on the customer attractiveness, supplier satisfaction and preferred customer status knowledge. However, it is important to highlight some important basics about our investigation:

- Our perspective is on the supplier relationships with other customers through the whole investigation because these are subject to the research gap that we would like to explore (Lambe et al., 2001; Ping, 1994) - not on the supplier relationships with the focal company.
- We are interested in the knowledge about customer attractiveness, supplier satisfaction and preferred customer status and how to gather it – not in the degree of these constructs.
- Therefore, we conduct a survey with purchasers, while the above mentioned constructs are usually measured in supplier satisfaction surveys or dyadic research.

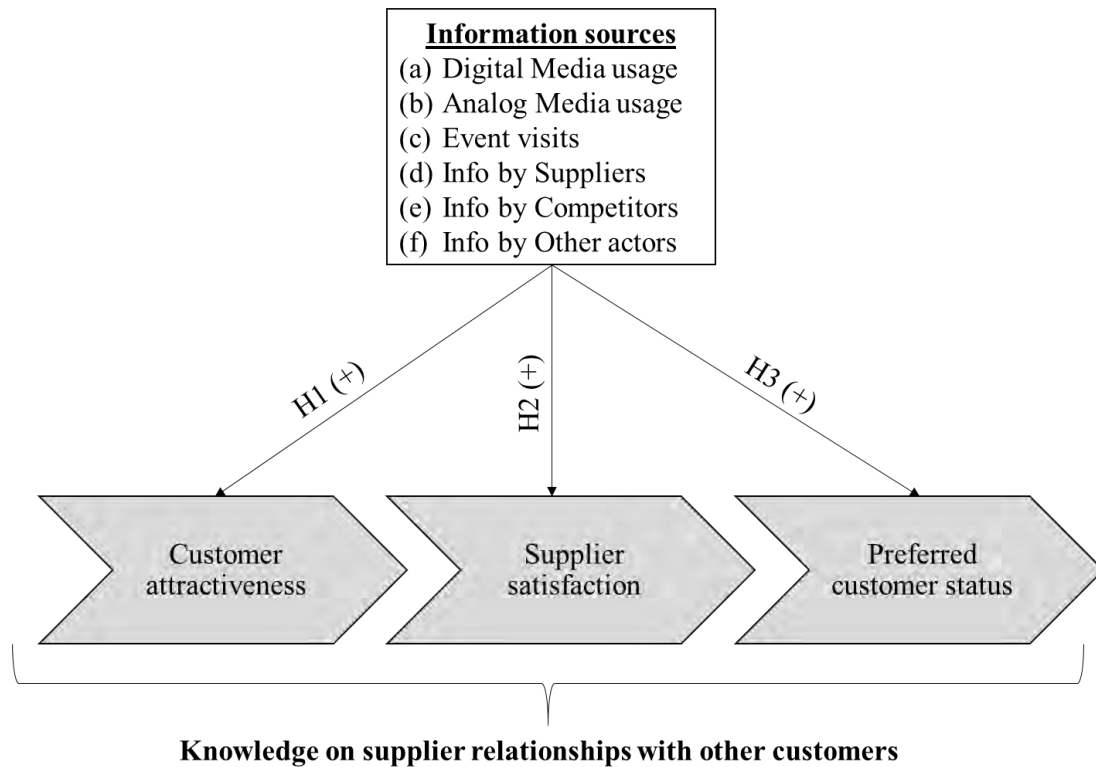


Figure 36: Research Model

5.3 Research Design: Online survey based on existing and new measures

5.3.1 Final data set of 624 responses collected via different communication channels

Our study addressed purchasers in private procurement. We created an online questionnaire in the software Lime Survey to collect the dataset “Supply Network Mapping”. This survey consisted of 140 questions and was available in the three languages English, French and German.

Communication Channel	Sample Size	Responses	Response Rate
Mailing	7,890	364	5%
LinkedIn	1,776	142	8%
XING	616	118	19%
TOTAL	10,282	624	6%

Table 13: Sample Size and Response Rate

In order to invite purchasers to participate in our survey, we used three different communication channels presented in table 13: We used the tool Newsletter2Go to spread information on our research project and the link to our survey via e-mail to 7,890 purchasers. Although the response rate of this communication channel was the lowest with 5%, the absolute number of 364 participants was the highest due to the large sample size. Moreover, we used the professional networks LinkedIn and XING to get into contact with purchasers. Many buyers could be

contacted via LinkedIn and 142 of them answered our questionnaire. Due to use limits, the possibilities to address a big sample via XING are more limited; however, the contact quality is very high, so that we could finally attain the highest response rate of 19% in this network.

The total sample size across all channels was 10,282. In the end, our final dataset included 624 complete responses, resulting in an overall response rate of 6%. As figures 37 and 38 show, our participants come from large employers. Most represented companies have between 1,001 and 10,000 employees and generate an annual turnover of 1.1 bn up to 10 bn €.

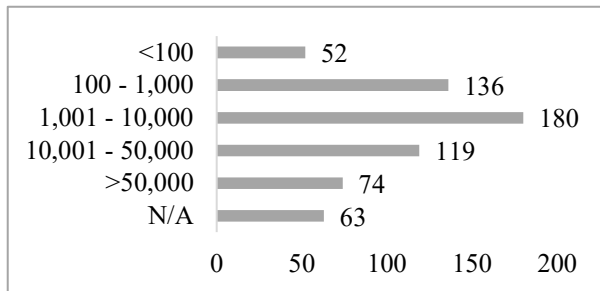


Figure 37: Employers by number of employees

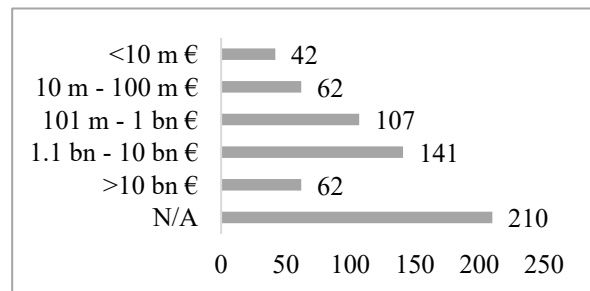


Figure 38: Employers by annual turnover

Figure 39 presents an overview of the participants by commodity. Most purchasers work in the automotive, semi-finished product or electric engineering industry. These industries are characterized by many innovations, high value-added shares and high cost pressure. Only 94 of the participating buyers representing 15% of the sample are responsible for indirect material.

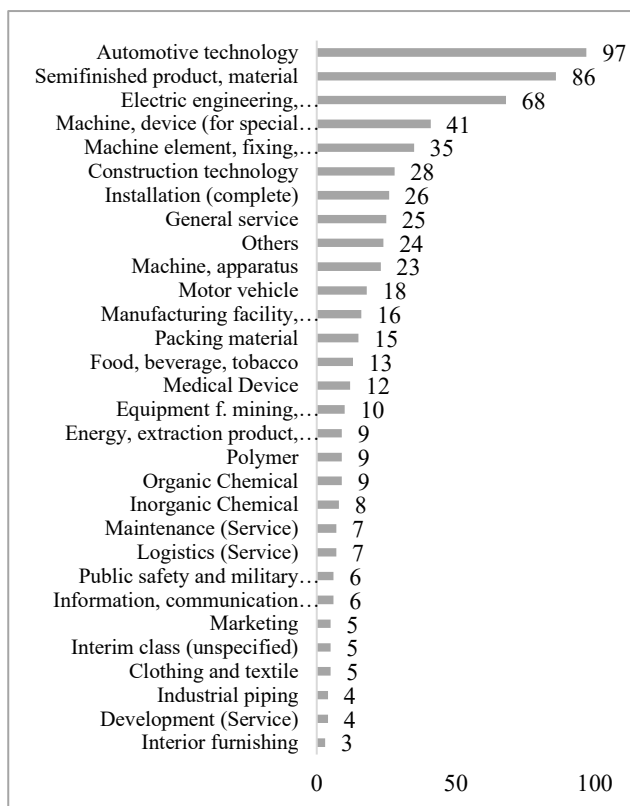


Figure 39: Participants by commodity



Figure 40: Participants by workplace

Figure 40 shows the workplaces of the participants. Half of the employers are located in Germany, followed by other Western European countries, but partially have their headquarters

in other countries like the USA. The skew of the sample towards German respondents will result from XING as a professional network for German-speaking countries and from the fact that most of the collected contact details in the mailing list belonged to German purchasers.

5.3.2 An inductive approach to develop formative constructs, reflective measures existing in the literature

As no appropriate constructs for the information sources could be found in literature, we needed an inductive research approach for construct development. Therefore, we searched for a suitable exploratory-qualitative research method prior to our quantitative research to determine the indicators. The advantages of the chosen World Café method created by Brown and Isaacs (Brown et al., 2005) lie in its high output attainable in a short period of time compared to other qualitative research methods such as longitudinal case studies or interviews. Due to the iterative process of the method, high stability and reliability of data are ensured (Kidd & Parshall, 2000). Varying group constellations enable to achieve rich data and to reduce bias (Fouché & Light, 2010). Hence, we carried out the World Café with 14 purchasers from an agricultural machinery company. This firm faced a complex supply network, including various suppliers, competitors and complementors with different exchange relationships. During the World Café, small focus groups discussed on selected subjects in a café-like atmosphere (Prewitt, 2011; Wibeck et al., 2007). This approach allowed to explore questions that matter to the participants (Brown et al., 2005; Fouché & Light, 2010; Lorenzetti et al., 2016; Tan & Brown, 2005), like for this study: “How do you find out information about your supplier relationships with other customers?”

In order to enhance the qualitative rigor of this inductive research, the Gioia Method complemented our World Café. This method is a holistic approach to inductive concept development. The huge advantage of this method was that it clustered the information sources mentioned by the participants of our World Café to subordinate constructs (Gioia, 2012). The analysis of the qualitative data starts with the creation of 1st-order categories by seeking redundancies or high similarities between answers of the focus group. In the next step, several categories are condensed to 2nd-order themes on a more abstract, theoretical level explaining the observed phenomena. The 2nd-order themes identified by these two methods in our study were media (which was further differentiated into analog and digital media for our quantitative survey later on), events, supplier, competitor and other actors. At the end of the analysis, these themes were again aggregated to higher dimensions. In our case, we had two big remaining categories: media/events and people.

The final questionnaire was tested and modified twice during a first pre-test with five purchasers in December 2017/January 2018 and a larger pre-study that was sent out to 1,376 purchasers in May/June 2018 and obtained 40 responses. The result of the two updates was the final questionnaire for information sources presented in table 14.

In our structural equation model, we measure the information sources as formative constructs, because the indicators are the causes of the latent variables (Fassott & Eggert, 2005; Jarvis,

Mackenzie, & Podsakoff, 2003). For instance, if purchasers search for information via Internet search engines, the overall usage of digital media will be higher (DM1). We choose mode B as the weighting scheme, which corresponds to regression weights taking into account also the correlations between the indicators (Hair, Sarstedt, Ringle, & Gudergan, 2018). Each information sources construct includes four indicators. All indicators are measured on 5-point Likert scales. The anchors for these scales are 1 = strongly disagree to 5 = strongly agree.

Construct	Code	<i>Which of the following sources do you use to search for supplier relationship information?</i>
Digital Media usage	DM1	I search for information via Internet search engines.
	DM2	I visit the websites of our suppliers, competitors and/or complementors.
	DM3	I use professional online networks like LinkedIn or XING.
	DM4	I read postings in Internet forums.
Analog Media usage	AM1	I read specialized industry magazines or newspapers.
	AM2	I read company magazines or newsletters.
	AM3	I read annual reports of different companies.
	AM4	I watch the news about different companies on TV.
Event visits	EV1	I visit events of industry associations, such as IFPSM, IPSERA, BME, BMÖ, NEVI, VDA or VDI.
	EV2	I visit supplier exhibition stands at trade fairs.
	EV3	I join working group meetings with other companies.
	EV4	I go to networking events.
Info by Suppliers	SU1	I visit the factories of our suppliers.
	SU2	I talk to the suppliers' sales representatives.
	SU3	I talk to the suppliers' engineers.
	SU4	I examine the documents provided by the suppliers.
Info by Competitors	CO1	I visit the factories of our competitors.
	CO2	I analyze the products of our competitors.
	CO3	I talk to the buyers working for our competitors.
	CO4	I talk to the product managers working for our competitors.
Info by Other actors	OA1	I visit the factories of our complementors.
	OA2	I talk to colleagues from other departments, e.g., product management.
	OA3	I talk to external consultants because of their specific knowledge.
	OA4	I talk to our customers.

Table 14: Questionnaire for information sources

To measure the dependent variables, we rely on reflective scales well known in the literature. The indicators are caused by these constructs (Fassott & Eggert, 2005; Jarvis et al., 2003). For instance, if the knowledge of purchasers on supplier satisfaction is high, they also know if their supplier already regretted to do business with other customers (KS3). Hence, we choose mode A consistent to estimate these constructs. This weighting scheme corresponds to correlation weights derived from bivariate correlations between each indicator and the construct (Hair et al., 2018). Each knowledge construct includes three indicators.

Two reflectively measured endogenous constructs listed in table 15 are based on the existing measurement of the preferred customer status (Schiele et al., 2012) and supplier satisfaction (Hüttinger et al., 2014). This list of questions was slightly modified to add the aspect of knowledge to these questions. In contrast to these two latent variables, the remaining reflective construct “Customer attractiveness knowledge” is as well an outcome of the above described World Café and was pre-tested following the above named steps. The rationale is that the amount of bonds with other customers gives an indication of a buyer’s lack of attractiveness to that particular supplier.

Construct	Code	<i>What do you know about the relationships of your suppliers <u>with other customers?</u></i>
Customer attractiveness knowledge	KA1	I know ...the shareholdings or joint ventures of my suppliers with other customers.
	KA2	...the modalities in the contracts or agreements of my suppliers with other customers.
	KA3	...the cooperation strategy of my suppliers with other customers.
Supplier satisfaction knowledge	KS1	...how satisfied my suppliers are with the relationships to other customers.
	KS2	...if my suppliers would still choose to work with these customers if they had to do it all over again.
	KS3	...if my suppliers already regretted to do business with other customers.
Preferred customer status knowledge	KP1	...if my suppliers treat other customers with higher priority than us.
	KP2	...if my suppliers allocate their best resources to other customers.
	KP3	...if my suppliers grant other customers prime access to their own suppliers.

Table 15: Questionnaire for desired supply network knowledge

In order to test our model with the data set from our survey in the next step, we calculated our model both in SmartPLS 3.2.8 by Ringle, Wende and Becker (Ringle et al., 2015), using consistent Partial Least Squares (PLSc) (Dijkstra & Henseler, 2015), and in ADANCO 2.1.1 by Henseler and Dijkstra (Henseler & Dijkstra, 2015). Our model consists of formative and reflective constructs, which is why a PLSc approach or the use of ADANCO is recommended. Both softwares allow us to use the different weighting schemes explained above within the same formative-reflective model. The results in both softwares are very stable and similar, as we are not detecting any difference regarding the outer weights, path coefficients or explained variance. The result of this paper is based on the figures in ADANCO.

5.4 Findings: A new helpful model highlighting the knowledge effects of people and events

5.4.1 Data quality: Dedicated tests showing that the formative and reflective constructs make sense

We validate the formative information sources constructs according to Hair et al. (Hair, Hult, Ringle, & Sarstedt, 2017), who recommend evaluating the formative measurement model in three steps: First, the formative measurement models have been tested for convergent validity, using redundancy analysis with an additional global item as illustrated in figure 41 (Chin, 1998). The formative construct is used as an exogenous variable to predict a reflective endogenous construct. Therefore, a single global item is added, by which the respondents indicate the overall use of a particular information source construct, e.g., “To summarize, I use a lot of digital media”. Afterward, the path coefficients have been calculated between each formative exogenous construct and the corresponding endogenous global-item construct.

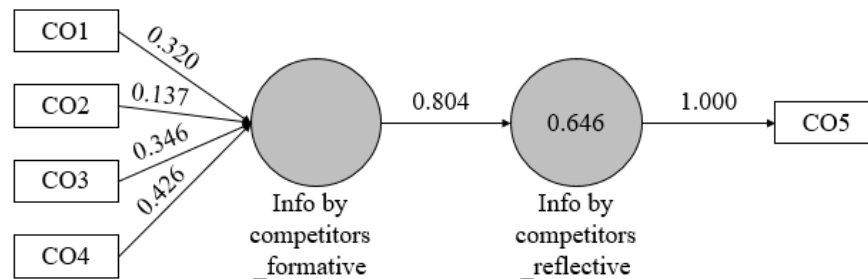


Figure 41: Convergent Validity: Redundancy Analysis with a global item

The result of this test is that the three path coefficients for the constructs “info by competitors” (0.804, see figure 41), “info by other actors” (0.711) and “event visits” (0.785) are above the minimum threshold of 0.7 (Hair et al., 2017), while the constructs “info by supplier” (0.690), “digital media” (0.576) and “analog media” (0.668) are below it. We tested if the path coefficients of the remaining three constructs increased if we deleted the indicators with the weakest outer loadings, but could not notice big improvements. Therefore, we decided to keep all indicators to preserve also the content validity of the formative constructs (Bollen & Lennox, 1991) with the qualitative findings from the World Café.

In a second step, we checked for multicollinearity in our data, based on variance inflation factors (VIF). All VIFs are below the threshold of 3.3 (Diamantopoulos & Sigauw, 2006), so that multicollinearity is not an issue in our study. Our indicators are well distinct and do not carry any critical level of redundant information. Finally, we had to assess the indicator relevance provided by the outer loadings of the constructs. Two outer loadings of different constructs are below the threshold of 0.5 (Hair et al., 2017). Still, we do not discard these indicators due to conceptual and theoretical reasons.

After having evaluated the data quality of the formative constructs, we assessed the convergent validity (table 16) of the reflective variables. The Average Variance Extracted (AVE) and the Composite Reliability (C.R.) are indicators of the convergent validity level. Another coefficient for composite reliability is Jöreskog's rho (ρ_c). The higher the composite reliability is, the more internal consistency among those indices exists. The average variance extracted shows the

percentage of variance interpreted by the latent factors from measurement error. The larger average variance extracted is, the larger indicator variance could be interpreted by the latent variables and the smaller relative measurement error is. All values exceeded the recommended thresholds of 0.5 for AVE (Fornell & Larcker, 1981; Hair, Black, Babin, Anderson, & Tatham, 2006) and 0.7 for C.R. (Bagozzi & Yi, 2011).

Moreover, we assessed the reliability of the reflective variables first with Cronbach’s alpha (α) as the most prominent reliability coefficient (Cronbach, 1951). All indicators of the reflective variables had an $\alpha > 0.75$, which is considered satisfactory because the generally accepted threshold is 0.7 (Nunnally, 1978). However, later researchers state that Cronbach’s alpha underestimates the reliability of PLS construct scores (Sijtsma, 2009). Hence, we also present Dijkstra-Henseler's rho (ρ_A), which in particular shows a higher value for preferred customer status knowledge (Dijkstra & Henseler, 2015). According to both coefficients, the constructs “knowledge on preferred customer status” and “supplier satisfaction” are most consistent.

Construct	Convergent Validity		Reliability	
	AVE	ρ_c	α	ρ_A
Pref. cust. st. knowledge	0.5970	0.8088	0.8090	0.8640
Sup. satisf. knowledge	0.5969	0.8161	0.8158	0.8172
Customer attr. knowledge	0.5085	0.7563	0.7570	0.7564

Table 16: Construct Validity and Reliability

Finally, we also assessed the discriminant validity of the reflective variables using the Fornell-Larcker criterion (Fornell & Larcker, 1981). Each reflective construct must have stronger relationships with its own indicators than these indicators have with any other constructs. As presented in table 17, the Fornell-Larcker criterion is fulfilled.

Construct	Pref. cust. st. knowledge	Sup. satisf. knowledge	Customer attr. knowledge
Pref. cust. st. knowledge	0.5970		
Sup. satisf. knowledge	0.4444	0.5969	
Customer attr. knowledge	0.1968	0.3190	0.5085

Note: Squared correlations; AVE in bold in the diagonal.

Table 17: Discriminant Validity (Fornell-Larcker criterion)

However, in some research situations, the Fornell-Larcker criterion does not reliably detect the lack of discriminant validity (Henseler, Ringle, & Sarstedt, 2014). Therefore, we also checked the Heterotrait-monotrait ratio of correlations (HTMT), which is shown in table 18, as another estimate of construct correlation for reflective constructs. The HTMT is clearly below the threshold of 0.85, as well (Henseler et al., 2014).

Construct	Pref. cust. st. knowledge	Sup. satisf. knowledge	Customer attr. knowledge
Pref. cust. st. knowledge			
Sup. satisf. knowledge	0.6770		
Customer attr. knowledge	0.4442	0.5652	

Table 18: Discriminant Validity (HTMT)

5.4.2 Model and hypothesis testing: Useful model sufficiently explaining the variance in knowledge

We use the Standardized Root Mean Square Residual (SRMR) as a measure of the approximate model fit. For our model, the SRMR is 0.0703, which is below the recommended threshold of 0.08 (Hu & Bentler, 1999). This criterion checks that the correlation matrix implied by our model is sufficiently similar to the empirical correlation matrix. The fit is satisfactory and our research model is useful.

To test the hypotheses, partial least squares structural equation modeling (PLS-SEM) was carried out. We report the results of our PLS-SEM analysis in ADANCO in tables 19 and 20:

Construct	R ²	Adjusted R ²
Preferred customer status knowledge	0.1631	0.1549
Supplier satisfaction knowledge	0.2806	0.2736
Customer attractiveness knowledge	0.3632	0.3570

Table 19: Coefficients of determination

As depicted in table 19, the information sources best explain the variance in the customer attractiveness knowledge (R² = 36.3 %). Also, for the supplier satisfaction knowledge with 28.1 % and even the preferred customer status knowledge with 16.3 %, the model still has satisfactory coefficients of determination, considering the fact that this was the first research on the subject.

	Hypothesis Effect	Path coefficient	p-value	Cohen's f ²
MEDIA	H1a Digital Media usage -> Customer attr. Knowledge	0.0440	ns	0.0025
	H2a Digital Media usage -> Sup. satisf. knowledge	0.1334	**	0.0207
	H3a Digital Media usage -> Pref. cust. st. knowledge	0.0096	ns	0.0001
	H1b Analog Media usage -> Customer attr. Knowledge	0.0614	ns	0.0046
	H2b Analog Media usage -> Sup. satisf. knowledge	0.0178	ns	0.0003
	H3b Analog Media usage -> Pref. cust. st. knowledge	-0.0134	ns	0.0002
EVENTS	H1c Event visits -> Customer attr. Knowledge	0.1658	***	0.0311
	H2c Event visits -> Sup. satisf. knowledge	0.1005	*	0.0101
	H3c Event visits -> Pref. cust. st. knowledge	0.0950	*	0.0078
PEOPLE	H1d Info by Suppliers -> Customer attr. Knowledge	0.0991	*	0.0129
	H2d Info by Suppliers -> Sup. satisf. knowledge	0.0887	*	0.0092
	H3d Info by Suppliers -> Pref. cust. st. knowledge	0.1832	***	0.0336
	H1e Info by Competitors -> Customer attr. Knowledge	0.3346	***	0.1075
	H2e Info by Competitors -> Sup. satisf. knowledge	0.2217	***	0.0418
	H3e Info by Competitors -> Pref. cust. st. knowledge	0.1390	**	0.0141
	H1f Info by Other actors -> Customer attr. Knowledge	0.1330	**	0.0163
	H2f Info by Other actors -> Sup. satisf. knowledge	0.1951	***	0.0310
	H3f Info by Other actors -> Pref. cust. st. knowledge	0.1503	**	0.0158

Note: **Bold** = significant paths, p-value *** <0.001, ** <0.01, * <0.05, ns = non-significant

Table 20: Path Effect sizes and significance

Table 20 shows that the information sources generally have a positive impact on the investigated knowledge. We can observe the strongest effect for competitors leading to customer attractiveness knowledge ($\beta = 0.3346$). Hence, all hypotheses are supported by the data, except H3b, stating that analog media has a negative impact on the preferred customer status knowledge.

Additionally, we used bootstrapping to test the significance of the paths. Table 20 clusters the information sources into the three clusters “media”, “events” and “people”, according to the outcome of the Gioia method. People show the highest impact, followed by events on the second rank and media with the lowest path effects. The following four effects caused by people are highly significant ($p < 0.001$): the information by suppliers on preferred customer status knowledge ($\beta = 0.1832$), the information by competitors on the customer attractiveness knowledge ($\beta = 0.3346$) and the information by competitors ($\beta = 0.2217$) and other actors ($\beta = 0.1951$) on supplier satisfaction knowledge. According to Cohen’s effect size test (Cohen, 1988), these paths also show at least a small effect with $f^2 > 0.02$ or medium effect with $f^2 > 0.1$ (originally $f^2 > 0.15$, but we would like to emphasize the biggest impact of information by competitors on the customer attractiveness knowledge). Events show several medium effects, thereof the highest effect on the customer attractiveness knowledge ($\beta = 0.1658$). On the other hand, the impacts of media are not significant, concerning also the negative path coefficient for H3b. However, the effect of digital media usage on supplier satisfaction knowledge ($\beta = 0.1334$) is an exception that appears significant.

5.5 Conclusion: Strong effects by people and events on the customer attractiveness knowledge

5.5.1 Utility of information sources decreasing along the cycle of preferred customership

Our study contributes significantly to the preferred customer literature in the context of the SET. The current literature on this subject focuses on the preferred customer status. This status refers to the supplier's intention and is a dependent variable of the supplier satisfaction in the cycle of preferred customership (Schiele et al., 2012). However, there is a gap in the literature because previous researchers assume that everyone is already aware of his supplier satisfaction and his own customer status, which is, in fact, not the case. Supplier relationships with alternative customers affect the customer status of the focal company (Lambe et al., 2001; Ping, 1994). Purchasers might over- or underestimate both their supplier satisfaction and their own customer status because, as in many situations from real life, the self-perception does not always correspond to the perception of others.

Therefore, our research deals with the knowledge on these alternative relationships. We test how various information sources can disclose knowledge on the attractiveness of other customers, the supplier satisfaction with these customers and the status of these customers. The utility of the investigated information sources decreases along the cycle of preferred customership, as illustrated in figure 42. While our model can explain 36.3% of the variance in the customer attractiveness knowledge and still 28.1% of the variance in the supplier

satisfaction knowledge, it only can explain 16.3% of the variance in the preferred customer status knowledge. Hence, especially the high R^2 of customer attractiveness knowledge significantly contributes to the preferred customer theory: Even if purchasers cannot find out exactly how satisfied their suppliers are and which status they achieve from them, they can still find out about the relationships of their suppliers with other customers. As all three constructs have been measured regarding the supplier relationships with alternative customers, buyers can draw conclusions on their own status and treatment as customers of the same suppliers.

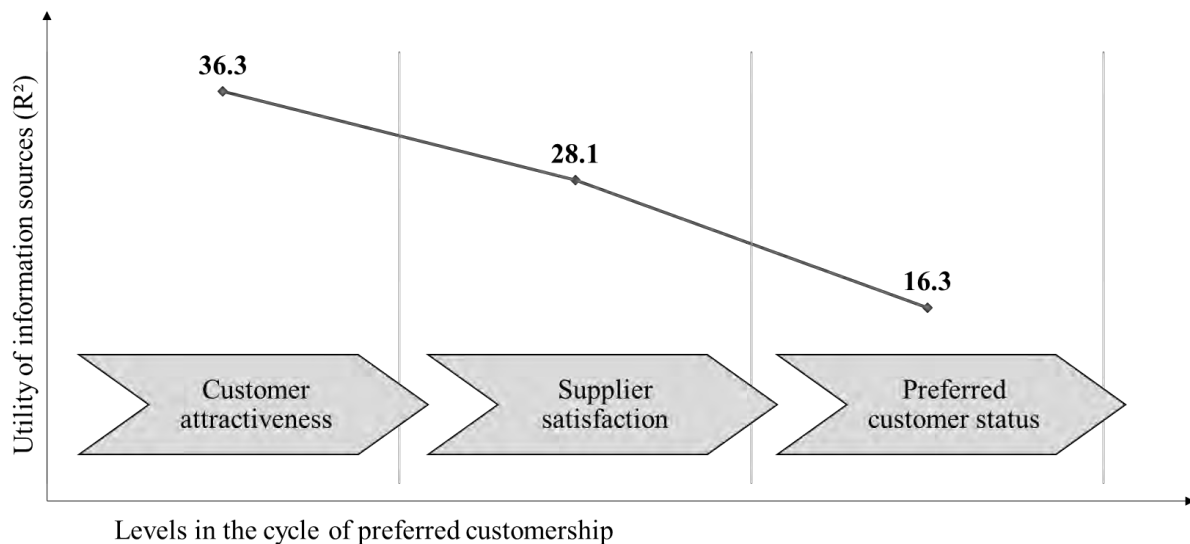


Figure 42: Utility of information sources on preferred customership recognition

5.5.2 *People and events being stronger information sources than media*

Another important outcome of our study is that people and events visited by people are stronger information sources than media. To answer our research question, the study has figured out that suppliers (H1d, H2d, H3d), competitors (H1e, H2e, H3e) and other actors (H1f, H2f, H3f) reveal the strongest paths and can, therefore, be very promising information sources. In general, people show a high resistance towards the disclosure of sensitive information, especially if the purpose for which it is to be used (in our case, e.g., renegotiations, supplier awarding decisions,...?) is not clear and if there are dependence-relationships from the requesting stakeholders (Anderson & Agarwal, 2011). As Anderson and Agarwal explain, they have experienced these obstacles, for instance, regarding the disclosure of personal health information for digitization. Even though this is a general problem, of course, our results still show that if there is a chance to gather the desired information, this will be a lot easier in a direct face-to-face contact than in public, more anonymous setting of, e.g., trade fairs or the Internet. Moreover, when discussing the implementation of real-time supply chain systems, Handfield states that under high-risk situations and a high level of workload stress, people will always trust humans over system data (R. Handfield, 2016). This outcome is not unexpected, as people provide more context than media. However, it fills an important gap in how to achieve

knowledge on the own customer status and supplier satisfaction in the preferred customer literature.

5.5.3 Awareness of the own customer status as a competitive advantage for purchasers

The assessment of the preferred customer status also has high practical relevance. Our results concerning the most important information sources help the purchasers to gain a high knowledge on the status and supplier satisfaction of other customers quicker than purchasers working for other buying firms. This is an important competitive advantage for them because they can anticipate their suppliers' behavior, have shorter reaction times to it than their competitors have and avoid investing time and resources into business relationships that are not reciprocated by the suppliers. Therefore, purchasers need to be aware of the suppliers, competitors and other actors as the information sources, which provide most of the desired knowledge.

Following these results, the evaluation of the customer attractiveness can ideally take place in cross-functional teams, because colleagues from other departments, e.g., product management or R&D, may also be in direct contact with the same suppliers and receive feedback from them on their customer attractiveness. Furthermore, purchasers benefit from being in close contact with their suppliers and finding legally correct ways to achieve information from competitors (e.g., by analyzing competitor products). Networking in professional settings seems to pay off, especially in order to investigate which relationships known suppliers have with other customers. In addition to these activities, purchasers can also go to events, because these information sources had a weaker, but also positive impact on the customer attractiveness, supplier satisfaction and preferred customer knowledge. This outcome regarding events is an important practical finding as from a managerial perspective, it urges CPOs to support the purchaser's attendance of such events, which is sometimes doubted as "tourism".

Once the purchasers have assessed who has a preferred and who has a neglected status for their suppliers, they can define or review their preferred customer strategy and adapt their supplier relationship management. For this purpose, they can draw a preferred customer matrix to differentiate between four different constellations of customer status and supplier competitiveness and choose the suitable generic strategy (Schiele, 2012). Based on these results, they can adjust the supplier classification and focus on those suppliers who treat them as preferred customers. Moreover, they can reflect on the reasons for the (un)attractiveness of themselves and others and conduct an additional supplier satisfaction survey for more insights. Finally, they can try to improve supplier satisfaction in order to maintain their preferred customer status or to be upgraded to a preferred status (Schiele et al., 2012). According to the SET, they might stop the relationship with suppliers who closely collaborate with their competitors or intensify projects with suppliers who closely work together with their complementors (Kelley & Thibaut, 1978).

5.5.4 Future research may deeper analyze the impact on the knowledge and purchasing performance

This study also has its limitations. Our model only has a medium explanatory power, which is acceptable for the first study in this field with a high complexity (Hair et al., 2017), but offers substantial room for scientific development, aimed at improving its theoretical and practical relevance (Richter, Sinkovics, Ringle, & Schlägel, 2016). The values for the R squared of the endogenous variables reach from 16.3% for the preferred customer status knowledge up to 36.3% for the customer attractiveness knowledge in supplier relationships with other customers. Thus, the examined information sources explain a greater variance of the buyer-supplier relationship than regarding the supplier intention (Vos et al., 2016). This result is not very surprising, as it can be expected that the intention of people acting in business contexts is harder to figure out through common information sources than information about business relationships with them. Nevertheless, this is the reason why the research interest in the preferred customer status knowledge is so high and needs to be further investigated in the future. Purchasers know little about their supplier's strategic interests. This knowledge must be increased. Hence, we encourage future researchers to try to improve the explanatory performance of information sources on the preferred customer status knowledge. An issue would also be to identify those concrete questions or observations buyers ask in order to access the relevant information on the behavior of their suppliers. The ultimate aim of this line of research is to enable purchasers to assess their standing with suppliers without having to ask them directly in a supplier satisfaction survey.

Further limitations of our research lie in the measurement model of the formative constructs. The indicators to measure the information sources were derived from a World Café that was carried out in a single company. A large group of 624 purchasers rated their usage of these information sources in our questionnaire. However, some information sources cannot be easily classified in one construct or another, e.g., if talking to people during events. Moreover, in this section of the survey, we did not ask any open questions, so that the purchasers could not add any additional sources that they would use more frequently. Moreover, the formative construct validation has revealed some problems with the items of these formative constructs. Probably, additional items could have increased the R squared – although a second wave of the survey would have been necessary to allow all purchasers to rate also the usage of these new proposed information sources. Therefore, we invite future researchers to recheck, which of the indicators for information sources that were proposed in this paper need to be kept, added or discarded.

This study ends with the assessment of the companies' knowledge on other customers' attractiveness, supplier satisfaction and customer status. However, this knowledge alone is not enough to make purchasers successful. Only with targeted follow-up actions, the knowledge on relationships in the supply network can lead to purchasing success regarding cost-saving, delivery and innovation performance and to a real competitive advantage and increased supplier satisfaction. Therefore, we recommend that future researchers also investigate the impact of the knowledge presented in this paper on purchasing performance as a valuable addition to this piece of research.

Finally, one strength of our research is the high absolute number of 624 respondents. However, these participants only reflect 6% of the original sample, although all contacted purchasers have received several reminders. Therefore, our study might be vulnerable to non-response bias. Future studies need to strive for response rates of >20% in order to mitigate this risk (Caniëls, Gehrsitz, & Semeijn, 2013; Corsten, Gruen, & Peyinghaus, 2011). Moreover, the skew of our sample towards German respondents, as well as the fact that the dataset is cross-sectional, might bias the results. Hence, future researchers might reflect the cultural and sector-specific dimension of the information disclosure topic.

Chapter 6: Cost savings through supply chain transparency: A transaction cost view

Abstract

Buying firms lack visibility about the relationships among sub-suppliers in their supply chains. The application of supply chain mapping can help them visualize and analyze these relationships. However, subsequent purchasing activities are necessary after supply chain transparency is achieved, and the impact of supply chain mapping on purchasing performance has not yet been explored in the literature.

Based on a case study and a survey, this paper suggests that volume bundling followed by direct sourcing, responsible practice and risk management are sourcing levers to be applied in addition to supply chain mapping. We figure out that the application of these levers fully mediates supply chain mapping. Furthermore, we test the effect of information quality and supply chain mapping on purchasing performance. Underlining transaction cost economics, we show that supply chain information and subsequent sourcing activities indeed improve cost-saving performance while also positively affecting sustainability and mitigating supply risks. Hence, our results highlight the benefits of supply chain mapping and help purchasers better manage their upstream supply chains.

Keywords

Transaction cost economics; Supply chain transparency; Supply chain mapping; Sourcing levers; Multi-tier Supply Chain Management; Case study research; Survey research

6.1 Introduction: Supply chain mapping as a tool to satisfy cost, risk and sustainability requirements requesting new levels of supply chain transparency

Supply chain transparency is an important challenge in today's buyer-supplier relationships and is becoming increasingly necessary (Kashmanian, 2017). To create transparency, a company must gain visibility into its own supply chain (Kraft et al., 2018). However, due to the division of labor in their supply chains, most buying firms know only their direct suppliers (T. Y. Choi & Linton, 2011; Theuvsen, 2004). At the same time, they continue pursuing outsourcing strategies, shifting even more value creation to suppliers. For instance, in the automotive industry, the value-added share of large producers has decreased to 38% by 2017 and is expected to further decrease to 35% until 2030 (Wyman & VDA, 2018).

Supply chain transparency is required for cost reasons. According to transaction cost economics (TCE), every transfer of goods between actors in a vertical supply chain involves payment (Williamson, 1981, 1985). Buying firms know only the costs of their direct suppliers through their transactions with them, and they are not usually aware of the transactions, negotiations and costs characterizing the interactions between their indirect and direct suppliers (T. Y. Choi & Linton, 2011). Hence, there is no multi-tier management or measurement of transaction costs across the upstream supply chain up to raw material level (R. Carter & Hodgson, 2006). Consequently, it can be assumed that there is a high cost-saving potential for buying firms, which is another motive for improving supply chain transparency.

Additionally, from a risk management perspective, there is a growing demand for supply chain transparency. Vulnerability in multi-tier supply chains is increasing (Norrman & Jansson, 2004). Disruptions result from unpredictable risks such as natural disasters, fire, terrorism, labor strikes or supplier bankruptcy (Chopra & Sodhi, 2004). Such problems are multiplied in international supply chains (Steinle & Schiele, 2008). Risk identification, assessment and mitigation are fundamental to risk management in multi-tier supply chains (Kleindorfer & Saad, 2005; Raj Sinha et al., 2004). Nevertheless, some 1st-tier suppliers are not sufficiently capable of managing the problems and risks at their sub-suppliers (Tang & Zimmerman, 2009). There may even be strategic risk involved, as suppliers may prefer one customer to another and hence rank customers (Reichenbachs, Schiele, & Hoffmann, 2017).

Finally, sustainability is one of the main and more recent motivations for multi-tier supply chain practices (Mena et al., 2013). Frequently, sustainability problems occur upstream at the sub-supplier level (Villena & Gioia, 2018; Wilhelm, Blome, Wieck, & Xiao, 2016). Therefore, buying firms must manage the entire supply chain to fulfill their sustainability aims (Foerstl, Reuter, Hartmann, & Blome, 2010; Reuter, Foerstl, Hartmann, & Blome, 2010; Sauer & Seuring, 2018) and to prevent reputational damage due to unsustainable behavior (Lechler, Canzaniello, & Hartmann, 2019). Moreover, customers and governments increasingly want to know where and how the products they purchase were made (Kassahun et al., 2014; Kraft et al., 2018). Hartmann and Moeller suggest the notion of "chain liability" (Hartmann & Moeller, 2014).

While supply chain transparency has been desirable in the past, it is becoming increasingly imperative for sustainability requirements, risk management and cost reasons. Consequently, parties responsible for supply management search for appropriate tools to achieve visibility about all actors involved in their supply chains and the relationships between them. Although the need for supply chain transparency is high (Kashmanian, 2017), appropriate measurement instruments for supply chain transparency are still largely lacking (T. R. Morgan et al., 2018). Supply chain maps have been proposed as a tool to create the necessary transparency in the supply chain. Such maps visualize the material, financial and information flow into all directions of the supply chain and through a firm (J. T. Gardner & Cooper, 2003), but like supply chain transparency in general, they are still an emerging topic (Farris, 2010; Wieland et al., 2016). In particular, two issues arise: first, published supply chain maps are the outcome of single-case studies, but these studies lack generalizable findings. Second, mapping is nice, but solutions require subsequent actions.

Examples of case studies on supply chain mapping or containing supply network illustrations include the Boeing 787 Dreamliner aircraft (Tang & Zimmerman, 2009) and the IKEA PAX wardrobe in the context of global sourcing (Hultman et al., 2012), or the risk management Petri-net developed by Blackhurst et al. (Blackhurst, Rungtusanatham, Scheibe, & Ambulkar, 2018). Attempts have been made to use I4.0 techniques through, for instance, natural language processing to support supply chain map creation (Wichmann, Brintrup, Baker, Woodall, & McFarlane, 2018). However, such tools must rely on published information, and companies are often afraid to disclose information as they see their supply chain secrecy among competitors being endangered. Positive counterexamples are Nike and Levi's, which voluntarily published their supplier lists (Doorey, 2011). To make more companies follow these examples, firms must see evidence that tools such as supply chain mapping really improve their purchasing success. The current literature, however, still lacks evidence about the benefits of mapping. Almost all published papers are conceptual research or single-case studies (T. Y. Choi & Hong, 2002; Cox, 2004; Doran, 2005; Hultman et al., 2012; Sako, 2002). To close this gap, we test the impact of supply chain mapping on cost savings and delivery excellence as well as sustainability targets in a large empirical study to answer the following research question:

RQ1: What are the measurable benefits of supply chain mapping?

However, transparency is not a means in itself; rather, it simply creates the potential for (re)action. The current literature still lacks advice on how to work with supply chain maps and apply their potential. It remains unclear which action needs to follow once supply chain transparency about the interactions in the supply chain is established. Therefore, our research aims to operationalize the supply chain mapping concept to fill this first literature gap. We investigate different sourcing levers that can be applied after supply chain mapping, and we analyze whether they lead to purchasing success. The second research question emerges as follows:

RQ2: *Which action can be taken once advanced supply chain transparency has been established, i.e., which sourcing levers benefit most from supply chain transparency through supply chain mapping?*

In this paper, we study the supply chain transparency and TCE literature to deduce our hypotheses and the research model. In the model, we use vertical information quality, supply chain mapping, various sourcing levers and purchasing performance as the constructs building the framework of our research. Our research is based on a mixed-methods research approach. First, we use a qualitative case study and collect primary data to explore the procedure and results of supply chain mapping in a manufacturing company. Second, we conduct a quantitative survey to measure and explain the effect of supply chain mapping on purchasing performance. Our survey is based on a data set that we gathered from 624 participating buyers. Structural equation modeling is applied to this data set to assess the unobservable latent variables. Our main findings are that supply chain information and mapping indeed improve cost-saving performance, in line with the TCE. Moreover, they lead to positive effects on sustainability and mitigate supply risks. In this context, volume bundling is a strong mediator of the remaining sourcing levers direct sourcing, responsible practice and risk management.

6.2 Theoretical Background: Transparency and chain transaction costs

6.2.1 Supply chain transparency and visibility

The demand for supply chain transparency is increasing (Marshall et al., 2016) and has extended beyond corporate boundaries in supply chains (Mol, 2015). Consumers want to find out where and how the products they buy were produced (Kassahun et al., 2014; Kraft et al., 2018). Previous research has shown that consumers value great supply chain transparency in the upstream supply chain, e.g., regarding a company's social responsibility practices. The higher the level of this transparency is, the more satisfied consumers are (Kraft et al., 2018). In this context, the regulatory pressure for companies to publish supply chain information is increasing. Recent examples are the Restriction of Hazardous Substances Directive and the Registration, Evaluation, Authorisation, and Restriction of Chemicals regulation in Europe as well as the 2010 Dodd-Frank Wall Street Reform and Consumer Protection Act and the California Transparency in Supply Chains Act of 2010 in the USA (Marshall et al., 2016). However, consumers perceive voluntary communication more positively than this mandatory publication of information (Kalkanci et al., 2016).

Supply chain transparency is defined as the “disclosure of information about the supply chain” (Doorey, 2011; T. A. Gardner et al., 2019; Mol, 2015). It is the fourth most underestimated emerging research theme, according to a study by Wieland et al. (Wieland et al., 2016), and an important challenge in today's buyer-supplier relationships (Kashmanian, 2017). Moreover, companies must decide what information they want to disclose as well as how, to whom and for what purpose (T. A. Gardner et al., 2019; New & Brown, 2011). Determining an appropriate

level of supply chain information disclosure is difficult and requires a deep understanding of stakeholders' information demands (Marshall et al., 2016). Regarding the disclosure of information in supply chain maps, Gardner et al. suggest developing a broader understanding of supply chain connections and associated risks to set priorities, developing a strategy and identifying situations in which detailed information is most needed (T. A. Gardner et al., 2019). To fill the first research gap regarding the actions linked to supply chain transparency, we show three application cases in which primary data has been collected and supply chains have been mapped according to different purposes and stakeholder requirements.

Before a company can create a transparent supply chain, it must gain supply chain visibility (Kraft et al., 2018). High visibility about the inbound supplier structure and the buyer-supplier relationships is necessary to be able to map and disclose supply chain information in the next step (Barratt & Barratt, 2011; Barratt & Oke, 2007; Jin et al., 2013; Tse & Tan, 2012). Supply chain visibility can be defined as “the extent to which a company has information about [...] its supply chain”, while the disclosure is “a company’s decision regarding what information to communicate to consumers” (Kraft et al., 2018). Therefore, supply chain visibility is basically the precondition of supply chain transparency (Egels-Zandén et al., 2015).

Nevertheless, many companies still have limited supply chain visibility. A recent study by The Sustainability Consortium reveals that 81% of the 1,700 participating companies lack full visibility into the social responsibility practices of their supply chains (The Sustainability Consortium, 2016). In a 2013 survey of Australian fashion companies, 93% of the companies surveyed did not know where their raw materials came from (Nimbalker et al., 2013). Gaining high supply chain visibility requires a significant investment of time and resources (Doorey, 2011; Marshall et al., 2016). Moreover, many companies have a poor understanding of their capabilities for capturing and reporting supply chain information (Marshall et al., 2016), which represents a serious research gap. Appropriate measurement instruments for supply chain visibility are still lacking (T. R. Morgan et al., 2018). Hence, in addressing our first research question, we explore the benefits of supply chain mapping, which justify the investment of time, resources and training.

6.2.2 Transaction cost economics and vertical integration

TCE is part of the new institutional economics and has been significantly influenced by Coase and Williamson. The theory is based on the transaction that occurs “when a good or service is transferred across a technologically separable interface” (Williamson, 1981). The costs of this transaction are regarded as friction losses in the exchange of goods and services. Williamson states that the goal of an organization is to minimize the sum of production and transaction costs (Williamson, 1979). Sub-suppliers may be able to perform functions at lower costs than direct suppliers (LaLonde & Pohlen, 1996). Our research focuses on the reduction in transaction costs between the indirect and direct suppliers of an original equipment manufacturer (OEM) (T. Y. Choi & Linton, 2011). Achieving supply chain transparency is a necessary precondition for

identifying relevant transactions with cost-saving potential (Doorey, 2011; Kraft et al., 2018; Mol, 2015).

Williamson differentiates between different categories of transaction costs, depending on their moment of occurrence. Information, search, negotiation and contracting costs are ex-ante transaction costs occurring prior to the exchange. The ex-post transaction costs accruing after the transaction include monitoring, conflict and enforcement as well as adjustment costs (Williamson, 1985). If an OEM sources goods from a sub-supplier indirectly via a 1st-tier supplier, as in our case study, all of these costs exist twice for both relationships.

Moreover, Williamson mentions three dimensions for characterizing transactions: asset specificity, uncertainty, and transaction frequency (Williamson, 1979). Transaction-specific assets are adjusted to a particular transaction and cannot be easily replaced outside the relationship of the parties involved in the transaction (Geyskens, Steenkamp, & Kumar, 2006). Uncertainty can relate to either environmental or behavioral uncertainty. Transactions that occur frequently require a constant monitoring effort in the market (David & Han, 2004). In our case study, we focus on transactions with high uncertainty or high frequency and thus higher cost-saving potential in order to identify potential action fields for improvement.

Transaction-specific cost-saving potentials can arise at the interface between a supplier and a buyer (Williamson, 2010) and are the focus of our case study. TCE is the dominant theory used to explain governance modes, which are part of the optimization problem (Williamson, 2010). Coase describes firms as alternative governance structures that differ in their transaction costs (Coase, 1937). Managers tend to make transaction cost-related decisions (Tsang, 2006). They aim to select governance modes that minimize transaction costs, such as vertical integration (John & Weitz, 1988).

Vertical integration means removing transactions from the market to organize them internally (Williamson, 1979). The aim is for the focal company to control more than one tier of the supply chain. According to the original TCE framework, the governance mode is a discrete choice between market exchange and internal production, commonly known as the make-or-buy decision (Rindfleisch & Heide, 1997). However, we extend this understanding to the sourcing activities across the upstream supply chain intending to control the prices, sustainability and risk of sub-suppliers. This understanding is a hybrid mechanism that reflects the current version of the theory, which “acknowledges that features of internal organization can be achieved without ownership or complete vertical integration” (Rindfleisch & Heide, 1997).

TCE is also the dominant theory used to analyze transaction risks (Wever, Wognum, Trienekens, & Omta, 2012). Even if focal companies source parts externally, they tend to monitor the less risk-averse upstream sub-suppliers themselves (Lafontaine & Slade, 2007). This approach will be shown in the application of supply chain mapping for the sub-suppliers of components in this paper. Supply reliability is one of the main reasons for vertical integration (Levy, 1985). As the level of uncertainty increases, so does the need for vertical integration.

6.3 Mixed-Methods Research Design: Three detailed case studies and a generalizing survey

In our study, we use a mixed-methods research design, which is an emerging field (Tashakkori & Teddlie, 2011; Timans et al., 2019). Combining qualitative and quantitative research provides a better understanding of the research problem (Johnson et al., 2007). Furthermore, articles using a mixed-methods approach have more impact on the field in terms of citations (Molina-Azorin, 2010).

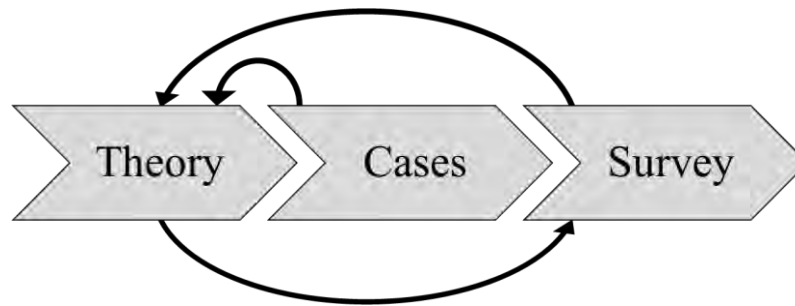


Figure 43: Procedural model of the research approach

The research in this paper consists of the three steps illustrated in figure 43. First, we review the literature on supply chain transparency and TCE to obtain a broader understanding of transparency and TCE-related optimization potential. Second, we use a long-term qualitative case study to explore the application of supply chain mapping in a single company. During the case study, we collect primary data while observing how purchasers generate supply chain transparency. In particular, we examine which sourcing levers they apply based on supply chain transparency. These insights help us deduce the hypotheses for our subsequent quantitative research. In the third step, we collect quantitative data with a survey on a large sample of 624 purchasers to test the hypotheses. The survey results enable us to explain the effects of supply chain transparency and supply chain mapping on purchasing performance.

While the three steps in our research approach follow this regular order, there are also backcouplings between the findings of the cases and the survey to theory. Moreover, the theory provides some direct hints for the hypotheses and measurement development concerning the survey, e.g., regarding sustainability.

6.4 Case Studies: Volume bundling, direct sourcing and risk management

6.4.1 Case Study Method: exploring the use of supply chain maps

A case study is an empirical inquiry that investigates a contemporary phenomenon in depth and within its real-life context, especially when the boundaries between the phenomenon and the context are not clearly evident (Yin, 1981b). Case study research is a powerful method to enhance knowledge in the field of management (Halinen & Tornroos, 2005; Larsson, 1993; Stake, 2006; E. J. Wilson & Vlosky, 1997). The focus of a case study is to examine why decisions were made, how they were implemented, and what the results were (Schramm, 1971).

Hence, case study research helps build new theories (Eisenhardt, 1989) or refine existing ones (Siggelkow, 2007).

There are exploratory, descriptive and explanatory case studies. The choice of the appropriate study type depends on the researcher's objectives (Yin, 1981a). In this paper, we use the case study in the exploratory stage of research. The purpose of this case is to explore the outcome of various supply chain mapping interventions in an agricultural machinery company.

Yin identifies four quality indicators of case study research that we try to adhere to in our study. These indicators are (1) construct validity: establish correct operational measures for concepts, (2) internal validity: establish robust causal relationships (for explanatory studies), (3) external validity: establish the domain for a generalization of the study results, and (4) reliability: demonstrate the repeatability of the case study operations with the same results (Yin, 2018).

6.4.2 Case 1: Volume bundling among tier-1 suppliers of OEMs

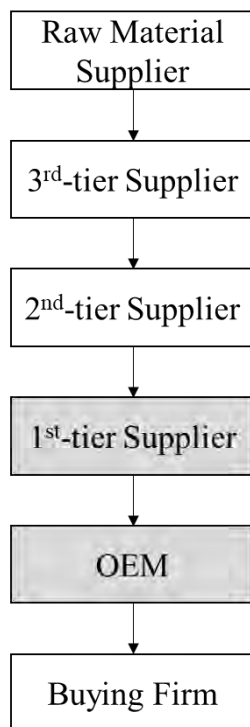


Figure 44: Focus of SC mapping for OEMs

The case study in the agricultural machinery company covers different application cases of supply chain mapping. The focus of the first case, the relationship between the tier-1 supplier and an OEM, is marked in grey in figure 44. The OEM develops and produces final products, such as vineyard tractors or telehandlers, and sells them to agricultural machinery manufacturers. These firms purchase the products from the OEM and sell them without modifications to their dealers and end-customers to offer them the full range of agricultural machinery. Hence, these firms have no visibility about the 1st-tier suppliers of their OEMs. To increase this visibility, the buying firm in our case study carries out a product analysis of five comparable products that it buys from two different OEMs to increase validity (Yin, 2018). With the help of supply chain mapping, the project leader identifies the 1st-tier suppliers for the commodity groups in these products.

Table 21 shows the simplified results of the mapping and OEM product analysis. The different colors and patterns represent different tier-1 suppliers. While the suppliers of commodity group 500000 cannot be identified, commodity group 300000 shows a monopoly: The two OEMs use the same supplier in all products, so the disruption risk is high. Previous research has shown that OEMs and tier-1 suppliers prefer a very overlapped supply chain (Ang, Iancu, & Swinney, 2017). C100000 displays an oligopoly in which the two OEMs use different suppliers for the same commodity group. In case of a supply problem of one OEM, the buying firm can propose the tier-1 supplier of the other OEM as an alternative. Moreover, table 21 illustrates two different types of polypolies: In C200000, the same suppliers are used for several products of one or both OEMs. C400000 even shows that the supply base of the same corresponding product types is identical. The analysis allows conclusions about the market constellation and

bundling potential at the tier-1 supplier level. Hence, we consider volume bundling as the first potential sourcing lever based on supply chain transparency for our survey.

		OEM 1					OEM 2					Market Constellation of Tier-1 Suppliers
Products		A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	
Commodity Group	C100000	[Solid Grey]					[Solid Grey]					Oligopoly
	C200000	[Dotted]	[Dotted]	[Dotted]	[Dotted]	[Dotted]	[Vertical Lines]	[Vertical Lines]	[Vertical Lines]	[Diagonal Lines]	[Cross-hatch]	Polypoly
	C300000	[Solid Grey]										Monopoly
	C400000	[Dotted]	[Diagonal Lines]	[Cross-hatch]	[Diagonal Lines]	[Vertical Lines]	[Dotted]	[Diagonal Lines]	[Cross-hatch]	[Diagonal Lines]	[Vertical Lines]	Polypoly
	C500000	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table 21: Results of OEM product analysis by tier-1 suppliers

Moreover, this analysis helps identify new potential suppliers for the buying firm (Ojasalo, 2004). Suitable suppliers must be investigated regarding their applicability to their own products. In this case, the firm agreed to evaluate six potential suppliers out of the 12 new sources in China, Italy, Austria and Germany that were identified during the OEM product analysis.

6.4.3 Case 2: Volume bundling and direct sourcing of spare parts

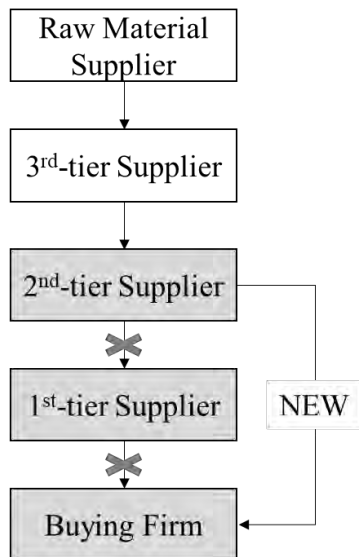


Figure 45: Direct sourcing from tier-2 suppliers

Figure 45 illustrates the material flow from the raw material supplier through different levels of sub-suppliers to the buying firm. Due to a lack of transparency (Theuvsen, 2004) and contractual barriers, most spare parts in the agricultural machinery company are initially purchased at component and system suppliers at the tier-1 level instead of the original manufacturers at the tier-2 level.

In the case of large components or products, every actor in this vertical supply chain adds value to the product (Theuvsen, 2004). However, in the case of spare parts, the 1st-tier supplier acts as a dealer who purchases parts from the original part manufacturers and sells them to the buying firm. He usually does not add his own value to the production of these parts but still adds a margin on their purchase prices for his handling effort. Therefore, the final purchase prices of the buying firm are often not competitive.

According to TCE, the buying firm aims to increase the visibility of the original manufacturers of parts with a high transaction frequency (David & Han, 2004; Williamson, 1979) in order to detect cost-saving potential. In a large investigation in the spare parts warehouse, purchasers check whether their manufacturers brand commodity groups. Sometimes, tier-2 suppliers also

contact the company and present their product portfolio and direct customers at the tier-1 level. In a few cases, dealers or end-customers provide the tier-2 supplier information. After the identification of the manufacturers, the purchasers bundle homogenous volumes and send RfQs to these suppliers. Based on the offers of the tier-2 suppliers, the purchasers relocate purchasing volumes to them or renegotiate their current prices with the 1st-tier suppliers. The larger the request package due to bundling is, the higher is the competitiveness of the purchase prices. A process flow chart is created to ensure repeatability and thus, the reliability of the direct sourcing process in line with the quality indicators of case study research mentioned by Yin (Yin, 2018). Hence, we consider direct sourcing as the next potential sourcing lever based on supply chain transparency for our survey. Furthermore, we aim to test the role of volume bundling as a mediator of direct sourcing in our survey, according to the practice in the agricultural machinery company.

Regarding direct sourcing, important risks must be managed. In some cases, the warranty costs claimed at tier-1 suppliers are higher than the savings. Hence, after relocation to tier-2 suppliers, there is the risk that these costs can no longer be claimed. In single-case decisions, this risk is monetarily evaluated, and a management decision in favor of total cost optimization is made. In other cases, ongoing contracts with tier-1 suppliers forbid volume relocation. Moreover, 2nd-tier suppliers sometimes have contracts with 1st-tier suppliers that prohibit them from selling to third parties. In mutual exchanges of opinions between all involved actors, agreements can usually be reached. Finally, spare parts volumes are planned based on forecasts but are not subject to fixed build programs. Hence, sales can sometimes decline and not fulfill agreed quantities, which may lead to price increases at tier-2 suppliers again.

Overall, the approach turned out to be very successful for the agricultural machinery company. Due to the elimination of transactions shown in figure 45 (Wan & Wu, 2015; Williamson, 1979), the spare parts purchasers achieved cost savings of >1 million € during the three-year project, which ran from 2016 to 2019. The direct sourcing of these spare parts led to further advantages beyond the monetary benefits. Second-tier suppliers, which were already supplying the agricultural machinery company with low volumes, gained significant volume shares. Due to these homogenous bundled volumes on the tier-2 level, such as compressors, filters, glazing, and water pumps, new commodity group management approaches for these commodities are possible, such as tenders, global sourcing, and preventive tier-2 risk management.

6.4.4 Case 3: Risk management of sub-suppliers for components

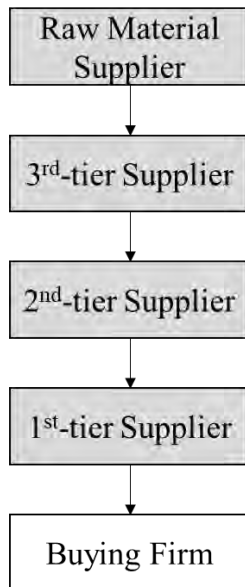


Figure 46: Focus of SC mapping for components

Figure 46 highlights the focus of the third application case. From 2015 to 2018, project managers created supply chain maps for three component suppliers for benchmarking to identify action fields for improvement. The maps show the 2nd-tier suppliers of these suppliers by their country, weight and number of parts. While suppliers A and C were open to disclosing the names of their sub-suppliers, supplier B shared only its sourcing countries with the buying firm, as shown in table 22.

Supplier A has a high production depth of fabricated parts. The product quality is good, leading to a comparatively high price level. Hence, the project managers recommend that this supplier increases its global sourcing share, which might lead to higher supply risk. Therefore, the supplier has to implement suitable tier-2 risk management (Tang & Zimmerman, 2009). Furthermore, the project managers suggest a renegotiation of raw material costs as well as a process cost reduction for standard parts.

The transparency in the supply chain map of supplier B is lower, as the unit of analysis is the sourcing country. Nonetheless, some action fields are identified: The supplier buys large material volumes in Turkey. Due to the political instability in this country, political risk management becomes a significant issue. Moreover, the buying firm also sources parts in this country, so synergies in global sourcing may be further analyzed. The process of buying standard parts needs to be optimized through, e.g., bundling, supplier reduction, IT platforms or outsourcing to service providers.

A large tender of the buying firm is allocated to Hungarian supplier C. The mapping of sub-suppliers becomes mandatory for this business to identify potential bottlenecks and to mitigate supply risks. Some identified tier-2 suppliers are common suppliers with the buying firm, so purchasing cooperation to negotiate volumes together is an option. Finally, supplier C needs to review its current make-or-buy strategy due to a bottleneck of skilled workers and increasing labor costs in Hungary. Hence, he needs to establish reliable external sources.

The focus of this third application case is clearly on risk management. While the risks are already present at suppliers B and C and require a political or a preventive supply risk management, the risk might occur for supplier A if he decides to increase his global sourcing share. Hence, we consider risk management as the third potential sourcing lever based on supply chain transparency for our survey.

YEAR	2015/16	2017	2018
Supplier	A	B	C
Unit of analysis	Sub-supplier	Sourcing country	Sub-supplier
Action fields	Increase supply risk to achieve savings	<u>Political</u> risk management	<u>Preventive</u> SC risk management
	Increase global sourcing share	Synergies in global sourcing	Increase global sourcing share
	Purchasing process for standard parts	Purchasing process for standard parts	Purchasing process for standard parts
	Renegotiation of raw material costs	-	Purchasing cooperation
	Make-or-buy analysis	-	Make-or-buy strategy review

Table 22: Results of supply chain mapping of sub-suppliers for components

Based on the insights of the cases and in combination with the theoretical frame established before, we derive testable hypotheses in the following section. These hypotheses serve as input for the subsequent survey.

6.5 Hypothesis development: Information quality, mapping, sourcing levers and performance outcomes

6.5.1 Vertical Information Quality: Perceived level of knowledge about suppliers and sub-suppliers

According to TCE, buying firms must know their vertical inter-organizational relationships across their upstream supply chains (T. Y. Choi & Hong, 2002; Rindfleisch & Heide, 1997). To manage their entire supply chains, they must extend their view beyond 1st-tier suppliers to identify and map their sub-suppliers (Farris, 2010). The information quality construct can measure this necessary supply chain visibility and knowledge about the upstream supply chain. Information quality is defined as the degree to which information meets the expectations and requirements of the information customer (W. Choi et al., 2013).

If the information quality on the vertical supply chain is high, the buying firm can process its supply chain knowledge. In this context, supply chain mapping is a helpful tool to identify and visualize the supply chain structure (Altmayer & Stölzle, 2016). Therefore, we assume that buyers who successfully collected knowledge about their 1st- to 2nd-tier supplier relationships want to apply it, leading us to hypothesis H1.

H1: Vertical information quality leads to the usage of supply chain mapping (keeping all other variables equal).

Following Williamson, an important goal of an organization is to minimize its transaction costs. In a modern understanding of TCE, transactions can be eliminated not only by insourcing production (Williamson, 1979) but also by sourcing directly from sub-suppliers to eliminate margin levels. Direct sourcing was also the sourcing lever applied in the second studied case concerning spare parts. This change in the buyer-supplier relationships is also described as climbing up the supply chain from the supplier perspective or climbing down the chain from the buyer's point of view (Wan & Wu, 2015). Another possibility to minimize transaction costs is volume bundling to aggregate transactions and to achieve the best competitive prices for large request packages. The bundling lever was applied to the 1st-tier suppliers of OEMS and to spare parts during the case study. Therefore, we assume that vertical information quality causes price-related activities such as direct sourcing (H2a) and volume bundling (H2b).

Moreover, multi-tier supply chain visibility implies a responsibility for sustainable practice at sub-suppliers (Mena et al., 2013; Sauer & Seuring, 2018). Sustainability is one of the main motivations for multi-tier supply chain practices (Mena et al., 2013). Consequently, we hypothesize that knowledge of sub-suppliers leads to responsible practice (H2c). Finally, knowing all sub-suppliers involved in the production of its products, the focal company intends to monitor the supply risks caused by the lower tiers of the supply chain (Lafontaine & Slade, 2007). Risk management was the main action field identified in the case of sub-suppliers for components and is expressed in H2d.

H2: Vertical information quality leads to (a) direct sourcing, (b) volume bundling, (c) responsible practice and (d) risk management (keeping all other variables equal).

Corresponding to the previous hypothesis, an important area of interest regarding multi-tier supply chain management is cost reduction opportunities (Farris, 2010). Hence, we deduce that vertical information quality positively influences cost-saving performance (H3.1). Besides, high supply chain visibility enables better adherence to sustainability standards throughout the entire extended supply chain, as most sustainability problems occur at the sub-supplier level (Villena & Gioia, 2018; Wilhelm et al., 2016). Consequently, we also measure the impact of vertical information quality on sustainability performance (H3.2). Furthermore, high vertical information quality allows the buying firm to identify, assess and mitigate the supply risks caused by sub-suppliers (Kleindorfer & Saad, 2005). Anticipating supply risks will ensure on-time deliveries. Hence, we also measure the impact of vertical information quality on delivery performance (H 3.3).

H3: Vertical information quality positively influences (1) cost-saving performance, (2) sustainability performance and (3) delivery performance (keeping all other variables equal).

6.5.2 Supply Chain Mapping: Visualizing supply chains and software support

Due to the high supply chain complexity caused by the increasing globalization of value-creating processes and further complexity drivers, the transparency for the buying firm decreases. According to TCE, the outsourcing of manufacturing causes transaction risks and can even cause a lack of control (Y. H. Kim & Davis, 2016; Levy, 1985; Serdarasan, 2013). However, supply chain maps can visualize the material, financial and information flow into all directions of the supply chain and through a firm (J. T. Gardner & Cooper, 2003). This mapping increases supply chain visibility again (Barratt & Barratt, 2011; Barratt & Oke, 2007; Jin et al., 2013; Tse & Tan, 2012). Nevertheless, mapping is mainly a visualization tool that is typically accompanied by dedicated follow-up activities, such as the sourcing levers that were presented when deducing the second hypothesis. Hence, we assume the following:

H4: Supply chain mapping leads to (a) direct sourcing, (b) volume bundling, (c) responsible practice and (d) risk management (keeping all other variables equal).

In our research model, supply chain mapping plays a partial mediating role because information quality itself can already positively influence purchasing performance. Nevertheless, we suppose that through the application of a tool dedicated to supply chain transparency, we can improve purchasing performance even further.

Buying firms face high cost pressure. Recently, they have realized that supply chain costs are one of the few areas with cost-saving potential (C. Morgan, 2007). Using the TCE perspective, North argues that traceability may reduce transaction costs (North, 1991, 1994). For instance, Ojasalo shows an opportunity for cost reduction by choosing a new supplier in his supply chain map (Ojasalo, 2004). As supply chain maps may detect cost-saving potentials, we deduce H5.1.

Furthermore, supply chain transparency has high relevance for sustainability (Foerstl et al., 2010; Reuter et al., 2010). It is very important in sensitive industries such as the food sector (Banterle & Stranieri, 2008). Sustainable behavior and the execution of chain liability improve a buying firm's sustainability performance (Hartmann & Moeller, 2014; Lechler et al., 2019). Hence, we also state that the transparency tool is useful for sustainability (H5.2).

According to TCE, mapping the extended supply chain can also support the analysis of transaction risks (Wever et al., 2012). Knowing and monitoring lower-tier suppliers is mandatory to prevent supply risks and can help ensure on-time deliveries (Kleindorfer & Saad, 2005; Lafontaine & Slade, 2007; Waller & Fawcett, 2013), leading to hypothesis H5.3.

H5: Supply chain mapping positively influences (1) cost-saving performance, (2) sustainability performance and (3) delivery performance (keeping all other variables equal).

6.5.3 Sourcing levers: tactics to achieve sourcing targets and their match with transparency requirements

Empirical research in TCE often uses transactional attributes as independent variables and governance modes as dependent variables (Tsang, 2006). That is why we integrate the sourcing levers, which we presented when we deduced H2, as endogenous variables into our research model. Prior literature has shown that these sourcing levers have a positive impact on purchasing performance (Schiele, 2007; Schiele, Horn, & Vos, 2011; Stevens, 1989). We hypothesize that one target-oriented sourcing lever usually improves the purchasing performance in the specific performance dimension related to this lever. Consequently, we argue as follows:

H6: The sourcing levers (a) direct sourcing and (b) volume bundling positively influence (1) cost-saving performance. The lever (c) responsible practice has an impact on (2) sustainability performance, while (d) risk management is positively related to (3) delivery performance (keeping all other variables equal).

In the case study of spare parts, the purchasers bundle homogenous volumes and send RfQs to the original manufacturers after they have been identified. Based on the offers of the tier-2 suppliers, the purchasers relocate purchasing volumes to them or renegotiate their current prices with the 1st-tier suppliers. The larger the request package due to bundling is, the higher is the competitiveness of the purchase prices. Hence, we assume that volume bundling is a mediator of direct sourcing in our research model. Consequently, we also test the effect of this potential mediator on the further sourcing levers direct sourcing, responsible practice and risk management. Therefore, we hypothesize the following:

H7: The sourcing lever (b) volume bundling is a mediator of (a) direct sourcing, (c) responsible practice and (d) risk management (keeping all other variables equal).

Figure 47 summarizes the different hypotheses in our research model:

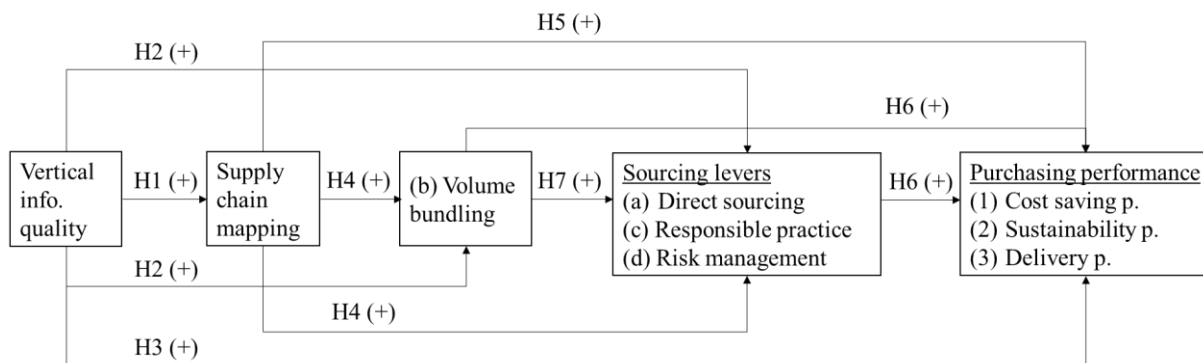


Figure 47: Research model

6.6 Survey Method

6.6.1 Measurement Development: reflective and formative variables derived from literature

To measure the quality of information on the vertical supply chain, we took the existing construct “information quality” from the literature. This construct has been applied in various supply chain-related contexts, such as in the order fulfillment process by Forslund and Petersen (Forslund, 2007; Petersen, 1999) or in the internal production planning process by Lindau (Lindau, 1995). Information quality can be defined as the degree to which information meets the expectations and requirements of the information customer (W. Choi et al., 2013). In the context of our study, the purchaser is this information customer. As Forslund argued that the construct can be measured on an ordinal scale, we choose a 5-point Likert scale (Forslund, 2007).

The quality of information can be measured by evaluating whether the information is accurate, timely, reliable, complete and relevant. The indicator *accuracy* describes the preciseness of the received information (W. Choi et al., 2013; Eppler & Wittig, 2000; Li & Lin, 2006). Depending on the state of accuracy, the information customer might have to correct obvious mistakes in the received information (Forslund, 2007). *Timeliness* defines the adherence to the agreed time when the customer of the information wants to have the desired information (W. Choi et al., 2013; English, 1999; Forslund, 2007; Li & Lin, 2006; Lindau, 1995). Moreover, other authors evaluate whether the information is sufficiently up-to-date regarding timeliness (Eppler & Wittig, 2000; Kahn, Strong, & Wang, 2002). *Reliability* refers to the probability that this information will remain unchanged (W. Choi et al., 2013; Forslund, 2007; Li & Lin, 2006). *Completeness* describes the extent to which information is not missing and is of sufficient breadth and depth for the task at hand (Kahn et al., 2002; Li & Lin, 2006). The information needs to represent reality with all required descriptive elements (Eppler & Wittig, 2000). Finally, the *relevance* of information concerns its impact and pertinence to the customer (W. Choi et al., 2013; Eppler & Wittig, 2000; Kahn et al., 2002).

Furthermore, we added the last indicator emphasizing information’s usefulness (Kahn et al., 2002), value (Kahn et al., 2002) and fit for use (Huang, Lee, & Wang, 1999) for the purchaser: “I can make good decisions based on my knowledge about the relationships of my suppliers.” Finally, we adapted the existing information quality construct to knowledge about relationships with sub-suppliers in the vertical supply chain. Table 23 gives an overview of all indicators of the vertical information quality construct:

Code	How do you evaluate your knowledge about the relationships between your direct suppliers and their sub-suppliers?
	My knowledge about the relationships between my suppliers and their sub-suppliers is
VI1	... accurate.
VI2	... timely.
VI3	... reliable.
VI4	... complete.
VI5	... relevant.

VI6	I can make good decisions based on my knowledge about the relationships between my suppliers and their sub-suppliers.
-----	---

Table 23: Vertical information quality

An explicit, measured supply chain mapping construct in prior literature did not yet exist. Nevertheless, the indicators of our supply chain mapping construct are based on the list of supply chain map attributes, according to Gardner and Cooper (J. T. Gardner & Cooper, 2003). However, Gardner and Cooper describe the visual shape of maps, while the focus of our research is mapping activity. Hence, we could apply the attributes presented by Gardner and Cooper as indicators of our supply chain mapping construct; nevertheless, necessary adoptions to the context of our research had to be made, and we had to define the proper scale to measure our construct. As the order of the values behind our indicators matters, but the difference between them does not, we again chose an ordinal 5-point Likert scale with the anchors 1 = strongly disagree and 5 = strongly agree.

The attributes of supply chain maps cover their geometry, perspective, and implementation issues. Regarding the geometry of supply chain maps, they have two characteristics: The first one is the tiers, meaning the number of sequential business units performing transactions that end with the final consumer. Hence, our first question asks about the number of different levels in the supply chain structure (MA1). The second characteristic is the spatiality describing whether the map is geographically representative. Our third indicator, MA3, concerning the geographical locations of the organizations mapped, refers to this attribute. The perspective of a supply chain map refers to the focal point concerning the actors displayed on the map (MA2) and the scope with regard to the processes that are included in the map (MA4).

The implementation issues of supply chain maps include information density, live links to databases and the delivery mode. Information density describes the amount of information integrated into supply chain maps. We discarded this indicator because we identified it as redundant with the completeness indicator of the information quality constructs. In line with Gardner and Cooper, MA5 contains the link to company databases, while MA6 covers the delivery mode by assessing the accessibility of the maps by others. In this time of increasing process digitization, we added software support as the last indicator MA7 to our construct (see table 24).

<i>Code</i>	<i>How do you map your supply chains graphically?</i>
MA1	I visualize ... the different levels in my supply chain structure.
MA2	... the different suppliers, competitors and/or complementors on each level.
MA3	... the locations of the organizations on a geographical map.
MA4	... the relationships, transport and/or other processes between the organizations.
MA5	I link the maps to my company's database or ERP system for automatic data updates.
MA6	I store the supply chain maps centrally to make them accessible for other purchasers.
MA7	I use software support for the mapping.

Table 24: Supply chain mapping

A sourcing lever is a set of measures that can improve the sourcing performance in a commodity group (Schiele, 2007). Sourcing levers address the actions to be taken on a tactical level in order to achieve performance targets (Schiele, Horn, et al., 2011; Stevens, 1989). In this research, we developed special levers that are suitable for multi-tier supply chains. We chose a formative measurement to measure these sourcing levers (Hesping & Schiele, 2016). External sourcing can be divided into direct sourcing from manufacturers and indirect sourcing through agents or intermediaries (Niu, Chen, Zhuo, & Yue, 2018; Popp, 2000). For our research, direct sourcing is the first relevant sourcing lever. Knowing the original manufacturers allows sending RfQs to them (DS1) and sourcing directly from them (DS3). However, it is also possible to renegotiate prices with 1st-tier suppliers based on direct offers from sub-suppliers (DS2).

Volume bundling means aggregating several items into a bundle that is sent to potential suppliers in a single RfQ (Schoenherr & Mabert, 2008). The drivers of bundling are volume effects and associated price discounts due to scale effects (Kaicker, Bearden, & Manning, 1995; Prince, Geunes, & Smith, 2013). First, in VB1, we measure whether demand can be consolidated at the same sub-suppliers across product groups (Karjalainen & van Raaij, 2011; Nollet & Beaulieu, 2005). In VB2, we investigate whether the new global sourcing volume of the sub-suppliers can be tied to the existing global sourcing volume (Schoenherr & Mabert, 2008; Stremersch & Tellis, 2002). Finally, we measure bundling complementary products in VB3 (Kaicker et al., 1995).

Buying firms establish direct links with lower-tier suppliers if they have an impact on the final product quality (T. Y. Choi & Hong, 2002; H. Lee, Plambeck, & Yatsko, 2012; Tse & Tan, 2011). Hence, we measure whether purchasers control the product quality at the sub-suppliers (RP1). Second, we measure whether purchasers provide sustainability requirements such as codes of conduct to sub-suppliers (Boyd, Spekman, Kamauff, & Werhane, 2007; Caniëls et al., 2013; Mueller, dos Santos, & Seuring, 2009; Tachizawa & Wong, 2014; Zhu & Sarkis, 2004). Finally, we measure the implementation of environmental practices at sub-suppliers (RP3).

Supply chain monitoring is related to the collection, control and analysis of information to support decision-making (Cai, Liu, Xiao, & Liu, 2009). Purposes for monitoring are the control of supply chain performance by setting targets (Cheng, Law, Bjornsson, Jones, & Sriram, 2010) and predictive data analytics to support the identification of potential risk events (Waller & Fawcett, 2013). Hence, it is important to integrate sub-suppliers into the monitoring to check whether they might endanger on-time deliveries (RM1) or whether they fulfill credit indices (RM2). Risk management in complex supply chains also enhances the buying firm's traceability capabilities to track and trace parts at risk through various stages of the supply chain, as measured through our third indicator, RM3 (DiMase et al., 2016).

<i>Code</i>	<i>Which actions do you take based on good supplier relationship knowledge?</i>
DS1	I ask the sub-suppliers for direct quotes to compare them with my current 1st-tier supplier prices.
DS2	Based on prices from sub-suppliers, I renegotiate the prices with my current 1st-tier suppliers.
DS3	I switch the current 1st-tier suppliers and source directly from the sub-suppliers.
VB1	I analyze which commodities share the same sub-suppliers for volume bundling.
VB2	I analyze the global sourcing volume at the sub-suppliers for volume bundling.

VB3	I analyze synergies with complementors who share the same suppliers for volume bundling.
RP1	I control the product quality of all semi-finished products at the sub-suppliers.
RP2	I implement sustainable practices and ethical standards at the sub-suppliers.
RP3	I implement management for packaging, recycling and/or waste reduction at the sub-suppliers.
RM1	I analyze and reduce the supply risk of the sub-suppliers.
RM2	I integrate the sub-suppliers in the supplier monitoring and control, e.g., their credit rating.
RM3	I track and trace the order status, stock level and/or deliveries at the sub-suppliers.

Table 25: Sourcing levers

Purchasing performance is clustered into the six major categories cost, time, quality, flexibility, innovation and sustainability, according to Caniato et al. (Caniato, Luzzini, & Ronchi, 2012). The three dimensions cost, time and sustainability are relevant in the context of our research project. The performance measures used for the cost-saving performance in our study are based on the scales developed by Krause et al. and Terpend et al. (Krause, Pagell, & Curkovic, 2001; Terpend, Krause, & Dooley, 2011). We adopted the measurement of sustainability and delivery performance to ensure cost-saving performance in order to keep it similar for the respondents.

Azadegan and Dooley added the aspects of target achievement and comparison with competitors to the measurement of purchasing performance (Azadegan & Dooley, 2010). These scales were later refined by Hesping, who asked whether the performance was better than average and better than expected (Hesping, 2015). We again slightly modified these questions by adding an inter-department comparison. Moreover, we aggregated the indicators used by the other authors to three questions for each performance category in order to equalize the number of indicators among the different performance constructs and to shorten the survey. While previous authors mostly used 7-item scales, we again chose 5-point scales to follow the same logic through the complete questionnaire. Table 26 shows the final questions that we used to measure the three relevant dimensions of the purchasing performance in our research:

<i>Code</i>	<i>How successful do you rate your performance as a purchaser?</i>
CP1	Due to my actions, the material cost savings in my team are above the industry average.
CP2	Compared with other departments, my department achieves higher reductions in material costs.
CP3	The reductions in material costs achieved in my department are considerably higher than our targets.
SP1	Due to my actions, the sustainability level in my team is above the industry average.
SP2	Compared with other departments, my department achieves a higher sustainability level.
SP3	The sustainability level achieved in my department is considerably higher than our target.
DP1	Due to my actions, the delivery performance of the suppliers in my team is above the industry average.
DP2	Compared with other departments, my department achieves better supplier delivery performance.
DP3	The supplier delivery performance achieved in my department is considerably better than our target.

Table 26: Purchasing performance

6.6.2 Data Collection and Sample: 624 returns from an online survey through professional portals

We conducted a large survey on supply chain mapping in 2018. Our study addressed purchasers in private procurement. To gather the relevant data, we created an online questionnaire using Lime Survey software. This survey consisted of 140 questions and was available in English, French and German. To invite purchasers to participate in our survey, we used three different communication channels: sending mail and using the professional networks LinkedIn and XING. The mailing was sent to 7,890 purchasers and recruited 364 participants. Moreover, 142 purchasers answered our questionnaire via LinkedIn, and another 118 participants did so via XING. The final sample size across all communication channels was 10,282, with an overall response rate of 6%. The final dataset included 624 complete responses.

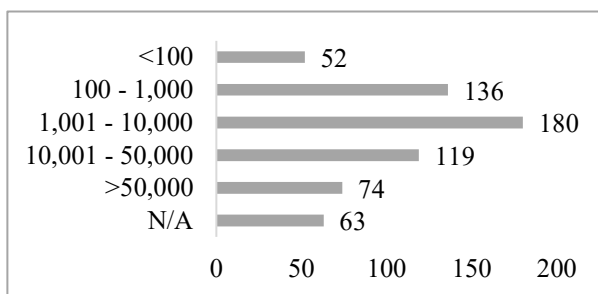


Figure 48: Employers by number of employees

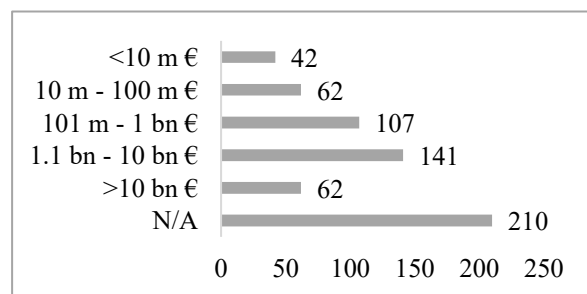


Figure 49: Employers by annual turnover

As figures 48 and 49 illustrate, our participants come from large employers. Most represented companies have between 1,001 and 10,000 employees and generate an annual turnover of 1.1 bn up to 10 bn €. Most participants work in the automotive, semi-finished product or electrical engineering industry, which are characterized by high cost pressure and high requirements for timely deliveries at production sites. Only 94 of the participating purchasers representing 15% of the sample are responsible for indirect material.

6.7 Survey Results

6.7.1 Data Quality and Test: Using consistent PLS to test the model

To test our model with the data set from our survey in the next step, we calculated our model both in SmartPLS 3.2.8 (Ringle et al., 2015), using consistent Partial Least Squares (PLSc), and in ADANCO 2.1.1 (Henseler & Dijkstra, 2015). Our model consists of formative and reflective constructs, which is why a PLS approach is recommended. Both software programs allow us to use different weighting schemes within the same formative-reflective model. In accordance with Hair et al., we chose mode A (mode A consistent in ADANCO) as the weighting scheme to estimate the reflective constructs and mode B for the formative constructs (Hair et al., 2018). Mode A corresponds to correlation weights derived from bivariate correlations between each indicator and the construct, while mode B corresponds to regression weights, also taking into account the correlations between the indicators (Hair et al., 2018). The results in both software programs are very stable and similar, which gives us confidence in the reliability of the method.

We do not detect any difference regarding the outer weights, path coefficients or explained variance. The findings in this paper are based on the figures in PLSc.

Regarding the data quality of the reflective constructs, we first assessed the reliability with Cronbach's alpha (α) as the most prominent reliability coefficient (Cronbach, 1951). All reflective variables had an $\alpha > 0.7$, which is the generally accepted threshold (Nunnally, 1978). However, later researchers state that Cronbach's alpha underestimates the reliability of PLS construct scores (Sijtsma, 2009). Hence, we also present Dijkstra-Henseler's rho (ρ_A), which shows slightly higher coefficients (Dijkstra & Henseler, 2015).

Moreover, we assessed the convergent validity of the reflective variables. The average variance extracted (AVE) and the composite reliability (CR) are indicators of the convergent validity level. The higher the CR is, the more internal consistency among those indices exists. All reflective variables are above the threshold of 0.7 for CR (Bagozzi & Yi, 2011). The constructs "supply chain mapping" and "vertical information quality" are most consistent. The AVE shows the percentage of variance interpreted by the latent factors from measurement error. The larger the AVE is, the larger the indicator variance that can be interpreted by the latent variables and the smaller the relative measurement error is. Table 27 shows that nearly all values exceeded the recommended thresholds of 0.5 for AVE (Fornell & Larcker, 1981; Hair et al., 2006). The only exception is the cost-saving performance being slightly below the threshold with an AVE = 0.485, although it was measured based on the scales developed by Krause et al. and Terpend et al. (Krause et al., 2001; Terpend et al., 2011). Hence, a small measurement error might exist for this construct.

Construct	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted
Cost-Saving Performance	0.740	0.740	0.738	0.485
Delivery Performance	0.803	0.805	0.803	0.576
Supply Chain Mapping	0.894	0.903	0.892	0.545
Sustainability Performance	0.886	0.887	0.885	0.721
Vertical Information Quality	0.926	0.937	0.925	0.677

Table 27: Construct Validity and Reliability

Finally, we also assessed the discriminant validity of the reflective variables using the Fornell-Larcker criterion (Fornell & Larcker, 1981). Each reflective construct must have stronger relationships with its own indicators than these indicators have with any other constructs. As presented in table 28, the Fornell-Larcker criterion is fulfilled.

Construct	Cost-Saving Performance	Delivery Performance	Supply Chain Mapping	Sustainability Performance	Vertical Information Quality
Cost-Saving Performance	0.696				
Delivery Performance	0.672	0.759			
Supply Chain Mapping	0.239	0.294	0.739		
Sustainability Performance	0.522	0.585	0.320	0.849	
Vertical Information Quality	0.315	0.333	0.397	0.373	0.823

Note: Squared correlations; AVE in bold in the diagonal.

Table 28: Discriminant validity (Fornell-Larcker criterion)

6.7.2 Model and hypothesis testing following the standard procedure by Hair et al.

We use the standardized root mean square residual (SRMR) as a measure of the approximate model fit. For our model, the SRMR is 0.070, which is below the recommended threshold of 0.08 (Hu & Bentler, 1999). This criterion confirms that the correlation matrix implied by our model is sufficiently similar to the empirical correlation matrix. The fit is satisfactory and our research model is useful.

To test the hypotheses, consistent partial least squares (PLSc) was carried out. We report the results of our PLSc analysis in tables 29 and 30:

R Squared	with mediator SC Mapping		without mediator SC Mapping	
	R Squared	R Squared Adjusted	R Squared	R Squared Adjusted
Supply Chain Mapping	0.158	0.156		
Volume Bundling	0.257	0.254	0.195	0.194
Direct Sourcing	0.331	0.327	0.332	0.330
Responsible Practice	0.451	0.449	0.412	0.411
Risk Management	0.474	0.472	0.425	0.423
Cost-Saving Performance	0.224	0.219	0.224	0.220
Sustainability Performance	0.239	0.234	0.230	0.226
Delivery Performance	0.208	0.203	0.204	0.200

Table 29: Coefficients of determination with mediation analysis

As depicted in table 29, the model best explains the variance in the application of risk management ($R^2 = 47.4\%$) and responsible practices ($R^2 = 45.1\%$). An additional mediation analysis shows that the usage of the supply chain mapping tool increased the coefficients of determination for these two sourcing levers by 4 to 5% compared to the same model without supply chain mapping. Likewise, for the sourcing lever volume bundling, the mediator supply chain mapping explains 6% more of its variance (25.7% compared to 19.5%). Consequently, supply chain mapping enables the use of the investigated sourcing levers and is usually applied in combination with them. However, there is no important difference in the R^2 of the final purchasing dimensions. The results show that supply chain mapping is a visualization tool that has no direct influence on purchasing performance without further target-oriented activities.

Significant path coefficients								
	Supply chain mapping	Volume bundling	Direct sourcing	Responsible practice	Risk management	Cost saving performance	Sustainability performance	Delivery performance
<i>Vertical info. quality</i>	0.397***	0.333***	0.085	0.233***	0.259***	0.132*	0.173***	0.126*
<i>Supply chain mapping</i>		0.272***	0.013	0.231***	0.247***	0.030	0.094	0.080
<i>Volume bundling</i>			0.526***	0.386***	0.370***	0.380***	0.035	0.208***
<i>Direct sourcing</i>						0.009		
<i>Responsible practice</i>							0.297***	
<i>Risk management</i>								0.159*

Note: **Bold** = significant paths with p-value *** < 0.001, ** < 0.01, * < 0.05, grey paths do not exist

Table 30: Path coefficients and their significance

The overview of the path coefficients in table 30 shows that in general, vertical information quality, supply chain mapping and the analyzed sourcing levers indeed have a positive impact on purchasing performance. Additionally, we used consistent PLS bootstrapping to test the significance of the paths. The results reveal several strong and highly significant relationships. The first one exists between vertical information quality and the application of the supply chain mapping tool ($\beta = 0.397$). As discovered in the case study, high information quality on the vertical supply chain leads to the usage of supply chain mapping.

Moreover, all relationships between vertical information quality or supply chain mapping and the three sourcing levers volume bundling, responsible practice and risk management are highly significant at the $p < 0.001$ level. In line with previous qualitative research, volume bundling shows a strong mediating effect on the remaining three levers. The strongest path coefficient of all is the relationship between volume bundling and direct sourcing ($\beta = 0.526$). Bundling the tier-2 volumes turns out to be a very important step before sourcing them directly.

Regarding purchasing performance, volume bundling has a strong and significant impact on cost-saving performance ($\beta = 0.380$), as expected. As bundling is a mediator of direct sourcing, this explains the very small direct effect of direct sourcing on cost-saving performance ($\beta = 0.009$). Moreover, bundling has a large effect on delivery performance ($\beta = 0.208$), although this was not an initial hypothesis. Finally, vertical information ($\beta = 0.173$) and responsible practices ($\beta = 0.297$) strongly influence sustainability performance.

6.7.3 Summary of the survey results: Full mediation of supply chain mapping by the application of sourcing levers

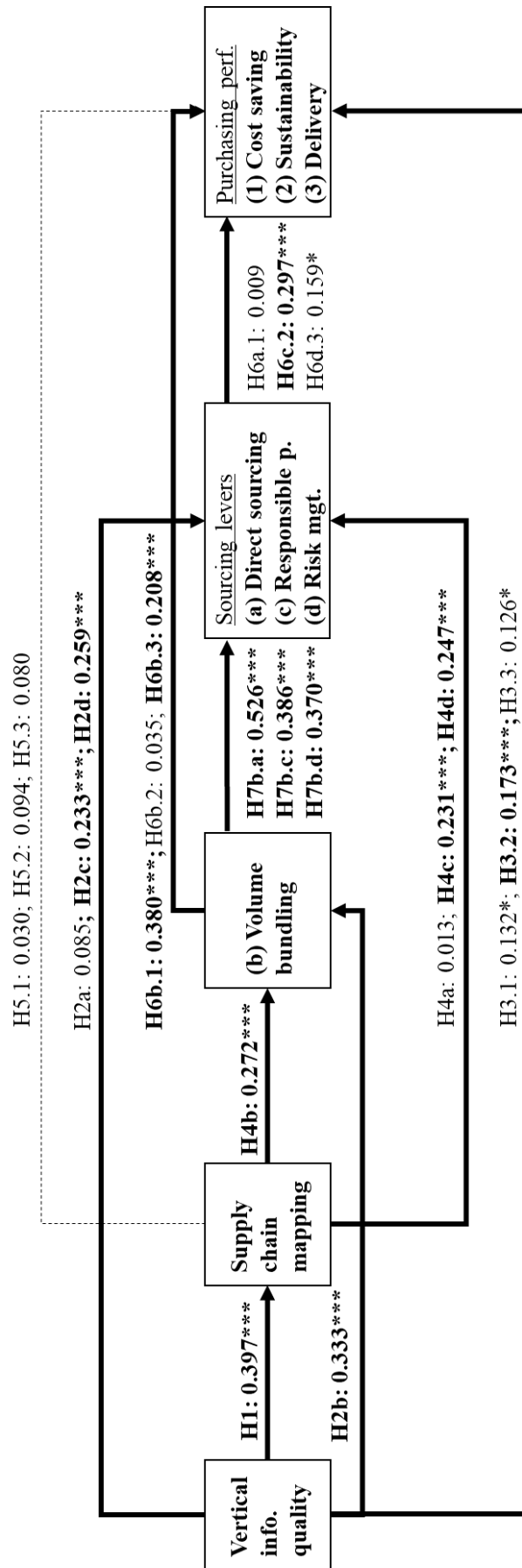
The direct link between supply chain mapping and the performance indicators is insignificant (H5), as shown by the dotted line in our research model in figure 50. However, supply chain mapping has a strong and significant influence on the successful application of volume bundling and other sourcing levers.

The survey results support hypotheses H1 and H2: If information about sub-suppliers is available, the supply chain mapping tool or appropriate sourcing levers are applied. Moreover,

supply chain mapping is significantly more often implemented in line with these follow-up activities. All four levers have been identified as relevant in combination with supply chain mapping, supporting H4a regarding direct sourcing, H4b about volume bundling, H4c about responsible practices and H4d concerning risk management.

In this context, we can statistically confirm the mediating effect of volume bundling on the further sourcing levers direct sourcing, responsible practice and risk management, as observed during the qualitative case study (H7). In accordance with TCE, purchasers bundle their tier-2 volumes before they eliminate the previous transactions and start to source goods directly. They must also bundle their volumes at sub-suppliers to establish sustainable standards at the tier-2 suppliers or to integrate them into their tier-2 risk management. The mediating effect of volume bundling significantly enhances the understanding of our research problem and is thus a very strong finding.

Regarding purchasing performance, volume bundling contributes to financial success, as observed during the case study (H6b.1). Furthermore, it has a positive effect on delivery performance (H6b.3). Due to vertical information and responsible practices, sustainability performance is also positively affected in our model (H3.2 and H6c.2). Finally, risk management has a moderate effect on delivery performance at a $p < 0.05$ level (H6d.3).



Note: Bold = significant paths with p-value *** < 0.001, ** < 0.01, * < 0.05

Figure 50: Results of the survey

6.8 Conclusion and Future Research: Mapping alone does not help, but it establishes the basis for subsequent sourcing activities

6.8.1 Contributions to supply chain transparency literature

In this paper, we explored supply chain mapping in the vertical supply chain. Our research was based on a mixed-methods research approach: We used a qualitative case study to explore the application of supply chain mapping in an agricultural manufacturing company followed by a quantitative survey to explain the effect of supply chain mapping on purchasing performance. Our study has led to several important theoretical findings that add to our understanding in three different aspects of the supply chain mapping literature:

1.) Relation of supply chain mapping to transaction cost economics

Supply chain mapping is known in the prior literature as a tool for practitioners to visualize the material, financial and information flow into all directions of the supply chain and through a firm (J. T. Gardner & Cooper, 2003). However, a broader classification into organizational theory is missing. In our research, we examined the supply chain mapping method against the background of TCE because the exchange of goods across the vertical supply chain leads to costs, and the goal of an organization is to minimize these costs (Williamson, 1979). Supply chain mapping enables organizations to gain the necessary visibility about the transactions taking place beyond the 1st-tier suppliers of an organization (T. Y. Choi & Linton, 2011; Kraft et al., 2018; Theuvsen, 2004). Both the case study and the survey have shown that buying firms can achieve savings by eliminating these transactions through volume bundling and direct sourcing (Williamson, 1979). Hence, these two sourcing levers based on the vertical integration of sourcing activities are new governance modes for buying firms (Williamson, 2010) to minimize their transaction costs (John & Weitz, 1988).

2.) New sourcing levers

Purchasers can employ a wide range of sourcing levers, depending on their current situation. However, most levers focus either on the direct supplier, such as price negotiation or supplier integration, or on optimization of products or processes (Schiele, Horn, et al., 2011). Therefore, we had to set up new levers sizing multi-tier supply chain transparency, thus contributing to the strategic sourcing and lever literature. We transferred the existing volume bundling to the sub-supplier level and added direct sourcing, responsible practice and risk management.

3.) Operationalization of supply chain mapping (RQ2)

Supply chain mapping and supply chain transparency, in general, are still emerging topics (Wieland et al., 2016). Hence, the few published supply chain maps, e.g., for the Boeing 787 Dreamliner aircraft (Tang & Zimmerman, 2009), are the outcomes of single-case studies. Therefore, we carried out a quantitative empirical study on supply chain mapping to contribute to the supply chain transparency literature. This study is the first to give recommendations on how to proceed with the mapping results, which was the motivation of our first research question. A supply chain map is only a visualization of a buying firm's

vertical supply chain and thus helps the firm gain knowledge about its inter-organizational relationships. However, the buying firm must take action based on the maps to make the results usable and beneficial. A set of the four above-mentioned sourcing levers direct sourcing, volume bundling, responsible practice and risk management help operationalize the supply chain mapping method. As an answer to RQ2, our survey showed that all of these levers benefit from supply chain transparency exercises. Furthermore, volume bundling mediates the effect of vertical information and supply chain mapping on the other three levers. These findings are also important for practitioners, as they give helpful recommendations regarding the application of supply chain mapping.

4.) Benefits of supply chain mapping (RQ1)

Although prior research has already pointed out that supply chain transparency is of growing importance for buying firms (Kashmanian, 2017), the current literature still lacks evidence about the benefits of supply chain mapping. Therefore, we explored the impact of the mapping tool on three different dimensions of purchasing performance to answer RQ1. We showed that supply chain mapping is used as an input for targeted sourcing levers, which indeed have a positive impact on cost savings, sustainability and delivery performance. We provide a theoretical explanation for supply chain transparency benefits based on TCE. Moreover, the monetarily measurable benefits of transparency are an interesting result for practitioners. As sustainability and risk management are further emerging topics in companies, the mapping tool can be a useful aid for purchasers.

6.8.2 Limitations and Future Research: Detailing supply chain mapping and adding further actionable levers

Our research started with a single-case study in an agricultural machinery company. As single-case studies are often criticized, we decided in favor of a mixed-methods research approach and carried out a large survey with 624 purchasers in addition to the case study. The survey helped us to determine additional aspects that were not discovered in our case study, such as sustainability, and thus enhanced our understanding of the research problem. Nevertheless, we had a response rate of only 6% in the survey. Therefore, our study might be vulnerable to non-response bias. Future studies need to strive for response rates of >20% to mitigate this risk (Caniëls et al., 2013; Corsten et al., 2011).

In our case study, we tried to adhere to the quality indicators of case study research mentioned by Yin (Yin, 2018). Nevertheless, several researchers criticize single-case studies for lacking validity (Schofield, 2006; Yin, 2018) or for having limited generalizability of their results (Leonard-Barton, 1990; Lincoln & Guba, 2006). These studies can result in a narrow or biased theory (Eisenhardt, 1989, 1991; Yin, 2018) while overlooking real phenomena (Jick, 1979; Trim & Lee, 2004). Consequently, such research may have low validity and relevance. Hence, we encourage future researchers to carry out more case studies. The more comparable cases within one commodity group exist, the more helpful and interesting the benchmarking results

become. Nevertheless, the limited transparency and the high number of sub-suppliers in upstream supply chains certainly remain economic barriers (Hofstetter, 2018).

Finally, our research model has only medium explanatory power for purchasing performance, although it contains many strong and significant paths. The R-squared values of the different performance dimensions range from 21% for delivery performance to 24% for sustainability performance. Thus, we encourage future researchers to refine our model. Additional sourcing levers may be necessary to increase the model's explanatory power for purchasing performance. We suggest that future researchers investigate the new sourcing levers that we detected at the end of our case study, such as the identification of new potential suppliers or a change in a 1st-tier supplier's make-or-buy strategy.

Chapter 7: Cost versus Innovation Leaders: Performance effects of Supply Network Mapping

Abstract

Increasing complexity in large and global supply networks raises the information and visibility challenges buying firms are facing. The application of dedicated tools such as Supply Network Mapping - depicting vertical supply chains and their horizontal embedding in the competitive landscape - can help to visualize and analyze such relationships. However, the impact of Supply Network Mapping on the purchasing performance has not been explored yet. Which benefits does visibility in general and the use of such tools in particular generate? Even more, companies with different competitive strategies might have different benefits. Therefore, this paper tests the impact of supplier relationship information and Supply Network Mapping on the cost-saving and innovation performance. A multi-group analysis compares when cost and innovation leaders apply Supply Network Mapping. While better visibility might generally be assumed to benefit buying firms, in its empirical content, our findings draft a much more differentiated picture: Firms with cost leadership strategies directly benefit from vertical information about their sub-suppliers for the cost-saving performance but do not from applying mapping tools. Firms pursuing innovation leadership strategies, on the other hand, benefit most from horizontal information quality about other customers for innovation performance. For them, the application of Supply Network Mapping further enhances the performance effect. We conclude that purchasers may need to draft the emphasis of their information-seeking efforts reflecting their company's overall strategic direction, rather than taking this as a personal trait, an individual commodity decision or a "one fits all" model.

Keywords

Supply Network Mapping; Supply Chain Visibility; Supplier Relationship Management; Strategic Purchasing; Competitive Advantage; Multi-Group Analysis

7.1 Introduction: Increasing supply chain complexity requiring better visibility

Most industrial firms currently concentrate on their core competences. For instance, in the automotive industry, it is assumed that the low value-creation share of 38% of OEMs in 2017 will even further decrease to 35% until 2030 (Wyman & VDA, 2018). Contrasting with the increasing reliance on a well-functioning supply chain, however, the buying firms struggle in maintaining visibility extending beyond their 1st-tier suppliers, because they pursue system or modular sourcing strategies to focus on their core competences (Gadde & Jellbo, 2002). Often, firms miss extensive information about the lower tiers in their supply structure (Trimble & O’Kane, 2008).

Moreover, the supply chain complexity increases significantly (Hamta et al., 2015) and managers need to respond to this severe challenge (Cagliano et al., 2009; Turner et al., 2018). The growing complexity results from several causes: globalization, customization, innovation, product complexity, flexibility, sustainability, volatile markets and unpredictable demands (Kavilal et al., 2017; Sun & Rose, 2015). The growing supply chain complexity may result in negative consequences on cost, customer service and reputation. Secondly, organizational aspects of complexity are often reflected in process-related or structural deficits, bottlenecks, information gaps or further obstacles. The supply chain complexity drivers denote the number and variety of suppliers, customers, products, processes and uncertainties, which are highly interdependent (Kavilal et al., 2017). Last but not least, uncertainty in material planning due to supply chain complexity can lead to inaccurate forecasts that will result in overstocks caused by bullwhip effects (Blecker et al., 2005) or in late deliveries (Wilding, 1998).

As the supply chain complexity increases, while the overview about value creation architectures declines, purchasing managers need appropriate tools to achieve visibility about the relevant actors in the supply network and their relationships for their strategic sourcing decisions. Before a company can create a transparent supply chain, it needs to gain supply chain visibility (Kraft et al., 2018). High visibility about the inbound supplier structure and the buyer-supplier relationships is necessary to be able to map and disclose supply chain information in the next step (Barratt & Barratt, 2011; Barratt & Oke, 2007; Jin et al., 2013; Tse & Tan, 2012). Supply chain visibility can be defined as “the extent to which a company has information about [...] its supply chain”, while the disclosure is “a company’s decision regarding what information to communicate to consumers” (Kraft et al., 2018). However, the popular Supply Chain Mapping approaches are not sufficient to fulfill the transparency task anymore as it only covers the linear, vertical supply chain. Competing supply chains rather have the shape of overlapping networks, i.e., the immediate vertical chain is also influenced by the horizontal relationships of its actors (Bellamy & Basole, 2013; T. Y. Choi & Wu, 2009; Lambert, 2008). The availability of suppliers serving one buying firm is contingent to their service towards other customers. Buying firms are competing for supplier resources with rival firms that share the same suppliers (Pulles, Veldman, & Schiele, 2016). As a consequence, our research focuses on the opportunities of Supply Network Mapping (SNM), defined as the simultaneous representation of the vertical supply chain of a company and its horizontal embedding, thus including direct business

relations and their competitors and complementors at each value creation step. In this way, SNM is a novel approach to reflect the reality of business systems as interacting networks.

Although the need for supply network visibility doubtlessly exists, it is still subject to critical discussions. First of all, reaching 100% visibility and knowledge about all actors in the supply network requires too much effort (Doorey, 2011; Marshall et al., 2016), so that companies need to set priorities and to select their mapping object carefully (Farris, 2010; Ojasalo, 2004; Singh Srai & Gregory, 2008). Moreover, suppliers and buyers are afraid to disclose the required information because they see their supply chain secrecy among competitors endangered, even though, in many countries, transparent supply chain practices are already common. Positive counterexamples are Nike and Levis, who voluntarily published their supplier lists. Following the decision to be industry leaders in supplier disclosure, the two companies successfully managed their way from resistance to supply chain visibility and transparency (Doorey, 2011). They were convinced that the disclosure of a company's working practices would lead to a positive institutional change due to greater accountability for the working conditions under which the products are manufactured. However, in order to make more companies follow these examples, the firms need to see evidence that tools like SNM really improve the purchasing performance and justify the effort. The impact of SNM on the purchasing performance is thus the first research gap that we would like to address in our study, resulting in our first research question:

***RQ1:** Does Supply Network Mapping increase cost-saving and innovation performance?*

Strategic management theory deals with the reasons why firms differ (Carroll, 1993). These motives beyond a firm's business strategy influence the decisions and actions taken on the operations management level (Wheelwright, 1984). Operations must derive priorities from the business strategy (Hobbs & Heany, 1977). Strategic decisions in operations management must be consistent among themselves and with the firm's overall goals and strategies (Galbraith & Kazanjian, 1986; Pehrsson, 2006; Schroeder, Anderson, & Cleveland, 1986; Swamidass, 1986). Ensuring coherence and consistency in the implementation of the organization's strategy is also described as the need for fit in decision-making and action (Powell, 1992; Venkatraman, 1989). External fit refers to the linkages that exist between business strategy and the supporting elements of the organization's operations strategies. Skinner describes the need for firms to have the proper external fit when developing and implementing a manufacturing strategy (Skinner, 1969). Next to manufacturing, other authors argue that purchasing decisions and actions need to be consistent with the business strategy (A. S. Carr & Pearson, 2002; Cousins, 2005; Reck & Long, 1988; Watts, Kim, & Hahn, 1992). Hence, the operative SNM tool has to fit to the company's competitive strategy, which determines the company's need for visibility. However, no evidence about this fit in literature exists so far, as almost all published papers are conceptual research or single-case studies (T. Y. Choi & Hong, 2002; Cox, 2004; Doran, 2005; Hultman et al., 2012; Sako, 2002), not attempting to generalize their results on a company's competitive strategy. Testing the fit between SNM and the competitive strategy will therefore be the second research gap that we will try to fill:

RQ2: *Under which conditions do cost and innovation leaders apply Supply Network Mapping, depicting their vertical and horizontal network?*

In order to answer these two research questions, we study the supply network, Supply Chain Mapping, preferred customer and competitive strategy literature to deduce our hypotheses and the research model. In the model, we use information quality, SNM, cost-saving performance and innovation performance as the constructs building the framework of our research. The structural equation modeling method is applied to assess these unobservable latent variables. This method helps us also to investigate the causal relationships between the variables. We extend it by the Partial Least Squares Multi-Group Analysis, which allows us to contrast cost and innovation leaders regarding their use of SNM. We find out that firms with cost leadership strategies directly benefit from vertical information about their sub-suppliers for the cost-saving performance, but do not from applying mapping tools. Firms pursuing innovation leadership strategies, on the other hand, benefit most from horizontal information quality about other customers for innovation performance. For them, the application of Supply Network Mapping further enhances the performance effect.

7.2 Hypothesis Development

7.2.1 *Horizontal information: Supplier relationships with other customers*

The current theory on buyer-supplier relationships suggests triads in order to capture buyer-supplier relationships in complex supply networks. While a dyadic framework allows us to describe the interaction between two firms, it cannot fully account for the relational behaviors of the two firms embedded in a supply network (Wasserman & Faust, 1994). A triadic framework is the first step to understanding the underlying relationship intricacies and making thoughtful relationship decisions (T. Y. Choi & Wu, 2009). Choi et al. differentiate between a competitive, a cooperative and a co-opetitive buyer-supplier-supplier triad. The buying firm needs cooperation capabilities (Wilhelm & Sydow, 2018) within the supply network's horizontal supply chain relations (Wilhelm, 2011; Wu, Choi, & Rungtusanatham, 2010). Depending on the triad, the buyer needs to understand how the relationships between the suppliers can potentially change his competitive advantage. For instance, events such as mergers and acquisitions, joint ventures, and other alliances need to be proactively evaluated by the buyer in order to understand how such activities will affect the dynamics and his own position in the supply network (T. Y. Choi et al., 2002). Suppliers might tacitly form a coalition and even share the private cost information to improve their position towards their customers (Shi, Zhou, Wang, Xu, & Xiong, 2013). As these relationships concern several suppliers next to each other on the same level, we regard this as the *horizontal* perspective of the supply network according to the wording used by Choi and Hong (T. Y. Choi & Hong, 2002).

There have been a few empirical studies on triads that chose either a qualitative case-study approach (Dubois & Fredriksson, 2008; Obstfeld, 2005; Roseira, Brito, & Henneberg, 2010; Wu & Choi, 2005) or a quantitative data analysis approach (R. B. Handfield & Melnyk, 1998;

Madhavan, Gnyawali, & He, 2004; Surya D. Pathak, Wu, & Johnston, 2014; Wuyts, Stremersch, Van Den Bulte, & Franses, 2004) to examine triadic relationships in supply networks and to enhance their understanding. Moreover, prior empirical studies have already highlighted the positive impact of increased visibility about the supply network on the supply chain performance (Bartlett, Julien, & Baines, 2007; Ho Lee, Kim, & Kim, 2014). Information sharing often acts as a mediator between information quality and supply chain performance and facilitates a higher overall performance (Marinagi, Trivellas, & Reklitis, 2015). Horizontal supply chain collaborations may involve not only information sharing but also shared production resources in case of low capacity (Björnfot & Torjussen, 2012).

If we consider a supply network with further buying firms next to company A, as illustrated in figure 51, the dynamics get even more complex. There are direct links to the buying firm and invisible structural links between the suppliers and other customers, which can impact the performance of the buying firm dramatically (Lu & Shang, 2017). In this context, the emerging field of big data analytics can be used to extract the number of existing supplier links, the overlaps between supplier product portfolios, product outsourcing opportunities, and shared suppliers. The analytics are used to predict interdependencies across the horizontal level of the supply network to improve supply chain visibility (Brintrup et al., 2018).

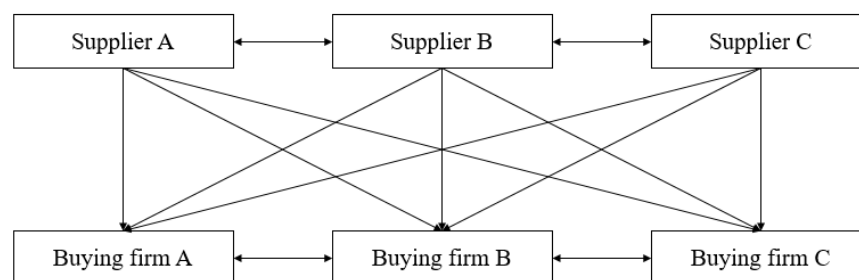


Figure 51: Supplier relationships with other customers

The number of actively managed first-tier suppliers by a buying firm in such complex supply networks is often an indicator of transaction costs. Determining and reducing the horizontal supply base complexity may be a cost-efficient approach (T. Y. Choi & Krause, 2006; Lu & Shang, 2017). One major implication of different buyer-supplier-supplier models is their impact on the relative bargaining power between the buyer and the suppliers. This bargaining power can affect cost-reduction (T. Y. Choi et al., 2002). Hence, we argue that Horizontal information quality positively influences the cost-saving performance (H1a).

In complex supply networks with many suppliers and buyers, not only the suppliers, but also the buyers compete. Consequently, in these networks, it becomes increasingly important for the buying firms to establish a stable, trustful relationship with their suppliers and to become interesting (Christiansen & Maltz, 2010) and hopefully even their preferred customers (Pulles, Schiele, et al., 2016; Schiele et al., 2012). Supplier satisfaction is an antecedent of this preferred customer status. Previous research has shown that purchasers with highly satisfied suppliers receive a better status and ultimately better treatment than their competitors (Vos et al., 2016). They derive greater benefits from suppliers' resources and capabilities and thus gain competitive advantage (Pulles, Schiele, et al., 2016; Pulles, Veldman, et al., 2016; Schiele et

al., 2012). In this context, buyers struggle hard to get the best innovation of their suppliers (Christiansen & Maltz, 2010; Ellis et al., 2012). In a cooperative relationship, the buyer and his suppliers even work together in a team to reach a common goal, such as joint product development (T. Y. Choi et al., 2002). Consequently, we also state that Horizontal information quality has a further positive impact on innovation performance (H1b).

SNM is a tool that can help the buyers to visualize and evaluate the important triad constellations, relationships in the horizontal supply chain and events for the buying firm (see hypothesis 3 for further explanation). Thus, we state that horizontal information quality positively influences the use of SNM (H1c).

H1: Horizontal information quality positively influences (a) cost-saving performance, (b) innovation performance and (c) Supply Network Mapping (keeping all other variables equal).

7.2.2 Vertical information: Supplier relationships with sub-suppliers

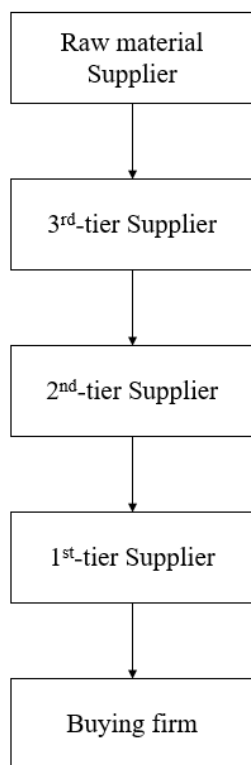


Figure 52: Supplier relationships with sub-suppliers

The current theory on vertical supply chains suggests that buying firms must extend their interest beyond 1st-tier suppliers to manage their entire supply chain (Farris, 2010). This approach allows them to identify and map their sub-suppliers, as shown in figure 52. A high supply chain visibility has a positive impact on supply chain performance (Bartlett et al., 2007; Ho Lee et al., 2014). For instance, firms with high visibility into their conflict minerals supply chains achieve higher profitability than firms with less visibility. Moreover, firms with high visibility into their conflict minerals supply chains realize improved sales performance and stock market valuations (Swift, Guide, & Muthulingam, 2019). As these relationships reflect a buying firm's upstream supply chain, we regard this as the *vertical* perspective of the supply network (T. Y. Choi & Hong, 2002).

Prior empirical research on the vertical supply chain took mainly place in a logistics context examining the effect of a high forecast information quality (Forslund & Jonsson, 2007) on the delivery performance (Bartlett et al., 2007). However, supplier collaboration across the vertical supply chain also has a positive effect on purchasing performance both in terms of innovative capability and financial results (Corsten & Felde, 2005). Hence, we will

investigate the impact on the cost-saving and innovation performance in our study.

According to Farris, one key strategic area of interest regarding 1st- to 2nd-tier supplier relationships are cost reduction opportunities (Farris, 2010). An overall supply chain information transparency is positively associated with a joint profit performance of buyers and suppliers (Cho, Ryoo, & Kim, 2017). End-to-end visibility can reduce operating costs. Visibility about the firm's raw material and finished goods inventory levels in a multi-tier supply chain is significant for a company's return on assets and competitive advantage

(Holcomb, Ponomarov, & Manrodt, 2011). While new competitors in the automotive industry have vertical upstream supply chains, which indicates better profitability, the traditional automotive industry is horizontal, depends on fewer tier-1 suppliers and is disconnected from tier-2, impacting negatively in the transaction costs and supply chain management. In Brazil, it is common that tier-2 suppliers have financial difficulties, negatively affecting transaction costs and sometimes ending in bankruptcy (Sakuramoto, Di Serio, & Bittar, 2019). Hence, it is important to achieve high vertical information quality to prevent cost problems. Prior research has shown that also first-tier suppliers use upstream supply chain strategy with sub-suppliers to improve cost performance and flexibility (Scannell, Vickery, & Droge, 2000). We deduce that vertical information quality positively influences the cost-saving performance (H2a).

Moreover, sub-supplier relationships are also interesting for the buying firm concerning new product opportunities, new technologies and technological knowledge (Farris, 2010). Innovations are developed through the exchange and interplay of different actors in the supply network (Freeman & Soete, 1997; H Hakansson & Eriksson, 1993; Lazzarotti & Manzini, 2009; Steinle & Schiele, 2002; von Hippel, 1988). Collaborative innovation is a joint process between the buyer and the supplier. Therefore, a good upstream supplier knowledge and integration are necessary for open innovation (Schiele, Veldman, & Hüttinger, 2011). This aspect leads to the hypothesis that vertical information quality positively influences innovation performance (H2b).

SNM is a helpful tool to identify and visualize the supply chain structure (Altmayer & Stölzle, 2016; J. T. Gardner & Cooper, 2003). Therefore, we assume that buyers who successfully collected knowledge about their 1st- to 2nd-tier supplier relationships want to apply it, leading us to hypothesis H2c.

H2: Vertical information quality positively influences (a) cost-saving performance, (b) innovation performance and (c) Supply Network Mapping (keeping all other variables equal).

7.2.3 Supply Network Mapping enabling network visibility

Due to a high supply chain complexity caused by the increasing globalization of value-creating processes and further complexity drivers, the visibility for the buying firm decreases. The outsourcing of manufacturing can even cause a lack of control (Y. H. Kim & Davis, 2016; Serdarasan, 2013). Therefore, firms need to develop upstream visibility to exercise control over their supply chains (Swift et al., 2019). The need for supply chain transparency is high (Kashmanian, 2017).

Supply chain maps can visualize the material, financial and information flow into all directions of the supply chain and through a firm (J. T. Gardner & Cooper, 2003). The mapping is a tool that helps to generate and maintain the structural visibility of a company's supply chain based on available supply chain information (Wichmann et al., 2018). Therefore, the maps help to increase the supply chain visibility again (Barratt & Barratt, 2011; Barratt & Oke, 2007; Jin et al., 2013; Tse & Tan, 2012). We adopt this concept to complex supply networks in our research with the two previously explained horizontal and vertical view directions and name it "Supply

Network Mapping”. As Supply Chain Mapping continues to evolve, more and more users find the term “chain mapping” inappropriate (Farris, 2010), because supply chains rather have the shape of complex overlapping networks (Bellamy & Basole, 2013; T. Y. Choi & Wu, 2009; Lambert, 2008).

In our research model, SNM will have a mediating role, because information quality itself can already positively influence the purchasing performance. Nevertheless, we suppose that by the application of a tool dedicated to increasing the visibility in the supply network, we can even further improve the purchasing performance. For instance, Ojasalo shows an opportunity for cost reduction by choosing a new supplier in his supply network map (Ojasalo, 2004), leading to H3a. Moreover, on the one hand, we have seen that Horizontal SNM is important to become aware of who will enjoy preferential treatment from the suppliers regarding innovation (Schiele, Calvi, & Gibbert, 2012; Pulles et al., 2016; Schiele et al., 2012). On the other hand, also the discovery of direct partnerships with sub-suppliers to develop innovations achieves rising attention (Altmayer & Stölzle, 2016; C. Morgan, 2007), leading to H3b. Hence, we assume:

H3: Supply Network Mapping has a positive impact on (a) cost-saving performance and (b) innovation performance (keeping all other variables equal).

7.2.4 Competitive Strategies requiring a strategic fit of operative tools

According to Strategic Management theory, operative decisions must be consistent with the firm’s business strategy (Galbraith & Kazanjian, 1986; Pehrsson, 2006; Schroeder et al., 1986; Swamidass, 1986). Effective operations create consistency between business capabilities and competitive strategy (Wheelwright, 1984). While some researchers highlight a direct moderating impact of the competitive strategy on the firm performance (Su, Guo, & Sun, 2017), Hayes and Wheelwright argue that the alignment between strategies at the business and functional levels has a positive impact on the performance (Hayes & Wheelwright, 1984). This statement is supported by more recent studies, which find that a greater degree of alignment between business and manufacturing strategies leads to improved performance (Lindman, Callarman, Fowler, & McClatchey, 2001; Papke-Shields & Malhotra, 2001; T. Smith & Reece, 1999). Furthermore, some researchers even revealed that the fit of the business strategy with operational elements is of far greater importance to performance than the actual choice of strategy (James & Hatten, 1995; T. Smith & Reece, 1999).

Empirical studies in operations management have examined the role of strategy and the importance of strategic fit. Many researchers depict the appropriateness of operations-related decisions as contingent on the strategy being pursued, e.g., in salesforce management or manufacturing (Adam & Swamidass, 1989; Allen & Helms, 2006; Kotha & Vadlamani, 1995; Roth & Nigh, 1992; Slater & Olson, 2000; Swink, Narasimhan, & Wang, 2007; Swink & Song, 2007; Vickery & Droge, 1993). As a counterpart to manufacturing, further researchers investigated the strategic fit between the business strategy and decisions for services. They recommended that firms will benefit from considering the corporate service strategy early in the service design process and from adjusting the service concept to the service strategy

(Goldstein, Johnston, Duffy, & Rao, 2002) in order to increase customer satisfaction (Miles, Miles, & Cannon, 2012).

The theory of strategic fit has led to several generic business strategies. The logic of these strategies is that multiple approaches are possible as long as an appropriate fit is achieved. Indeed, some researchers argue that finding such a fit is the precondition of strategy (Hambrick & Fredrickson, 2001; Rumelt, Schendel, & Teece, 1991). The most popular strategic framework widely used in prior research are Porter's generic competitive strategies (Dess & Davis, 1984). Porter's framework integrates the firm's choice of competitive approach with the choice regarding product and market to describe generic strategies that will lead to competitive advantage. Porter states that a company can defend its position against the market's competitive forces with a consistent approach, although the foundation of competitive advantage differs across the strategies (Porter, 1980). According to Porter, a company can reinforce its competitive position by following one of two possible competitive strategies: (a) a differentiation strategy, where the company creates a unique product, and (b) a cost leadership strategy, wherein the firm strives to provide the lowest priced-product in the industry (Porter, 1980, 1985).

According to strategic management theory, we argue that the application of an operational tool like Supply Network Mapping needs to be aligned with the firm's competitive strategy to ensure strategic fit. Buying firms with a differentiation strategy are increasingly looking for technological innovations that enhance the competitive position of their new products. Suppliers represent a key source of this information for the buying firms. However, suppliers share innovations only with preferred customers who value their mutual relationships (Ellis et al., 2012). Thus, the buying firms need to be aware of the relationships of their suppliers with other customers in order to assess their own customer attractiveness and status. The attractiveness and strategic fit between the supplier and the buyer will strongly influence the supplier's motivation for resource allocation (Mortensen & Arlbjørn, 2012). Hence, we deduce that companies with a differentiation strategy use SNM if they have high horizontal information quality (H4a). On the other hand, the tier 2-suppliers in the vertical supply chain have a low level of innovation, as most of them have a low capacity for investment (Sakuramoto et al., 2019). Hence, there is a lack of correlation between upstream SCM strategy and innovation performance (Scannell et al., 2000). While supplier cooperation is positively associated with product innovation to a certain point, an over-embeddedness of the upstream suppliers may affect the innovation performance negatively (Hagedoorn & Frankort, 2008; Tomlinson & Fai, 2016; Villena, Revilla, & Choi, 2011). Consequently, for buying firms with a differentiation strategy and high requirements in innovation capability, vertical information quality can be neglected.

Buying firms with a cost leadership strategy face high cost pressure. They need to purchase at low rates in order to be capable of selling at low sales prices, as well. Recently, the firms have realized that supply network costs are one of the few areas of savings open to many companies (C. Morgan, 2007). Consequently, future performance measurement and controlling face the challenge to cover the whole supply network, including the sub-suppliers (Altmayer & Stölzle,

2016; C. Morgan, 2007). Especially the margins between the suppliers and sub-suppliers are highly interesting for buying firms to generate savings. This insight leads us to the conclusion that companies with a cost leadership strategy use SNM if they have high vertical information quality (H4b).

H4: Companies with a) a *differentiation strategy* use SNM if they have a high *horizontal information quality*, while companies with b) a *cost leadership strategy* use it if they have a high *vertical information quality*.

Figure 53 shows the directions of the different hypotheses in our research model:

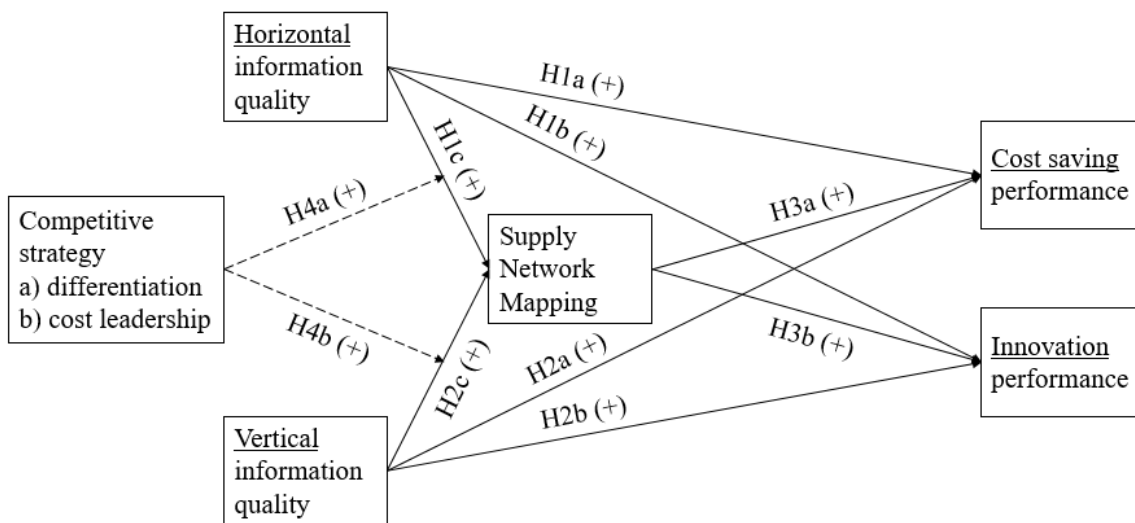


Figure 53: Research Model

7.3 Research Design

7.3.1 Sampling and Data Collection: 440 survey participants with a differentiation strategy and 125 purchasers with a cost leadership strategy

We created an online questionnaire in the software Lime Survey to collect the relevant data. This survey consisted of 140 questions that were structured in ten question blocks. It was available in the three languages English, French and German, as we intended to roll out the survey internationally. Our study addressed all purchasers working for private organizations, while the public procurement sector was out of scope due to its specific regulations.

In order to validate the questionnaire, figure 54 shows how we first tested the understanding of the created questions in December 2017/January 2018 with five purchasers for the horizontal and another five purchasers for the vertical perspective of the supply network. After refining the questionnaire, we again pretested the survey instrument with a random sample of 1,376 purchasers in May/June 2018 in order to obtain a representative size of 40 respondents to test our research model.

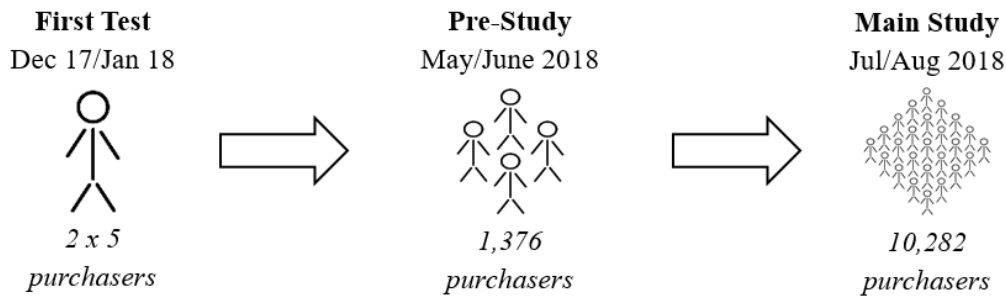


Figure 54: Validation of the survey instrument

After some last modifications based on the results from this pretest, the final survey was carried out in July/August 2018. In order to mitigate a potential response bias caused by the summer period, we made sure to leave the survey open long enough so that all purchasers taking three or four weeks of summer holidays still had the chance to take part. Some even profited from the distance to their stressful jobs during their holidays to deal with this interesting, emerging topic. In order to invite purchasers to participate in our survey, we used three different communication channels: a mailing as well as the professional networks LinkedIn and XING. The mailing was sent to 7,890 purchasers and gathered 364 participants. Moreover, 142 out of 1,776 contacted purchasers answered our questionnaire via LinkedIn and another 118 participants out of 616 were acquired via XING. In the end, the total sample size across all communication channels was 10,282, with an overall response rate of 6%. The final dataset included 624 complete responses.

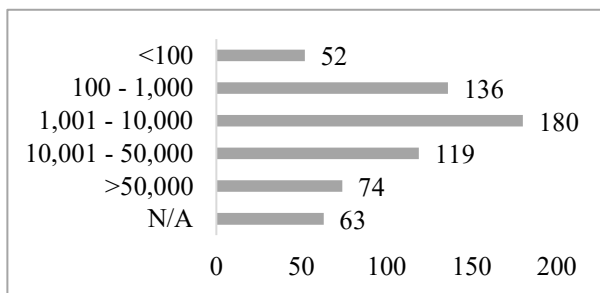


Figure 55: Employers by number of employees

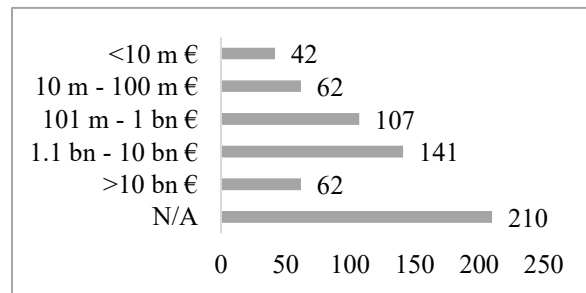


Figure 56: Employers by annual turnover

Most participants come from Western European countries, such as Germany, Switzerland, France and the Netherlands. As figures 55 and 56 illustrate, they mostly work for large employers. Most represented companies have between 1,001 and 10,000 employees and generate an annual turnover of 1.1 bn up to 10 bn €. Most participants work in the automotive, semi-finished product or electrical engineering industry, which are characterized by many innovations and high cost pressure. Only 94 of the participating purchasers representing 15% of the sample are responsible for indirect material.

Furthermore, we divided our sample according to the competitive strategies by Porter (Porter, 1985). Figure 57 shows that 440 participants in our study, representing 71% of the sample, follow a differentiation strategy, while 125 purchasers, representing 20% of the sample, have a cost leadership strategy. Only 9% of the interviewed companies focus on a niche market. These companies are not further considered in our study.

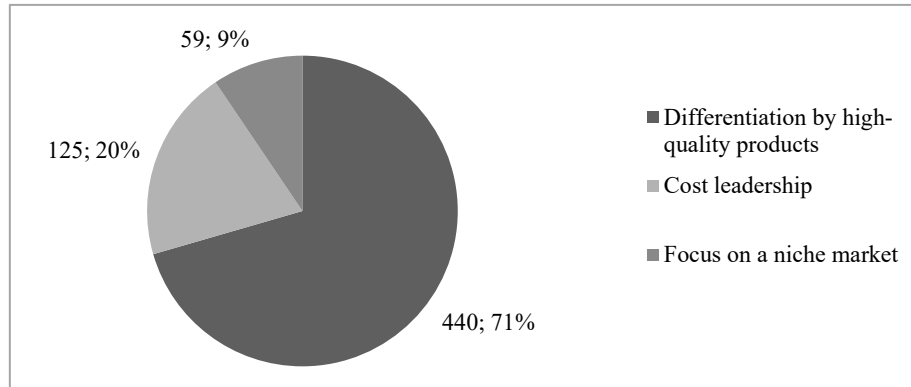


Figure 57: Participants by competitive strategy

7.3.2 Measurement Development: Adapting existing constructs in the literature

In order to measure the horizontal and vertical information quality, we took the existing construct “information quality” from the literature. This construct was already applied in various supply chain-related contexts, like in the order fulfillment process by Forslund and Petersen (Forslund, 2007; Petersen, 1999) or in the internal production planning process by Lindau (Lindau, 1995). Information quality can be defined as the degree to which information meets the expectations and requirements of the information customer (W. Choi et al., 2013). In the context of our study, the purchaser is this information customer. As Forslund argued that the construct can be measured on an ordinal scale, we chose a 5-point Likert scale (Forslund, 2007).

The quality of information can be measured by evaluating if the information is accurate, timely, reliable, complete and relevant. The indicator *accuracy* describes the preciseness of the received information (W. Choi et al., 2013; Eppler & Wittig, 2000; Li & Lin, 2006). Depending on the state of accuracy, the information customer might have to correct obvious mistakes in the received information (Forslund, 2007). *Timeliness* defines the adherence of the agreed time when the customer of the information wants to have the desired information (W. Choi et al., 2013; English, 1999; Forslund, 2007; Li & Lin, 2006; Lindau, 1995). Moreover, other authors also evaluate if the information is sufficiently up-to-date regarding the timeliness (Eppler & Wittig, 2000; Kahn et al., 2002). The *reliability* refers to the probability that this information will remain unchanged (W. Choi et al., 2013; Forslund, 2007; Li & Lin, 2006). The *completeness* describes the extent to which information is not missing and is of sufficient breadth and depth for the task at hand (Kahn et al., 2002; Li & Lin, 2006). The information needs to represent reality with all required descriptive elements (Eppler & Wittig, 2000). Finally, the *relevance* of the information concerns its impact and pertinence to the customer (W. Choi et al., 2013; Eppler & Wittig, 2000; Kahn et al., 2002).

Furthermore, single authors also mention additional dimensions of the information quality construct that we regarded as either self-evident or as irrelevant in the context of our research, e.g., the information’s believability and understandability (Kahn et al., 2002). Instead, we added the last indicator emphasizing the information’s usefulness (Kahn et al., 2002), value (Kahn et al., 2002) and fit for use (Huang et al., 1999) for the purchaser: “I can make good decisions based on my knowledge about the relationships of my suppliers.”

Finally, we adapted the existing information quality construct to knowledge about supplier relationships with other customers (horizontal information quality) and knowledge about supplier relationships with sub-suppliers (vertical information quality). Table 31 gives an overview of all indicators of our two information quality constructs:

CONSTRUCTS
<p>Horizontal information quality <i>How do you evaluate your knowledge about the relationships of your suppliers with other customers?</i> My knowledge about the relationships of my suppliers with other customers is</p> <ul style="list-style-type: none"> ...accurate. ...timely. ...reliable. ...complete. ...relevant. <p>I can make good decisions based on my knowledge about the relationships of my suppliers with other customers.</p>
<p>Vertical information quality <i>How do you evaluate your knowledge about the relationships of your direct suppliers with their sub-suppliers?</i> My knowledge about the relationships of my suppliers with their sub-suppliers is</p> <ul style="list-style-type: none"> ...accurate. ...timely. ...reliable. ...complete. ...relevant. <p>I can make good decisions based on my knowledge about the relationships of my suppliers with their sub-suppliers.</p>
<p>Supply Network Mapping <i>How do you map your supply networks graphically?</i> I visualize</p> <ul style="list-style-type: none"> ...the different levels in my supply network structure. ...the different suppliers, competitors and/or complementors on each level.

<p>...the locations of the organizations on a geographical map.</p> <p>...the relationships, transports and/or other processes between the organizations.</p> <p>I link the maps to my company's database or ERP system for automatic data updates.</p> <p>I store the supply net maps centrally to make them accessible for other purchasers.</p> <p>I use software support for the mapping.</p>
<p>Cost-saving performance</p> <p><i>How successful do you rate your cost-saving performance as a purchaser?</i></p> <p>Due to my actions, the material cost savings in my team are above the industry average.</p> <p>Compared with other departments, my department achieves higher reductions in material costs.</p> <p>The reductions in material costs achieved in my department are considerably higher than our targets.</p>
<p>Innovation performance</p> <p><i>How successful do you rate your innovation performance as a purchaser?</i></p> <p>Due to my actions, the innovations developed with the suppliers in my team are above the industry average.</p> <p>Compared with other departments, my department achieves more innovations.</p> <p>The innovations achieved in my department are better than planned.</p>

Table 31: Questionnaire for the different constructs

An explicit, measured SNM construct in prior literature did not exist yet. Nevertheless, the indicators of our SNM construct are based on the list of supply chain map attributes, according to Gardner and Cooper (J. T. Gardner & Cooper, 2003). However, Gardner and Cooper describe the visual shape of the maps, while the focus of our research is the mapping activity. Moreover, the scope of Supply Chain Mapping are only linear supply chains while we transfer this tool in our research to supply networks. To sum this up, we could apply the attributes presented by Gardner and Cooper as indicators of our SNM construct; nevertheless, necessary adoptions to the context of our research had to be made and we had to define the proper scale to measure our construct. As the order of the values behind our indicators matters, but not the difference between them, we chose again an ordinal 5-point Likert scale with the anchors 1 = strongly disagree to 5 = strongly agree.

The attributes of supply chain maps cover their geometry, perspective, as well as implementation issues. Regarding the geometry of supply chain maps, the authors mention that they have two characteristics: The first one are the tiers meaning the number of sequential business units performing transactions leading to the final consumer. Hence, we ask in our first question for the number of different levels in the supply network structure. The second attribute is the spatiality describing if the map is geographically representative. Our third question concerning the geographical locations of the organizations mapped refers to this attribute. The perspective of a supply chain map refers to the focal point concerning the actors displayed on

the map, as covered by our second question, and the scope with regards to the processes that are included in the map (question 4).

Implementation issues of supply chain maps cover information density, live links to databases and the delivery mode. Information density describes the amount of information integrated into the supply chain maps. We discarded this indicator because we identified it as redundant with the completeness indicator of the information quality constructs. In line with Gardner and Cooper, we integrated questions containing the link to the company's databases and the accessibility of the maps by others (delivery mode). In times of increasing process digitization, we added software support as the last indicator of our SNM construct.

The performance measures that we use in our study are based on the scales developed by Krause et al. and Terpend et al. regarding cost savings (Krause et al., 2001; Terpend et al., 2011) and the scales by Azadegan and Dooley, Schiele et al. and Terpend et al. for innovation (Azadegan & Dooley, 2010; Schiele, Veldman, et al., 2011; Terpend et al., 2011). Azadegan and Dooley added the aspects of target achievement and comparison with competitors to the measurement of the purchasing performance (Azadegan & Dooley, 2010). These scales were later on refined by Hesping, who asked for every purchasing performance category whether the performance was better than average and better than expected (Hesping, 2015). We again slightly modified these questions by adding an inter-department comparison as the second question of each construct because we were convinced that due to data access, an internal performance benchmarking can sometimes be easier than an external comparison with competitors. Moreover, we aggregated the indicators used by the other authors to three powerful questions for each performance category in order to equal the number of indicators among the different performance constructs and to shorten the survey. While the previous authors mostly used 7-item scales, we again chose 5-point scales, to follow the same logic through the complete questionnaire. Table 31 lists the final questions that we used to measure cost-saving and innovation performance.

7.4 Findings

7.4.1 Good data quality of reflective constructs and satisfactory model fit

Our model consists only of reflective constructs. To test the model, we applied partial least squares structural equation modeling (PLS-SEM) in SmartPLS 3.2.8 by Ringle, Wende and Becker (Ringle et al., 2015). We chose mode A as the corresponding weighting scheme, which is numerically more stable and faster than Mode B (Dijkstra & Henseler, 2015). We also tested the model using consistent Partial Least Squares (PLSc), not detecting any difference (Dijkstra & Henseler, 2015).

Regarding the data quality of the reflective constructs, we first assessed the convergent validity. The Average Variance Extracted (AVE) and the Composite Reliability (C.R.) are indicators of the convergent validity level. The higher the composite reliability is, the more internal consistency among those indices exists. The average variance extracted shows the percentage

of variance interpreted by the latent factors from measurement error. The larger average variance extracted is, the larger indicator variance could be interpreted by the latent variables and the smaller relative measurement error is. Table 32 shows that all values exceeded the recommended thresholds of 0.5 for AVE (Fornell & Larcker, 1981; Hair et al., 2006) and 0.7 for C.R. (Bagozzi & Yi, 2011).

Moreover, we assessed the reliability of the reflective variables first with Cronbach's alpha (α) as the most prominent reliability coefficient (Cronbach, 1951). All indicators of the reflective variables had an $\alpha > 0.7$, which is the generally accepted threshold (Nunnally, 1978). However, later researchers state that Cronbach's alpha underestimates the reliability of PLS construct scores (Sijtsma, 2009). Hence, we also present Dijkstra-Henseler's rho (ρ_A), which shows slightly higher coefficients (Dijkstra & Henseler, 2015). The construct "vertical information quality" appears to be most consistent.

Construct	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
Cost saving performance	0.740	0.741	0.852	0.657
Horizontal information quality	0.891	0.901	0.917	0.648
Innovation performance	0.876	0.879	0.924	0.802
Supply Network Mapping	0.894	0.907	0.916	0.610
Vertical information quality	0.926	0.937	0.942	0.732

Table 32: Construct Validity and Reliability

Finally, we also assessed the discriminant validity of the reflective variables using the Fornell-Larcker criterion (Fornell & Larcker, 1981). Each reflective construct must have stronger relationships with its own indicators than these indicators have with any other constructs. As presented in table 33, the Fornell-Larcker criterion is fulfilled.

Construct	Cost saving performance	Horizontal information quality	Innovation performance	Supply Network Mapping	Vertical information quality
Cost saving performance	0.810				
Horizontal information quality	0.256	0.805			
Innovation performance	0.442	0.258	0.896		
Supply Network Mapping	0.197	0.333	0.279	0.781	
Vertical information quality	0.262	0.554	0.305	0.367	0.855

Note: Squared correlations; AVE in bold in the diagonal.

Table 33: Discriminant Validity (Fornell-Larcker criterion)

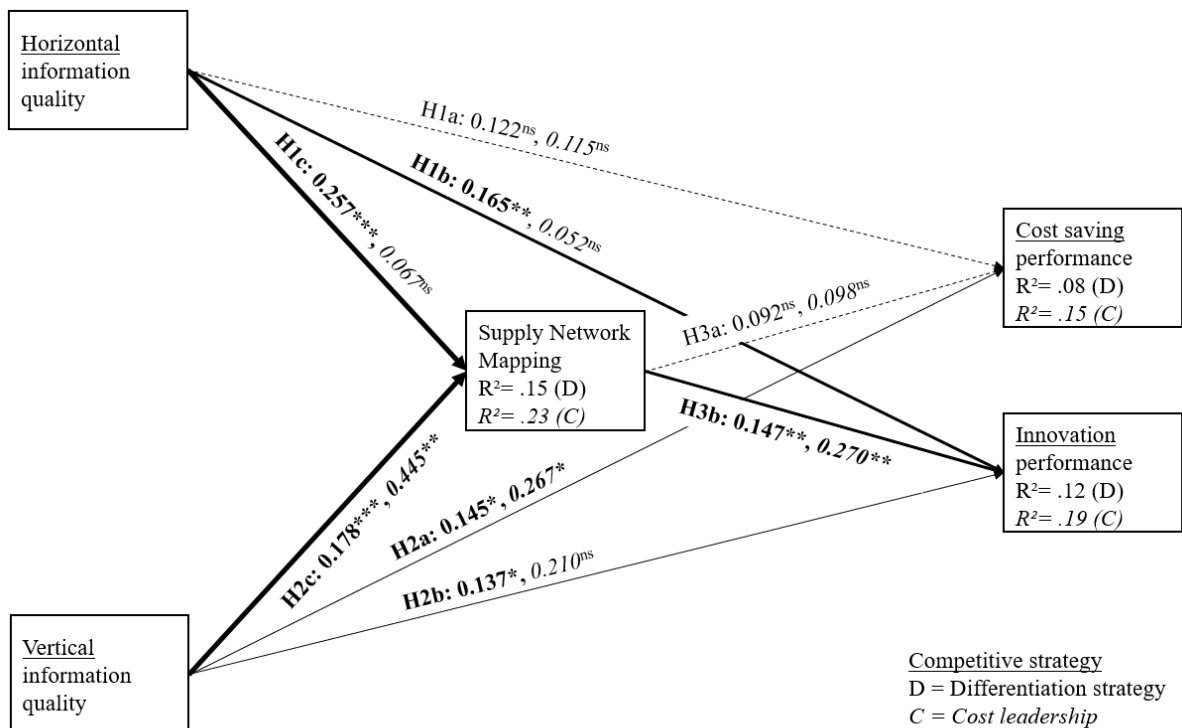
However, in some research situations, the Fornell-Larcker criterion does not reliably detect the lack of discriminant validity (Henseler et al., 2014). Therefore, we also checked the Heterotrait-monotrait ratio of correlations (HTMT), which is shown in table 34, as another estimate of construct correlation for reflective constructs. The HTMT is clearly below the threshold of 0.85, as well (Henseler et al., 2014).

Construct	Cost saving performance	Horizontal information quality	Innovation performance	Supply Network Mapping	Vertical information quality
Cost saving performance					
Horizontal information quality	0.307				
Innovation performance	0.545	0.285			
Supply Network Mapping	0.233	0.356	0.309		
Vertical information quality	0.309	0.606	0.336	0.389	

Table 34: Discriminant Validity (HTMT)

We use the Standardized Root Mean Square Residual (SRMR) as a measure of the approximate model fit. For our model, the SRMR is 0.068, which is below the recommended threshold of 0.08 (Hu & Bentler, 1999). This criterion demonstrates that the correlation matrix implied by our model is sufficiently similar to the empirical correlation matrix. The fit is satisfactory and our research model is useful.

7.4.2 Model and Hypothesis testing: Cost and innovation leaders profiting from supply network visibility in a different way



Note: **Bold** = significant paths, * *p*-value < 0.05, ** < 0.01, *** < 0.001, ns = non-significant

Figure 58: Results of PLS-MGA Analysis

As illustrated in figure 58, 23% of the variance in SNM can be explained by cost leaders and 15% by companies following a differentiation strategy. Equally, the information quality and SNM better explain the variance in the purchasing performance for companies with cost leadership ($R^2 = 15\%$ for cost-saving performance and $R^2 = 19\%$ for innovation performance). This result is not surprising, as SNM traces back to the pure mapping of supply chains (Farris, 2010; J. T. Gardner & Cooper, 2003) and was thus applied by practitioners who wanted to optimize their own vertical chain with regards to cost, time and quality. Only later managers discovered that the horizontal view might optimize their strategic positioning, as well.

In general, all antecedents have a positive impact on SNM, cost-saving and innovation performance for companies pursuing either cost leadership or a differentiation strategy. The strongest effect can be detected between vertical information quality and SNM (H2c: 0.445): Cost leaders use SNM if they know their supplier relationships with sub-suppliers. They directly benefit from vertical information about their sub-suppliers for the cost-saving performance (H2a: 0.267) but do not from applying mapping tools (H3a: 0.098), which is a non-significant path. Horizontal information quality, on the other hand, has a positive impact on innovation performance for companies with a differentiation strategy both directly (H1b: 0.165) and indirectly via the use of SNM (H1c: 0.257) and its effect on innovation performance (H3b: 0.147). For innovation leaders, the application of Supply Network Mapping thus further enhances the effect on the innovation performance.

7.4.3 Multi-Group Analysis: Cost and innovation leaders using Supply Network Mapping for different purposes

The Partial Least Squares Multi-Group Analysis (PLS-MGA) allows testing if pre-defined data groups have significant differences in their group-specific parameter estimates (Hair et al., 2018; Henseler, Ringle, & Sinkovics, 2009; Sarstedt et al., 2011). By applying the MGA in our research, it compares whether path coefficients between variables are significantly different regarding the cost leadership and differentiation strategy.

Before being able to undertake our MGA, it is important to test for measurement invariance. Multigroup analyses require establishing measurement invariance to ensure the validity of outcomes and conclusions (Hair et al., 2017). To assess measurement invariance, Henseler, Ringle and Sarstedt developed the measurement invariance of composite models (MICOM) procedure, which involves three steps: (1) configural invariance, (2) compositional invariance and (3) equality of composite mean values and variances (Henseler, Ringle, & Sarstedt, 2016). The three steps are hierarchically interrelated. Step 1 is a qualitative assessment of the composites' specifications. In our study, we can ensure the use of identical indicators, data treatment and algorithm settings across all the groups. Configural invariance is a precondition for compositional invariance being assessed in step 2 (Hair et al., 2017).

For steps 2 and 3, we have run a permutation algorithm. Tables 35 and 36 show the MICOM outcomes of step 2 and 3. In the second step, we have tested if the variables are measured in a similar way. As table 35 displays, the composite scores do not differ much in both groups. Even though the permutation p-value is slightly above 0.95 for the cost-saving performance, we still argue that compositional invariance is established because this deviation is very small and there is no content-wise reason for a difference in measurement. We also tested the model using sum scores, not detecting any difference. Therefore, the results of steps 1 and 2 support measurement invariance so that the results and differences of our MGA are valid. Finally, we tested if the variable has the same mean and variance among the groups, which is optional, according to Hair et al. (Hair et al., 2018). As this is the case, full measurement invariance is established and the data of the different groups can be pooled (Henseler et al., 2016).

Construct	Original	Correlation	5.0%	Permutation
	Correlation	Permutation Mean		
Cost saving performance	1.000	0.990	0.966	0.958
Horizontal information quality	0.999	0.997	0.992	0.780
Innovation Performance	1.000	0.999	0.996	0.644
Supply Network Mapping	0.997	0.997	0.993	0.428
Vertical information quality	0.999	0.999	0.997	0.242

Table 35: MICOM outcome of step 2

Construct	Mean -	Mean -	2.5%	97.5%	Permutation	Variance -	Variance -	2.5%	97.5%	Permutation
	Original	Permutation				Original	Permutation			
Cost saving performance	-0.044	-0.001	-0.196	0.192	0.646	0.264	-0.018	-0.377	0.332	0.162
Horizontal information quality	-0.082	0.000	-0.179	0.187	0.400	0.013	-0.008	-0.315	0.234	0.948
Innovation Performance	-0.073	-0.002	-0.202	0.200	0.454	-0.051	-0.006	-0.355	0.324	0.752
Supply Network Mapping	0.190	-0.009	-0.201	0.179	0.050	0.100	-0.008	-0.226	0.184	0.344
Vertical information quality	0.044	-0.004	-0.216	0.188	0.668	0.071	-0.012	-0.288	0.232	0.622

Table 36: MICOM outcome of step 3

The outcome of the PLS-MGA is based on the bootstrapping results from every group. A result is significant at the 5% probability of error level if the p-value is smaller than 0.05 or larger than 0.95 for a certain difference of group-specific path coefficients. Table 37 shows significantly high path differences for H1c (horizontal information quality -> SNM) and H2c (vertical information quality -> SNM). Corresponding to literature, companies with a differentiation strategy tend to use SNM if they have good knowledge about supplier relationships with other customers, while companies with a cost leadership strategy use it if they have a broad knowledge about supplier relationships with sub-suppliers. Thus, hypothesis 4 about the different information requirements depending on the competitive strategy is confirmed.

Hypothesis	Path	Path Coefficients-diff Cost leadership - Differentiation (H4)	p-Value Cost leadership vs Differentiation (H4)
H1a	Horizontal information quality -> Cost saving performance	0,007	0,511
H1b	Horizontal information quality -> Innovation performance	0,113	0,755
H1c	Horizontal information quality -> Supply Network Mapping	0,190	0,954
H2a	Vertical information quality -> Cost saving performance	0,121	0,197
H2b	Vertical information quality -> Innovation performance	0,073	0,312
H2c	Vertical information quality -> Supply Network Mapping	0,266	0,010
H3a	Supply Network Mapping -> Cost saving performance	0,006	0,466
H3b	Supply Network Mapping -> Innovation performance	0,123	0,109

Note: **Bold** = significant path differences

Table 37: Path Differences according to PLS-MGA Analysis

7.5 Conclusion and Future Research

During the last decades, the complexity of the supply chain structures has increased and they have evolved to large networks. The activities of other actors in these networks influence the competitive position of the firms. Hence, also well-known tools in purchasing and supply management that focus on supply chains need to adapt to these new structures. Supply Chain

Mapping must be able to cover also the supplier relationships in complex networks. In today's world, visibility is an important emerging topic. However, buying firms hardly ever have a full overview of their supplier's relationships until now.

7.5.1 Contributions to supply chain mapping, preferred customer and strategic management literature

In this context, our study has led to several important theoretical findings that add to our understanding in three different aspects of the Supply Chain Mapping/supply network literature:

1.) Measurement of the Supply Network Mapping construct

Most studies on the SNM topic use exploratory qualitative research approaches without hypothesis testing. Therefore, to the best of our knowledge, the construct of the SNM activity was not measured so far. Nevertheless, the attributes of supply network maps, which are the outcome of SNM activities, were already defined by Gardner and Cooper (J. T. Gardner & Cooper, 2003). Hence, we asked the purchasers if they visualize these different map characteristics and how they implement the maps in order to measure the SNM activity on a Likert scale. As we published our corresponding questionnaire in this paper, the measurement model can be reused in future studies on this upcoming topic.

2.) Impact of Supply Network Mapping on cost-saving and innovation performance (RQ1)

Most papers end with the creation of a map, e.g., for the PAX wardrobe supply network by IKEA in a particular context (Hultman et al., 2012). For instance, this is a paper on global sourcing that happens to include a figure showing a very basic supply network drawing to illustrate a particular phenomenon. Consequently, it is not further explored, if the effort that was invested in the mapping in order to achieve this visibility on the supply network has really generated advantages for the company. Therefore, we explored the impact of SNM on the cost-saving and innovation performance in order to answer RQ1. We could demonstrate that SNM indeed has a positive impact on purchasing performance. Cost leaders directly benefit from vertical information about their sub-suppliers for cost-saving performance but do not from applying mapping tools. Innovation leaders, on the other hand, benefit most from horizontal information quality about other customers for innovation performance. For them, the application of Supply Network Mapping further enhances the performance effect.

3.) Fit between Supply Network Mapping and a company's competitive strategy (RQ2)

SNM and also supply chain visibility are still emerging topics. Hence, the few published supply chain maps, e.g., for the Boeing 787 Dreamliner aircraft (Tang & Zimmerman, 2009), are the outcome of single case studies. The companies decided to map their supply network due to different triggering events, such as supply shortages and disruptions. However, there were no results prior to this research giving recommendations under which company conditions which scope and way of mapping has to be selected. Operations, dedicated tools and decisions always need to fit a company's strategy (Galbraith & Kazanjian, 1986; Pehrsson, 2006; Schroeder et al., 1986; Swamidass, 1986). We could start

filling this gap by our research outcome that cost leaders benefit from using SNM if they know their supplier relationships with sub-suppliers, while product differentiators need it to understand supplier relationships with other customers. This different application, depending on the company's competitive strategy, answers our second research question.

Next to supply chain literature, our study contributes to further literature streams: The first one is the preferred customer literature, to which SNM contributes as an operative tool. Customers who want to achieve and maintain a preferred status and to enjoy preferential treatment by their suppliers need to be aware of their suppliers' activities with other customers in order to self-assess their own customer attractiveness. Even though this might be difficult due to restricted competitor data access and take much time, our study has shown that the effort is definitely worth it, because this horizontal information quality has significant effects both directly and indirectly on the innovation performance. Moreover, our study contributes to strategic management literature. Porter has differentiated between the two large competitive strategies cost leadership and differentiation strategy (Porter, 1985). By combining these two strategies with supply chain principles, we could contrast cost leaders and product differentiators on their motivation for supply network visibility. With their emphasis on competitors, classical strategic management literature may have served more the needs of differentiators, neglecting the vertical focus required for cost leaders.

Our study has high managerial implications, as well. As our study supports the usefulness of supply network visibility and SNM, it might help to decrease the natural resistance towards information disclosure in companies. New software tools for emerging topics such as risk management and SNM are currently introduced on the market. However, a strongly discussed topic among managers regarding new software is always its cost-benefit ratio. In our study, we have shown that SNM indeed improves the cost-saving performance, even though it is a rather weak and not significant path in our model. Nevertheless, we can see that the direct impact of vertical information quality on cost-saving performance for cost leaders is already far higher (0.267), which is, in fact, nothing else but an antecedent of SNM. This finding gives evidence that the effect of a strategic information disclosure and analysis approach is positive. Typically for upcoming topics, it is just the tool and its usefulness, which still need to gain more awareness. As the benefits are monetarily measurable now, practitioners may rather give it a try.

Moreover, also the answer to our second research question has high practical relevance. Many tools with great functionalities are presented to purchasing executives, yet they need to assess their suitability for their own companies. In our results, they can find two use cases: Cost leaders apply SNM on their supplier relationships with sub-suppliers, while product differentiators apply it to their supplier relationships with other customers. As the differentiation and the cost leadership strategy are the two most important competitive strategies reflecting 91% of our sample, one of these two use cases is likely to apply to their companies, as well.

7.5.2 Limitations in explanatory power offer possibilities to modify the research model

This study also has its limitations. Our model only has a medium explanatory power, which is acceptable for the first study in this field. The values for the R squared of the endogenous variables reach from 8% for the cost-saving performance (differentiation strategy) up to 23% for SNM (cost leadership strategy). Thus, we encourage future researchers to refine our model in order to increase its explanatory power.

Our research model contains horizontal and vertical information quality as antecedents of SNM because a critical degree of information is necessary in order to apply software tools for SNM or risk management properly. They can only illustrate relationships and display risk alerts if they know a company's supplier base. SNM takes a mediating position in our model because it can optionally be applied, yet information quality already has a direct effect on cost-saving and innovation performance. However, maybe this is just one side of the coin. Probably in truth, the paths are mutual relationships, as SNM again increases the information quality: After the purchasers in a company have imported all the sub-suppliers of the direct key suppliers in a certain commodity into the software, they can detect and analyze, e.g., monopolistic structures and bottlenecks on the tier-2 and -3 level. That is why we suppose that due to the mapping, the knowledge about supplier relationships will again evolve. Probably it will get more accurate, reliable and complete. Therefore, future researchers might want to explore if there are significant double-sided paths.

Furthermore, our model only contains direct paths from information quality and SNM to the purchasing performance. We state that knowing and analyzing your supplier relationships already improves purchasing performance. However, some researchers have figured out that the application of additional sourcing levers such as volume bundling or risk management can again increase the performance (Hesping, 2015). Therefore, future studies may add such levers as mediators between information quality/SNM and the purchasing performance to our model, in order to fully grasp the functionality of the tool and to give recommendations for its use. This modification might also further increase the model's explanatory power.

In our study, we investigated the impact of supply network information quality and SNM on the cost-saving and innovation performance. These two performance clusters were relevant for this paper because we wanted to contrast companies pursuing a cost leadership with those having a differentiation strategy. However, the importance of achieving visibility across the supply network has also been recognized in further research streams such as logistics, risk management and sustainability. Hence, we encourage future researchers to examine also the impact of information quality and SNM on, e.g., a company's logistics, risk management and sustainability performance in addition to our research.

In our sample, we had 59 purchasers representing 9% of the companies who focused on a niche market. These companies were not considered in our study. Probably, a further contrasting of the companies with differentiation and cost leadership strategies with the companies focusing on a niche market would have led to additional results. However, this was the smallest group in our sample and it would have meant the need for two additional multi-group-analyses.

We base our results on a large sample of 624 respondents. Nevertheless, these participants only reflect 6% of the original sample, although all contacted purchasers have received several reminders. Therefore, our study might be vulnerable to non-response bias. Future studies need to strive for response rates of >20% in order to mitigate this risk (Caniëls et al., 2013; Corsten et al., 2011).

Chapter 8: Summary of the main research findings

8.1 Theoretical Contributions per Chapter

The following sections summarize and discuss the research findings of chapters 2 to 7. The findings are linked to the three research objectives of this dissertation. The following sections summarize the contributions to both theory and practice as well as suggestions for future research that can be derived from the work presented in each chapter.

8.1.1 Chapter 2: Supply Chain Mapping: A structured literature review and a bibliometric analysis

Chapter 2 contains a structured literature review, including a bibliometric analysis, on Supply Chain Mapping. In this section, the structure of supply chain maps has been investigated in detail. We found out that many supply chain maps share a similar geometry: Most maps are structural and show chains or netchains, covering both the supply and distribution side with an average length of five and an average width of four tiers. Most of them have a general company or commodity as the unit of analysis, but some have a relation to one sector, thereof mostly to the automotive, electronics or food industry. Hence, these results mainly contribute to theory, because they deliver valuable conventions on how to map the supply structures properly, as inquired by Gardner and Cooper (J. T. Gardner & Cooper, 2003) and Farris (Farris, 2010) and also contribute to a standardized supply chain mapping terminology.

Moreover, publications in the field of Supply Chain Mapping and related research streams, such as supply chain complexity or vertical integration, often do not distinguish clearly between a Supply Network Map as the output of the mapping activity and the Supply Network Mapping procedure that is necessary in order to achieve such visualization. By synthesizing the analyzed articles, we deduced a generalized draft for the mapping procedure, which contributes to the Supply Chain Mapping literature. Furthermore, we examined the objectives of Supply Chain Mapping mentioned in literature. The mapping is used for a broad range of purposes, thereof mostly for the analysis of supply chain relationship management and integration and risk management. This analysis of the objectives again contributes to theory. In current literature, single case studies of companies using supply chain mapping have been published, but there was no synthesized overview of the application cases of supply chain mapping.

Finally, almost all papers that have been analyzed during the structural literature review are conceptual research or case studies, which is another valuable theoretical finding. Hence, the biggest identified gap in the current literature is that there is no large empirical study so far that analyzes if the tool really leads to success. Concrete cost and benefit figures are missing in the papers published so far. Consequently, chapters 6 and 7 of this dissertation deal with the cost savings and non-monetary benefits achieved through Supply Chain Mapping activities.

8.1.2 Chapter 3: Coping with rising Supply Chain Complexity: Conceptualizing a Supply Network Map Structure Model to address that challenge

Based on the design science, chapter 3 extends the linear Supply Chain Mapping view to a holistic mapping of supply networks. These Supply Network Maps show the material, information and money flows in all directions of a focal company's environment: towards suppliers, customers, competitors and complementors. They can either show the structural or the geographical view of the relations. Supply Network Mapping can support the decision-making process of strategic purchasers in the following main areas: identifying cost-saving potential, risk management and achieving competitive advantage.

The result of this chapter is a new Supply Network Map Structure Model. The model is based on the relevant actors that appear in several well-known strategic management models and combining these with the analysis of multi-tier network links from relevant PSM models. The core of the new Supply Network Map Structure Model is a cross shape that implies that a focal company needs to gain transparency about all actors with a direct link to this company: the whole vertical supply chain as well as all complementors and competitors with their 1st-tier suppliers and customers. Regarding flows and interactions in the network, vertical, horizontal and hybrid directions of Supply Network Mapping have been identified with the help of semi-structured interviews and the application of the model in various test cases.

This research contributes to both strategic management and PSM literature. It is closing a gap between these disciplines by adopting the analysis of the multi-tier interactions regarding suppliers and customers, which is known from supply chain maps, complex supply chains and the supplier pyramid as discussed in the PSM literature (Becker, 2007; Lambert et al., 1998; Smirnov et al., 2006) to integrate further actors like competitors, complementors, subcontractors and customers' customers as discussed in the strategic management literature (Moore, 1996; Nalebuff & Brandenburger, 1997; Porter, 1979, 1998). In terms of the PSM literature, this transfer leads to a network-like understanding of the focal company's environment, fitting well into the continuously evolving roles and relationships in an ecosystem instead of the antecedent linear chain interpretation (Jarzabkowski & Wilson, 2006). Competition between several companies' supply chains is a scenario often described in the literature but rarely illustrated in a structural model approach until now (Lambert, 2008). Considering the strategic management literature, a visualization of actor relationships via multi-tier links is a new, valuable addition.

Caused by the extension to competitors' and complementors' supply chains, many complex overlapping interactions result that take the current literature on buyer-supplier-supplier triads and possibly new supply network patterns to a higher level. Such new triad constellations are among others: buyer-competitor-supplier, buyer-complementor-supplier, buyer-competitor-customer, buyer-complementor-customer, competitor-supplier-2nd-tier-supplier, complementor-supplier-2nd-tier-supplier, competitor-customer-2nd-tier-customer and complementor-customer-2nd-tier-customer. The new term Supply Network Map that has been introduced in this chapter is linked to this evolution from chain-like structures towards network-

like structures' visualization. In terms of spatiality, the model can be used both structurally and geographically. These two approaches reflect the existing literature on Supply Chain Mapping and take this field further on the network level.

8.1.3 Chapter 4: Supplier relationships with competing customers: How can purchasers find out who is the preferred customer?

Strategic purchasers of a focal company need to know how their suppliers are related to their competitors and complementors. For this purpose, 14 purchasers were asked to participate in a World Café on information sources, desired supplier relationship knowledge and contingency factors for the need for transparency in chapter 4. Their answers have been clustered according to the Gioia Method. The most desired information are the prices for other customers and the delivered customer plants. Purchasers regard the supplier and supplier factory visits as the most promising information sources. Volatile times with increasing supply risks and a decreasing supplier performance require a high supply network transparency. This research leads to the following main theoretical contributions:

The article explains which knowledge purchasers need to have about the relationships of their suppliers with other customers. It investigates when and how purchasers can find out how their suppliers work together with other customers. Consequently, this transparency contributes to the assessment of customer attractiveness, supplier satisfaction and the preferred customer status. In particular, this research investigates the different dimensions of customer attractiveness and supplier satisfaction. By increasing the robustness of these dimensions, purchasers can better assess their own customer attractiveness. An increased attractiveness better matches the suppliers' expectations and increases their satisfaction. A standardized procedure to gather information enables companies to react faster. They can assess their status as perceived by the suppliers and in the next step, actively influence it to become a preferred customer. These insights contribute to the literature on the benefits of preferential treatment.

The current literature on supply chain mapping presents the supply chain maps as an output but neglects the procedure of how to create them. This research contributes to the procedure of supply chain mapping. It examines the information gathering phase, which is an initial step before anything can be mapped. It suggests which information has to be collected and where it can be found. Furthermore, the current literature focuses on the mapping of vertical supply chains. This article investigates the horizontal mapping of supplier relationships with competitors and complementors according to the wording used by Choi and Hong (T. Y. Choi & Hong, 2002). The authors explain when it is important to know and map these relationships. Combining both directions enables the mapping of complex supply networks. While most supply chain mapping literature focuses on the mapping of nodes, this article proposes characteristics of supply chain linkages to be examined. It also gives ideas on how these connections can be quantified. This approach differentiates the current research from pure market research on suppliers.

8.1.4 Chapter 5: Knowing your supplier relationships with other customers: People or media as key sources of information?

Chapter 5 contributes significantly to preferred customer literature. The current literature on this subject focuses on the preferred customer status. This status refers to the supplier's intention and is a dependent variable of supplier satisfaction. However, there is a gap in the literature because previous researchers assume that everyone is already aware of his supplier satisfaction and his own customer status, which is, in fact, not the case. Purchasers might over- or underestimate both their supplier satisfaction and their own customer status because, as in many situations from real life, the self-perception does not always correspond to the perception of others.

Therefore, our research deals with the assessment of this preferred customer status knowledge. With the help of our model, we can explain 16.3% of the variance in the preferred customer status knowledge. According to the SET, our research also includes the two additional levels: supplier satisfaction knowledge, which influences the preferred customer knowledge and customer attractiveness knowledge. The model explains 28.1% of the variance in the supplier satisfaction knowledge and even 36.3% of the variance in customer attractiveness knowledge. Hence, especially the high R squared of this third endogenous construct regarding customer attractiveness significantly contributes to the preferred customer theory: Even if purchasers cannot find out exactly how satisfied their suppliers are and which status they achieve from them, they can still find out about the satisfaction of their suppliers with other customers and about the attractiveness of these customers. From these alternatives available to their suppliers, they can deduce and anticipate if they will gain preferential treatment from them or not.

Another important outcome of chapter 5 is that people and events visited by people are stronger information sources than media. The study has figured out that suppliers, competitors and other actors reveal the strongest paths and can, therefore, be very promising information sources. In general, people show a high resistance towards the disclosure of sensitive information, especially if the purpose for which it is to be used (in our case, e.g., renegotiations, supplier awarding decisions,...?) is not clear and if there are dependence-relationships from the requesting stakeholders (Anderson & Agarwal, 2011). Even though this is a general problem, our results show that if there is a chance to gather the desired information, this will be a lot easier in direct face-to-face contact than in public, more anonymous settings of, e.g., trade fairs or the Internet. Moreover, when discussing the implementation of real-time supply chain systems, Handfield states that under high-risk situations and a high level of workload stress, people will always trust humans over system data (R. Handfield, 2016). This outcome is not unexpected, as people provide more context than media. However, it fills an important research gap of how to achieve knowledge on the own customer status and supplier satisfaction in the preferred customer literature.

8.1.5 Chapter 6: Cost savings through supply chain transparency: A transaction cost view

In chapter 6, we explored Supply Chain Mapping in the vertical supply chain. Our research was based on a mixed-methods research approach: We used a qualitative case study to explore the application of Supply Chain Mapping in an agricultural manufacturing company and to collect targeted sourcing levers which are applied in addition to Supply Chain Mapping. The case study was followed by a quantitative survey to explain the effect of Supply Chain Mapping on the purchasing performance. Our study has led to several important theoretical findings that add to our understanding in three different aspects of the Supply Chain Mapping literature:

First, Supply Chain Mapping is known in prior literature as a tool for practitioners to visualize the material, financial and information flow into all directions of the supply chain and through a firm (J. T. Gardner & Cooper, 2003). Still, a broader allocation to Organizational Theory is missing. In our research, we examined the Supply Chain Mapping method against the background of Transaction Cost Economics. Both the case study and the survey have shown that buying firms can achieve cost savings by the elimination of transaction costs (Williamson, 1979). Direct relationships with tier-2 suppliers based on direct sourcing or volume bundling are new governance modes for the buying firms (Williamson, 2010) in order to minimize their transaction costs (John & Weitz, 1988).

Based on these findings, it is important to examine which activities purchasers carry out if they have this transparency and how successful they are with these activities. These results will create an additional contribution to decision-making literature. There were no results prior to this research giving recommendations on how to proceed with the mapping results, which was the motivation of our research. A supply chain map is only a visualization of a buying firm's vertical supply chain and thus helps to gain knowledge about its inter-organizational relationships. However, the buying firm needs to deduce activities from the maps in order to make the results usable and beneficial. A set of the four proposed sourcing levers direct sourcing, volume bundling, responsible practice and risk management in this paper helps to operationalize the Supply Chain Mapping method. Our survey has shown that all of these levers are frequently used based on Supply Chain Mapping. Furthermore, volume bundling mediates the effect of vertical information and Supply Chain Mapping on the other three levers.

Although prior research has already pointed out that supply chain transparency is of growing importance for the buying firm (Kashmanian, 2017), current literature still lacks evidence about the real benefits of transparency tools like Supply Chain Mapping. Therefore, we explored the impact of the mapping tool on three different dimensions of the purchasing performance. We showed that supply chain mapping is used as an input for targeted sourcing levers, which indeed have a positive impact on cost savings, sustainability and delivery performance.

8.1.6 Chapter 7: Cost versus Innovation Leaders: Performance effects of Supply Network Mapping

During the last decades, the complexity of the supply chain structures has increased and they have evolved to large networks. The activities of other actors in these networks influence the competitive position of the firms. Hence, also well-known tools in purchasing and supply management that focus on supply chains need to adapt to these new structures. Supply Chain Mapping must be able to cover also the supplier relationships in complex networks. In today's world, transparency is an important emerging topic. However, buying firms hardly ever have a full overview of their supplier's relationships until now. In this context, chapter 7 has led to several important theoretical findings that add to our understanding in three different aspects of the Supply Chain Mapping/supply network literature:

Most studies on the SNM topic use exploratory qualitative research approaches without hypothesis testing. Therefore, to the best of our knowledge, the construct of the SNM activity was not measured so far. Nevertheless, the attributes of supply network maps, which are the outcome of SNM activities, were already defined by Gardner and Cooper (J. T. Gardner & Cooper, 2003). Hence, we asked the purchasers if they visualize these different map characteristics and how they implement the maps in order to measure the SNM activity on a Likert scale. As we published our corresponding questionnaire in this paper, the measurement model can be reused in future studies on this upcoming topic.

Furthermore, most SNM papers end with the creation of a map, e.g., for the PAX wardrobe supply network by IKEA in a particular context (Hultman et al., 2012). For instance, this is a paper on global sourcing that happens to include a figure showing a very basic supply network drawing to illustrate a particular phenomenon. Consequently, it is not further explored, if the effort that was invested in the mapping in order to achieve this visibility on the supply network has really generated advantages for the company. Therefore, we explored the impact of SNM on cost-saving and innovation performance. We could demonstrate that SNM indeed has a positive impact on purchasing performance. Cost leaders directly benefit from vertical information about their sub-suppliers for cost-saving performance but do not from applying mapping tools. Innovation leaders, on the other hand, benefit most from horizontal information quality about other customers for innovation performance. For them, the application of Supply Network Mapping further enhances the performance effect.

Finally, SNM and supply chain visibility, in general, are still emerging topics. Hence, the few published supply chain maps, e.g., for the Boeing 787 Dreamliner aircraft (Tang & Zimmerman, 2009), are the outcome of single case studies. The companies decided to map their supply network due to different triggering events, such as supply shortages and disruptions. However, there were no results prior to this research giving recommendations under which company conditions which scope and way of mapping needs to be selected. An operative tool always needs to fit a company's strategy (Galbraith & Kazanjian, 1986; Pehrsson, 2006; Schroeder et al., 1986; Swamidass, 1986) and to achieve a predefined target. We could start filling this gap by our research outcome that cost leaders use SNM if they know their supplier relationships

with sub-suppliers, while product differentiators need it for supplier relationships with other customers.

Next to supply chain literature, our study contributes to further literature streams: The first one is the preferred customer literature. Customers who want to achieve and maintain a preferred status and to enjoy preferential treatment by their suppliers need to be aware of their suppliers' activities with other customers in order to self-assess their own customer attractiveness. Even though this might be difficult due to restricted competitor data access and take much time, our study has shown that the effort is definitely worth it, because this horizontal information quality has significant effects both directly and indirectly on the innovation performance. Moreover, our study contributes to strategic management literature. Porter has differentiated between the cost leadership and differentiation strategy (Porter, 1985). By combining these two strategies with supply chain principles, we could contrast cost leaders and product differentiators on their motivation for supply network transparency.

8.2 Practical implications for supply network structure, mapping procedure and benefits

The research results of this dissertation on supply network transparency and mapping are well suited to be used in the wider social context. Table 38 summarizes the main practical implications for purchasing professionals:

RQ	Research finding	Chpt.
RQ1: Transparency on network structure	Supply chain map geometry and unit of analysis	C2
	Holistic Supply Network Map Structure Model	C3
	Maps created during the long-term case study	C6
RQ2: Procedure for transparency and mapping	Draft: object, data collection, execution, analysis, improvements	C2
	Desired supplier relationship knowledge	C4
	Most important information sources	C4, 5
	Contingency factors for the need for transparency	C4
	Sourcing levers in addition to mapping	C6
	Mapping application in a long-term case study	C6
RQ3: Transparency and mapping benefits	Objectives: cost savings, risk management, competitive advantage	C2, 3
	Impact on the cost-saving, sustainability and delivery performance	C6
	Impact on the cost-saving vs. innovation performance	C7

Table 38: Overview of the main findings for practitioners

The first research interest of this dissertation lies in transparency about the supply network structure. Many purchasing professionals have heard about supply chain maps already but do not know how they look. Published examples show there is no convention for their shape. Hence, we investigated the geometry and unit of analysis of existing supply chain maps presented in the literature to define their basic elements. Based on these findings, we created a Supply Network Map Structure Model in a second step, because we figured out that companies are part of complex supply networks instead of linear supply chains. The new model gives shape and framework to the actors and links of these networks and can be considered as a tool to facilitate strategic purchasing decisions and processes. Finally, we created several maps for OEMs and tier-1 suppliers during a case study in order to analyze and benchmark them.

Regarding the second research question, the high managerial implications of our study concern the procedure for transparency and mapping. While practitioners can find many supply chain maps in the media, there are hardly any instructions on how to create them. By synthesizing the analyzed articles, a generalized draft for the mapping procedure has been deduced. The procedure comprises the following steps: identification of the mapping object, data collection, mapping execution, analysis phase and deduction of improvements. Hence, practitioners learn that they need to select a small part of their supply network before the mapping because the mapping of their whole supply network is unfeasible. They can also check first if they have access to the necessary information, which is the precondition for the mapping.

The dissertation provides a checklist of this necessary information for purchasers. It covers knowledge about the suppliers themselves, the business of their suppliers with other customers, and the collaboration between both parties. This knowledge can help purchasers to check and revise their supplier strategies. A well suitable supplier relationship management can again lead to a competitive advantage compared to other customers who do not have as much transparency about the relationships of their suppliers as the focal company. It helps the purchasers to assess their own customer status and to switch it from neglected to preferred status eventually. This assessment of the preferred customer status has high practical relevance. Gaining the required knowledge quicker than purchasers working for other customers is an important competitive advantage for purchasers because they can anticipate their suppliers' behavior and have shorter reaction times.

Moreover, practitioners can profit from the collection of information sources in this dissertation covering media that they can read, events where they can go or people whom they may contact in order to gather the desired information. Networking in professional settings pays off, especially in order to investigate which relationships known suppliers have with other customers. In addition to these activities, purchasers can also go to events and follow the news in the media, because these information sources have a weaker, but also positive impact on the preferred customer, supplier satisfaction and the knowledge of alternative supplier relationships with other customers. Additionally, we investigated in which general situations and particular occasions this knowledge is important. Purchasers can now create an early-alert-system of severe changes that require a sudden increase in supplier relationship transparency.

Furthermore, we figured out that buyers need to apply successful activities in addition to the mapping in order to improve their purchasing performance. The four sourcing levers direct sourcing, volume bundling, responsible practice and risk management help to operationalize the Supply Chain Mapping method for purchasing managers. Our survey and several applications in a long-term case study have shown that all of these levers are frequently used based on Supply Chain Mapping. Furthermore, volume bundling mediates the effect of vertical information and Supply Chain Mapping on the other three levers.

Finally, many tools with great functionalities are presented to purchasing executives, yet they need to assess their suitability for their own companies. In our results, they can find two use cases: Cost leaders apply SNM on their supplier relationships with sub-suppliers, while product differentiators apply it to their supplier relationships with other customers. As the differentiation and the cost leadership strategy are the two most important competitive strategies, one of these two use cases is likely to apply to their companies, as well.

Concerning the third research question, this dissertation provides insights into the benefits of transparency and mapping. First, we discovered the most important mapping objectives: the identification of cost-saving potential, risk management and competitive advantage supported by the subordinate targets benchmarking and sourcing market analysis. Secondly, we analyzed the impact of mapping on purchasing performance. We could show that Supply Network Mapping has a positive impact on cost saving, sustainability, delivery and innovation performance. Hence, the mapping tool can be a useful aid for purchasers. Moreover, these findings are interesting for practitioners, because they underline that there are monetarily measurable benefits of Supply Network Mapping. Nevertheless, in a direct comparison with other performance dimensions, the impact on the cost-saving performance is still rather low.

8.3 New research fields concerning Supply Network Mapping or modifications of the existing research models suggested as future research directions

We encourage future researchers to investigate Supply Network Mapping further and suggest that they choose their research subject in one of the two directions presented in table 39. Either they decide to explore a new field related to Supply Network Mapping, which has been out of the scope of this dissertation, or they base their research on one of the three research models proposed in chapters 5 to 7 in order to increase these models' explanatory power.

First, we recommend to carry out empirical research concerning the cultural differences in supply network transparency. Supply network transparency is defined as the “disclosure of information” (Doorey, 2011; Mol, 2015) about the supply network. This disclosure is “a company’s decision regarding what information to communicate to consumers” (Kraft et al., 2018). However, we believe that the companies do not take this decision independently, but are strongly influenced by the cultural context in which they are operating. While the regulatory pressure for companies to disclose supply chain information increases in general, the concrete requirements are mainly laid down by national law, such as the California Transparency in Supply Chains Act of 2010 (Marshall et al., 2016). Hence, we suggest to collect data from

representative samples in different countries and to contrast them in a multi-group analysis regarding supply network transparency.

Arguing from this international perspective, we furthermore suggest to extend the research on geographic Supply Network Mapping. 95% of the research papers analyzed in the literature review in chapter 2 of this dissertation deal with structural mapping. Nevertheless, geographic mapping certainly has its relevance in the context of global sourcing. Mapping the countries of origin can show in which countries parts are originally manufactured and from where they might, therefore, be sourced. A future research agenda in this context needs to cover not only the geometric spatiality of the maps but also the opportunities offered by mapping software, for instance, in the context of supply risk management software.

Regarding the directions of Supply Network Mapping, only the upstream part of the supply network has been explored in detail in this dissertation. However, the customers of the various supply network tiers have also been defined, so that sales experts can carry out future research on the downstream part of the supply network. A follow-up study could take place concerning correlations between the upstream and the downstream part of the supply network. This also involves new triad constellations in the downstream supply network, which have not been examined in detail in this dissertation and thus require further analysis, such as: buyer-competitor-customer, buyer-complementor-customer, competitor-customer-2nd-tier-customer and complementor-customer-2nd-tier-customer.

The scope of this paper is limited to product-related material, while non-product related material and services were excluded from this research. Therefore, future researchers are encouraged to investigate the structure of the supply networks and the applicability of the Supply Network Map Structure Model for non-product related material and services. Moreover, this dissertation focuses on the purchasing department. However, there are far more services in a company that are in a strategic collaboration with suppliers such as the research and development, material planning or product management department. For instance, the model might also be tested for logistic applications, such as stock control at all levels in the supply network or the transport optimization in operations research in future research.

An important result of this dissertation is that it is mandatory to define a suitable object to be mapped (Heimbrock, 2001). If a whole system of a focal company were manually mapped, the effort and complexity would be very high and visualization could hardly provide a precise overview. Hence, a big advancement in Supply Network Mapping might take place in the course of the digitalization. If supply network information could be gathered and processed automatically, it would be possible to map the whole network of focal companies. First attempts have been made to use I4.0 techniques through, for instance, natural language processing to support supply chain map creation (Wichmann et al., 2018). This dissertation is the conceptual basis for this approach, while future researchers may explore the antecedents, usage and effect of Big Data analytics in Supply Network Mapping.

New research fields	<p>Cultural differences concerning supply network transparency</p> <p>Geographic Supply Network Mapping</p> <p>Supply Network Mapping software</p> <p>Mapping of the downstream supply network</p> <p>New triad constellations in Supply Network Maps</p> <p>Supply Network Mapping for services</p> <p>Supply Network Mapping by other departments</p> <p>Impact of digitalization on Supply Network Mapping</p>
Modifications of the research models	<p>New information sources</p> <p>New sourcing levers</p> <p>Mutual relationships between information quality and SNM?</p> <p>New purchasing performance clusters</p>

Table 39: Summary of research proposals

Secondly, we encourage future researchers to refine our research models in chapters 5 to 7. For instance, the model in chapter 5 only has a medium explanatory power. Hence, we encourage future researchers to try to improve this explanatory power of information sources on the preferred customer status knowledge. We invite them to recheck on new data samples, which of the indicators for information sources can be kept, added or discarded.

Even though our research model in chapter 6 contains many strong and significant paths, it only has a medium explanatory power on the purchasing performance. The values for the R squared of the different performance dimensions reach from 21% for the delivery performance up to 24% for the sustainability performance. Thus, we suggest that future researchers also investigate the new sourcing levers, which we detected in the course of our case study, and integrate them into their questionnaires. These levers are the identification of new potential suppliers or a change in a 1st-tier supplier's make or buy strategy.

Our research model in chapter 7 only has a medium explanatory power, as well. The values for the R squared of the endogenous variables reach from 8% for the cost-saving performance (differentiation strategy) up to 23% for SNM (cost leadership strategy). Thus, we encourage future researchers to refine also this last model in order to increase its explanatory power. The model contains information quality as an antecedent of SNM because a critical degree of information is necessary in order to apply software tools for SNM or risk management properly. However, maybe the paths are mutual relationships so that SNM would again increase the

information quality: After the purchasers in a company have imported all the sub-suppliers into the software, they can analyze, e.g., market structures on the tier-2 and -3 level.

Finally, we investigated the impact of supply network information quality and SNM on cost-saving, sustainability, delivery and innovation performance in the course of this dissertation. However, purchasing performance is clustered into the six major categories cost, time, quality, flexibility, innovation and sustainability according to Caniato et al. (Caniato et al., 2012). Hence, we encourage future researchers to examine also the impact of information quality and SNM on quality and flexibility performance.

Included Publications

This dissertation is cumulative in nature and is based on six individual papers (chapters 2 to 7). The following list summarizes the included publications:

Chapter 2:

Kappel, A., Schiele, H., Buchholz, W., 2019. Supply Chain Mapping: A structured literature review and a bibliometric analysis.

This paper is currently under review at the International Journal of Production Economics.

Chapter 3:

Kappel, A., Schiele, H., Buchholz, W., 2016. Coping with rising Supply Chain Complexity: Conceptualizing a Supply Network Map Structure Model to address that challenge.

This paper has been accepted for publication in the International Journal of Procurement Management.

Prior versions of this paper were presented at (1) the 25th IPSERA conference in Dortmund, Germany, March 2016; (2) the 21st IFPSM Summer School in Advanced Purchasing and Supply Management at the University of Twente, Enschede, the Netherlands, June 2016; (3) the 19th Gießener Management-Workshop, Gießen, Germany, July 2016; (4) the 22nd BVL International PhD Candidates Workshop, Berlin, Germany, October 2016 and (5) the Doctoral Symposium of the University of Applied Sciences Muenster, Germany, November 2016.

Chapter 4:

Kappel, A., Schiele, H., Buchholz, W., 2018. Supplier relationships with competing customers: How can purchasers find out who is the preferred customer?

This paper is currently under review at Supply Chain Management: an International Journal.

Prior versions of this paper were presented at (1) the 27th IPSERA conference in Athens, Greece, March 2018; (2) the 20th Gießener Management-Workshop, Gießen, Germany, June 2018; (3) the 26th IPSERA conference in Balatonfüred, Hungary, April 2017 (working version before data gathering) and (4) the IPSERA Doctoral Workshop, Corvinus University Budapest, Hungary, April 2017.

Chapter 5:

Kappel, A., Schiele, H., Buchholz, W., 2019. Knowing your suppliers: people or media as key sources of information?

This paper is currently under review at Industrial Marketing Management.

A prior version was presented at the 28th IPSERA conference in Milan, Italy, April 2019.

Chapter 6:

Kappel, A., Schiele, H., Buchholz, W., 2019. Cost savings through supply chain transparency: A Transaction-Cost View.

This paper is currently under review at the Journal of Operations Management.

Chapter 7:

Kappel, A., Schiele, H., Buchholz, W., 2019. Cost versus Innovation Leaders: Performance effects of Supply Network Mapping.

This paper was presented at the 28th IPSERA conference in Milan, Italy, April 2019. It has been selected as one of the best competitive papers by the guest editors and invited to be submitted for the conference special issue in the Journal of Purchasing and Supply Management. After revision, it currently goes through the journal's peer review process.

Additional Publications

Next to the publications, which have been included in this dissertation, I also worked on three further papers during my PhD project. Since these papers are out of the scope of this dissertation, but also interesting for the readership of purchasing and supply management literature, I would like to mention these additional publications:

Excluded Paper 1:

Kappel, A., Buchholz, W., 2020. Beyond service triads: The role of visibility across the service network for sourcing IT, logistics and MRO services.

This paper is currently under review at the 29th IPSERA conference in Knoxville, Tennessee, April 2020.

Excluded Paper 2:

Jeschke, F., Kappel, A., Buchholz, W. and Ruppe, C., 2019. One way or another - The relationship between trust and transparency in buyer-supplier relationships.

This paper is currently under review at the Journal of Trust Research.

A prior version was presented at the 28th IPSERA conference in Milan, Italy, April 2019.

Excluded Paper 3:

Buchholz, W., Albersmann, A., Kappel, A. and Huang, J., 2019. Conceptualization of a preventive and reactive supply chain risk management approach to manage supply shortages.

This paper was presented at the 28th IPSERA conference in Milan, Italy, April 2019.

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Appendix

Author	Year	Title	Journal
Allesina, S., et al.	2010	Performance measurement in supply chains: new network analysis and entropic indexes	International Journal of Production Research
Barratt, M. and A. Oke	2007	Antecedents of supply chain visibility in retail supply chains: A resource-based theory perspective	Journal of Operations Management
Barratt, M. and R. Barratt	2011	Exploring internal and external supply chain linkages: Evidence from the field	Journal of Operations Management
Berry, D. and D. R. Towill	1992	Material Flow in Electronic Product Based Supply Chains	International Journal of Logistics Management
Berry, D. and M. M. Naim	1996	Quantifying the relative improvements of redesign strategies in a P.C. supply chain	International Journal of Production Economics
Bode, C. and S. M. Wagner	2015	Structural drivers of upstream supply chain complexity and the frequency of supply chain disruptions	Journal of Operations Management
Borgatti, S. P. and X. Li	2009	On social network analysis in a supply chain context	Journal of Supply Chain Management
Braziotis, C., et al.	2013	Supply chains and supply networks distinctions and overlaps	Supply Chain Management: An International Journal
Capaldo, A. and I. Giannoccaro	2015	How does trust affect performance in the supply chain? The moderating role of interdependence	International Journal of Production Economics
Caridi, M., et al.	2010	Do virtuality and complexity affect supply chain visibility?	International Journal of Production Economics
Catalan, M. and H. Kotzab	2003	Assessing the responsiveness in the Danish mobile phone supply chain	International Journal of Physical Distribution & Logistics Management
Choi, T. Y. and Y. Hong	2002	Unveiling the structure of supply networks case studies in Honda, Acura and DaimlerChrysler	Journal of Operations Management
Corsaro, D., et al.	2011	Actor network pictures and networking activities in business networks. An experimental study	Industrial Marketing Management
Creazza, A., et al.	2012	Applying an integrated logistics network design and optimisation model: the Pirelli Tyre case	International Journal of Production Research
Dadhich, P., et al.	2015	Developing sustainable supply chains in the UK construction	International Journal of Production Economics

		industry. A case study	
Doran, D.	2005	Supplying on a modular basis: an examination of strategic issues	International Journal of Physical Distribution & Logistics Management
Doran, D. and M. Giannakis	2011	An examination of a modular supply chain: a construction sector perspective	Supply Chain Management: An International Journal
Doran, D., et al.	2007	Supply chain modularisation: Cases from the French automobile industry	International Journal of Production Economics
Dubois, A. and P. Fredriksson	2008	Cooperating and competing in supply networks: Making sense of a triadic sourcing strategy	Journal of Purchasing and Supply Management
Ellram, L. M., et al.	2007	Product-process-supply chain: an integrative approach to three-dimensional concurrent engineering	International Journal of Physical Distribution & Logistics Management
Fabbe-Costes, N., et al. (a)	2011	Future sustainable supply chains: what should companies scan?	International Journal of Physical Distribution & Logistics Management
Fabbe-Costes, N., et al. (b)	2014	Sustainable supply chains: a framework for environmental scanning practices	International Journal of Operations & Production Management
Farris, M. T.	2010	Solutions to strategic supply chain mapping issues	International Journal of Physical Distribution & Logistics Management
Galaskiewicz, J.	2011	Studying supply chains from a social network perspective	Journal of Supply Chain Management
Gardner, J. T. and M. C. Cooper	2003	Strategic Supply Chain Mapping Approaches	Journal of Business Logistics
Grimm, J. H., et al.	2014	Critical factors for sub-supplier management: A sustainable food supply chains perspective	International Journal of Production Economics
Harland, C., et al. (a)	1999	Developing the concept of supply strategy	International Journal of Operations & Production Management
Harland, C., et al. (b)	2003	Risk in supply networks	Journal of Purchasing and Supply Management
Hearnshaw, E. J. S. and M. M. J. Wilson	2013	A complex network approach to supply chain network theory	International Journal of Operations & Production Management
Hultman, J., et al.	2012	An interaction approach to global sourcing: A case study of IKEA	Journal of Purchasing and Supply Management
Jin, Y., et al.	2013	Awareness is not enough	International Journal of Physical Distribution & Logistics Management
Johnsen, T. and D. Ford	2005	At the receiving end of supply network intervention: The view from an automotive first tier	Journal of Purchasing and Supply Management

		supplier	
Kim, Y., et al.	2011	Structural investigation of supply networks: A social network analysis approach	Journal of Operations Management
Koh, S. C. L., et al.	2012	Cross-tier ripple and indirect effects of directives WEEE and RoHS on greening a supply chain	International Journal of Production Economics
Kumar, M., et al.	2013	Mapping of the UK food supply chains: capturing trends and structural changes	Journal of Advances in Management Research
Lambert, D. M. and M. A. Schwieterman	2012	Supplier relationship management as a macro business process	Supply Chain Management: An International Journal
Lambert, D. M. and M. C. Cooper	2000	Issues in Supply Chain Management	Industrial Marketing Management
Lambert, D. M. and T. L. Pohlen	2001	Supply Chain Metrics	International Journal of Logistics Management
Lambert, D. M., et al.	1998	Supply Chain Management: Implementation Issues and Research Opportunities	International Journal of Logistics Management
Lamming, R., et al.	2000	An initial classification of supply networks	International Journal of Operations & Production Management
Lau, A. K. W., et al.	2010	Factors influencing the relationship between product modularity and supply chain integration	International Journal of Operations & Production Management
Lin, Y., et al.	2009	3C framework for modular supply networks in the Chinese automotive industry	International Journal of Logistics Management
Lyons, A. C. and A. Ma'aram	2014	An examination of multi-tier supply chain strategy alignment in the food industry	International Journal of Production Research
MacCarthy, B. L., et al.	2013	Supply network structures in the international clothing industry: differences across retailer types	International Journal of Operations & Production Management
Marufuzzaman, M. and A. M. Deif	2010	A dynamic approach to determine the product flow nature in apparel supply chain network	International Journal of Production Economics
Mena, C., et al.	2013	Toward a theory of multi-tier supply chain management	Journal of Supply Chain Management
Miemczyk, J., et al.	2012	Sustainable purchasing and supply management: a structured literature review of definitions and measures at the dyad, chain and network levels.	Supply Chain Management: An International Journal

Miyake, D. I., et al.	2010	Supply chain mapping initiatives in the Brazilian automotive industry: challenges and opportunities	Journal of Operations and Supply Chain Management
Mizgier, K. J., et al.	2012	Modelling defaults of companies in multi-stage supply chain networks	International Journal of Production Economics
Nasir, M. H. A., et al.	2017	Comparing linear and circular supply chains: A case study from the construction industry	International Journal of Production Economics
Norrman, A. and U. Jansson	2004	Ericsson's proactive supply chain risk management approach after a serious sub-supplier accident	International Journal of Physical Distribution & Logistics Management
Oglethorpe, D. and G. Heron	2013	Testing the theory of constraints in UK local food supply chains	International Journal of Operations & Production Management
Ojasalo, J.	2004	Key network management	Industrial Marketing Management
Raj Sinha, P., et al.	2004	Methodology to mitigate supplier risk in an aerospace supply chain	Supply Chain Management: An International Journal
Rao, S. and T. J. Goldsby	2009	Supply chain risks: a review and typology	International Journal of Logistics Management
Rigot-Muller, P., et al.	2013	Optimising end-to-end maritime supply chains: a carbon footprint perspective	International Journal of Logistics Management
Sha, D. Y., et al.	2008	The strategic fit of supply chain integration in the TFT-LCD industry	Supply Chain Management: An International Journal
Shockley, J. and G. Fetter	2015	Distribution co-opetition and multi-level inventory management performance: An industry analysis and simulation	Journal of Purchasing and Supply Management
Singh Srail, J. and M. Gregory	2008	A supply network configuration perspective on international supply chain development	International Journal of Operations & Production Management
Smith, M., et al.	2009	Forest industry supply chain mapping	Forest Products Journal
Sohal, A. S. and M. Perry	2006	Major business-environment influences on the cereal products industry supply chain	International Journal of Physical Distribution & Logistics Management
Stewart, G. T., et al.	2009	Leveraging public-private partnerships to improve community resilience in times of disaster	International Journal of Physical Distribution & Logistics Management
Tachizawa, E. M. and C. Y. Wong	2014	Towards a theory of multi-tier sustainable supply chains: a systematic literature review	Supply Chain Management: An International Journal
Thomé, A. M. T., et al.	2014	A multi-tier study on supply chain flexibility in the automotive industry	International Journal of Production Economics

Tse, Y. K. and K. H. Tan	2012	Managing product quality risk and visibility in multi-layer supply chain	International Journal of Production Economics
Tummala, R., et al.	2011	Assessing and managing risks using the Supply Chain Risk Management Process SCRMP	Supply Chain Management: An International Journal
Viswanathan, S., et al.	2007	Value of information exchange and synchronization in a multi-tier supply chain	International Journal of Production Research
Wang, G., et al.	2016	Big data analytics in logistics and supply chain management: Certain investigations for research and applications	International Journal of Production Economics
Wilding, R. (a)	1998	Chaos Theory: Implications for Supply Chain Management	International Journal of Logistics Management
Wilding, R. (b)	1998	The supply chain complexity triangle: Uncertainty generation in the supply chain	International Journal of Physical Distribution & Logistics Management
Zokaei, K. and P. Hines	2007	Achieving consumer focus in supply chains	International Journal of Physical Distribution & Logistics Management

Table 40: Articles analyzed in the literature review

(1)	<i>Prices and margins</i>	The prices and margins of the supplier achieve 15 votes. This is a cumulated value: 14 points refer to the pricing of identical or similar products towards other customers, while one point is granted to the pricing of the whole supplier portfolio.
(2)	<i>Delivered competitor plants</i>	To which plants of the competitor does the supplier deliver his goods? Do the supplier and the competitor go "local-for-local"? This means that the production processes of the supplier are transferred to another country, e.g., a low-cost country if the competitor opens a new plant there.
(3)	<i>Aftermarket deliveries</i>	Does the supplier deliver the aftermarket of the competitor directly?
(4)	<i>Turnover share and development</i>	How high is the share of the focal company's turnover at the supplier and how has it developed during the last years?
(5)	<i>Shareholdings and joint ventures</i>	Does a competitor own shares of the focal company's supplier or even has a joint venture with him? Especially shares of a low percentage are very interesting to find out for the purchasers, as they are not as known as joint ventures, which appear in public media.
(6)	<i>Contact Person and meetings</i>	Do the purchaser of the focal company and the purchaser of the competitor have a contact person on the same hierarchy level at the supplier? Do they maybe even share the same contact person? This would be a very difficult situation regarding the exchange of confidential information. Does the competitor achieve management attention from the supplier; is he invited to VIP-meetings? Are there any private relationships on top management-level between both companies? Such close relationships that have existed for years would be very hard to break up.
(7)	<i>Contracts and agreements</i>	Not only contracts between the competitor and his suppliers are interesting for the focal company, but also any other kind of agreement, such as logistics and tooling agreements. How are the payment terms and how is the transfer of risk fixed in the incoterms? Is there a forecast for the needs of the competitor?
(8)	<i>Cooperation strategy</i>	If a supplier is a cooperation partner, the company exchanges information with him on important topics, such as business strategies or marketing activities, on management level. This cooperation sometimes already has a long history. It is helpful to know this history and the roots of cooperation. In some cases, the cooperation between a competitor and his suppliers is fixed within a strategic cooperation agreement, which expresses the high mutual importance of the partners. Such agreements may decide, for instance, that referent engineers of the supplier are sent to the customer for a certain period of time in order to push common development projects.

(9)	<i>Dependency</i>	Does the competitor have alternative suppliers? A first approach to figure out the answer is to ask the supplier “Who are your competitors?” Each important competitor of the supplier might be a potential alternative supplier to the focal company's competitor.
(10)	<i>Supplier classification</i>	Concerning the supplier classification, the participants of the World Café are used to work with an ABCD-classification: A-suppliers are strategic partners and B-suppliers are alternative suppliers to them. C-suppliers describe developing suppliers, while D-suppliers will be phased out after the end of the ongoing project and will currently not get any future business.
(11)	<i>Supplier evaluation</i>	The supplier evaluation assesses the performance of a supplier at his customer. Does he show a comparable performance for the competitor as he does for the focal company? Evaluated parameters include, among others, the supplier reliability, e.g., measured by the ppm-rate, any awards as well as audit results.
(12)	<i>Technology exclusivity agreements</i>	If a supplier has an exclusivity agreement for new technologies with one customer, he always has to present his innovation to this customer first.
(13)	<i>Delivery scope</i>	Which products does the supplier deliver to the competitor? Are these identical or just similar products?
(14)	<i>Development projects</i>	Do the supplier and the competitor have common development projects with HR exchange, meaning that the supplier's referent engineer works in the competitor's facility to exchange with his engineers? Who applies for a patent for this development and owns the rights for it - the competitor, the supplier or both?
(15)	<i>Open-book for the competitor</i>	Is the supplier willing to provide an open-book calculation to the focal company's competitors? The relevant customer's market power usually influences the supplier's willingness to this open communication culture. However, if a purchaser knows that the supplier refuses an open-book policy to him but practices it with his competitors, he can confront the supplier with this fact and insist on it before signing a deal.
(16)	<i>Targets for the supplier</i>	Companies often measure their suppliers by targets without knowing how challenging these targets are in comparison to goals set by other customers. Consequently, it would be interesting to figure out their goals. If the competitors are less demanding regarding the ppm-rate, for example, the focal company might be able to realize higher sales prices as their purchased quality is better. The mentioned targets also involve the reactivity of the supplier to realize more or less volume. It is important to consider the goals set in order to properly compare the supplier's performance results in the supplier evaluation between different customers.

(17)	<i>Award decision process</i>	How does the competitor assign a project to his suppliers? Which criteria does he take into consideration and how does he rate price, quality and time to make his decision?
(18)	<i>Process optimization</i>	Common process optimizations between the supplier and the competitor in order to decrease product costs can also decrease the prices of the focal company for identical products.
(19)	<i>Production processes</i>	Does the supplier provide a whole production line and a dedicated team for the competitor? This information can often be achieved during visits to the supplier's production if the supplier marks the different areas of his production by the customer names.
(20)	<i>Innovations of the competitor</i>	Does the supplier offer his innovations with priority to the competitors? The decision which customer to prioritize might be influenced by the volume or the margin that the supplier hopes to realize with this dedicated customer.
(21)	<i>Logistic concepts</i>	The logistic concepts used by the supplier for the competitor give important details about their collaboration: Does the supplier use reusable packaging? Is the supplier able to manage the competitor's inventory (VMI)? Did he invest in a new consignment warehouse dedicated to the competitor?
*	<i>Unknown suppliers</i>	Purchasers show an interest in supplier-complementor relationships to learn about new suppliers in the meaning of market research.
*	<i>Supplier audit results</i>	A new supplier has to be audited before he can be released in a focal company. Sometimes he forwards the audit report of another comparable customer, e.g., a competitor or a complementor of the focal company, who has audited him before according to the same standards such as VDA 6.3. After a single case decision, this reference might avoid a new audit.
*	<i>Supplier flexibility</i>	Purchasers are confronted with time pressure, as their sales representatives often have already communicated fix delivery dates to their end-customers. Therefore, the reactivity and flexibility of the supplier regarding his customers are very important. By knowing the flexibility of the supplier towards the complementors, the purchasers of the focal company wish to detect who is the preferred customer for the supplier.
(22)	<i>Factory visit supplier</i>	During a factory visit at the supplier, the purchasers shall pay special attention to the production line as well as to the shipping area inside the warehouse in order to find out: To which other customers does the supplier deliver? Labels, customized packaging or special container management for one customer might provide this information.

(23)	<i>Supplier</i>	The supplier sometimes mentions customers on reference lists on his website or in his company presentations. If not, the purchasers of the focal company can ask the supplier's back-office staff who knows about delivery dates and quantities of deliveries to the competitor and who maybe has worked with both companies for years. Moreover, the supplier's sales representative might disclose the desired information, as he wants to sell his products. Project leaders and engineers at the supplier are further potential contacts. More information about existing relationships can be found in supplier self-assessments with non-disclosure agreements, in which other supplied competitors are mandatory information, as well as in audit reports by competitors, which are provided by the supplier.
(24)	<i>Exchange with colleagues</i>	Networking helps to achieve information, for example, from former employees, colleagues working at the competitors or the own engineers. Team meetings also provide an important platform to exchange with colleagues or rumors can circulate among colleagues in any other way.
(25)	<i>Competitor machine analysis</i>	A competitor machine analysis can provide the information which parts supplied by a shared supplier are mounted onto a competitor machine. Usually, either the competitor himself or an independent dealer publishes this kind of analysis or the focal company carries it out in the context of a technical benchmark.
(26)	<i>Internet</i>	In the Internet, suppliers publish reference lists containing the names of further customers; search engines display information on projects between different companies; dealer portals list supplier parts and link their original equipment manufacturer references; awards honor the successful cooperation between suppliers and their customers and supplier videos show customer machines working with their parts for marketing purposes.
(27)	<i>Fair visits</i>	Purchasers appreciate visiting fairs to examine the exhibition objects of their suppliers, competitors or complementors and to collect information material such as pictures and catalogs.
(28)	<i>Factory visit competitor</i>	A factory visit at the competitor would allow the focal company to analyze the competitor and to find out about his relationships with suppliers. However, to examine relationships in this direction is less common than a supplier visit on the opposite side.
(29)	<i>Specialized press</i>	Specialized press includes not only dedicated test reports and company magazines, but also product recalls appearing in other magazines. Moreover, annual reports indicate the supplier's turnover for each branch. If a purchaser reads in the report that his supplier makes 10 million € of turnover in the agricultural business, but he knows that he only purchases 1 million € thereof, he can deduce that the remaining 9 million € must be distributed among others.

(30)	<i>External consultants</i>	External consultants provide specific knowledge, e.g., on a specific market like Russia. They might be able to name the top suppliers owing production facilities in Russia and in an ideal case also their turnover with certain customers.
(31)	<i>Market activities</i>	Market changes or activities by competitors, suppliers or sub-suppliers are usually reported in the press or presented at conferences.
(32)	<i>Associations</i>	Industry associations (e.g., the German associations VDA, VDI or BME) meet regularly on conferences to exchange across different companies about the order situation and similar issues.
(33)	<i>Espionage</i>	Espionage is an illegal way to achieve information, yet frequently practiced, especially by hackers due to IT security lacks. However, it has also been proposed rather in the sense of observations: The forwarders of the focal company can observe how many loading meters of goods the other forwarders, working for competitors or complementors, charge at the same supplier.
(34)	<i>Software providers and industry</i>	Software providers like SAP or SupplyOn work for various companies and migrate their data. Therefore, they can quantify these companies' relationships.
*	<i>Complementors</i>	Complementors can serve as an information source in different ways. The achieved twelve points are a cumulated value of eight points given to an organized exchange with complementors, four points granted to the proposal to ask complementors who are willing to provide information and three answers that refer to complementors but achieved zero points each: benchmarking with complementors regarding supplier evaluations, workshops with the complementors and sales statistics of the complementors.
*	<i>Internet-based RfQ platforms</i>	The RFQ process can be designed openly via internet platforms where everyone can see which supplier bids for which projects according to which product specification sheet.
*	<i>Supplier self-assessment</i>	Supplier self-assessments provide information about the suppliers' customers as they contain confidentiality declarations.
*	<i>New employees</i>	New employees who have worked before at suppliers or complementors can provide information. The idea is to implement a standardized process under the responsibility of the HR department, which automatically identifies and interviews these employees about their former employer's relationships.
*	<i>Dealers and customers</i>	Dealers frequently offer end-products from a focal company and its complementors in their shops. Moreover, they have to purchase the spare parts for all end-products from the focal company and its complementors. Therefore, they see the branding on the parts and quite often know the suppliers who have manufactured these parts.

		Sometimes, an end-customer directly disassembles his machine and can also see and provide the same information.
(35)	<i>Change of risks</i>	A change of risk, e.g., the supply risk, triggers a high need for information about the supplier relationships. A high supply risk can be suspected if parts are tool-specific, in case of supplier insolvency or due to changes in the supplying company's property.
(36)	<i>Decreasing supplier performance</i>	The performance of a supplier will decrease, for instance, if his products have quality problems. This trend will also result in a bad supplier evaluation. Customers need to be aware of this negative trend in performance.
(37)	<i>Single source</i>	Single sourcing increases supply risk. In case of a disruption of the supplies, the customers of the supplier compete for the supplier's resources. Therefore, they need to know as concrete as possible which volumes the supplier delivers to which customers.
(38)	<i>Supplier and industry changes</i>	Supplier and industry changes can influence the need for transparency in the supply network. Such trends include e-mobility drive technology, the signature of a contract to extend a business relationship or a change in the supplier's strategy.
(39)	<i>Market structure</i>	Does the market structure show a monopoly or an oligopoly? If the focal company is a monopolist, it does not have to bother about relationships that might improve or endanger its situation. However, especially for small and medium-sized enterprises that are not market leaders, it is extremely important to capture their suppliers' relationships. On the other hand, if the supplier is a monopolist or an oligopolist, the market structure requires high transparency, because there are only a few suppliers available.
(40)	<i>Part criticality</i>	The part criticality signifies the percentage share of the part of the final product. Thus, an A-part like the gearbox or the engine for vehicles endangers the shipment of the final product to the customer significantly more than, e.g., attachment parts.
(41)	<i>Preparation of a negotiation</i>	If a supplier asks for a price increase, high transparency on his relationships is required. During the preparation of the corresponding negotiation, the purchaser of the focal company need to figure out: How many options does the supplier have? Does he deliver other customers or industries, as well?
(42)	<i>Strategic suppliers</i>	It makes a difference, if a supplier is selected only for a single project, or if he gets a long-term or even a lifetime contract and hence becomes a strategic supplier. If the purchaser of the focal company knows that such a contract exists for A-parts between one supplier and the competitor of the focal company, this might be a reason not to assign a new project to him. Moreover, during the acquisition phase of a strategic supplier or the beginning of a joint venture with him, the purchaser has to try to find out as much information about his relationships as possible.

(43)	<i>Part complexity</i>	The technical complexity of a part differentiates assemblies from standard parts. High transparency is needed for the suppliers of complex assemblies, while low transparency is sufficient for the suppliers of standard parts.
(44)	<i>Development projects</i>	Development projects in which both parties commonly work on high-level technologies, innovations and patents cause a high need for transparency.
(45)	<i>Market upswing</i>	If there is a boom in the market, the companies would like to know if the supplier has enough capacity to fulfill the orders of all customers. If not: Who is the preferred customer of the supplier?
(46)	<i>Complementor = competitor</i>	The complementor of a focal company can get into a competing position if he starts to sell his complementary products directly to end-customers, although the focal company sells these products to them.
(47)	<i>Product specification</i>	After the phase of product specification, the purchaser achieves his budget to source this part. In order to benchmark this target price and to get a better feeling for the supplier's manufacturing costs, he tries to find out: Which product delivered by which manufacturer at which price does the competitor use? The answers indicate if the own company is in line with the competitor's specification or if it has over- or underspecified the said part.
(48)	<i>Direct sourcing from manufacturer</i>	Parts that have been purchased from dealers, complementors or component suppliers before being relocated to their real manufacturers in order to reduce margin levels and to save purchasing costs. High transparency is necessary regarding potential exclusivity agreements between the manufacturer and the previous supplier of the parts.
(49)	<i>Supplier development</i>	Supplier development projects are run only with a few selected first-tier suppliers of the focal company. During such a project, the company matches its purchasing statistics with the data of the developing supplier to check how he manages his commodities, selects his suppliers, etc. (which consequently are the second-tier suppliers of the focal company). Such a project requires a high degree of effort and trust. Therefore, the purchaser wants to know first who the preferred customer of the developing supplier is. If this supplier also does huge business with the competitor of the focal company, he might not start the project as he does not want to exchange the relevant data.

Table 41: Glossary

Summary

The general quest for supply chain transparency is increasing and has extended beyond corporate boundaries in supply chains. Companies need extensive information on the organizations that might influence their market position and on the relationships between these organizations. To achieve this information, companies need to gain visibility into their own supply chains first. However, high visibility requires a significant investment of time and resources and there are several barriers to achieve it. Consequently, many companies still only have limited supply chain visibility today. In order to create the desired visibility on their supply chains, they started to develop appropriate tools like Supply Chain Mapping.

While prior research has studied the mapping of linear, vertical supply chains, this dissertation extends the view to the complex supply networks frequently occurring in practice. Hence, the first research objective is to figure out how a company may capture the structure of its supply network. Furthermore, previous researchers agree that transparency conceptually makes sense. However, only a few empirical studies have examined the procedure of how to establish supply chain transparency in practice. Consequently, this dissertation adds empirical research on the mapping procedure. Finally, current literature lacks evidence about the impact of supply network transparency and Supply Network Mapping on the purchasing performance. Hence, this dissertation assesses the cost savings and non-monetary benefits that purchasers can achieve through increasing supply network transparency and applying Supply Network Mapping.

To sum the major contributions of this dissertation up, it analyzes the geometry and unit of analysis in supply chain maps in order to transfer these insights to network level and to conceptualize a new holistic Supply Network Map Structure Model. Secondly, this dissertation reveals new findings regarding the mapping procedure. It proposes a generalized draft of the procedure and highlights the desired supplier relationship knowledge, most important information sources and contingency factors for the need for transparency. Furthermore, this dissertation investigates useful sourcing levers in addition to the mapping and presents two use cases for the application of Supply Network Mapping: cost and innovation leaders. Finally, the findings provide evidence that supply network transparency and Supply Network Mapping indeed lead to purchasing success and can be a useful aid for purchasers.

Samenvatting (Summary in Dutch)

De behoefte van bedrijven aan transparantie is toegenomen en reikt tot over de bedrijfsgrenzen in de toeleveringsketens of supply chains. Bedrijven hebben behoefte aan relevante informatie over organisaties die hun marktpositie kunnen beïnvloeden en over de relaties tussen die organisaties. Om deze informatie te verkrijgen, moeten bedrijven eerst inzicht krijgen in hun eigen toeleveringsketens. Een hoge zichtbaarheid vereist echter een aanzienlijke investering van tijd en middelen en er zijn verschillende obstakels om dit te bereiken. Bijgevolg hebben veel bedrijven tot op heden nog steeds slechts een beperkt zicht op hun toeleveringsketens. Om de gewenste zichtbaarheid op hun toeleveringsketen te creëren, zijn verschillende bedrijven begonnen met het ontwikkelen van geschikte tools zoals Supply Chain Mapping.

Terwijl eerder onderzoek zich heeft gericht op het in kaart brengen van lineaire, verticale toeleveringsketen, breidt dit proefschrift het beeld uit naar de complexe toeleveringsnetwerken, die in de praktijk veel voorkomen. Daarom is het eerste onderzoeksdoel om erachter te komen hoe een bedrijf de structuur van zijn toeleveringsnetwerk kan vastleggen. Verder zijn eerdere onderzoekers het erover eens dat transparantie conceptueel zinvol is. Niettemin hebben slechts enkele empirische studies de procedure onderzocht hoe transparantie in de toeleveringsketen in de praktijk kan worden bewerkstelligd. Bijgevolg levert dit proefschrift een empirisch bijdrage aan de mapping-procedure. Ten slotte ontbreekt het in de huidige literatuur aan inzichten ten aanzien van de impact van de transparantie van het aanbodnetwerk en de allocatie van het aanbodnetwerk tot de inkoopprestaties. Dit proefschrift presenteert daarom de kostenbesparingen en de niet-monetaire voordelen, die kopers kunnen bereiken door de transparantie in het toeleveringsnetwerk te vergroten en door Supply Network Mapping toe te passen.

De belangrijkste bijdragen van dit proefschrift zijn samengevat, ten eerste, de analyse van de geometrie en de analyse-eenheid in toeleveringsketen-kaarten om deze inzichten vervolgens te projecteren op netwerkniveau en door een nieuw holistisch Supply Network Map Structure Model te conceptualiseren. Ten tweede onthult dit proefschrift nieuwe bevindingen met betrekking tot de mapping-procedure. Het stelt een algemeen ontwerp van de procedure voor en benadrukt de gewenste kennis van leveranciersrelaties, de belangrijkste informatiebronnen en onvoorziene factoren voor de behoefte aan transparantie. Verder onderzoekt dit proefschrift naast de mapping, nuttige sourcing-hefbomen en presenteert het twee praktijkcasussen voor de toepassing van Supply Network Mapping op het gebied van kosten en innovatie. Ten slotte leveren de bevindingen bewijs dat transparantie van het aanbodnetwerk en Supply Network Mapping inderdaad tot aankoopsucces leiden en een nuttig hulpmiddel kunnen zijn voor inkopers.

INCREASING SUPPLY NETWORK TRANSPARENCY: STRUCTURE MODEL, MAPPING PROCEDURE AND PERFORMANCE IMPACT

The general quest for supply chain transparency is increasing and has extended beyond corporate boundaries in supply chains. Companies need extensive information on the organizations that might influence their market position and on the relationships between them. However, high visibility requires a significant investment of time and resources and there are several barriers to achieve it. Consequently, many companies still only have limited supply chain visibility today. In order to create the desired visibility on their supply chains, they started to develop appropriate tools like Supply Chain Mapping.

This dissertation analyzes supply chain maps in order to transfer these insights to network level and to conceptualize a new holistic Supply Network Map Structure Model. Secondly, this dissertation proposes a generalized draft of the mapping procedure and highlights the desired supplier relationship knowledge, most important information sources and contingency factors for a high need for transparency. Furthermore, this dissertation investigates useful sourcing levers in addition to the mapping and presents two use cases for the application of Supply Network Mapping: cost and innovation leaders. Finally, the findings provide evidence that supply network transparency and Supply Network Mapping indeed lead to purchasing success and can be a useful aid for purchasers.



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