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Christian F. Durach

A Theoretical and Practical Contribution to Supply Chain Robustness

Developing a Schema for Robustness in Dyads

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Content Overview

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List of Abbreviations

ASV	Average Shared Variance
AVE	Average Variance Extracted
BME	German Association Materials Management Purchasing and Logistics
BSC	Business Source Complete
CFA	Confirmatory Factor Analysis
CFI	Confirmatory Fit Index
CMV	Common Method Variance
CR	Composite Reliability
DM	Disruption Management
DMAssetInvest	Buyer Relation-Specific Disruption Management Asset Investment
DMComplementarity	Relational Disruption Management Complementarity
DMKnowSharing	Relational Disruption Management Knowledge Sharing
DV	Dependent Variable
DyDMPerf	Buyer Dyadic Disruption Management Performance
EFA	Exploratory Factor Analysis
ETA	Estimated Time of Arrival
FormalDMGov	Formal Disruption Management Governance
GFI	Goodness-of-Fit Index
HTMT	Heterotrait-Monotrait
IF	Impact Factor
InformalDMGov	Informal Disruption Management Governance
ISIC	International Standard Industrial Classification
IV	Independent Variable

MECE	Mutually Exclusive and Commonly Exhaustive
MSV	Maximum Shared Variance
NGT	Nominal Group Technique
Re-deplDMPerf	Buyer Re-deployable Disruption Management Performance
RMSEA	Root Mean Square Error of Approximation
RO	Research Objective
RV	Relational View
SCI	Supply Chain Integration
SCM	Supply Chain Management
SLR	Systematic Literature Review
SRMR	Standardized Root Mean Square Residual
US-SIC	United States Standard Industrial Classification

1 Introduction

Despite almost a decade of research on disruptions in supply chains, recent developments suggest that this area remains as topical as ever (Sáenz and Revilla, 2014). As Christopher and Holweg (2011) reported, many current supply chain configurations seem to no longer fit the context they now operate in, and they argue that most current supply chain management (SCM) concepts still emanate from a period of relative stability. This now poses a mismatch against an increasingly unstable environment, resulting in a heightened vulnerability of such networks. For example, Aon Risk Solution's 2013 survey among 1,415 firms report that loss of income for global firms due to supply chain disruptions has increased from 28 percent in 2011 to 42 percent in 2013 (McGill, 2013). A recent study by the German Association Materials Management Purchasing and Logistics e.V. (BME) among 182 firms supports this notion, showing that more than 76.2 percent of polled firms are faced with increasing risks in their supply chains (Wittenbrink and Gburek, 2015).

Broadly defined, *supply chain disruptions* are understood as "*unplanned and unanticipated events that disrupt the normal flow of goods and materials*" (Craighead *et al.*, 2007, p. 132). Multiple practical examples in this century demonstrate the impact of supply chain disruptions quite plainly. In 2000, Ericsson, the Swedish multinational provider of communication technology and services, lost € 400m after a plant of Philips, its semiconductor supplier, caught fire (Norrman and Jansson, 2004). In 2001, the British car manufacturer Land Rover had to lay off 1,400 workers after their main supplier of chassis frames for the popular Discovery vehicles became insolvent and production could not be continued without parts (Sheffi and Rice Jr., 2005). In 2007, Aston Martin, also a British manufacturer of luxury cars, had to recall more than 5,000 cars after its supply chain quality control failed and a tier-three supplier used counterfeit material for throttle pedals (Farnham, 2014). The same year, Mattel, an American multinational toy manufacturer, had to recall over 18 million toy cars because its subcontractor used paint from unauthorized suppliers which contained high levels of lead (Sodhi and Tang, 2012).

In the effort to build supply chains that are capable of dealing with such supply chain disruptions, literature concentrates on strategies such as agility (e.g. Braunscheidel and Suresh, 2009; van Hoek *et al.*, 2001), robustness (e.g. Klibi *et al.*, 2010; Vlajic *et al.*, 2012) and resilience (e.g. Pettit *et al.*, 2013; Sheffi and Rice Jr., 2005). Agility is a supply chain strategy that is usually understood as a quick adjustment of the network in order to cope with disruptions ex-post to their occurrence. Robustness, as a second

concept is rather proactive in nature. Robust supply chains implement measures ex-ante to the disruptive event, decreasing the supply chain's vulnerability to such events. Christopher and Rutherford (2004, p. 24) state that a "*resilient supply chain is certainly robust*" and that a "*resilient supply chain must also be adaptable*," thus suggesting that resilience is a combination of agility and robustness.

Research has long shown that robustness is a highly promising strategy. Robustness is the only of these two strategies that has been shown to have a direct positive relationship with business performance (Wieland and Wallenburg, 2012). Agility, on the other hand, is only indirectly related with business performance, as it, just like robustness, increases the customer value which in turn increases business performance. Though, a direct performance gain through agility has not been detected.

Imagine a supply chain that only reacts to disruptions after their occurrence; such a supply chain will certainly outperform an idle supply chain but then again initial interruptions to its operations have to be implicitly accepted, something a robust supply chain is designed for to prevent. This discovery, however, has not yet been reflected in the tenor of recent research in the area of supply chain risk management. A plethora of studies still focus on agility. Recognizing this grievance, Colicchia and Strozzi (2012) call for more research on supply chain robustness.

> *"Although most researchers would agree that supply chains are inherently risky, one issue remains relatively unexplored; that is: a practical perspective to improve supply chain robustness […] in order to deal with unexpected events."* (Colicchia and Strozzi, 2012, p. 415)

Jüttner *et al.* (2003, p. 201) define supply chain risk management as the "*identification and management of risks for the supply chain, through a co-ordinated [sic] approach amongst supply chain members, to reduce supply chain vulnerability as a whole*". Contrary to this definition, the aforementioned BME study has also shown that, in their efforts to increase supply chain robustness, the majority of the firms studied still solely count on intra-organizational risk management measures, seeking to reduce a firm's exposure to the supply chain partners. Such measures include insourcing, increased inventory levels or operational slack and usually act as shock absorbers. While these measures should not be disregarded, as they have proven to be efficient in multiple instances (Norrman and Jansson, 2004), they undermine managers' efforts to improve cost efficiency (Chopra and Sodhi, 2014; Gudehus and Kotzab, 2012).

Taking the preceding discussion into view, one can clearly see a mismatch between intra-organizational risk management foci and the needs of managers to adhere to cost savings through a supply chain orientation. Supply chain managers have therefore started to also expand their risk management focus to the strategic management of supply chain relationships (Bode et al., 2011; Käki et al., 2015). This focus expansion goes hand in hand with observations made during recent industry projects conducted at the department where this thesis has been written. In line with Jüttner *et al.*'s (2003) definition of supply chain risk management, several firms that had taken part in these projects started looking at their supply chain partners as part of their supply chain risk management practices. Such firms understand their supply chain relationships as being instrumental in dealing with supply chain disruptions. One executive from a multinational chemical firm even pointed out that: *"Today, we can no longer manage disruptions in our supply chain independently. We heavily rely on our suppliers with which we seek to find joint coping strategies*."

This observation, however, has not yet been reflected in the literature stream on supply chain disruption management and robustness. Literature in the area of supply chain risk management still often looks at intra-organizational management approaches such as multiple sourcing (Costantino and Pellegrino, 2010), increasing operational slack (Azadegan *et al.*, 2013) or building strategic stock (Tang, 2006). It thereby misses out on the theoretical and practical value of studying relational determinants[1] in supply chain relationships which facilitate more robust supply chains.

1.1 Research Objective and Approach

Two things are notable from the discussion lead in the introduction. First, while robustness has been shown to have its merits over agility, research on building supply chain robustness is still lacking behind research on supply chain agility. Second, management research on supply chain disruption management often focus on intra-organizational, shock absorbing strategies, while current trends in supply chain management require to also include a more inter-organizational focus.

It is the overall goal of this thesis to narrow these gaps by consolidating current research on supply chain robustness, and proposing a schema of buyer-supplier relational determinants which supports managers in making their supply chain relationships more effective so as to increase supply chain robustness. In order to achieve this over-

[1] Within the scope of this thesis, relational determinants are understood as factors that rest within a buyer-supplier relationship, facilitating the dyadic management of supply chain disruptions and increasing supply chain robustness.

all goal, four research steps have been followed, which will be explained in the present sub-chapter. In its conclusion, the thesis will then tie together the findings from these four research steps and propose a recapitulatory dyadic disruption management schema. Drawing on Bode *et al.* (2011), *dyadic disruption managemen*t is defined as the management of supply chain disruptions through a buying-firm's use, modification and governance of supplier relationships. The schema is to be seen as a design element for buyer-supplier relationships, depicting the relational determinants in disruption management and their impact on the reduction of supply chain disruptions in order to increase the buying-firm's supply chain robustness.

The recapitulatory schema will portray the proposed and tested relational determinants. While the first half of the thesis provides the basis for understanding the status quo of research on supply chain robustness, the second half researches the role of supplier relationships in managing disruptions for the buying-firm.

In detail, several researchers have already suggested supporting ideas and concepts of supply chain robustness. However, there is still a huge gap when it comes to understanding the dimensions, antecedents, and moderators of the construct. Research has not yet sought to establish a comprehensive theoretical basis for supply chain robustness which connects the insights and information available in the literature.

As a first step, this thesis therefore seeks to address this gap by developing a conceptual framework which highlights antecedents and dimensions of supply chain robustness. The identification of antecedents will help us to understand which factors enable the effective implementation of supply chain robustness measures. The identification of dimensions, meanwhile, will help to build a formal definition of the construct of supply chain robustness. In this research step the systematic literature review (SLR) methodology will be applied to identify, analyze and synthesize literature pertinent to the field. However, before doing so, this thesis has to develop refined guidelines for conducting SLRs in SCM.

Pioneering research on guidelines for conducting SLR in the field of medicine already been conducted by Mulrow (1987). However, research conducted by Tranfield *et al.* (2003) raised concerns that a blunt adoption Mulrow's (1987) guidelines in SCM is questionable with respect to its applicability, calling for a further refinement of such guidelines. An initial attempt at refined guidelines was later put forward by Denyer and Tranfield (2009). In 2012, Seuring and Gold (2012) published a meta-review of SCM-related literature reviews, revealing a remarkable lack of rigor in reviews in the field of

SCM; giving rise to concerns of a still prevalent lack of rigorous guidelines in the field of SCM. This in turn prompted an immediate call for improvements in SCM review endeavors, as it is doubtful whether inferences made from studies with insufficient reliability and validity can help in advancing the field of SCM. Until now, this call has remained unanswered.

As a first step, this thesis will thus set out to develop refined guidelines for conducting SLRs in SCM. Leading to the first research objective (RO):

> **RO 1:** *Develop refined guidelines for conducting systematic literature reviews in supply chain management to foster methodological coherence in the discipline and further improve the scope, impact, and quality of systematic literature reviews.*

Only after having developed these guidelines, can this thesis move forward, in a second step, to identifying antecedents and dimensions of supply chain robustness. Antecedents enable the effective implementation of robustness measures; dimensions of supply chain robustness will eventually allow for the provision of a still missing formal definition of the construct. Thus the second research objective is formulated:

> **RO 2:** *Develop a comprehensive conceptual framework that highlights antecedents and dimensions of supply chain robustness.*

Jumping ahead to the results of this research step, one will see that supply chain robustness can be achieved through intra- and inter-organizational robustness antecedents. The thesis will then “drill down” into the inter-organizational aspect of supply chain robustness. An original schema of buyer-supplier relational determinants will be developed, which depicts factors that increase supply chain robustness through the use, modification and governance of supplier relationships. The relational view (RV) perspective by Dyer and Singh (1998) will be analyzed and elaborated on, as to its usefulness for providing a theoretical footing in this endeavor.

Even though researchers in the broad field of SCM have increasingly focused on buyer-supplier relationships as a source of competitive advantage over the past 20 years, this same focus could not be identified in the subfield of supply chain risk management. Scholars, who research the value of supply chain relationships, often draw on the RV perspective to explain value creation in dyads. The RV suggests that the resources that give a firm a competitive advantage may extend beyond the firm’s boundaries into its network. That is, a firm can gain a competitive advantage from being embedded in a

network of firms. Extant literature on supply chain integration and supplier development provides encouraging signs that this theoretical perspective might also add value to supply chain disruption management between buying and supplying-firms. However, it is yet not clear what relational determinants enable buying firms to have a successful disruption management with their suppliers. This thesis therefore sets out to reconcile the theory with the idiosyncrasies of disruption management in buyer-supplier relationships. Following the concept of theory elaboration, RO 3 is to find a refined understanding of the usefulness of the relational determinants proposed in the RV as a theoretical lens in disruption management. Drawing on inductive reasoning, a qualitative approach will be followed to move from specific empirical observations to broader generalizations on the applicability of the RV in disruption management:

> **RO 3:** *Theorize what determinants in buyer-supplier relationships can be used by buying-firms to facilitate its supply chain robustness.*

The results from RO 3 will highlight the importance of the RV perspective in disruption management, providing a theoretical model for its applicability in supply chain disruption management. The results indicate that the determinants of relational rent, as proposed in the RV perspective, also bear practical and theoretical value in a supply chain disruption management context. The findings offer a useful picture about the value of buyer-supplier relationships in disruption management, and provide indications of the impact of the four relational determinants.

In order derive more reliable inferences from the identified relational determinants and their relationship with successful dyadic disruption management, RO 4 will develop a hypothetico-deductive model, testing it in an empirical, quantitative context. In this step, the thesis will develop the RV perspective further and argue that the benefits of the identified relational determinants cannot completely be tied to a single relationship. It is hypothesized that the buying-firm can to a lesser degree use such relational benefits to improve their disruption management with other partners. Leading to the fourth research objective:

> **RO 4:** *Test the value of the determinants proposed in the relational view theory in a dyadic disruption management context, and identify what governmental mechanisms can be employed by buying-firms to make best use of their supplier relationships.*

In its conclusion, the present thesis will provide refined guidelines for conducting SLRs in SCM, a conceptual framework for supply chain robustness as well as a set of four relational determinants. It will culminate in an original schema of buyer-supplier relational determinants that depicts the factors in a relationship which are necessary to increased supply chain robustness. The thesis is intended to further the research community's and managers' understanding of factors in a buyer-supplier relationship necessary to facilitate disruption management.

1.2 Outline of the Thesis

Figure 1 depicts the overall structure of the present thesis. It consists of eight chapters, addressing the four main research objectives in chapters 3 to 6. Besides the introductory section, the thesis incorporates a delimitation and definitional framing (chapter 2), a conceptual study on developing guidelines for conducting SLRs in SCM (chapter 3), a literature review on dimensions and antecedents of supply chain robustness (chapter 4), a qualitative study on elaborating the RV perspective to reconcile with the idiosyncrasies of the disruption management field (chapter 5) and a structural equation model to test the determinants of the RV in supply chain disruption management (chapter 6). Chapters 3 to 6 are written in the form of standalone articles. The chapters build upon each other, as identified research opportunities are picked up by later chapters. Chapter 7 culminates in the proposing of a recapitulatory dyadic disruption management schema that visualizes the common thread of chapters 3 to 6. Chapter 8 closes with a summary of the main findings as well as with a discussion of limiting factors and avenues of further research.

The methodological development of the thesis follows an iterative process of inductive and deductive reasoning. It incorporates four different qualitative and quantitative methods in order to address the overall research goal: systematic literature reviews, nominal group technique, case studies and structural equation modeling. Chapter 3 uses a literature review in order to conceptualize guidelines that show how SLRs can be properly conducted to serve as a useful tool to advance the field of SCM. Departing from previous studies in the field, this chapter does away with a singular focus on the analysis phase and includes all other necessary research steps of an SLR. Thus, it is able to provide comprehensive guidelines for increasing thoroughness and coherence in the methodological process. Chapter 4, in order to generate an overview of existing research in the area of supply chain robustness, sets out to conduct an SLR following the proposed guidelines. The findings from chapter 4 set the scene for conducting further research on supply chain robustness using an inter-organizational perspective.

Chapter 5 elaborates on the theoretical framework of an existing theory (i.e. the RV, borrowed from management science)[2] in a supply chain disruption management context. By collecting empirical data from case studies and group exercises (following the nominal group technique) it attempts to make sense of the data post factum. Chapter 6 follows a deductive approach to test the RV in an inter-organizational disruption management context. This chapter provides clear guidance for the value of each of the proposed four determinants, and therefore provides a main building block of the recapitulatory schema in chapter 7.

[2] The research field of logistics and supply chain management has been criticized for not having many theories, suggesting that borrowing theories from related disciplines might be a fruitful endeavor (Huynh, 2013).

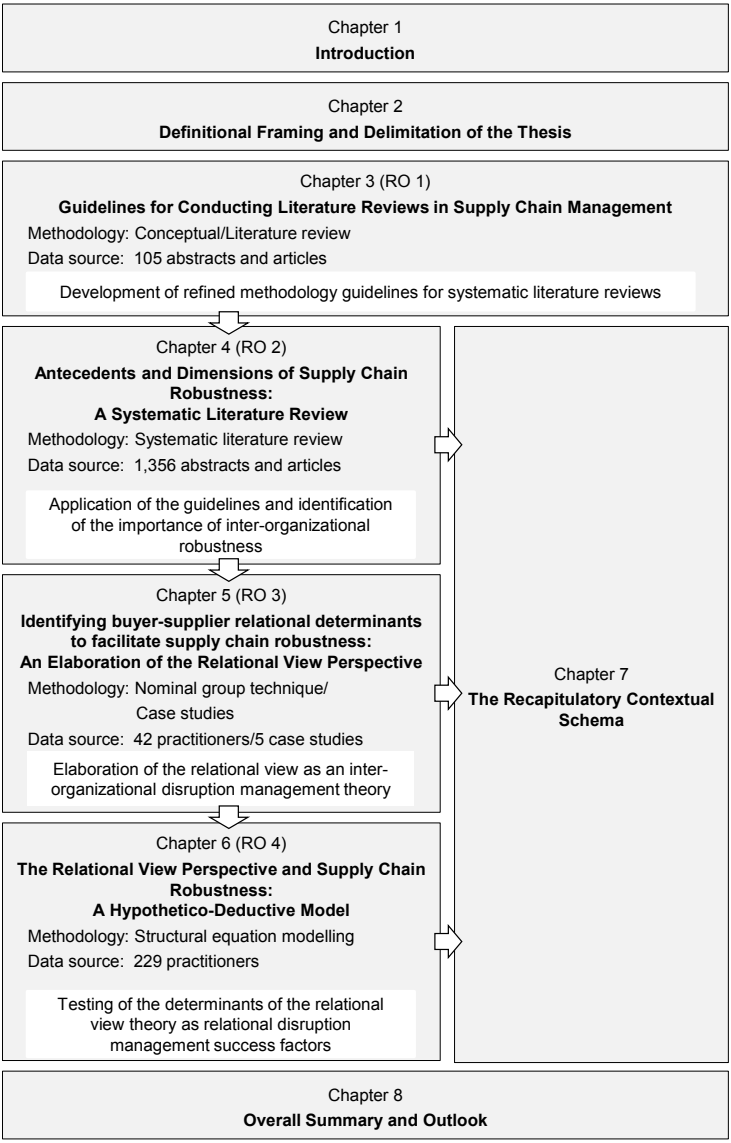

Figure 1 Thesis Structure

2 Definitional Framing and Delimitation of the Thesis

This chapter briefly provides the definitions necessary to understand both context and framing of the present thesis. Due to the thesis's cumulative nature, further definitions necessary to comprehend the individual chapters, will be provided in due course of each chapter. Chapter 2 also serves to delimit the research field as to the functional areas addressed in this thesis. Further delimitations regarding the unit of analysis are provided in each chapter.

2.1 Supply Chain Management and Logistics

The debate about the differences of SCM and logistics has been subject to years of discussion. To this day, the academic literature still often draws on complex words to seek an unambiguous differentiation between both terms, often amplified by linguistic backgrounds, to agree in principle that no common perspective on the definition can be agreed upon.

2.1.1 Perspectives on Supply Chain Management versus Logistics

About a decade ago, Larson and Halldorsson (2004) conducted a survey among 98 logistics educators in Asia, Europe, North America and South America. Based on their perceptions, the researchers identified four perspectives on SCM versus logistics:

- traditionalist,
- re-labeling,
- unionist, and
- intersectionist.

The **traditionalist school** positions SCM within logistics, seeing it as a subset of logistics (Gudehus, 2007; Gudehus and Kotzab, 2012). Advocates of this perspective view SCM as "*logistics outside the firm to include customers and suppliers*" (Lambert, 2008, p. 287). This reduces SCM to a subtype of logistics, external logistics, understanding SCM as a refined body of rules to manage logistical networks (Straube, 2004).

The **re-labeling school** simply changes the names; what was logistics is now SCM. For example, in 2005 the Council of Logistics Management followed this trend and renamed itself the Council of Supply Chain Management Professionals. This school has increasingly gained in importance in today's globalized world (Nilsson and Gammelgaard, 2012).

The **unionist school** is quite the contrary to the traditionalist school, as it sees logistics as being a part of SCM. In this perspective, SCM "*subsumes many traditional business functional areas, including purchasing, logistics, operations, and marketing*" (Larson *et al.*, 2007, p. 4).

The **intersectionist school** is somewhat more complicated, as it understands SCM as a strategy that cuts across business processes that are partly attributed to logistics. Clearly delimited definitions of both concepts are yet required to identify the intersecting functions. Generally speaking, SCM is understood as all coordinating cross-functional strategic activities with network partners, while at the intersection logistics is involved in negotiating with potential partners.

A schematic representation of the perspectives is shown in Figure 2.

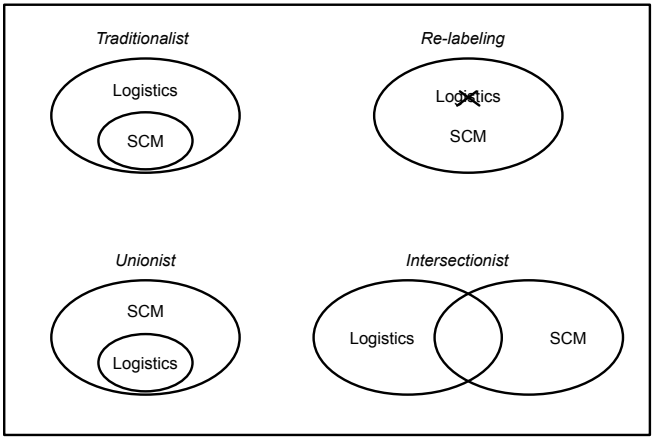

Figure 2 Perspectives on SCM vs. Logistics (Source: Larson and Halldorsson, 2004, p. 19)

A clear trend towards adopting the re-labeling school is experienced in English speaking literature, making it a common view amongst a plethora of scholars (Nilsson and Gammelgaard, 2012). This thesis will therefore follow this trend, and make no explicit distinction between the terms SCM and logistics; making primary use of the term SCM. The following sub-chapter will further detail this thesis's understanding of the term SCM.

2.1.2 Defining Supply Chain Management

The term "supply chain management" can be traced back to Oliver and Webber (1982).[3] In order to solve conflicts of interest along the supply chain, the authors saw the need to bring logistics to the top management level. Thereafter, Pine and Davis (1999) and others identified that long-term supplier relationships can help to reduce costs and foster joint process innovation. What is today known as the philosophies of 'lean management' and 'integrated logistics' can be seen as precursors of today's SCM.

Despite an increasing interest in the SCM discipline, no clear definition has yet emerged. This is partly attributed to the still lacking theory of the supply chain (Carter *et al.*, 2015). The following Table 1 provides an overview over the development of the term in the previous two decades:

Table 1 Definitions of Supply Chain Management

Source	Definition
Johannson (1994, p. 525)	*"SCM is really an operations approach to procurement. It requires all participants of the supply chain to be properly informed. With SCM, the linkage and information flow between various members of the supply chain are critical to the overall performance of the supply chain."*
Mentzer *et al.* (2001, p. 18)	*"The systemic, strategic coordination of the traditional business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole."*
Christopher (2005, p. 5)	*"The management of upstream and downstream relationships with suppliers and customers to deliver superior customer value at less cost to the supply chain as a whole."*
Simchi-Levi *et al.* (2007, p. 1)	*"Supply Chain Management is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses and stores, so that merchandise is produced and distributed at the right quantities, to the right locations, and at the right time, in order to minimize systemwide costs while satisfying service level requirements."*

[3] A first theory that recognizes the integrated nature of organizational relationships was already put forward by Forrester (1958).

Stock and Boyer (2009, p. 706)	*"The management of a network of relationships within a firm and between interdependent organizations and business units consisting of material suppliers, purchasing, production facilities, logistics, marketing, and related systems that facilitate the forward and reverse flow of materials, services, finances and information from the original producer to final customer with the benefits of adding value, maximizing profitability through efficiencies, and achieving customer satisfaction."*

The diversity of these definitions reflects the diversity of perceptions towards this field. Johannson (1994) views SCM from a mere buyer-supplier perspective, and mainly focuses upon the provision of information to the supplier. Mentzer *et al.* (2001) developed this further, understanding SCM as the strategic coordination of intra- and inter-organizational processes, looking at the construct from a pure management function. Christopher (2005) takes a mere coordinative approach in SCM and addresses its relational aspects, seeing it as the management of relationships up- and downstream from the focal firm. Simchi-Levi *et al.* (2007) then provides a very broad definition, seeking to integrate different functions along the supply chain, addressing the logistical variables of quality, costs and time. In 2009, Stock and Boyer (2009) eventually compiled over 1,000 publications and definitions in order to derive their embracing definition. They detail essential parts of SCM, and emphasize on the management of relationships between and within firms. While it is somewhat similar to previous definitions, it also takes into account interdependencies between the supply chain partners. Moving forward, this thesis will make use of Stock and Boyer's (2009, p. 706) definition of SCM, seeing it as "*[t]he management of a network of relationships within a firm and between interdependent organizations […] that facilitate the forward and reverse flow of materials, services, finances and information from the original producer to final customer […].*"

2.2 Supply Chain Risk Management and Disruptions

The previous sub-chapter discussed different perspectives on SCM and logistics and outlined the definition of SCM as used in the present thesis. It is being highlighted that SCM seeks to increase customer satisfaction and profitability through actively managing a network of relationships. In this sense, supply chain risk management resembles a fundamental pillar of a successful SCM.

This sub-chapter now seeks to further the reader's understanding of supply chain risk management and its functional positing in a firm, thereby delimiting the functional focus

of this thesis. Thereafter, the need for decoupling re-current and disruptive events when managing supply chain risks will be highlighted, showing that this thesis will focus on the latter.

2.2.1 Supply Chain Risk Management and its Functional Positioning

Going back to Jüttner *et al.*'s (2003, p. 201) definition of supply chain risk management, as given in the introduction, supply chain risk management is understood as the whole process of identifying and managing risks. Manuj and Mentzer (2008) took this understanding a step further and developed a whole conceptual framework around the term. They tied together literature from disciplines such as logistics (including SCM), operations management and international business to propose a five-step risk management process. Those steps are (1) risk identification, (2) risk assessment and evaluation, (3) risk management strategy formation, (4) strategy implementation, and (5) risk mitigation. In step 1, firms identify all potential risks in their supply chain. In step 2, they seek to identify what risks identified in the previous step are critical for their supply chain. Thereafter, in step 3, an appropriate strategy to manage the risks has to be selected. The selection of such a strategy should be in line with the supply chain strategy of the firm. Step 4 is concerned with the implementation of the risk management strategy selected in step 3; a step that might require certain structural, and/or procedural changes in the firm. As not all risks can be mitigated, step 5 includes planning for situations with potential losses caused by unexpected events. While this thesis touches upon all five of these steps, it mainly falls into the perhaps less studied category of (3) risk management strategy formation. It seeks to propose an original schema for dealing with supply chain risks on an inter-organizational level, contributing a new idea to the array of already existing concepts in this area.

Supply chain risk management commonly plays a role in both system-planning/development and system-operations. Even though the schema to be development in this thesis, will mainly address the layers of system-planning/development, the importance of the risk management task commonly affects all management layers, as depicted in Figure 3.

Drawing on Arnold *et al.* (2008) and Straube (2004), research and practice usually structure logistical subtasks into normative, strategic, tactic and operative phases. With respect to supply chain risk management the normative layer provides for the definition of norms and guidelines of all risk related activities, as well as a general definition of the overarching goal. Besides quantitative goals, such as Plowman's (1964) seven

rights, the normative layer also provides for qualitative SCM goals such as commitment or informational transparency towards supply chain partners. The norms and guidelines offer unambiguous rules for the behavior of the organization itself as well its individuals. In crafting this layer, firms have to align them with the organizational vision and mission, in order to achieve internal consistency. Due to its goal of positing the firm towards its supply chain partners, the normative layer provides an important design parameter for supply chain risk management.

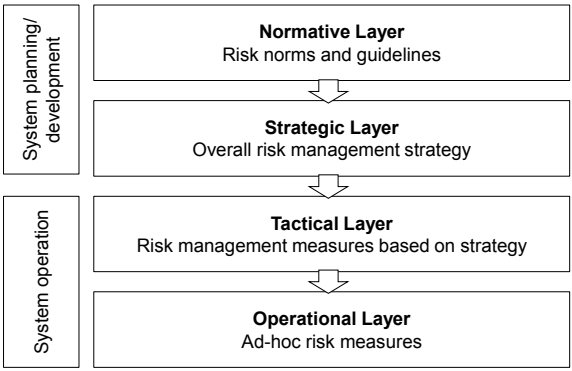

Figure 3 Functional Positioning of Supply Chain Risk Management

The strategic layer builds upon the normative layer. The norms and guidelines defined in the normative layer are the operational basis for strategic decision making. The strategic layer positions a firm's supply chain risk management within its business strategy. This includes an overall decision towards the strategic direction of seeking agility or robustness, including traditional make-or-buy decisions as well as supplier selection processes. It therefore provides a second, important design parameter for this thesis's main objective.

The strategic layer provides the basis for the tactical layer, which deals with system configuration. It is usually associated with demand planning and resource deployment, as well as the resulting measures that need to be implemented according to the strategic directive (e.g. increase stock keeping, improve relationships or choose multiple sourcing). According to ISO 31000:2009 the coordination and application of resources is an essential element of a successful risk management.

Lastly, the operational layer incorporates tasks of transactional everyday business. Individuals are expected to act according to the processes defined in the above dis-

cussed layers. Unexpected short-term events may require short-term adjustments of the system to uphold the flow of material. While the individual short-term measures in this layer are an essential part of supply chain risk management, they do not fall into the focus of this thesis. However, they will provide an essential part of a broader discussion on theory elaboration in chapter 5.

2.2.2 Re-current and Disruptive Supply Chain Risks

Until now, no cross-disciplinary definition of the term “risk” has emerged. In defining the term, some researchers focus on the mere deviation from an anticipated situation, seeing risk as both danger and opportunity (Jüttner *et al.*, 2003). This definition is mainly applied in decision theory and finance literature. A more intuitive definition, however, is that risk inherits primarily negative consequences, equating the term with damage or loss resulting from a supply chain disruption. Rao and Goldsby (2009, p. 100), for example, define risk as “*the potential for unwanted negative consequences to arise form an event or activity*;” an understanding that will be followed in this thesis.

Risks are highly heterogeneous in their characteristics and emerge from a variety of sources. From a SCM perspective it is thus difficult to discourse on “risks” and general procedures of their mitigation. Kleindorfer and Saad (2005), for example, argue that that there are two broad categories of risk affecting supply chains. Risks arising from the problems of coordinating supply and demand, and risks arising from disruptions to normal activities. Chopra *et al.* (2007) elaborated on this matter and recommended that managers need to decouple re-current and disruptive supply chain events when planning appropriate risk mitigation actions. Recurrent risks are associated with scheduling errors and forecast risks, while disruptive risks correspond to the interruption of material flow in the supply chain.

Abundance of research has yet focused on how supply chains can mitigate recurrent risks. Unfortunately, as Chopra and Sodhi (2014) point out, a blind eye has yet been turned to the fact that supply chain managers are often well aware of their re-current risks, while they have the tendency to underestimate disruptive risks. The lack of research on disruption management is all the more surprising regarding the disruption management figures presented at the outset of the present thesis. In light of this development, this thesis will restrict the development of its main schema to the management of disruptive risks. Disruptive supply chain events, as understood in this thesis, may include transport interruptions (caused by traffic, weather etc.), insufficient supplier

capacity, misaligned processes or any other upstream event that originates in the supply chain and disrupts the flow of material to the buying-firm.

As it has been indicated in the introduction, supply chain disruptions arise from the vulnerability of interconnected flows of material in networks. Though there are exceptions, even in geographically, politically and economically stable locations, firms are exposed to disruptions. Especially firms that deal with the physical manufacturing of products are highly dependent on external sources (Pfeffer and Salancik, 1978), i.e. suppliers and suppliers' suppliers. Such firms consequently have to expose themselves to network risks. Supply chain disruptions, as defined in this thesis, involve at least two tiers in the supply chain. The smallest unit of analysis for research on inter-organizational relational determinants to facilitate disruption management would therefore be the dyad, or the buyer-supplier relationship. In developing its schema in chapters 5 and 6, this thesis will therefore have the dyad as its unit of analysis.

Concluding this chapter, Table 2 depicts the delimitations of the present thesis.

Table 2 Thesis Delimitation

Categories	**Manifestation**				
Event	*disruptive*		*re-current*		
Strategy	*robustness*		*agility*		
Predictability	*high*	*medium*	*low*		
Origin	*endogenous*	*exogenous*	*internal*		
Strategy Focus	*upstream (supply base)*	*internal*	*downstream (customer)*		
Risk management process	*identification*	*assessment*	*management strategy formation*	*strategy implementation*	*mitigation*
Firm Units	*manufacturer*	*service provider*	*retailer*	*others*	

Note, chapter 4 also includes disruptions that stem from internal processes. Only after an extensive literature review (see chapter 4), the thesis will be able to "drill" deeper and limit itself to disruptions stemming from endogenous and exogenous sources, seeking to identify buyer-supplier relation determinants to facilitate a buying-firm's sup-

ply chain robustness. Table 2 thus highlights the “internal” focus in light grey upward lines. The same holds true for the category “strategy focus”. While the original schema, being developed in chapters 5 and 6, focuses on buyer supplier relationships, chapter 4 still shows the value of intra-organizational robustness.

3 Guidelines for Conducting Literature Reviews in Supply Chain Management

The following chapter sets out to propose coherent guidelines for conducting SLRs in SCM. The chapter is organized as follows: Sub-chapter 3.1 gives a brief introduction into the need for this research; Sub-chapter 3.2 outlines the methodological steps taken to identify, analyze and discuss SLRs published between 2009 and 2014; Sub-chapter 3.3 presents the results of this review, identifies shortcomings in current SLR applications, recommends good practices and puts forward guidelines to support procedural uniformity; and sub-chapter 3.4 summarizes the findings and provides recommendations for future crafting and evaluation of SLRs in SCM.

3.1 The Need for Refined Guidelines

Literature reviews have been described as the backbone of almost every academic piece of writing (Mentzer and Kahn, 1995), and a literature review can be seen as a scholarly contribution in its own right (Short, 2009). Research that applies a literature review as its principal method usually seeks to map research developments to formulate a new research agenda (e.g. Carter and Ellram, 1998; Giunipero *et al.*, 2008), examines methodological approaches (e.g. Shah and Goldstein, 2006; Denk *et al.*, 2012), pulls fragmented research together to create, broaden or deepen theory (e.g. Choi *et al.*, 2001; Carter and Rogers, 2008), or makes a comparison of studies that have sought to test the same theory while they came to diverging conclusions (e.g. Foerstl *et al.*, 2010; Leuschner *et al.*, 2013).

The important role of literature reviews has also been acknowledged by scholars in SCM. A strong literature review shows a rigorous methodology application, is independently replicable, and should typically ensure a substantial theoretical contribution in terms of scientific and pragmatic usefulness (Mulrow, 1987). A form of literature review that cultivates such requirements through providing a predefined structure that increases objectivity and reduces bias is the SLR.

Groundbreaking research on guidelines for conducting SLRs in medicine have been proposed by Mulrow (1987). In 2003, recognizing that the field of management substantially differs in its ontological status, Tranfield *et al.* (2003) proposed a scheme for transferring such guidelines to management research. However, the same authors also raised concerns that their rather blunt adoption of the methodology is still questionable with respect to applicability, calling for more specific guidelines. An initial attempt for

such guidelines was later put forward by Denyer and Tranfield (2009). In the same year, Briner *et al.* (2009) and Short (2009) also provided a set of recommendations of what makes review articles in management a valuable work of art.

In 2012, Seuring and Gold (2012) published a meta-review of SCM-related literature reviews published between 2000 and 2009, revealing a striking lack of rigor and uniformity in reviews in the field of SCM. This prompted a call for improvement in SCM review endeavors, as it is doubtful whether the conclusions drawn from studies with insufficient reliability and validity can help in advancing the discipline.

Since 2009, the field of SCM has experienced a surge in SLRs, mostly trigged by several calls for papers from prestigious journals in the field, such as the *International Journal of Physical Distribution & Logistics Management* or *Supply Chain Management: An International Journal*. It is thus timely to investigate if researchers have changed their procedural approaches in the light of the aforementioned scientific developments and research findings. Following a meta-review approach, the objectives of this chapters are (1) to analyze different procedural approaches that have been adopted in SCM-related SLRs since 2009, (2) to identify and discuss procedural advancements and continuing shortcomings and, (3) with reference to seminal methodology articles and drawing on identified notable procedural steps, provide authors, reviewers and editors with refined guidelines to foster methodological coherence in the discipline and further improve the scope, impact, and quality of SLRs.

3.2 Review of Published Systematic Literature Reviews

Following the research approaches in Mulrow (1987) and Seuring and Gold (2012), 105 articles were assessed in a meta-review of the procedures of current SLR articles. To identify articles that apply the SLR methodology, two electronic databases (SciVerse Scopus and Business Source Complete [via EBSCOhost]) were searched. These two databases provide some of the largest repositories of business research, complement each other in providing access to the majority of business journals and are typically used in SCM literature reviews (e.g. Wallenburg, 2009; Seuring and Gold, 2012). The search was limited to articles published from 2009. In 2009, seminal research has been published suggesting ways for improving SLRs (Briner *et al.*, 2009; Denyer and Tranfield, 2009; Short, 2009). The year also marks the end of the last meta-review of reviews in the SCM field (Seuring and Gold, 2012). The final set of literature for the review was compiled in December 2014 to cover a period of six years. Building on Seuring and Gold (2012), the following search strings were used: Scopus –

TITLE-ABS-KEY((systematic literature review OR structured literature review OR systematic review OR structured review) AND supply chain management) AND (LIMIT-TO(DOCTYPE, "ar") OR LIMIT-TO(DOCTYPE, "re")) and EBSCO – *(*systematic literature review OR structured literature review OR systematic review OR structured review*) AND supply chain management.* The term "structured" was found to be a close and frequently used synonym for "systematic" and therefore included in the strings as "structured literature review" or "structured review". No further restrictions were applied. The search resulted in 60 articles being identified in Scopus and 72 in Business Source Complete.

Table 3 Inclusion Criteria

	Criteria	**Rationale**	**Number of Articles excluded***
Inclusion Criteria	1) The title and/or abstract must explicitly mention that a systematic/ structured literature review methodology is applied.	Some authors deliver their review results systematically, but do not apply a systematic literature review approach.	45
	2) The literature review must be the article's primary method.	The authors seek to identify how research questions are being answered through systematic reviews. A mixture of methods used to answer a question does not support this approach. Further, the application of multiple methods reduces the space to outline the methodological approach taken.	16
	3) The title and/or abstract must demonstrate that the authors' conduct research in the area of supply chain management.	As this research is not restricted to SCM-related journals, research various may occur. Included articles must conduct SCM research (Harland *et al.*, 2006), instead of just mentioning the term.	15
	4) The article must be written in English.	English, as the dominant research language in the SCM field, ensures accessibility and comparability of results.	2
Quality Criteria	5) The research outlet hast to have an impact factor ≥ 1.0 according to 2013 Thomson Reuters Journal Citation report.	To limit the sample of articles to a high quality subset that allows for the identification of methodological advancements.	14

**including multiple entries*

The set of identified articles was further screened for relevant literature. First, duplicates were eliminated from the 132 articles, leaving 105 articles. An initial random sub-

set of 50 titles and abstracts from those 105 articles was read by two researchers to independently identify inclusion criteria (see Table 3). Thereafter, all 105 articles were assessed based upon these inclusion criteria through reading titles and abstracts – also including journal quality criteria. If the information presented therein was not sufficiently clear, the author resorted to the full paper. The assessment for inclusion was conducted independently by two researchers in a blind screening, i.e. any additional information (e.g. authors' names, publication dates, publication titles) was hidden. Inclusion criteria functioned as a refinement of the electronic keyword search, to ensure that the keywords applied in the search have been deployed within the meaning of this study. Subsequent comparison resulted in the inclusion of 37 articles in the following research steps (see Appendix A).

This assessment yielded an observed inter-rater agreement rate of 91 percent. Taking into account that agreement could occur by chance Cohen's Kappa (κ) was calculated as 0.82 (Cohen, 1960), indicating an "almost perfect agreement" of the blind assessment on the Landis and Koch κ scale (Landis and Koch, 1977). Whenever there was disagreement, the issue was discussed and resolved.

The 37 articles were then subjected to a qualitative top-down content analysis. The articles were coded based on the review phases proposed in Tranfield *et al.* (2003) and Denyer and Tranfield (2009) and assessed based on the six quality criteria proposed in Briner *et al.* (2009) – see Table 4 for the coding scheme. The 37 articles were independently read and coded by two researchers. A third researcher check coded the articles in case of disagreement.

Eventually, the papers were analyzed to identify the extent to which each article contributes to the SLR cornerstones of being systematic, transparent, replicable and providing a substantial research contribution (Mulrow, 1987; Tranfield *et al.*, 2003). As the analysis and synthesis was subjective in nature, the author sought methodological discussions with several experts to reduce bias. Initial findings and data were informally discussed with senior SLR researchers at two international conferences, four librarians at three research institutes, and several researchers who had just completed their own SLR projects.

Table 4 Coding Scheme

Question Formulation	**Does the review explore a clearly specified, answerable question?**	Research question
		Purpose, objective or aim
	Were a broad range of stakeholders involved in the review?	Number of involved academicians
		At which point were the academicians involved?
		Number of involved practitioners
		At which point were the practitioners involved?
Locating Studies	**Were extensive searches conducted of both published and unpublished studies?**	Method of data gathering (Database/Library search ...)
		Databases/search engines used.
		Reasoning for search methodology.
		How many journals were selected?
		How were the journal selected?
		Reasoning for journal selection.
		Search string.
		Where were the keywords applied?
		Time period purposely covered (only if purposely covered)
		Reasoning
	What type of literature was reviewed?	Journal Articles/Books/Firm Reports…
		Was the paper selection restricted to any research methods?
		How many studies were retrieved/found?
Study selection and evaluation	**Were pre-specified relevance and quality criteria for the selection/inclusion of studies created and made explicit before the review commenced?**	Inclusion/exclusion criteria are given
		Inclusion/exclusion criteria are applied to … (Abstract, Titles etc.)
		Quality criteria for identification of best available evidence are used.
		How many papers were analyzed in the review?
Analysis and synthesis	**Are the findings analyzed and synthesized into a coherent whole?**	Do the authors clearly specify how they analyzed the papers?
		How did the authors synthesize the papers?
Reporting and using the results	**Does the review summarize the findings from all of the individual studies in a transparent and accessible format?**	Are the reviewed papers listed or marked?
		Are the paper summarized in a transparent way?
Further aspects	**Special Measures taken to reduce bias?**	
	Number of words (paper)	
	Number of words (references)	
	Number of words (methodology)	

Coding scheme is based on Briner et al. (2009), Denyer and Tranfield (2009) and Tranfield et al. (2003).

Insights and a draft of a uniform SLR procedure (hereafter referred to as guidelines) were derived from these discussions as well as from the experiences of the author of this study in conducting his own SLR. Five Ph.D. students then used an early version of this paper to conduct their SLR projects and discussed procedural observations with the author.

Table 6 depicts the refined guidelines, proposing a six step process that future SLR research is encouraged to follow and report upon to further create coherence in the discipline and make SLRs more transparent.

The recommendations in the following sub-chapter go beyond a mere summary of what has been done in the 37 articles and aim to ensure that future SLR projects apply a rigorous methodology – a prerequisite for a strong theoretical contribution.

3.3 Review Results and Discussion

Results from the qualitative analysis are reported and discussed in this sub-chapter. The goal is to describe the methodological advancements and shortcomings identified in the 37 articles, and provide recommendations about what could and should be a common denominator for future execution and assessment of literature reviews.

SLRs originated in the field of medicine and are traditionally related to meta-analyses. A meta-analysis uses statistical methods to combine the results of distinct primary studies (Mulrow, 1987). These quantitative reviews pool data across studies to increase the power of statistical analysis and enhance overall reliability of the study findings. Conducting meta-analysis in SCM is, however, challenging, as such research has to correct for individual study artifacts to draw the right conclusions. The approach requires the reviewed studies to quantitatively research the relationships of the same constructs – something that is rather uncommon in the SCM field.

Henceforth, it is not surprising to find that all 37 articles apply the SLR method to conduct a qualitative review – often called narrative review. Table 5 depicts the qualitative research aims of all reviewed articles, including multiple entries, if applicable. The following discussion of study results will thus be restricted to qualitative reviews. The reader is referred to Shelby and Vaske (2008) for more insights on quantitative reviews.

Table 5 Research Aims of Reviewed Articles

Research Aim	Reviewed Articles
Develop, broaden or deepen theory	Bastl *et al.* (2010); Chicksand *et al.* (2012); Delbufalo (2012); Fayezi *et al.* (2012); Gimenez and Tachizawa (2012); Gligor and Holcomb (2012); Gligor (2014); Kache and Seuring (2014); Kamal and Irani (2014); Kembro *et al.* (2014); Santos and D'Antone (2014); Tachizawa and Wong (2014); Thomé *et al.* (2014); Wong *et al.* (2012)
Map research/identify gaps	Gosling and Naim (2009); Zhang *et al.* (2009, 2011); Irani *et al.* (2010); Grubic and Fan (2010); Carter and Easton (2011); Guo *et al.* (2011); Abbasi and Nilsson (2012); Ashby *et al.* (2012); Chicksand *et al.* (2012); Delbufalo (2012); Ghadge *et al.* (2012); Matthews and Marzec (2012); Miemczyk *et al.* (2012); Pilbeam *et al.* (2012); Govindan (2013); Kauppi *et al.* (2013); Abidi *et al.* (2014); Alexander *et al.* (2014); Fischl *et al.* (2014); Kembro *et al.* (2014); Kembro and Näslund (2014); Narayana *et al.* (2014); Ringsberg (2014)
Examine methodology application	Denk *et al.* (2012)

It turns out that much methodological progress has been made since Seuring and Gold (2012). In particular, the steps of question formulation, locating of studies as well as study selection and evaluation have mostly been reported in a transparent and replicable manner. Though, coherence in the way these methodological steps are presented is still missing. The author of this study takes this as an encouraging sign that an interchange of these steps in the form of refined guidelines will be beneficial. Further, it is still quite difficult to follow how some researchers have gone about analyzing and synthesizing their studies. In that sense, SLRs in SCM still substantially deviate from what has been proposed in seminal method articles in the management field.

Table 6 summarizes the normative discussion of this sub-chapter. It lists notable procedural steps singled out from the reviewed articles and proposes procedural recommendations (including method literature) for each step.

Table 6 Procedural Guidelines and Template for Methodology Presentation of Reviews

Step	Aspects to consider	Recommendations and method literature	Exemplary literature from the reviewed articles
Step 1: Determination of focus of review	Making a significant contribution	Formulate a clear question or objective that is answerable through a review of literature.	Denk *et al.* (2012); Pilbeam *et al.*, (2012); Alexander *et al.* (2014)
		Ensure theoretical contribution in terms of originality and utility of the research. See Carter (2011), Fawcett and Waller (2011) and Tsang and Ellsaesser (2011) for a discussion on "theoretical contribution."	Gligor and Holcomb (2012); Kembro and Näslund (2014)
	Involving stakeholders	Involve academicians and/or practitioners to identify genuine research gaps and improve the focus of the review.	Chicksand *et al.* (2012); Wong *et al.* (2012); Abidi *et al.* (2014)
Step 2: Preparation for the literature search	Crafting inclusion and/or exclusion criteria	Identify and describe inclusion and/or exclusion criteria that can be applied to assess relevance of the literature. These criteria may include characteristics such as study design, content, study focus, study language and study quality.	Delbufalo (2012); Denk et al. (2012); Pilbeam et al. (2012); Alexander *et al.* (2014)
	Deciding on pre-limitations of the literature search	Be explicit about and motivate the selection of publication types (e.g. journals, book chapters).	Chicksand *et al.* (2012); Wong *et al.* (2012)
		Be aware that any ex-ante limitations (e.g. timeframe) of searches may limit your study findings as well. Limitations must be well justified.	Denk *et al.* (2012); Fayezi *et al.* (2012); Alexander *et al.* (2014)
Step 3: Search for literature	Choosing appropriate procedure for literature search	Multiple procedures (e.g. databases searches, snowball sampling, references cross check) may be appropriate to reduce the risk of missing out on important literature. This process, however, must be transparently reported upon.	Gosling and Naim (2009); Carter and Easton (2011); Gligor and Holcomb (2012)
	Crafting search strings for electronic database searches	Searching electronic databases has been identified as the most dominant search method. Involving database experts in this process step may help to better identify appropriate literature search engines and databases. Librarians and topic experts can assist in crafting search strings. See Duff (1996) for more insights on systematic electronic database searches.	Wong *et al.* (2012); Alexander *et al.* (2014); Fischl *et al.* (2014)

Step 4: Selection of pertinent literature	Applying inclusion and/or exclusion criteria to select pertinent literature	Include multiple researchers who individually and blindly include and/or exclude articles from the identified set of literature in order to reduce bias. Agreement between authors in this process should be calculated and presented with indices such as Cohen's κ (Cohen, 1960), Fleiss's κ (Fleiss, 1971) or the r_{wg} index (James *et al.*, 1984).	Kauppi *et al.* (2013); Gligor (2014); Thomé *et al.* (2014)
	Appraising literature quality or validity	Either filter search results for certain publication outlets (e.g. journals that apply a rigorous peer-review process) or try to build own quality or validity criteria checklists. Restrictions to peer-reviewed journals may already be applied in the electronic database search or be part of the inclusion and/or exclusion criteria.	Wong *et al.* (2012); Alexander *et al.* (2014)
		Applying individual quality or validity criteria checklists to filter the identified set of literature may reduce the risk of prematurely excluding relevant research. Experts from different areas, such as appropriate specialists and research methodologists, may help to develop the checklist and rank the literature.	
Step 5: Analysis and synthesis of literature	Making a valid contribution	To enhance study validity, researchers need to show that they follow a systematic analysis and integration. Qualitative reviews should depict whether they followed a top-down or bottom-up approach, and be transparent on the definition of the coding scheme.	Ghadge *et al.* (2012; Pilbeam *et al.* (2012)
		It is highly recommended to include multiple researchers in this step to minimize errors and bias.	Carter and Easton (2011); Denk *et al.* (2012)
Step 6: Reporting and using the review results	Presenting reviewed articles and disseminating findings	Provide a full listing of the reviewed literature and, if possible, the relevant information retrieved from it. This could be done by including a supporting table in the appendix or uploading digital appendices. Regarding dissemination, see Fawcett *et al.* (2014) for a guide to writing meaningful and influential research.	Kache and Seuring (2014); Narayana *et al.* (2014)

3.3.1 Step 1: Determination of Focus of Review

3.3.1.1 Making a Significant Contribution

Research questions provide the necessary starting point of all forms of scientific knowledge development (Holweg, 2011; Alvesson and Sandberg, 2013). Just as in any other type of research, literature reviews need to justify why their research question needs to be addressed; they should be grounded in theory; and they should demonstrate a clear theoretical contribution (Carter, 2011; Fawcett *et al.*, 2014). Researchers applying the SLR methodology need to understand how their choice of research question(s) impacts the research process.

Qualitative reviews depart from the traditional use of SLR and commonly apply the methodology for induction: "Switching from deduction to induction may bring new light and perspective to common problems and widely accepted theories" (Fawcett and Waller, 2011, p. 3). Though, as shown in Denyer and Tranfield (2006), qualitative reviews do not fit comfortably with the traditional SLR method. Trying to assess the theoretical contribution of qualitative reviews has thus proven to be difficult. Rigorously following the methodology of SLR is a critical step in a successful research project; and it is no less important that researchers who intend to publish their qualitative work in highly ranked journals should provide a substantive justification for their research question and report on why their research is timely, relevant and impacts the field (Whetten, 1989). An ideal topic is one where a number of articles have accumulated without previous review efforts, or if a certain amount of time has elapsed since the last review, hence providing an up-to-date assessment of the field (Short, 2009). The reader is referred to Rindova (2011), and Tsang and Ellsaesser (2011) for a detailed discussion on how ideas develop into theoretical contributions and how researchers should craft research questions to achieve this.

3.3.1.2 Involving Stakeholders

It is surprising to find only three articles explicitly reporting on a team of academicians and/or practitioners that was involved in developing the research question (Chicksand *et al.*, 2012; Wong *et al.*, 2012; Abidi *et al.*, 2014). Involving academicians/colleagues – besides the authors of a study – could help to "*improve [the] ability to make meaningful theoretical contributions*" (Fawcett and Waller, 2011, p. 3). Academicians from different countries (e.g. developed versus emerging markets) and with different research foci within the SCM field (e.g. commercial versus humanitarian SCM) might help to establish a broader perspective and to assess whether the research can make a meaningful contribution to the field. For more practical studies, Salvador (2011, p. 20)

suggests SCM researchers to "*get in contact with practitioners and to try to understand how they react to the central theoretical ideas proposed*." Future SCM researchers are thus recommended to be more assiduous in involving academicians and/or practitioners in making – and reporting – an assessment of the need for the research *before* commencing to identify literature.

3.3.2 Step 2: Preparation for the Literature Search

3.3.2.1 Crafting Inclusion and/or Exclusion Criteria

SLRs require researchers to apply inclusion and/or exclusion criteria to manually assess whether the literature that is to be identified helps to answer the research question (Tranfield *et al.*, 2003) – a process step that is prone to researcher bias. Departing from the traditional SLR procedure, where objective inclusion and/or exclusion criteria should be formulated only after literature has been identified, some researchers have decided to conduct this step *before* the literature search (cf. Alexander *et al.*, 2014). This approach has the merit of allowing the research panel to use the list of criteria to objectively and independently assess the relevance of literature used to craft search strings and judge the outcome quality of the database searches (see step 3). The precise definition of the review question may determine whether characteristics such as study design, study content, study focus, study language and study quality (see also step 4) should be used as criteria for selecting the literature. On the basis of this list, a manual selection of pertinent literature has to be conducted in step 4. The list of criteria usually evolves from initial scoping studies in the field and should be challenged within the review team and with outside researchers. As in Wong *et al.* (2012), an initial set of criteria can be tested on a small sub-sample of articles independently with multiple researchers. This helps to reveal ambiguity in interpreting the criteria and to align the positions of the raters on how to apply the criteria, as discussed in step 4. Pilbeam *et al.* (2012) provide a particularly detailed list of such criteria as well as short rationales for each criterion.

3.3.2.2 Deciding on Pre-Limitations of the Literature Search

In preparation for the literature search, researchers need to find answers to two related questions: (1) Should the search be limited to a certain publication type? and (2) Are other search limitations necessary and warranted?

Contrary to some believes (e.g. Short, 2009), traditional SLRs are recommended to appraise as much research as possible that is relevant to the research question (Denyer and Tranfield, 2009). Nevertheless, this recommendation is not suitable for all

reviews. Researchers need to align their search strategy with the research question(s). As pointed out by Light and Pillemer (1984), studies that review the application of a certain method may benefit from exclusively searching in high-quality journals (cf. Denk *et al.*, 2012), whereas reviews that seek to identify what is known and not known about a certain topic could incorporate a larger number of different publication types (cf. Pilbeam *et al.*, 2012). Research on emerging research topics could, due to relatively longer publication lead-times of journals, also benefit from including studies published in proceedings of recent conferences (cf. Guo *et al.*, 2011).

Surprisingly, most of the identified articles do not elucidate why they have chosen a specific publication type. Thirty-three articles exclusively included journal articles; four articles also conducted searches in books and/or conference papers (cf. Guo *et al.*, 2011; Pilbeam *et al.*, 2012; Abidi *et al.*, 2014; Tachizawa and Wong, 2014). Regardless of the research question, future research is encouraged to specify the type of literature reviewed and properly justify the choice.

Most of the articles tend to limit their research to certain timeframes, often justified by the fact that the specific period chosen covers a majority of relevant published research (cf. Bastl *et al.*, 2010). This search strategy runs the risk that further relevant research published before or after that period is not included. Reviews should refrain from placing too many of such ex-ante limitations on the literature search. Timeframe limitations, as with any other limiting variables in literature searches, should only be used if absolutely necessary. Authors need to be explicit about their decision and properly justify it. As a positive example, Kache and Seuring (2014) limited their review on SCM collaboration and integration to the period from 1989 to 2012 in order to align with a previous review.

After a careful consideration of whether pre-limitations of the search should be applied, researchers need to find an appropriate (combination of) search procedure(s) to identify literature. Some electronic search engines, for example, allow for an automatic inclusion of the identified limitation criteria. If not, the limitation criteria have to be made part of the inclusion and/or exclusion criteria and manually applied to the literature (see also step 4).

3.3.3 Step 3: Search for Literature

3.3.3.1 Choosing an Appropriate Procedure for the Literature Search

This research step aims to identify a preliminary set of literature for the review.

The procedures used to search for literature can be manifold, including electronic database searches, manual searching, asking for recommendations from experts and cross-referencing (Briner *et al.*, 2009). A thorough pre-determination of search procedures to be used for the literature search is of high importance.

The most dominant procedure in the reviewed articles is searching in electronic literature databases. Thirty-two articles mention the use of one or more databases and/or search engines. The most commonly used databases/search engines are EBSCO (18), ABI/INFORM (16), Science Direct and Emerald (12 each).

However, the findings indicate that the reason for choosing a certain electronic database seems to be the availability of that database at the respective research institute(s) rather than indexing of and access to relevant research in such database. It is important to consider that not all journals and studies are accessible through or listed in periodical databases (Adriaanse and Rensleigh, 2013). Researchers should, therefore, look for the literature indexing of the particular database when making their choice. Note that different databases typically complement each other. It is, therefore, recommended to use at least two databases in order to decrease the probability of missing out on relevant literature.

To identify appropriate databases and get valuable insights about the features and pitfalls of certain search engines, it could be useful to involve experts, such as specialized librarians (Duff, 1996). When preparing their literature search, researchers commonly need to make informed decisions on whether they want to search full-text databases (Nolan, 2009), citation databases (Adriaanse and Rensleigh, 2013), or a combination of both. Librarians could assist in making this decision, provide information about the features of citation databases and help in crafting search strings.

Search string searches in electronic databases are not as straightforward as might be expected, and the risk of missing out on important literature is high. This issue is underscored by Pilbeam *et al.* (2012), who include several papers in their review manually as they were unable to identify such through their database search. Even with optimized search strings, database searches may not allow all seminal literature to be found and thus alternative search procedures are called for. Exceptions to exclusive database searches often include snowball sampling (cf. Gosling and Naim, 2009; Gligor and Holcomb, 2012; Govindan, 2013; Abidi *et al.*, 2014) and manual searches of journal issues (cf. Carter and Easton, 2011; Kauppi *et al.*, 2013). Adding literature through multiple search procedures is consistent with the SLR methodology (Mulrow,

1987). Thereby, citations databases, for example, may provide useful tools for re-researchers as they facilitate automated citation analysis of the pertinent literature. However, researchers need to be aware that using multiple procedures makes it more challenging to transparently report on the search process, a fundamental requirement of SLRs.

3.3.3.2 Crafting Search Strings for Electronic Database Searches

Due to the aforementioned intricacies of electronic database searches, crafting reliable search strings is even more important. This paper proposes a procedure for crafting search strings that has evolved from the author's own experiences. It has proven to be effective in application. Similar to Alexander *et al.* (2014), it is first recommended to identify pertinent literature and keywords on the topic before starting to build search strings. Whereas Alexander *et al.* (2014) conduct a manual scoping study, pertinent literature and keywords can also be solicited from experts in the field, such as frequently cited authors. It is important, that researchers, through external help or from their own experience, ensure that some of the most pertinent literature is identified in this ex-ante process step. Applying the previously developed set of inclusion and/or exclusion criteria to this literature assists in making these decisions as objectively as possible. Second, the keywords retrieved from the experts and taken from the pertinent literature should then be crafted into search strings and validated on the basis of this literature, i.e. whether the search strings are capable of identifying the literature again in the respective database. A proper documentation of this procedure helps to demonstrate that the pertinent literature, which forms the basis for the search string, adequately represents the research field. It is important to note that the keywords and databases used in this process should be understood as input factors into a system whose output variables need to be optimized in terms of relevance of the identified literature. The interested reader is referred to Duff (1996) for more insights on systematic electronic searching.

One interesting feature that evolved through discussions between the author of this thesis and librarians is that the algorithms of different search engines often require different search strings. In other words, a tailored search string helps to ensure that the ratio of relevant to less relevant literature remains high. It is therefore critical to devote considerable effort in crafting the search string. For that reason, and considering replicability of a study, it is also critical to report on the particular search strings applied and the date of the searches. It is surprising to find that only 18 articles explicitly present their search strings, while the remaining articles only present keywords or do

not mention the strings at all. This is a notable finding because a database search can only be replicated if the search strings (and not just the keywords) are fully listed. Journal reviewers are thus encouraged to demand a complete listing of search strings, in order to support the readers' comprehension of the study. Findings that appear surprising to the reader might be explained through the search strings.

3.3.4 Step 4: Selection of Pertinent Literature

3.3.4.1 Applying Inclusion and/or Exclusion Criteria to Select Pertinent Literature

To reduce the previously identified set of literature to a subset that helps to answer the research question, the literature needs to be selected based on the list of inclusion and/or exclusion criteria (Tranfield *et al.*, 2003). This chapter's findings show that some studies still lack transparency in making their selection of pertinent literature accessible to the reader. Twenty-two of the articles are explicit about the inclusion/exclusion criteria applied to identify pertinent literature, and 17 articles, explicitly reveal which part (title, keywords, abstract and/or full text) of an article they apply such criteria to. That means, a total of 20 articles, corresponding to more than half of the total number of articles analyzed, do still not provide sufficient information to fully understand how the literature selection process was carried out.

Due to potential of literature selection to be prone to bias, researchers conducting future SLRs are especially encouraged to provide details on which inclusion and/or exclusion criteria they apply. It is important for readers to understand to what these criteria have been applied to (title, keywords and/or abstract). Bias in applying the criteria can be reduced through the use of multiple researchers (cf. Narayana *et al.*, 2014). Researchers should individually and blindly apply the inclusion and/or exclusion criteria to the set of literature (cf. Kauppi *et al.*, 2013). To what extent agreement in the selection process is a product of chance can be calculated using indices such as Cohen's κ (Cohen, 1960), Fleiss's κ (Fleiss, 1971) or the r_{wg} index (James *et al.*, 1984). Future research is recommended to calculate either of these indices to test for and show inter-rater agreement.

3.3.4.2 Appraising Literature Quality or Validity

Appraising the quality or validity of each article in the literature identified is of great concern in SLRs (Tranfield *et al.*, 2003). Researchers should seek to appraise quality or validity through a critical examination of the methods used and an assessment of whether the conclusions drawn are justifiable (Mulrow, 1987). Sixteen of the reviewed articles restrict their review to peer-reviewed journals with the aim of enhancing validity

and to prevent the inclusion of studies with biases and errors. Another two articles ap-apply their own quality criteria (Wong *et al.*, 2012; Narayana *et al.*, 2014). Nineteen articles are not clear or do not mention how they assured quality or validity.

Denyer and Tranfield (2009) recommend researchers to build their own quality criteria checklists to evaluate the studies' method application and infer the reliability of findings. SLRs in the field of SCM commonly involve a range of heterogeneous studies applying heterogeneous methodologies, which complicates the process of appraising quality. To counter this issue, excluding non-peer-reviewed journals and/or adhering to journal rankings sometimes seems warranted. However, it is important to be aware of the risk of missing out on relevant research if too many ex-ante quality limitations are used (see the discussion in step 2). Alexander *et al.* (2014) explicitly addressed this issue by deciding to refrain from restricting their research on the basis of journal titles, as they were afraid of missing out on high-quality evidence that may be found outside their specific field. Especially in SCM, a field that tends to have its research dispersed in a wide range of publication outlets (McKinnon, 2013), a thoroughly reasoned justification on the journals to be included or excluded needs to be provided.

If the researchers decide to restrict their search to certain publication outlets (e.g. journals with a rigorous peer-review process), this limiting criterion can, if possible, be included in step 2. If researchers decide to design their own quality or validity checklist, in an attempt to save resources, it is recommended that this manual quality assessment is followed only after the application of inclusion and/or exclusion criteria. This step commonly requires the researchers to read the entire study. As pointed out by Mulrow (1987), the quality of a manual assessment can be enhanced through the inclusion of experts from different areas, such as appropriate specialists and research methodologists, to help develop the checklist and rank the literature.

3.3.5 Step 5: Analyzing and Synthesizing Literature

The goal of this research step is to extract and synthesize the relevant data from the pertinent literature. Researchers who seek to be original should depart from a mere summarizing and organizing of existing research. Instead, they need to integrate and juxtapose the literature to create unique and novel insights. Thoroughness in this research step is even more important, as this step decides on the extent of the theoretical contribution of the study. The research question usually drives the approaches taken during the analysis. Articles can be analyzed and synthesized in different ways: Commonly, qualitative reviews include content analyses or vote counting. Lately, the use of vote counting has drawn harsh criticism as the preferred

method for vote counting should be meta-analysis (Combs *et al.*, 2011). Vote counting is thus not further discussed in this paper.

To enhance study validity, researchers need to show that they follow a systematic rather than a selective analysis and integration of the literature content. It is important for the reader to know what efforts have been taken to carefully explore the literature, to identify potential divergent findings and to derive scientifically valid conclusions and limitations of the study. Conclusions are justified only when the aforementioned processes of analyzing and synthesizing literature is systematically and thoughtfully applied (Mulrow, 1987).

Though not exclusively, all articles within the present review followed a content analytic approach. While content analyses and syntheses do not readily fit with the traditional use of SLR, they can still make a meaningful contribution (Denyer and Tranfield, 2006). Even though a considerable lack of transparency and consistency in this process step prevails (e.g. six studies do not even mention this step), from those studies that are explicit in their strategies, two main approaches could be singled out. One set of articles follows a top-down analysis through coding the articles into predefined dimensions (cf. Denk *et al.*, 2012; Kembro and Näslund, 2014), while the second set applies a bottom-up approach through identifying key themes from the literature (cf. Guo *et al.*, 2011; Ghadge *et al.*, 2012). The author of the present study acknowledges from his own experiences that it can be difficult to present the coding steps and the data synthesis of a qualitative review. Nevertheless, the mere mentioning of the applied approach (top-down vs. bottom-up) and the associated coding schemes could already provide much transparency to future reviews. A prime example of how such a synthesis could be explained in a qualitative review is provided by Ghadge *et al.* (2012). They offer a particularly detailed description of various pre-determined criteria they used to analyze and synthesize 120 articles.

It is noteworthy that despite the proneness of this research step to research bias, only five of the 37 SLRs reported on more than one researcher included in this process (Carter and Easton, 2011; Chicksand *et al.*, 2012; Denk *et al.*, 2012; Pilbeam *et al.*, 2012; Kauppi *et al.*, 2013). The small number of research studies that use two or more researchers in the analysis is troublesome because bias cannot reliably be reduced – one of the challenges that SLR is actually designed to overcome (Tranfield *et al.*, 2003).

3.3.6 Step 6: Reporting and Using the Results

One of the most important elements of the scientific mode of inquiry is that it calls for repeatability and transparency of results (Barratt *et al.*, 2011). Transparently presenting the literature sample that was covered in the SLR could be of value in itself. The data pool of scientific research engines may change over time, making reproducibility of the raw data of the SLR otherwise difficult (Nolan, 2009). Similar to Wong *et al.* (2012), authors should report the findings of the reviewed literature in a comprehensive table or figure. It is not the researchers' task to report on each article spanning pages, but to provide a useful encapsulation of the relevant key message (Short, 2009).

With this in mind, it is remarkable to find that only 16 of the reviewed articles present a complete list of the literature reviewed. In the remaining 21 articles, it remains unclear which literature was analyzed and synthesized. As a positive example, Narayana *et al.* (2014) include several supporting tables in their appendix.

Authors conducting SLR have to weigh transparency of research steps against journal article length limitations – which in SCM journals often include references and appendices. The mean length of articles reviewed in this study is 13,297 words, including everything, of which about 21 percent on average is taken up by the reference section and about 11 percent by the methodology section. Commonly, literature reviews have extensive references sections (cf. Ashby *et al.*, 2012; Alexander *et al.*, 2014), leaving limited space for a thorough presentation of the need for the review, methodology, findings, implications and contributions. Even though readers and reviewers are curious to know the literature lists of reviews, journal word limitations sometimes force researchers to only report on a fraction of the screened literature. An encouraging sign is that some journals have come to support the option of uploading digital appendices (e.g. Wittstruck and Teuteberg, 2012; Keller *et al.*, 2013).

In future, to balance trade-off between demonstration of rigor and adherence to article word limits, researchers should be encouraged to use

Table 6 as a template for their research protocol. Similar to Alexander *et al.* (2014), who provided excerpts of their protocol to increase transparency, such a summarizing table could forestall the need for lengthy methodological descriptions (cf. Fischl *et al.*, 2014), while emphasizing on all relevant procedural aspects. This approach would not just significantly increase coherence in study presentation, but also better enable reviewers to evaluate quality, validity and reliability of reviews.

3.4 Implications

This chapter analyzed procedural approaches that have been taken in SCM reviews published since 2009, linking with a previous meta-review in the field (Seuring and Gold, 2012). It built on a sample of 37 articles that apply the SLR methodology, along with discussions and shared insights from experienced SLR researchers and librarians.

The literature review has shown that current SLRs in SCM are weighted towards reviews conducting qualitative content analyses. Many of these reviews do still not provide enough information to make them independently replicable, raising the risk that their conclusions might not be valid. However, in comparison to Seuring and Gold (2012), considerable methodological advancements could be identified.

To further improve the scope, impact, and quality of SLRs,

Table 6 proposes refined guidelines that build on such methodological advancements. Future research is encouraged to deploy these guidelines as their review protocol to increase efficiency and transparency in presenting procedural review steps. The guidelines are also intended to provide a useful tool for reviewers and editors to better assess the rigor of the applied research methodology.

Conducting a systematic review is a resource-intensive process. This chapter sought to show how SLRs can be properly conducted to serve as a useful tool to advance the field of SCM. It is not to be understood as a call for an increased use of the SLR methodology in SCM. However, SCM is a field that still lacks its own theories *(Chicksand et al.*, 2012; Harland *et al.*, 2006; Huynh, 2013). Therefore, approaches that can help create, broaden or deepen theory are most welcome. SLRs can be used not only for theory testing, but also to build new propositions through a proper synthesis of previously disconnected studies. Researchers, especially those who aim to make an original contribution, are encouraged to use this paper to improve validity and reduce bias in their findings. As Mulrow (1987, p. 487) concluded, "*by using [the] systematic methods of exploration, evaluation, and synthesis, the good reviewer can accomplish the task of advancing scientific knowledge.*"

Having developed refined guidelines for conducting SLRs in SCM; this thesis will now turn towards an analysis of antecedents and dimensions of supply chain robustness, drawing on the developed guidelines.

4 Antecedents and Dimensions of Supply Chain Robustness: A Systematic Literature Review

The previous chapter addressed the first research objective, and "*developed refined guidelines for conducting systematic literature reviews in supply chain management to foster methodological coherence in the discipline and further improve the scope, impact, and quality of systematic literature reviews*." The research community is now a step closer to a structured and coherent methodological tool that allows for a more rigorous analysis of its literature body. These refined guidelines will provide the methodological basis for identifying antecedents and dimensions of supply chain robustness in this chapter.

This chapter is organized as follows: Sub-chapter 4.1 motivates the need for developing a conceptual framework of supply chain robustness; Sub-chapter 4.2 outlines the research design and the efforts made to decrease bias; Sub-chapter 4.3 puts forward the conceptual framework; sub-chapter 4.4 discusses the scientific and managerial implications of the framework developed and sub-chapter 4.5 concludes with some final remarks.

4.1 Theoretical and Practical Relevance of a Literature Review on Supply Chain Robustness

After decades of relative stability, Christopher and Holweg (2011) observed the emergence of a new era of turbulence in supply chains. The literature provides two main strategies for the way that supply chains and their entities can cope with disruptions: reactive or proactive. Each of these strategies has been shown to reduce vulnerability (Wieland and Wallenburg, 2012).

A reactive strategy implies that the supply chain adjusts ex-post to disruptions, and supply chains adopting this strategy are usually referred to as agile supply chains (Braunscheidel and Suresh, 2009; Hoek *et al.*, 2001). This corresponds primarily to being flexible (Christopher and Towill, 2001) and being able quickly to adjust tactics and operations (Gligor and Holcomb, 2012). Postponement is a commonly used measure to achieve supply chain agility, as it delays the point at which the final customization step takes place, thereby reducing the time to respond to demand changes by adapting the final product (Feitzinger and Lee, 1997).

In contrast to a reactive strategy, a proactive strategy to cope with disruptions implies that the supply chain implements ex-ante measures, with no adaptation needed during times of disruption. Supply chains adopting this strategy are usually referred to as robust supply chains (Klibi *et al.*, 2010; Vlajic *et al.*, 2012), where robustness corresponds primarily with being physically sturdy (Christopher and Peck, 2004) and being able to retain the same stable situation as before disruptions occurred (Asbjornslett and Rausand, 1999). Incorporating redundancy, e.g. in reserves or back-up options, is a commonly used measure to increase supply chain robustness that can reduce vulnerability (Azadegan *et al.*, 2013).

Supply chain resilience, a third term used in this context, corresponds to balancing both reactive and proactive strategies (Melnyk *et al.*, 2014; Sáenz and Revilla, 2014). Christopher and Rutherford (2004, p. 24) state that a "*resilient supply chain is certainly robust*" and that a "*resilient supply chain must also be adaptable*," leading Wieland and Wallenburg (2013) to argue that agility and robustness are dimensions of resilience, a notion that will be followed within this thesis.

To date, many scholars in logistics and SCM have sought to define robustness in ways that emphasize different properties of the construct. Some of these definitions are presented in Table 7.

Research in SCM often seeks to identify dimensions and antecedents of vital constructs to develop a formal definition of the field and further develop its theory. Dimensions are understood as those mutually exclusive and commonly exhaustive (MECE) features that a robust supply chain consists of, while antecedents are understood as variables which predict the construct (Morris and Feldman, 1996). Prior research has identified dimensions (Gligor *et al.*, 2013) and antecedents (Gligor and Holcomb, 2012) of supply chain agility. However, research has not yet sought to establish a comprehensive theoretical basis for understanding supply chain robustness, connecting the insights and information available in the literature. This is astonishing: arguably, prevention is better than cure – it is better to engage in loss avoidance and pre-emptive disruption mitigation than deal with the consequences of actual disruptions (Kleindorfer and Saad, 2005). Lavastre *et al.* (2012) analyzed data collected from 142 general and supply chain managers and found that the majority prefer a robust supply chain strategy over an agile one, considering the latter "*expensive and uncertain in its implementation*" (ibid., p. 835). Wieland and Wallenburg (2012) analyzed data collected from 270 manufacturing managers to identify the effect

of robustness and agility strategies on business performance. They found that robust-robustness has a direct, strong positive effect on business performance, whereas only an indirect effect of agility could be shown. To date, research has identified different measures that lead to supply chain robustness (Nair and Vidal, 2011; Tang, 2006), but managers and academics still need to understand the theoretical basis of the construct. This research addresses this gap through developing a comprehensive framework that highlights the antecedents that enable the effective implementation of supply chain robustness measures.

Table 7 Definitions of Supply Chain Robustness

Source	Definition
Meepetchdee and Shah (2007, p. 203)	*"The extent to which the supply chain is able to carry out its functions despite some damage done to it."*
Ferdows (1997, p. 86)	*"A robust network is one that can cope with changes in the competitive environment without restoring to extreme measures."*
Klibi *et al.* (2010, p. 290)	*"A [supply chain network] design is robust, for the planning horizon considered, if it is capable of providing sustainable value creation under all plausible future scenarios"*
Kouvelis *et al.* (2006, p. 452)	*"The designed supply chain is robust in the sense that it hedges the firm's performance against the worst contingencies in terms of uncertain factors […] over a planning horizon."*
Vlajic *et al.* (2012, p. 177)	*"We define supply chain robustness as the degree to which a supply chain shows an acceptable performance […] during and after an unexpected event that caused disturbances in one or more logistics processes."*
Wieland and Wallenburg (2012, p. 890)	*"Robustness is a proactive strategy that can be defined as the ability of a supply chain to resist change without adapting its initial stable configuration."*
Asbjornslett and Rausand (1999, p. 220)	*"We define robustness as 'a systems ability to resist an accidental event and return to do its intended mission and retain the same stable situation as it had before the accidental event'."*

The purpose of this chapter is two-fold: First, to explore the multi-dimensional nature of supply chain robustness and thus to build a formal definition of it. Second, to identify

antecedents of supply chain robustness and moderators of the antecedent-construct relationship.

4.2 Research Design

This study applies a systematic review approach to identify dimensions, antecedents and moderators of supply chain robustness (cf. Tranfield *et al.*, 2003). In order to reduce bias during the research, the following steps were taken: The study (1) builds upon the feedback of a panel of experts, (2) embraces the expertise of librarians, (3) involves multiple researchers, (4) searches two databases and (5) avoids limiting itself to specific publications. The steps in this review process are outlined in detail below.

4.2.1 Locating Literature

A systematic literature search of databases should identify as complete a list as possible of pertinent literature while keeping the number of irrelevant hits low (Duff, 1996). In order to limit bias, a panel of experts from Asia, Europe and North America contributed keywords and recommended relevant articles (see Appendix B). The panel consisted of eight academics with long standing expertise in researching the area of supply chain risk management, and five supply chain managers from diverse industries with expertise in the field.

Two databases were selected for the literature search: Business Source Complete (via EBSCO) and SSCI-Database (via ISI Web-of-Knowledge). These databases were selected as they have some of the largest repositories of business research and are typically used in literature reviews (e.g. Carter and Easton, 2011; Hopp, 2004). With the assistance of two librarians specializing in business science and economics, the list of keywords provided by the panel was adjusted for keywords that were too broad or likely to identify literature related to other research areas.

In addition to the list of keywords, the experts provided eight articles (Chopra and Sodhi, 2004; Craighead *et al.*, 2007; Klibi *et al.*, 2010; Vlajic *et al.*, 2012; Wagner and Bode, 2006; Wieland and Wallenburg, 2012; Zsidisin and Wagner, 2010) which were central to the research question. All eight articles are listed in EBSCO's Business Source Complete database (BSC). To categorize literature, EBSCO manually assigns subject headings (also called descriptors). Whereas authors can (mostly) choose any keyword for their articles, EBSCO assigns subject headings only from a controlled list. Through combining the subject headings for the eight articles and the list of keywords, the search string was constructed applying the usual block building approach (see Ta-

ble 8). The first block of the dichotomous search string identifies articles discussing the construct of “robustness” or close synonyms. The second block confines the articles to those having the supply chain as their unit of analysis.

The ISI search engine does not provide subject headings but uses a keyword search. This requires a different approach since keywords, as opposed to subject terms, are a product of the authors of the individual articles. Whereas EBSCO’s standardized subject headings made it easy to identify relevant literature, additional keywords were needed to capture the literature in ISI. The second block of the initial search string was hence extended with additional keywords provided by the experts. For the second section of the search string a Title Search was chosen, as a comparison of the results of Title Search and Topic Search suggested better results and less irrelevant literature for the former.

The electronic search process resulted in the identification of 1,244 articles from BSC and 238 articles from SSCI, 1,356 articles in total. In spite of the different search approaches, the searches provided a considerable overlap of the results – an indication for substantial consistency of the search strings. The unbalanced results are due to the different listings of literature and literature types in the databases, and the fact that BSC’s repository is considerably bigger. The resulting records of citations and abstracts were exported and compiled using Citavi, a referencing database.

Table 8 Search Strings for Database Search

EBSCO	*(robust* OR continuity OR vulnerability OR resilient OR perturbation* OR (risk driver*) OR mitigation) AND ((DE "SUPPLY chains") OR ("supply chain") OR (DE "SUPPLY chain management") OR (DE "SUPPLIERS") OR (DE "REVERSE logistics"))*
ISI	*(TS=(robust* OR continuity OR vulnerability OR resilient OR perturbation OR (risk driver*) OR mitigation) AND TI=((supply chain*) OR (supply network*) OR (logistical network) OR (demand chain) OR (supply management) OR SCM OR (production and inventory) OR (supply risk) OR (reverse logistics)))*

DE: Descriptors; TI: Title Search; TS: Topic Search

4.2.2 Literature Selection and Evaluation

Pawson (2006) encourages reviewers to include a wide range of studies, suggesting the value of a report for a research synthesis can only be determined while conducting the synthesis. This standpoint is ultimately supported by other researchers discussing

journal rankings and their impact on the dispersion of SCM publications (McKinnon, 2013; Starbuck, 2005). After careful consideration, it was decided to apply no *a priori* restrictions to the database search. Following this decision, in the effort to follow the rigorous methodological approach proposed for an SLR (e.g. Denyer and Tranfield, 2009; Tranfield *et al.*, 2003), the author did not restrict his search to particular journals (Briner *et al.*, 2009). Consequently, the studies reviewed come from multiple research outlets. A related question, can additional relevant information be retrieved from publication outlets that have a low impact in the research community? is addressed at the end of this sub-chapter.

Based on a list of inclusion criteria (see Table 9), which was built on discussions among the author and two researchers, the summaries of all articles were independently checked in a blind procedure. Decisions were based on the content of the summaries, with any additional information hidden, and were inclusive, rather than exclusive. In order to check for inter-coder reliability, an initial sample of 50 summaries was reviewed for inclusion by two researchers. Whenever there was disagreement, the issue was discussed with a third researcher involved. If the summaries were not sufficiently clear, the complete article was read. Only 2.0 percent of the summaries resulted in disagreement between the researchers. To make sure that agreement was not a product of chance, Cohen's κ was calculated to be 0.96 (Cohen, 1960). This rate far exceeds the recommended minimum for "very high reliability" (Landis and Koch, 1977), indicating a reliable process of excluding and including articles for review. The aforementioned steps reduced the resultant number of full articles for analysis and synthesis to 94 (see Figure 4). In order to identify dimensions, antecedents and moderators, these remaining articles were studied in two rounds of reading.

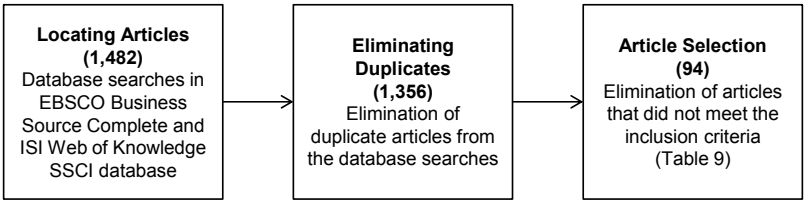

Figure 4 Literature Selection Process

Table 9 Inclusion Criteria

Inclusion Criteria	Rationale
Summary must demonstrate the supply chain as the clear focus/object of the research.	As this research is not restricted to any journals, research on other subjects than supply chains may occur.
A construct is mentioned that can be called "supply chain robustness," as it describes a supply chain's ability to maintain performance during disruptions, through proactively implemented measures.	The focus of the research is to study supply chain robustness.
Summary must show clear indication of dimension and antecedents or moderators of supply chain robustness	The focus of the research is to study dimensions/antecedents and moderators of supply chain robustness.
Article must be written in English.	English is the dominating research language in the field of supply chain management.

4.2.3 Analysis and Synthesis of Literature

For the analysis, the 94 studies were randomly entered into a Microsoft Excel spreadsheet, paying no attention to their publication outlets. They were then analyzed for those features used when describing a robust supply chain (dimensions). A subsequent discussion among the author and two researchers found two distinct dimensions used to describe robust supply chains: avoidance and resistance, described with various synonyms, e.g. "prevent" (Speier *et al.*, 2011) or "hedge" (Hofmann, 2011). Sixty-five studies were identified to use synonyms of resistance, and 61 to use synonyms of avoidance, showing a considerable overlap in the use of both dimensions. For this study, resistance is defined as the ability of a supply chain to withstand disruptions (see Table 10). A common measure suggested to increase resistance to disruptions is the implementation of buffers into the network (e.g. Sawik, 2013; Schmitt, 2011). However, as not all disruptions can be resisted, some need to be avoided in order to stay robust. Avoidance, as the second dimension of supply chain robustness, refers to the ability of a supply chain not to be affected by disruptions. This shows that during disruptions, a robust supply chain is either capable of resisting disruptions, or takes measures to avoid them.

Table 10 Dimensions of Supply Chain Robustness

Dimension	Definition
Resistance	Ability of a supply chain to withstand disruptions.
Avoidance	Ability of a supply chain not to be affected by disruptions.

Building upon these two dimensions, a formal definition of supply chain robustness was formed, which provided the basis of the robustness framework: *"the ability of a supply chain to resist or avoid disruptions."*

The new definition is plain and distinct from related constructs, an essential foundation for subsequently identifying antecedents.

In a second round of reading, variables were identified that were deemed either to predict the ability of a supply chain to resist or avoid disruptions (antecedent) or may explain the variability in effect sizes of such variables on the construct (moderator). The spreadsheet was extended by an additional column each time a variable was identified that had not previously been identified. Altogether, 62 such variables were identified.

The coded information was then synthesized in order to elevate the abstraction of the framework (Wacker, 1998). Studies that apply the same empirical data collection process on the same topic can usually be synthesized through a meta-analytic approach (Denyer and Tranfield, 2006). However, the reviewed literature is more heterogeneous, and therefore more amenable to an interpretative synthesis to "*interpret research to build higher-order theoretical constructs*" (for additional information see Rousseau *et al.* (2008, p. 492). To reduce human subjectivity in this research step, the author drew on aspects of the Q-methodology (cf. Ellingsen *et al.*, 2010), presenting three researcher with the 62 variables printed on small cards (Q-sample) instructing them independently to arrange the variables and put them into relation to one another to build higher-order antecedents and moderators. If a variable could not be synthesized with others due to its distinct structure and content, it was considered an antecedent in itself or, depending on the way it fit with the concept, a moderator. After no further synthesis of the variables was possible, the respondents

explained the placing of their cards (Q-sort) to each other. Similarities among the Q-sorts were then determined and consolidated, resulting in identifying 20 distinct antecedents including one moderator of supply chain robustness.

In a subsequent open discussion among participants and two outsiders, an initial framework of supply chain robustness was built out of the consolidated set of variables. Antecedents that were mentioned in more than five different studies were automatically included in the framework; below this limit, the theoretical soundness of the antecedents was discussed in depth with close reference to the studies they were extracted from. Only if all researchers were convinced of its importance was the antecedent included in the framework. The completed framework consists of eight antecedents and one moderator. [4]

In a further analysis to verify a posteriori whether outcomes would have been different by selecting journals according to impact factor (IF), the author ranked the 94 articles according to the IF reported in Thomson Reuters' Journal Citation Report (2012). It was found that the proposed theoretical framework of supply chain robustness could have been developed by only resorting to articles with an IF 1.3 or higher. That is, the remaining articles did not show any new or different insights to those revealed in the better ranked journals. Applying this restriction leaves 50 articles from 21 journals. This shows that research outcomes would not have been different had the choice been made to include only journals above the established threshold of IF. This finding supports the validity of reviews that solely build upon journals that are commonly recognized as primary outlets within the field of SCM research.

4.3 Review Results

Based on the aforementioned research steps, the study in this chapter develops a theoretical framework of supply chain robustness. In particular, it explores the multi-dimensional nature of the robustness construct, its antecedents and moderators. It is not an original observation that researchers in SCM usually see the dyad or the triad as the smallest unit of analysis in a network (Choi and Wu, 2009a). The reviewed articles partially reflect this, as one group of articles studies two (e.g. Baghalian *et al.*, 2013; Rothenberg and Ettlie, 2011) or multiple echelons of the supply chain (e.g. Klibi *et al.*, 2010; Meepetchdee and Shah, 2007). However, there is a second group of articles that

[4] A complete table relating the literature to the antecedents, the moderator and the dimensions can be found in Appendix C.

emphasizes the importance of firm internal processes for the supply chain (e.g. Hazra and Mahadevan, 2009; Vlajic *et al.*, 2012). The theoretical framework developed accounts for these different perspectives and shows that in order to achieve a robust supply chain, robustness needs to be achieved on both inter- and intra-organizational levels. For both levels, distinct antecedents were identified. Each level is interdependent in such ways that the achieved level of robustness of a single node usually impacts the robustness of the network. For example, when a firm makes a sourcing decision that aims to increase intra-organizational robustness, managers must consider the impact of this decision on inter-organizational robustness. For instance, the robustness of a firm can also be increased through the proper selection of supply chain partners (Sawik, 2013; Tomlin, 2006). A similar phenomenon can be experienced for outsourcing decisions. Outsourcing adds complexity to supply chains, since it impacts their design, but also has positive effects on robustness as it allows a firm to focus on its core activities (Hsiao *et al.*, 2010; Williamson, 2008). The results of the literature review are outlined below.

The framework developed consists of five parts. As Figure 5 shows, robustness on both inter- and intra-organizational levels consists of the dimensions resistance and avoidance. Figure 5 also illustrates the identified antecedents and the moderator.

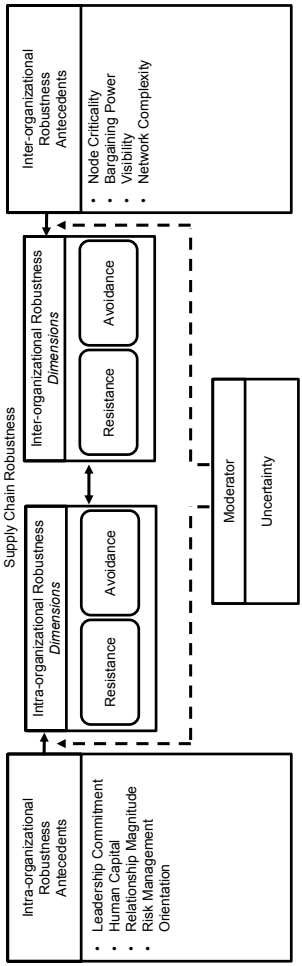

Figure 5 A Conceptual Framework of Supply Chain Robustness

4.3.1 Intra-Organizational Robustness and its Antecedents

4.3.1.1 Leadership Commitment

Leadership commitment to strategic initiatives is the foundation for the effective implementation of common goals within an organization (Speier *et al.*, 2011). Decision makers have a crucial role as they inspire as well as motivate employees (Grötsch *et al.*, 2013). Their cognitive style impacts the organization's attitude towards anticipation,

pro-activeness and, in turn, pursuit of robustness actions (Grötsch *et al.*, 2013; Speier *et al.*, 2011). They prioritize and help to ensure that resources are being employed in a more focused way (Hall *et al.*, 2012). Supply chain managers can make the implications of strategic decisions more transparent for the board and can prioritize on identifying and avoiding emerging problems (Peck, 2005). This suggests that leadership commitment to robustness plays an important role in enforcing planning efforts to build intra-organizational robustness. Leaders' actions, what they do or fail to do, can change the robustness of a firm.

Proposition 1: *Organizations that have leadership commitment to robustness will experience an enhanced intra-organizational robustness.*

4.3.1.2 Human Capital

Employees have a critical role to play, as the interface between strategy set at the top and operational execution. Their skillset is a valuable resource for implementing new initiatives within an organization (Figueira *et al.*, 2012; Vlajic *et al.*, 2012). As pointed out by Blackhurst *et al.* (2011, p. 380), if employees are well educated and properly trained, they are equipped with the "*necessary skills to know when it is appropriate to take action*," when it is reasonable to stock inventory, or whom to communicate with. Employees of an organization know how to properly apply IT systems (Hall *et al.*, 2012) and, as argued by Dynes *et al.* (2007), can also help to build resistance to disruptions of the IT system. As delivering order quantities or continuous production of products can commence only if standardized routines are being followed, supply managers are argued to be the key knowledge source for identifying potential supply problems and knowing the appropriate steps to take in order to enhance robustness (Zsidisin and Wagner, 2010). It is therefore argued that the human capital of an organization is a valuable resource, necessary to achieve intra-organizational robustness.

Proposition 2: *Within an organization, well-educated and skilled human capital has a positive influence on intra-organizational robustness.*

4.3.1.3 Intra-organizational Relationship Magnitude

The magnitude of interaction and exchange of information between different intra-organizational entities is central for enabling intra-organizational robustness. Strategic and operational sharing of information and knowledge on product design, production processes, logistics and quality, as well as supply and demand status, are argued to

enable better intra-organizational coordination and management (Hall *et al.*, 2012). Collaborative meetings can help to exchange timely and relevant information among departments (cf. Lavastre *et al.*, 2012). Increased collaboration between the engineering and purchasing departments could, for example, help to redesign products in such ways that necessary resources are more readily available in the market. Vlajic *et al.* (2012) advise managers that a closer cooperation between people who are doing planning and those who execute plans is helpful for enhanced strategic planning. From an internal perspective, it is suggested that communication between multiple people and functions within an organization increases awareness (Norrman and Jansson, 2004) and decreases process variability (Chen *et al.*, 2013). An enhanced intra-organizational relationship is therefore argued to foster the robustness of a firm.

Proposition 3: *The degree of an enhanced inter-departmental relationship within an organization of a supply chain is positively related with intra-organizational robustness.*

4.3.1.4 Risk Management Orientation

As suggested earlier, risk management at every node of a supply chain can help to prevent cascade failure of the supply chain (Wieland and Wallenburg, 2012). Risk management orientation is argued to be necessary on multiple levels (Jüttner and Maklan, 2011): tangible (e.g. product design), organizational (e.g. make-or-buy) and intangible (e.g. reputation). On an intra-organizational level it is understood as a culture that helps to facilitate the implementation of proactive risk measures and that fosters learning from previous events (Lin and Wang, 2011; Schmitt, 2011). Zsidisin and Wagner (2010) find that understanding a firm's propensity to risk helps to better implement measures to hedge for disruptions. An increased risk management orientation is hence suggested to foster intra-organizational robustness.

Proposition 4: *An increased risk management orientation within an organization has a positive impact on intra-organizational robustness.*

4.3.2 Inter-Organizational Robustness and its Antecedents

4.3.2.1 Node Criticality

A number of researchers identified a first antecedent of inter-organizational robustness in their discussion on the criticality of individual nodes in supply chains (e.g. Bhattacharya *et al.*, 2013; Craighead *et al.*, 2007). Even though each node within a

network (should) play a value-adding role, some nodes are typically more critical than others. The measure of node criticality is relative to other nodes within a supply chain. Nodes that are considered critical are, for example, organizations that have multiple suppliers or sell to relatively many customers. Reiner and Trcka (2004) show in their research the inherent criticality of distribution centers, as they have a crucial function in coping with demand changes. Joint measures, such as strategically storing inventory at critical nodes, can help to resist disruptions (Tang, 2006). This could be achieved through setting appropriate contracts among supply chain partners (Hazra and Mahadevan, 2009). It can be conjectured that disruptions that negatively impact critical nodes have an increased negative impact on the supply chain. It is hence suggested that increased criticality of a single supply chain node is negatively related to supply chain robustness.

Proposition 5: *The greater the relative criticality of individual nodes of a supply chain, the lower will be the level of achieved inter-organizational robustness.*

4.3.2.2 Bargaining Power

Bargaining power of a single node within a supply chain is identified as a second antecedent of inter-organizational robustness. Nodes with high bargaining power within a supply chain are, for example, single suppliers of a product or buyers of products that are readily available in the market (a situation often experienced in the automotive industry, cf. Thun *et al.*, 2011). Organizations that experience increased bargaining power in comparison with their supply chain partners can take advantage of this opportunity and, for example, favor one customer over another (Abercrombie, 2007; Sawik, 2013). Increased bargaining power is thus argued to raise the probability of opportunistic behavior among supply chain members – behavior that is detrimental to the network's capability to cope with changes (Jüttner and Maklan, 2011).

However, bargaining power can also function as an enhancer of inter-organizational robustness. As noted by Williamson (2008), taking advantage of one's own bargaining power is a myopic and sometimes inefficient behavior. If a node experiences increased bargaining power, it has the opportunity to play a vital role in increasing the robustness of the entire network. The node then forms a "benevolent dictator", an approach that is based not on good will (Hofmann, 2011), but aims to decrease the vulnerability of supply chain partners for the good of the "dictator" organization. It is therefore argued

that the relative bargaining power of a firm can have a two-sided impact on inter-organizational robustness.

Proposition 6a: *Supply chains with increased relative bargaining power of single nodes can be detrimental for inter-organizational robustness if the powerful node is not willing to support its supply chain partners.*

Proposition 6b: *Supply chains with increased relative bargaining power of single nodes enable an increased inter-organizational robustness if the powerful node sees the long-term benefit of its activity and is thus willing to support its supply chain partners.*

4.3.2.3 Visibility

Christopher and Lee (2004) suggest that a key element in any strategy to mitigate supply chain risks is improved visibility. The reviewed research that discusses visibility does this from either a relational or network structure perspective.

Relational aspects among supply chain members and their resulting impacts are subject of discussion in multiple studies (e.g. Lavastre *et al.*, 2012; Whipple and Roh, 2010). Lavastre *et al.* (2012) suggest that efforts to improve supply chain visibility through the sharing of risk-related information leads to increased supply chain risk avoidance, thus a compatible IT infrastructure can function as a key facilitator for information exchange among partners (Hall *et al.*, 2012, p. 201; Speier *et al.*, 2011). The reviewed literature also makes clear that information exchange at the lower echelons of relationships most effectively enables inter-organizational robustness. Wieland and Wallenburg (2013) empirically demonstrate that both communicative and cooperative relationships have positive influences on supply chain robustness.

Regional, and thus dense, supply chains are also argued to enhance network visibility (Shao, 2013; Wagner and Bode, 2006). Some of the motivation for organizations within a supply chain to locate in close proximity lies in the potential to gain access and share knowledge (Deane *et al.*, 2009). The network structure can thus be argued to enhance the visibility of a supply chain. However, a disruption affecting a dense part of a network could be quite severe as multiple of the members can be affected (Craighead *et al.*, 2007). The greater the geographical dispersion, the less it is likely that in case of catastrophic events close to a supply chain member the entire network will be affected. Thus, managers have to balance risks and enhanced communication when designing

their supply chain. Nevertheless, it is suggested that inter-organizational robustness seems to be enhanced through increased visibility in the network.

Proposition 7: *Supply chain visibility is positively related to supply chain robustness.*

4.3.2.4 Network Complexity

Increasing network complexity requires firms to invest more heavily in measures to mitigate supply chain risk (Craighead *et al.*, 2007; Speier *et al.*, 2011). Network complexity is thereby understood as the degree of connectivity within the network (Meepetchdee and Shah, 2007). Two related factors have been discussed as contributing to increased network complexity and hence to decreased robustness: (1) number of nodes (Blackhurst *et al.*, 2011) and (2) network length (Nair and Vidal, 2011). As the number of nodes in a supply chain increases, the supply chain becomes longer and more complex. A complex supply chain potentially implies that more efforts and resources are needed to synchronize and coordinate activities within the network to describe the state of the system (Meepetchdee and Shah, 2007). If these efforts fail, unexpected changes in a supply chain that occur (or originate) at a single node can potentially propagate through the supply chain and cause harm to its members. It is therefore argued that increased network complexity is likely to be detrimental to increased inter-organizational robustness.

Proposition 8: *Reduced network complexity of supply chains (i.e. reduced number of nodes and network length) is positively related with a higher inter-organizational robustness.*

4.3.3 The Moderating Role of Uncertainty

A key characteristic of the supply chain robustness literature is the researchers' emphasis on uncertainty within and outside of the supply chain. Several scholars have argued that the level of uncertainty may form an important boundary condition for strategies in supply chains (e.g. Chopra *et al.*, 2007; Klibi *et al.*, 2010). Research that includes references to uncertainty can be clustered into two fields: studies researching how uncertainty impacts (a) the network or (b) firm decisions. Uncertainty usually occurs when information on the environment is incomplete or even non-existent. Klibi and Martel (2012, p. 645) define it as "*the inability to determine the true state of the future business environment which may be partially known or completely unknown*." That is, a business environment is certain under perfect information and uncertain

under partial information. However, uncertainty, though a precondition for disruptions to occur, need not necessarily lead to a risky situation (Leat and Revoredo-Giha, 2013).

Moderation of antecedents–intra-organizational robustness: Certainty concerning environmental factors on an intra-organizational level is needed to detect potential changes and to subsequently disseminate pertinent information to relevant entities within the organization (Azadegan *et al.*, 2013). Managers need to reduce uncertainty to reduce disruptions and allocate resources to manage them (Lavastre *et al.*, 2012), but the more unpredictable the system, the harder it is for an organization to take effective measures to achieve intra-organizational robustness. In the reviewed literature, several analytical methods and mathematical programming tools have been proposed to help identifying potential changes in an uncertain environment (cf. Fernández *et al.*, 2012; Van Landeghem and Vanmaele, 2002).

Van Landeghem and Vanmaele (2002) identified in the literature different sources of uncertainty that have medium or high leverage on strategic decision making: stochastic costs, political environment, customs regulations and stochastic demand. Hazra and Mahadevan (2009), in their procurement model, use capacity reservation in the presence of demand uncertainty, while Chopra *et al.* (2007) and Tomlin (2006) mathematically show that the sourcing strategy of a firm should be different depending on the degree and type of uncertainty the firm is exposed to. Although these authors were not explicitly testing for leadership commitment, human capital, communicative relationship or risk management, the studies indicate a decreased robustness effect of intra-organizational antecedents under increased uncertainty.

Moderation of antecedents–inter-organizational robustness: Several studies discuss robust supply chain network design problems under uncertainty (e.g Baghalian *et al.*, 2013; Klibi *et al.*, 2010; Lin and Wang, 2011), with Azadegan *et al.* (2013) researching the impact of operational slack on environmental uncertainty. Uncertainty on a network level is thereby defined through instability, turbulence, environmental complexity and scarcity of resources. Despite these articles, very few studies have formally considered uncertainty's influence on node importance, bargaining power and network complexity, although exceptions include Shao (2013) and Deane *et al.* (2009), who found that dense node clusters become more prone to uncertainty affecting multiple nodes of the system than a more dispersed network.

The following sub-chapter discusses the scientific and managerial implications of the framework developed.

4.4 Implications

The identified framework helps managers and researchers alike to consider the impact of various intra- and inter-organizational variables on the focal construct. It provides value to managers through deriving nine propositions relating supply chain robustness to eight antecedents. The antecedents offer enhanced guidance to help a firm systematically assess the extent to which it is capable of increasing the robustness of its supply chain particularly in the instance of scarce resources.

The relationships within this framework are derived from the literature. Deciding the degree to which the findings presented in this review can inform practice is a matter of judgment for the practitioner. Three of the antecedents have been researched in 49 percent of the reviewed studies (visibility, risk management orientation, network complexity) and are, therefore, considered to have a relatively strong impact on supply chain robustness. Others, however, are less reliable, as they occur less frequently, thus posing potential future research opportunities.

The set of antecedents show managers the settings that will enable the proper implementation of supply chain robustness measures. In particular, managers should foster supply chain visibility in order to be able to map their supply chain and identify changes ahead of time to be able to implement proactive avoidance or resistance measures (cf. Sáenz and Revilla, 2014). Building supply chain visibility is a non-trivial matter. Visibility can be increased through enhanced relationships or through redesigning the network.

The study findings also reveal that firms should show an adequate risk management orientation. When Ericsson changed its risk management approach, it decided to create a corporate risk management function that cooperates and works with other functions and business units in a matrix-oriented way (Norrman and Jansson, 2004). Ericsson emphasized the importance of risk management in its organization and clearly defined responsibilities to better enable a proactive risk management approach. They also showed that such a redesign of organizational principles and responsibilities can be supported by a risk management council of business functions which seeks to increase intra-organizational information exchange – a vital aspect of the supply chain robustness antecedent of intra-organizational relationship magnitude.

Further, global sourcing has been argued to contribute to the structural complexity of the supply chain (Hendricks and Singhal, 2005). The robustness framework suggests a negative impact of network complexity on supply chain robustness. The author therefore encourages managers to adopt thinking in total costs when assessing their supply chain structure (cf. Chopra and Sodhi, 2014). That is, some drivers for sourcing abroad, such as cheap labor and products may sometimes prove disadvantageous if non-direct cost elements for sourcing globally, such as increased exposure to risks, are allowed for as well.

Through the findings in this chapter, managers are also encouraged to identify critical nodes through analyzing informational and physical flows in their supply chain. The identification of critical nodes is a prerequisite for the efficient and effective implementation of supply chain robustness measures.

It is further suggested that managers need to be aware of the power position their firm takes up in their supply chain. This research suggests that supportive actions towards supply chain partners may, in the long run, pay off for powerful firms through increased supply chain robustness.

Managers are also encouraged to foster well-educated and skilled personnel as well as leaders who are committed to robustness. Cappelli (2008) suggests that managers follow four principles to ensure an effective talent management: Using internal development programs, implementing modularized training systems, developing novel cost-sharing programs, and generating firm internal incentives to retain personnel.

4.5 Final Remarks

Several researchers have suggested supporting ideas and concepts of supply chain robustness. However, there is still a huge gap when it comes to understanding the dimensions, antecedents, and moderators of the construct in producing a theoretical basis of supply chain robustness.

The theoretical framework identified in this chapter fills this gap. It provides groundwork for an emerging theory of supply chain robustness through synthesizing many hitherto disconnected studies published in multiple research outlets. The framework seeks to explain how and why variables are related and makes specific predictions of such relationships. To increase the soundness of the framework, the author involved

academicians, practitioners and librarians to identify, analyze and synthesize the 94 studies.

This study complements prior research on dimensions and antecedents of supply chain agility (Gligor *et al.*, 2013; Gligor and Holcomb, 2012), with the provision of two dimensions and eight antecedents of supply chain robustness. It is a vital building block for better understanding the foundation of the two fundamental reactive and proactive supply chain strategies.

This paper also presents a call for researchers to conduct rigorous quantitative testing of the framework to derive reliable practical implications. The focus of such research should be to test the existence of and identify differences in the strength of the relationships. More empirical research is also encouraged on the moderator of the framework to further deepen the understanding of the extent to which this variable affects the effect size of each antecedent.

Besides the theoretical and practical findings of this chapter, it also reveals some interesting methodological insights for literature reviews in SCM. In the effort to follow the rigorous methodological approach proposed for an SLR (Pawson, 2006; Tranfield *et al.*, 2003), the author did not restrict his search to particular journals. Consequently, the reviewed articles came from multiple research outlets. During the analysis it was found that the theoretical framework of supply chain robustness can be developed using only journals with an IF of 1.3 or higher; the other articles did not show any new or different insights than those in the more highly-ranked journals. Hence, the resulting framework is solely built upon journals that are considered primary outlets within the field of SCM (see list in Appendix D).

A cautious methodological conclusion at this point would be that literature reviews that restrict their database searches to specialized journals listed in the upper echelon of journal rankings do not necessarily miss out on basic research contributions. Despite this interesting methodological finding, it needs to be emphasized that one should not jump to conclusions about the usefulness of doing a literature review using journal rankings versus using a broad literature review approach (see chapter 3). These results ought to be treated as tentative until more specific research is conducted on the need to include a broad range of publications.

The findings in this chapter are limited by the method applied. In conducting research, the reviewed articles commonly focus on goods, although no restriction was made on

this. Therefore, successful application of the framework to service supply chains re-remains uncertain. The findings could possibly be flawed if published research does not reflect what is identified, reflecting a bias regarding only publishing research that is interesting enough, i.e. publication bias (Rosenthal, 1979). The author believes that this research can still be considered to be representative, supported by the fact that the analysis made a posteriori about the IF of the selected journals has revealed that the list used in this research included the most prestigious research outlets, suggesting that most relevant and high quality research has been taken into account. This is supported by other literature reviews made in prestigious journals (e.g. Leuschner *et al.*, 2013; Machuca *et al.*, 2007).

This chapter developed both a formal definition and a theoretical framework of supply chain robustness. Though rigorous testing of the framework is still missing, it already provides valuable insights as to the enablers of an effective implementation of robustness measures. In the following chapters, a refined focus will be given on the inter-organizational aspect of the supply chain robustness framework.

5 Buyer-Supplier Relational Determinants to Facilitate Supply Chain Robustness: An Elaboration of the Relational View Perspective

The previous chapter has addressed the second research objective and "*developed a comprehensive conceptual framework that highlights antecedents and dimensions of supply chain robustness*." The developed framework is a contribution to an overall understanding of supply chain robustness and its antecedents. The community is now a step closer to providing structured and reliable managerial concepts to achieve more robust supply chains.

Chapter 5 now "drills" down into inter-organizational robustness and elaborates on the usefulness of an existing management theory in explaining dyadic disruption management performance. In particular it elaborates on the RV and the explanatory value of its four determinants of relational rent in an inter-organizational disruption management context. This chapter provides the theoretical footing of chapter 6 and a main building block of the recapitulatory schema proposed in chapter 7.

The remainder of this chapter is organized as follows. Sub-chapter 5.1 discusses the need for and the originality of this research step; Sub-chapter 5.2 briefly reviews the relevant literature on supply chain disruptions, robustness and dyadic disruption management; Sub-chapter 5.3 outlines data collection methods and analysis; Sub-chapter 5.4 presents the data analysis process; Sub-chapter 5.5 draws on associations between the RV and dyadic disruption management practices, and develops a set of propositions. Finally, sub-chapter 5.6 summarizes the results, and closes with theoretical and managerial implications as well as limitations and avenues for further research.

5.1 The Need for an Elaboration of the Relational View Perspective

While the strategic management of relationships to improve firm performance has been discussed in the supply chain integration and supplier development literature for quite some time (e.g. Krause *et al.*, 2007; van der Vaart and van Donk, 2008), this aspect has received scant attention in the area of supply chain disruption management. With the exception of Grewal *et al.*'s (2007) qualitative study on the impact of inter-firm relationships on crises (and vice versa), and Bode *et al.*'s (2011) study on firms' situational choice of intra- versus inter-organizational disruption management patterns, the literature is limited in that it has not yet had seen many publications on disruption management issues spanning firm boundaries.

Drawing on information processing and resource dependence theory Bode *et al.* (2011) proposed two strategic management patterns firms commonly take in order to respond to supply chain disruptions. For one, strategies on an intra-organizational level, the authors call them "buffering" strategies. Such strategies seek to reduce a firm's exposure to its supply chain partners through building up slack resources (i.e. inventory, time buffers and multiple suppliers). Intra-organizational responses to supply chain disruptions have already been investigated in various studies applying many theoretical lenses (e.g. Azadegan *et al.*, 2013; Costantino and Pellegrino, 2010; Tang, 2006; Viswanadham and Samvedi, 2013).

For two, the authors discuss strategies on an inter-organizational level, which the call "bridging". Such strategies have been researched to a lesser extent. They are aimed at managing supply chain disruptions through the use, modification and governance of supplier relationships. The buying-firm may manipulate such relationships, ranging from the strategic formation of alliances with important suppliers to integration (Bode *et al.*, 2011; Ulrich and Barney, 1984). Strategies on the inter-organizational level may be associated with investments in collaborative structures, or the strategic exchange of disruption related knowledge, or with the co-ordination of joint responses.

These two clusters of strategic management patterns go hand in hand with the supply chain robustness framework recently proposed by Durach *et al.* (2015). The authors propose intra- and inter-organizational robustness to be two fundamental building blocks of achieving overall supply chain robustness. Taking these two clusters, Bode *et al.* (2011) sought to research under what conditions firms choose intra-organizational or inter-organizational strategies to manage disruptions. They could quantitatively demonstrate that a firm's choice of organizational response depends on the level of trust and on the occurrence of supply chain disruptions. Their study furthered our understanding of *when* firms choose to respond on an inter-organizational level, however, our knowledge is still limited in understanding *what* relational determinants facilitate inter-organizational disruption management responses; a research question that has to the best of the authors knowledge not yet been addressed.

This research question also bears practical relevance, as multiple firms already follow disruption management strategies on an inter-organizational level not knowing what relational determinants to facilitate supply chain robustness exist and how they are put into most effective use. Toyota, for example, has managed to establish inter-organizational processes to facilitate the exchange of crucial knowledge with their suppliers, leading to a 50 percent decrease in defective parts (Dyer and Hatch, 2004).

Walmart works with its suppliers to better predict and meet local customer demand compiling demand maps in a vast joint database (Rigby and Vishwanath, 2006). Ford has invested in a supplier campus that is located half a mile away from its plant in Chicago (Kerwin, 2004). The campus houses tier-1 and tier-2 suppliers and is linked to the plant by a special conveyor system. While the park was initially designed to cut costs, it also increased robustness to unexpected quality errors and demand changes. Similarly, Dell and Nissan encourage some of their strategic suppliers to set up operations close to their facilities in order to facilitate information exchange, supplier visits and responsiveness to the challenges of supply disruptions (Chappell, 2013; Fields, 2004).

The study in this chapter sets out to research relational determinants that facilitate supply chain robustness for the buying firm. A strategic disruption management on an inter-organizational (buyer-supplier) level will be referred to as *dyadic disruption management*. Drawing on Bode et al. (2011), d*yadic disruption management* is defined as the resistance and avoidance of supply chain disruptions through a buying-firm's use, modification and governance of supplier relationships.

The RV perspective will be used as a theoretical lens in this research with which to explore and explain relational determinants in dyadic disruption management (Dyer and Singh, 1998). The findings of this study provide two contributions to the extant literature. First, the study argues and demonstrates that relational determinants to facilitate supply chain robustness through dyadic disruption management can be conceptualized through the RV perspective. Second, it extends and elaborates the RV perspective, for example by proposing that (1) an appropriate disruption management governance structure depends on the industry sector and (2) that the relationship between knowledge sharing and supply chain robustness follows a quasi-concave shape.

Identifying what buyer-supplier relational determinants facilitate supply chain robustness for the buying firm, requires a sound understanding of current disruptions and strategies to avoid and resist them. Methodological triangulation in the form of two group exercises and five case studies was used to widen practical insights, increase theoretical understanding and reduce methodological shortcomings.

5.2 Supply Chain Disruptions, Robustness and Dyadic Disruption Management

This sub-chapter will briefly delimit the focus of chapter 5, define its constructs and provide an overview of related literature streams. In their seminal research, Chopra *et*

al. (2007) show that managers have to decouple recurrent and disruptive supply chain events when planning appropriate management strategies. For this study, the research focus is restricted to upstream supply chain disruptions.

Table 11 provides an overview of some important definitions of supply chain disruption. Supply chain disruptions arise from the vulnerability of flows of material in firm networks (Talluri *et al.*, 2013; Wagner and Bode, 2008). Firms that depend on external resources are forced to expose themselves to the disruption of such flows (Pfeffer and Salancik, 1978). Supply chain disruptions involve at least two tiers in the supply chain and usually materialize upstream in the supply chain (Bode and Wagner, 2015). Drawing on the definitions in Table 11, this study defines *supply chain disruptions* as events that materialize upstream in the supply chain and disrupt the normal flow of goods and material for the buying-firm.

Table 11 Definitions of Supply Chain Disruption

Source	Definition
Wagner and Bode (2008, p. 309)	"*Combination of (1) an unintended, anomalous triggering event that materializes somewhere in the supply chain or its environment, and (2) a consequential situation which significantly threatens the normal business operation of the firms in the supply chain.* "
Craighead *et al.* (2007, p. 132)	"*Unplanned and unanticipated events that disrupt the normal flow of goods and materials within a supply chain.*"
Bode and Wagner (2015, p. 132)	*"The combination of an unintended and unexpected triggering event that occurs somewhere in the upstream supply chain (the supply network), the inbound logistics network, or the purchasing (sourcing) environment, and a consequential situation which presents a serious threat to the normal course of business operations of the focal firm.*"
Blackhurst *et al.* (2005, p. 4079)	*"Unplanned delays or stoppages of planned product flow, can be costly and result in significant supply-chain delays."*
Talluri *et al.* (2013, p. 254)	*"A disruption occurs when the supply chain is radically and unexpectedly transformed through nonavailability of certain production, warehousing, distribution, or transportation options, such as equipment failure.*"

Robust supply chains are able to maintain their functions despite internal or external disruptive events (Brandon-Jones *et al.*, 2014). Kouvelis *et al.* (2006) suggested that a supply chain is robust if it hedges the firm's performance against such events. Considering that any property of a supply chain is always relative to a point of reference (Carter *et al.*, 2015), this chapter will observe supply chain robustness from a buying-firm's perspective, hereafter termed *buying-firm's supply chain robustness*. Durach *et al.* (2015) find that, in order to deal with disruptions, a buying-firm will strive to implement measures that help to *resist* or *avoid* disruptions. Drawing on their research, Figure 6 shows that robust supply chains are designed so as to reduce the probability of a disruption to happen (*avoid*) and/or reduce the impact of a disruption (*resist*). Supply chain robustness can be qualitatively assessed through looking at the degree to which the buying-firm has managed to avoid or resist disruptions stemming from its supply chain (Durach *et al.*, 2015).

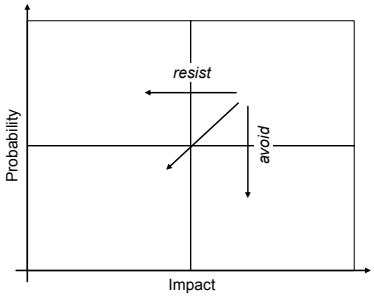

Figure 6 Supply Chain Robustness and the Disruption Probability/Impact Matrix

This study is closely linked with literature on supply chain integration (SCI) and supplier development. The SCI field mainly focuses on the degree to which a manufacturer strategically collaborates with its supply chain partners on intra- and inter-organizational processes, in order to achieve effective and efficient flows of products, services, information and finances to provide maximum value to the customer (Flynn *et al.*, 2010). While SCI literature is mainly concerned with the collaborative aspects of SCM, dyadic disruption management is concerned with the use, modification and governance of an existing inter-firm linkage and may thus also include non-collaborative aspects. The still evolving conceptualization of the SCI field has led to inconsistent findings regarding how individual dimensions of SCI are related to different dimension of performance. Nonetheless, the field provides useful and promising insights to this study. For example, several authors see a close link between SCI and operational effectiveness (e.g. Armistead and Mapes, 1993; Marquez *et al.*, 2004).

Looking at the upstream supply chain, Gimenez and Ventura (2005) found that inter-organizational integration contributes to achieving stock-out and lead-time reduction. Both, stocks and lead-times are closely linked with situations of product unavailability and supply chain disruptions.

Literature on supplier development draws on the aspects of knowledge sharing and relation-specific asset investment with the goal of improving operational performance between the supply chain partners (Krause *et al.*, 2000; Takeishi, 2001). "*Investments are made by buyers in the development of suppliers in order to accrue tangible benefits such as reduced cost, greater quality and flexibility, and more reliable delivery*" (Krause *et al.*, 2007, p. 530). This stream of literature has already shown that the direct involvement of suppliers through activities such as training and education of a supplier's personnel has a positive impact on performance improvement (Krause *et al.*, 2000), providing initial indication that a well-developed supplier relationship can reduce both probability and impact of supply disruptions and finally improve supply chain robustness.

These studies show the usefulness of the relational determinants of the RV perspective in different supply chain disciplines. However, they only touch upon the explanatory value of the RV in inter-organizational (dyadic) disruption management. In the following, this study seeks to elaborate on the theoretical contribution of the RV in disruption management.

5.3 Methodology

This research asks "what", "how" and "why" types of questions, seeking to identify inter-organizational avoidance and resistance strategies of buying-firms when faced with disruptions (Barratt *et al.*, 2011). Elaborating on the RV perspective, the author tries to identify patterns across the strategies to explain and propose relational determinants that facilitate more robust supply chains (Carter, 2011; Ketokivi and Choi, 2014). Given this nature and in order to increase confidence in this study's findings, two qualitative methodologies have been chosen to provide methodological triangulation. First, systematic data collection in group exercises provides data across a large range of firms (Delbecq and Van de Ven, 1971), and second, multiple case studies allow the generation of more in-depth, contextual data (Eisenhardt, 1989). As Mintzberg (1979, p. 587) puts it: "*[f]or while systematic data create the foundation for our theories, it is the anecdotal data that enable us to do the building*." Hence, in order to achieve both

breadth and depth of knowledge, the author conducted two group exercises and under-undertook five case studies.

This study draws on the idea of theory elaboration (Ketokivi and Choi, 2014). In line with studies on SCI and supplier development (e.g. Devaraj *et al.*, 2007; Krause *et al.*, 2007; Schoenherr and Swink, 2012), the RV is employed as a theoretical background for explaining robustness in dyads. This theory provides an explanation of how individual firms can achieve performance improvement through existing supply chain relationships.

The RV postulates that a firm's competitive advantage cannot merely be attributed to resources owned and controlled by the firm but may also extend beyond the firm's boundaries into its network. In particular, it proposes that a firm can benefit from inter-firm integration and strategic partnerships through acquiring resources they do not possess or cannot capture (Lavie, 2006; Leuschner, *et al.*, 2013). Dyer and Singh (1998) propose four relational determinants: relation-specific assets, knowledge sharing routines, combining synergistic resources and capabilities, and effective governance.

However, the field of inter-organizational disruption management is not yet well enough researched to provide sufficiently detailed premises that the relational determinants of the RV can be used in conjunction with the performance construct of supply chain robustness. As postulated by Williamson (2008), SCM is a promising hybrid between traditional buy and make decisions. Johnson and Templar (2011) corroborated this notion by identifying a positive link between SCM and firm performance. Wieland and Wallenburg (2012) showed a positive relationship between supply chain risk management practices and supply chain robustness, which in turn is a part of business performance. Looking at this multitude of research, and the potentially fruitful link between the supply chain integration and supplier development literature and the area of supply chain risk management, it is surprising to find hardly any research in this area.

5.3.1 Group Exercises

By conducting group exercises, the author was able to gather empirical data on a multitude of dyadic disruption management strategies. The two group exercises followed the structured group discussion process proposed in the nominal group technique (NGT; Van de Ven and Delbecq, 1971). Previous research in logistics and SCM has shown that the technique is a sound methodology to solicit expert knowledge

(e.g. Schoenherr *et al.*, 2012). Traditional focus group discussions usually do not en-encourage less secure members to participate. While Delphi studies try to overcome this issue by allowing no face-to-face meetings, they depend strongly on the moderator's capabilities. The NGT takes the best of both worlds, generating ideas through bringing people together face-to-face (Green, 1975) and balancing their input through a moderated and partially anonymous process that ensures integrity (Lloyd, 2011). The NGT has been found to outperform both the Delphi method and focus group discussions (Goodman, 1987; Van de Ven and Delbecq, 1971). Because of these traits of NGT, this was regarded as the most appropriate approach for the group exercise.

Following the NGT process guidelines proposed by Delbecq and Van de Ven (1971), 42 participants were asked to identify potential disruption causes first and determine suitable dyadic management strategies second. The identification and assessment of disruption causes took place online, while the identification of strategies took place on-site in a moderated workshop setting following the round-robin approach (Chapple and Murphy, 1996).

Supply chain disruptions may be highly heterogeneous in their characteristics and emerge from a variety of sources. Due to the empirical nature of this study, a typical subset of most pressing disruption causes needed to be identified to have a common basis of discussion with the participants. Multiple scholars have attempted to categorize disruptions and provided taxonomies or dimensions (e.g. Christopher and Peck, 2004; Wagner and Bode, 2008). The categories of supply chain disruptions are often labeled "supply chain risk sources." Wagner and Bode (2008) proposed five categories (1) Demand Side Risks, (2) Supply Side Risks, (3) Regulatory, Legal and Bureaucratic Risk, (4) Infrastructure Risk and (5) Catastrophic Risk. More recent research by Jia and Rutherford (2010) added a sixth dimension: (6) Cultural Risks (e.g. corruption, cultural gap).

In order to allow for the recognition of all six supply chain disruption dimensions, this study sampled 42 participants from Western firms dealing with suppliers of a different cultural background. In particular, Western firms that procure in the Chinese market were selected. Paying heed to potential contextual idiosyncrasies the 42 participants were selected and grouped into homogenous sub-groups, building clusters of firms from the automobile, electronics and consumer goods industry. All firms occupied a variety of positions along their supply chains. All firm representatives have in common that they have profound knowledge of their firm's buying activities and have

responsibility for coordinating their purchasing activities. A small set of logistics service providers in the respective industries was also included in the sample as, from the author's experience, managers seldom command sufficient transformational expertise to identify disruption causes in complex logistics services. Table 12 depicts an anonymized excerpt of demographics provided by the participants.

Due to capacity constraints the sample was split into two groups of 21 participants each. All 42 participants were first sent an online questionnaire and, based on their views, asked in an open question to list the most relevant disruption causes in their supply chains. A list of 22 causes was compiled from the responses. The participants were then sent back the complete list and asked again in an open question to write down any additional ideas they might have. They were also invited to seek further explanation. Despite some minor clarifications to the wording, no additional item was identified in this phase.

Table 12 Sample Demographics

Firm Demographics			
Industry		***Origin***	
Automotive	*16*	*EU*	*40*
Electronics	*13*	*USA*	*2*
Consumer Goods	*13*		
Revenue in €*		***Total Employees***	
< 10m	*1*	*11 - 50*	*2*
10m - 50m	*6*	*51 - 250*	*4*
50m - 100m	*1*	*251 - 500*	*4*
100m - 250m	*3*	*501 - 2000*	*9*
250m - 500m	*4*	*2001 - 5000*	*2*
500m - 1bn	*3*	*> 5000*	*21*
1bn - 5bn	*9*		
> 5bn	*14*		

**one firm did not provide this metric*

In order to identify the acuteness of certain disruption causes and generate high personal commitment of the participants, a second online survey was conducted to rank them on the dimensions "probability" and "impact" on 7-point Likert scales (see Norrman and Jansson, 2004). This resulted in a mapping as depicted in Table 13. Due to the inclusive research approach of this study, some disruption causes are inevitably overlapping or interdependent. This, however, does not impede the study, as they are merely seen as the basis to solicit avoidance and resistance strategies.

The study then set forth to identify dyadic disruption management strategies in two separate workshops. The participants were asked to choose five disruption causes from Table 13 which have a high priority from their perspective (Thompson, 1965).

Table 13 Mapping of Identified Disruption Causes

Disruption Causes	**Probability**		**Impact**	
	Mean	STD	Mean	STD
Strikes	*3.2*	*1.1*	*4.9*	*1.6*
Supplier insolvency	*4.2*	*1.4*	*3.9*	*1.5*
Criminal acts (exogenous)	*2.6*	*1.1*	*3.8*	*1.3*
Legal uncertainty	*4.9*	*1.4*	*4.7*	*1.5*
Restricted number of appropriate suppliers	*4.4*	*1.5*	*4.7*	*1.5*
Inferior quality due to handling errors	*3.8*	*1.6*	*4.6*	*1.4*
Criminal acts (endogenous)	*2.8*	*1.1*	*4.6*	*1.7*
Discriminating political tendering	*4.6*	*1.2*	*3.6*	*1.2*
Transport infrastructure failure	*4.8*	*1.5*	*4.5*	*1.3*
Unfair competition	*4.1*	*1.5*	*4.5*	*1.3*
Political unrest	*4.5*	*1.8*	*4.5*	*1.5*
Customs compliance	*4.9*	*1.1*	*4.4*	*1.4*
Economic downturn	*4.2*	*1.4*	*4.4*	*1.3*
Industrial espionage	*4.4*	*1.4*	*5.2*	*1.1*
Counterfeit sub-products	*4.7*	*1.5*	*5.2*	*1.5*
Corruption	*4.2*	*1.4*	*4.2*	*1.2*
Natural disaster (Geological)	*4.0*	*1.3*	*3.2*	*1.2*
Non-compliant partner	*3.9*	*1.5*	*4.1*	*1.5*
Unexpected supplier plant outage	*3.8*	*1.5*	*4.1*	*1.7*
Cultural gap (misunderstanding)	*5.0*	*1.5*	*5.0*	*1.4*
Relocation of partner	*4.3*	*1.4*	*5.0*	*1.3*
Natural disasters (Metrological)	*3.9*	*1.6*	*3.0*	*1.1*

In order to support a common understanding of the selected disruption causes the participants first split up into the sub-groups and discussed their understanding of each disruption cause and potential resulting consequences. Each sub-group followed the round-robin procedure and was guided by a neutral external moderator (Delbecq and Van de Ven, 1971). That is, for each disruption cause, the participants were given five minutes to write down their opinion. They were then asked to present their results individually. The moderators ensured that each person was allowed to contribute and that the process was neutral, i.e. no judgment, criticism or immediate discussion. The

moderators consolidated the results across all groups and presented them to the as-assembly.

For each disruption cause, participants were then given 10 minutes to individually generate their ideas of appropriate dyadic disruption management strategies that when implemented can avoid or resist disruptions. In a round-robin manner, the participants were then individually asked to name their identified strategies. The moderators again consolidated the results across all groups and presented them to the assembly. Two weeks after the last workshop, all participants received a list showing the strategies compiled from both workshops. They were asked to provide a critical assessment of the strategies and to share any concerns they might have. Their feedback was incorporated in order to further develop the results. This systematic data collection resulted into a set of 43 strategies for five disruption causes (see Table 14).

Table 14 Mitigation Strategies Sorted According to the Determinants of Relational Rent

	Determinants of relational rents			
	Relation-specific investments	**Knowledge sharing**	**Complementary resources**	**Effective governance**
Cultural Gap (inter-organizational miscommunication)	1. Conduct intercultural training jointly with supplier (e.g. employee exchanges or language training) to further social soft-skills 2. Develop inter-organizational meta-language (i.e. make use of pictures, signs)	3. Socialize with representatives from a similar hierarchical level (e.g. visits, business lunches, sports activities) (†) 4. Share knowledge and expectations in a culturally insightful way 5. Build inter-organizational project teams 6. Build regional expert groups with the supplier	7. Generate cultural expertise through local suppliers 8. Seek access to social and business network through suppliers	9. Build a trustworthy relationship through socializing (†) 10. Increase trust in suppliers competence through social exchange (note: legal contracts are of less value in the Chinese market than in Western societies) (†) 11. Prefer verbal communication over written communication 12. Use standardized procedures with the supplier (‡)
Legal Uncertainty due to Legal Changes	13. Invest in inter-organizational task forces/logistics sounding boards to adapt to legal changes	14. Weekly/monthly meetings with suppliers to identify possible legal changes 15. Build up a network of network partners that allows for the seamless and quick flow of information (‡)	16. Legal departments can make use of local suppliers that are more familiar with local legal system 17. Learn from local suppliers how to balance the trade-off between lobbying and compliance (‡) 18. Join inter-organizational industry co-operations and associations to propagate interests	-

Transport Infrastructure Failure	19. Invest in infrastructure (e.g. port equipment and hubs) jointly with committed partners 20. Implement real-time information systems 21. Use technical solutions for joint material tracking and tracing 22. Adjust to use same information standards	23. Cooperate with supplier to exchange know-how on upcoming infrastructure issues 24. Joint long-term supply planning (†)	25. Select experienced supplier that can better organize transportation 26. Choose partners that have the necessary knowledge on finding multiple modes of transport 27. Jointly collect relevant data about disruptions (mean time to failure, mean time to repair, variance in lead time)	28. Authorize supplier to make independent transportation decisions (†) 29. Use revenue sharing contracts (‡)
Restricted Number of Appropriate Supplier	30. Develop existing suppliers in order to increase their capacities and capabilities 31. Plan and design component/material substitution with supplier (†) 32. Financially support suppliers to increase their reliability 33. Joint product design adjustment to better meet the capabilities of the supplier (†)	34. Build up close communication and close relationship with suppliers to allow for a timely response in case of issues on the supplier's side (†)	-	35. Increase ties with existing suppliers through social activities (†) 36. Offer long term perspective to deepen relationship to supplier 37. Use revenue sharing contracts (‡)
Counterfeit Sub-Products	38. Conduct supplier training to raise awareness for product counterfeiting and consequences 39. Establish joint methods for the design of products, processes and information, so as to have them undergo continuous development in order to provide protection against counterfeiting	40. Visits to suppliers' plants by purchasing managers and technical staff to provide feedback on their purchasing activities and raise awareness for product design, quality and technical performance issues due to counterfeit sub-products	41. Rely on 'local champions' as suppliers, as these have more experience in identifying the black sheep in the market 42. Jointly with suppliers create approved vendor lists for sub-suppliers	43. Work with suppliers that can be trusted to be supportive partners in protecting against counterfeit products

† Mainly applied by low complicated product industry
‡ Mainly applied by high complicated product industry

5.3.2 Multiple Case Studies

In order to generate additional data and provide further, in-depth substantiation of "what/how" – and particularly "why" – certain strategies identified in the workshops are followed, case studies were conducted subsequent to the group exercises.

Case study research is a well-established method in logistics and supply chain research (e.g. Blackhurst *et al.*, 2011). Consistent with other case-based research (e.g. Blackhurst *et al.*, 2011; Bode *et al.*, 2014), this methodological step adhered to the guidelines, protocols and analysis procedures outlined in Eisenhardt (1989) and Miles *et al.* (2013).

Case study data was gathered in five manufacturing firms using different data sources and collection methods (see Table 15). Firms were sampled that have not previously participated in the group exercise. The analysis of the group exercise suggested potential differences in the dyadic disruption management of firms from industries with complicated (e.g. automobile, electronics) vs. less complicated (e.g. consumer goods) products. To have a closer look into this notion, polar types of case study firms were chosen to fit in either of the two categories (see sub-chapter 5.4).

The majority of data was collected on multiple-day visits to the firms' headquarters. Data were collected through semi-structured interviews and presentations by key personnel. The purchasing managers were invited to bring their employees or other firm representatives to the interview sessions and presentations if deemed appropriate. Two investigators participated during the data collection process. During the interviews, the research objectives were explained to the participants. The participants were then asked to choose a particular supplier and a set of current disruptions, and then propose current successful dyadic management strategies (see Appendix E). They should base their answers solely on ongoing buyer-supplier relationships that have moved beyond an arm's length relationship.

Table 15 Case Studies

Industry Sector	Revenues	Total Employees	Headquarters	Data source	Main Data Content
Automotive (e.g. hydraulic pumps) (1st tier) SteelCom	> € 5bn	> 5000	GER	*Key information* Semi-structured interviews (total 210 min) Conducted face-to-face with six representatives (Head of Purchasing and team members) *Further information* Firm presentations	*Supply chain disruptions due to lack of trust; strategies employed and prospected with particular Chinese supplier(s); international logistics network; material and information flow*
Automotive (e.g. steering) (1st tier) SteerCom	> € 5bn	> 5000	LIE	*Key information* Semi-structured interviews total 210 min) Conducted face-to-face with three representatives (Project Manager SC Development, Project Manager SCM Operations, Supply Chain Manager) *Further information* Firm presentation	*Strategies of supplier governance; Supply chain disruptions caused by lacking coordination between suppliers and sub-suppliers; material and information flow*
Consumer Goods (e.g. perfumes) (OEM) LuxCom	> € 5bn	< 5000	FRA	*Key information* Semi-structured interviews (total 100 min) Conducted face-to-face with one representative (Logistics Director) *Further information* Presentations by logistics director, firm tour	*Customs issues and supply chain disruptions; dyadic avoidance and resistance strategies employed; global logistics strategy; material and information flow*

Consumer Goods (e.g. flash lights) (OEM) FlashCom	< € 10m	11-50	GER	*Key information* Semi-structured interviews (total 90 min) Conducted face-to-face with two representatives (Chief Executive Officer and Head of Purchasing) *Further information* Firm Tour	*Supply chain disruptions in face of legal changes; dyadic avoidance and resistance strategies employed; development of international logistics network; material and information flow*
Electronics (e.g. computer chips) (1st tier) ChipCom	> € 5bn	> 5000	GER	*Key information* Semi-structured interviews total 280 min) Conducted face-to-face with three representatives (Director Global Transit Management, Manager Global Purchasing and Logistic Manager) *Further information* Firm presentations	*Strategies of supplier selection; Supply chain disruptions caused by supplier; dyadic avoidance and resistance strategies, expanding social network through supplier use; material and information flow*

As recommended by Yin (2008), all notes related to the interviews and presentations were transcribed within 24 hours of data collection. All transcripts were sent back to the participants to check for accuracy and anonymity. The point where the researcher assumed that no new information relevant to this research could be obtained was reached after collecting data from five firms, following which data collection was ceased.

5.4 Data Analysis

Throughout the data collection phase, the author sought to achieve an overlap between data collection and analysis. After each workshop and each case study, the newly identified data was summarized, described, discussed with participating researchers and added to the existing data set.

For structuring and analyzing the group exercise data, the author built an initial tabulation that draws on the four determinants of relational competitive advantage as outlined in Dyer and Singh's (1998) RV. Eisenhardt (1989a, p. 536) suggests that the use of *a priori* constructs is valuable as *"it permits researchers to measure constructs more accurately. If these constructs prove important, then researchers have a firmer empirical grounding for the emergent theory*." The avoidance and resistance strategies identified in the workshops were, if possible, tabulated in those four determinants. To reduce human subjectivity in this research step, the author drew on the Q-methodology. Three researchers, who also participated as observers in the workshops, independently grouped the strategies into the predesigned matrix (see Table 14). The

author emphasized to all participating researchers that the determinants were only to be considered as tentative and that any strategy that cannot be classified, as its content is distinct from the determinants, will be regarded independently. In a subsequent open discussion, the researchers commented and elaborated on their positioning of the strategies (Q-sort). Similarities among the Q-sorts were then determined, discussed and consolidated (the interested reader is referred to Ellingsen *et al.* (2010) for a more detailed description of the Q-methodology).

This initial review of the group exercise data provided a basic classification of codeable behaviors (Miles *et al.*, 2013) and proved an important contribution to structuring the data. All strategies could be fitted into the four determinants of the RV. While this provided a first indication of the usefulness of the theory in dyadic disruption management, the study sought to go deeper with its analysis in order to better understand relational determinants that facilitate supply chain robustness.

A first discussion and analysis of the results (data source: identified strategies, discussions with practitioners and observations during moderating the industry groups) from the group exercises among the participating research did not show any indication for differences between the three industry clusters per se. Neither subjectively nor statistically could any difference in regards to impact and probability of disruption causes or differences in applied strategies be determined. However, indications have been given that the complicatedness of the products in the firms (often seen as a substitute for the number of individual parts that have to be procured to assemble a product; Inman and Blumenfeld, 2014) influences the way a buying-firm approaches an "effective disruption management governance" (Dyer and Singh, 1998) with their suppliers. As the group exercise setting could not account for this notion completely, the case study sampling paid heightened attention to this.

For analyzing the data collected in the case studies, potential constructs and relationships were discussed for the subject firm. This step explicitly focused on the 'why' behind the identified strategies. The gathered data (data source: interviews, observations, firm presentations) was analyzed for behaviors and examined by both investigators to see how they explain or not explain the determinants of the RV. The identified concepts were compared with the notions and initial findings emerging from the workshops. This analysis builds on "replication logic" (Yin, 2008) in that each case study and all workshop data was analyzed, whether or not they confirmed the inferences drawn from the other data.

Emerging concepts were discussed with all participating researchers and eventually sent out to all practitioners participating in this study in order to solicit their views on whether the generalized findings confirmed their experiences and adequately summarized their statements. The techniques used to ensure validity during this process of data analysis and interpretation are depicted in Table 16. The final draft of this study was also sent out to all participants to solicit further feedback. The reasoning behind this step is that some critical concerns may have been overlooked in the technical development of the study. No comments where received that required any major changes.

Table 16 Techniques Used to Increase Validity within this Research

Criteria	Techniques
Credibility and authenticity	• Initial group exercise/case study transcripts were sent to the participants directly after the meetings • During data interpretation, the author contacted the participants and participating colleagues several times to solicit their feedback and ask for the accuracy of the interpretation of the data • Participants were consulted on whether the results and identified phenomena presented in this article reflected their experiences
Criticality and integrity	• The author followed a systematic research design that was presented to the participants ex ante • Data interpretation has been recursive and repeatedly discussed with colleagues and participants

Source: Delbecq and Van de Ven (1971) and Whittemore et al. (2001)

5.5 Results

Common postures across a large group of firms could be identified. Five propositions emerge from the analysis and indicate what relational determinants facilitate supply chain robustness. This sub-chapter presents the study results and reflects and discusses its findings and contributions with the use of extant literature.

5.5.1 Complementarity in Disruption Management

Dyer and Singh (1998) suggest that buyer-supplier relations are most effective when firms can exhibit synergies in their assets. They use the term “complementarity” to

discuss capabilities possessed by both supply chain partners that match each other and thereby increase the potential for relational benefits. Lambe *et al.* (2002, p. 144) define complementarity as "*the degree to which firms in an alliance are able to eliminate deficiencies in each other's portfolio of resources […] by supplying distinct capabilities*." Synergies from such assets can be achieved through two dimension, (1) accumulating similar assets or (2) combining distinct assets (Larsson and Finkelstein, 1999). As Varadarajan and Cunningham (1995, p. 293) noted, "*a firm entering into a strategic alliance may either seek partners whose abilities augment its strengths or ameliorate its weaknesses*."

In the case of disruption management in dyads, it was found that supply chain partners who possess complementary capabilities can help each other to increase supply chain robustness through combining distinct capabilities and/or combining their assets. Prime examples of complementarity are given in the disruption causes of (1) "Transport Infrastructure Failure", and (2) "Counterfeit Sub-Products".

The factors involved in increasing supply chain robustness through distinct capabilities can be categorized into two clusters. First, suppliers have full command of their production schedule. That is, they can align their production schedule with available transportation capacity better than buying-firms can [25, 26 – compare with numbers is Table 14]. Especially if transportation capacity is scarce, e.g. shortly before federal holidays, suppliers are better capable of preventing disruptions in the material flow due to the lack of transportation capacity. As mentioned in the case studies, suppliers may also be able to allocate production capacities more efficiently than the buying-firm. For example, SteelCom has established contacts between two suppliers of the same strategic product. In out of stock situations, both suppliers are required to switch production between them in order to increase supply reliability for the buying-firm. Second, suppliers commonly know more about their own supply structure (i.e. sub-supplier information, lead times) than buying-firms. This enables suppliers to take appropriate and potentially more suitable actions to avoid supply disruptions for the buying-firm. Buying-firms in the workshop have thus started to jointly with the supplier discuss potential sub-supplier issues in order to increase supply chain robustness [41, 42].

These observations mainly look at the supplier providing complementary capabilities to the buying-firm. Yet similar patterns could be identified for how buying-firms can provide complementary assets to the supplier. During the firm visits, SteerCom presented an example of where their direct supplier A lacks the capability to effectively

manage its suppliers. Supplier A, a medium sized firm, has previously been forced to procure from a large global player B in order to meet the product needs of SteerCom. Supplier A, however, lacked the capability to find effective contracting terms with firm B. Multiple times, this situation caused batches being delivered late and/or with wrong specifications from firm B to firm A causing a supply disruption in the entire chain. Consequently, in order to avoid such disruptions, SteerCom, a large firm itself, agreed to contract sub-supplier B as SteerCom is financially sounder than supplier A and runs an elaborate legal department. Drawing on these observations of bilateral complementarity, it is postulated:

> **Proposition 1:** *The greater the buying and supplying-firms' possession of complementary disruption management capabilities and their willingness to combine those, the greater the buying-firm's supply chain robustness.*

5.5.2 Knowledge Sharing in Disruption Management

Research in the RV literature has shown that through vertical learning alliances supply chain partners can acquire knowledge which in turn increases different metrics of performance (e.g. Anand and Khanna, 2000; Dyer and Hatch, 2004). For example, examining the RV perspective, Mesquita *et al.* (2008) found that both suppliers' independent and joint buyer-supplier knowledge acquisition efforts are positively related with the supplier's business performance.

The relationship between knowledge exchange and performance has also been the subject of research efforts in the area of supply chain risk management (e.g. Wakolbinger and Cruz, 2011; Wieland and Wallenburg, 2013). Following Dyer and Singh (1998), Wieland and Wallenburg (2013) postulated a linear relationship between knowledge exchange and performance. They polled 270 manufacturing firms to research the relationship between communication and supply chain robustness. However, the identified positive linear relationship was only just significant ($p = 0.09$), bearing the risk of a Type II error.[5]

While the workshop data in this study concur that there is a positive relationship between knowledge exchange and supply chain robustness, the case study analysis disagrees with the linearity of this relationship. Discussion among and with the study participants indicate that the exchange of knowledge seems to have a greater value when the buying-firm has a lower amount of it, and hardly any additional value when it already has much of it.

[5] Type II error: "false negative"; the interested reader is referred to Riedl *et al.* (2014) to read more about statistical power issues in SCM studies

Two forms of knowledge exchange in disruption management emerged. First, sudden changes in the environment sometimes force an intervention by both partners. In the case of unexpected short-term events, most firms have pre-established inter-organizational sounding boards in position that are ready for ad-hoc meetings in order to jointly evaluate the new situation [5, 6, 13]. This supports Celly *et al.* (1999) who suggest in their game-theoretic conceptualization that investments knowledge sharing routines are often necessary to coordinate non-routine tasks that are reciprocally interdependent. Second, regular buyer-supplier meetings serve to avoid disruptions due to misaligned inter-organizational processes [24, 34]. For example, through sharing knowledge buying-firms can help the supplier to take appropriate actions. Only if buying-firms communicate clear deadlines can the supplier meet them. FlashCom therefore provides detailed project agendas to its suppliers with milestones such as ETA and the buying-firm's promised delivery time to the customer.

However, the data suggest that there is a limit to the value of knowledge sharing. Not all knowledge translates into competitive advantage (Mesquita *et al.*, 2008). While the buying-firms gain experience from the sharing of knowledge, the prolonged exchange of knowledge in regular operational meetings has been reported to lead partners to build up tacit knowledge for the joint processes which leads to a decreasing value of any additional meeting over time. This is a notable finding, as it may provide an explanation for why Krause *et al.* (2007) could not find a linear positive relationship between information sharing and performance in their deductive study on supplier development.

It is therefore suggested that in the presence of supply chain disruptions two different aspects are relevant: (1) knowledge has to be exchanged at the right time, and (2) the longer dyadic relationships follow routines of sharing knowledge, the lower the incremental value of any new knowledge, challenging the linearity perception of the RV. Drawing on the economic concept of utility, one could argue that the value of knowledge exchange in disruption management follows a very steep quasi-concave shape, finally reaching a level where there is little or no value in the exchange of additional knowledge. Drawing on these observations and discussions, it is postulated:

> **Proposition 2a:** *Routines to share knowledge about supply chain disruptions between buying and supplying-firms are positively associated with a buying-firm's supply chain robustness, yet the marginal benefit of knowledge sharing is always higher for non-routine tasks than for routine tasks and decreases with the extent of knowledge exchanged.*

It was further indicated that through providing valuable information to the buying-firm, a supplier can be a strategic partner in proactively coping with exogenous and endogenous disruptions. As pointed out during the group exercises, especially in new markets, local suppliers provide relevant insights regarding supply chain-relevant laws and policies, including their enforcement, execution and change [14, 15]. For example, a representative from a German car manufacturer complained in the workshop about a recent ad-hoc policy change in China that urged his firm to start sourcing certain spare parts locally. The change was officially announced only four days before it came into effect. One of his local suppliers had made him aware of this legal change a few days earlier, giving him a little more time to resist the negative impact of the event. Consequently, the participating Western firms often seek to strategically partner with local suppliers that provide access to crucial information and know-how [23, 24].

The case study firms confirmed this notion and reported that well-established partners in new markets are valuable sources of crucial knowledge. Access to such complementary knowledge can enable the buying-firm to better deal with local disruptions. ChipCom reported that the connectedness of a supplier is an important supplier selection criterion at their firm in order to gauge potential access to valuable information [see also 15]. The possession and provision of complementary knowledge between the supply chain partners can help both firms to improve their disruption management. It is therefore postulated:

> **Proposition 2b:** *Suppliers which own and share knowledge complementary to the buying-firm's basket of knowledge enable a proactive management of disruptions and increase the buying-firm's supply chain robustness*

5.5.3 The Interplay of Relation-Specific Disruption Management Investments and Knowledge Sharing

Suppliers can reduce self-induced disruptions to buying-firms by being independently proactive in their actions. This issue is also a topic of discussion in the supplier risk assessment literature (e.g. Blackhurst *et al.*, 2008; Wagner and Bode, 2006). That being said, buying-firms also make a stab at motivating their suppliers to take such actions.

The reasons for why suppliers are not willing to reduce or avoid their self-induced disruptions are a lack of trust and/or the preference for short term business with other buying-firms. The group exercises show that by investing in the relationship [1, 2, 30, 31, 32] and sharing of valuable knowledge [3, 4, 5, 6] a buying-firm can increase

transparency for the supplier regarding its value for the buying-firm, establish trust and reduce asymmetry of information. These measures are sought to increase relational ties with the supplier and curb opportunistic behavior. Measures that aim at investing in the relationship and at sharing knowledge foster confidence with the supplier and motivate it to increase its efforts to prevent self-induced disruptions (e.g. shift from a make-to-order to a make-to-stock production system; provision of sufficient quality to ensure recurring business). In the case studies, SteelCom noted that they substantially increased efforts to increase formerly lost trust with their suppliers by providing internal firm data. They stated: "*We seek to increase transparency for the supplier over our firm internal data, for example, sales, stock and even procurement structure in order to show the supplier that we need its products and increase its confidence. We even share information regarding ABC/XYZ-analyzes, our purchasing strategy that is purchasing quantity, forecast and supplier strategy … We have always been honest with this data*."

Signaling commitment to the relationship is usually fostered on two levels: first, at the organizational level, for example through scheduling regular meetings or down payments (e.g. FlashCom offers up to 50 percent down payments to its suppliers); and second, at the social level, for example through enabling purchasing personnel and their counterparts at the supplier to get to meet each other. Investments in employee exchanges and firm visits are deemed costly but worthwhile. Almost all firms in the sample seek to exchange employees with strategic suppliers in order to help both sides better understand each other's processes, get to know each other and tackle disruptions that may be caused from misunderstanding or lack of knowledge regarding the other party's operational capability [3, 40].

Developing a strong strategic partnership with suppliers will thus achieve both, facilitate their understanding and anticipation of the buying-firm's needs, in order to better meet its disruption management requirements and increase the supplier's commitment to the relationship. Drawing on these observations, it is postulated:

> **Proposition 3:** *The greater the buying-firm's capability to properly demonstrate the value of the relationship to the supplier through relational investments and exchange of relationship related information the greater the buying-firm's supply chain robustness.*

5.5.4 Effective Disruption Management Governance

In order to make the most out of the buyer-supplier relationship, buying-firms need to effectively govern their suppliers. Firms in this study report that with respect to disruption management a relationship that is informally governed (e.g. social norms, mechanisms) usually exceeds the positive outcomes generated through relationships that are solely governed by contracts [10, 28, 35, 43]. As indicated in the previous chapter, the goal in finding effective governance mechanisms is not just to curtail opportunism, but to generate commitment at the supplier level. This goes in line with a note from the Head of Global Purchasing at ChipCom: "*having a supplier that trusts you is [important] in our global business … A supplier that trusts us is usually convinced of the continuing business with us, encouraging it to increase stock or manufacture proactively*." As stated by Dyer and Singh (1998, p. 669), the right form of governance influences the willingness of suppliers to "engage in value-creation activities".

However, Table 14 indicates a different perception of what is seen as an effective form of governance in the different industry sectors. While firms from the automobile and electronics industry (marked with ‡) emphasize the need for both formal and informal disruption management governance, firms from the consumer goods industry (marked with †) accentuate the need for achieving more informal governance structures in disruption management.

This notion has been supported by the case studies. The Project Manager SC Development at SteerCom reported that his former experience in the consumer goods industry regarding appropriate governance structures were in direct contrast with the automobile industry. Formally cooperative approaches with suppliers had to be paralleled with formalized procedures, due to the complicatedness of the products, a heightened need for coordination and the profound impact of disruptions. The higher the number of unique parts in a product, the greater the risk of supply chain disruptions and resulting negative consequences. Complicated products seem to require much more emphasize on coordination of disruption management tasks. This supports organizational theorists who argued that complex-product industries tend to be characterized by a higher degree of reciprocal interdependence (Pfeffer and Salancik, 1978). It also supports Vachon and Klassen (2002) who have observed a strong linkage between the complicatedness of the product and delivery performance. Industries that manufacture more complicated products (such as cars or computers) eventually have to manage a more complex supply network. The value of the individual relationships in such networks is comparatively lower, thus intensifying the need for

formal disruption management governance. Drawing on these observations, it is postu-postulated:

> **Proposition 4:** *The higher the complicatedness of products within an industry sector the higher the need for formal disruption management governance and the less the value of informal governance in achieving buying-firm's supply chain robustness.*

Figure 7 depicts the resulting propositions in a summarizing framework. The buying-firm's supply chain robustness is the dependent variable because of the methodological focus on industrial buying-firms and their dyadic management of disruptions with their suppliers.

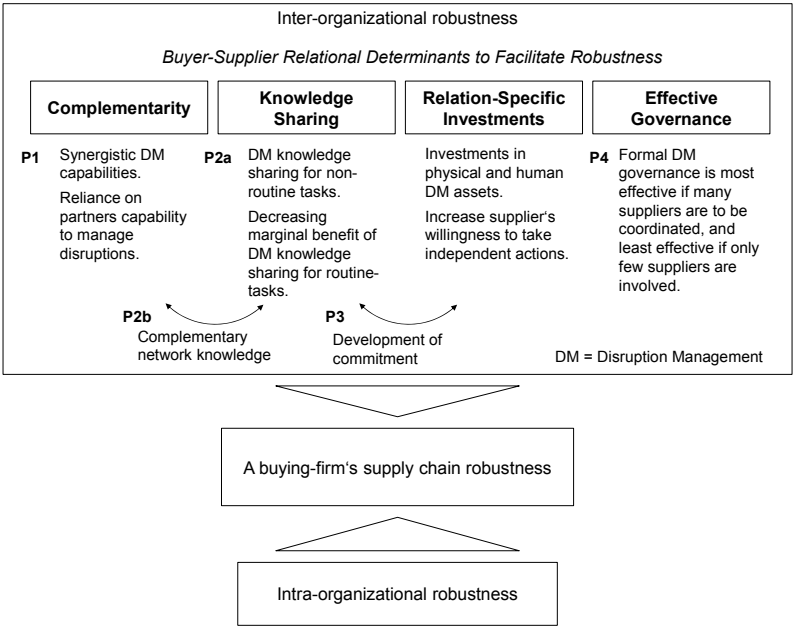

Figure 7 Framework Resulting from the Methodological Triangulation

5.6 Implications and Final Remarks

Despite the plethora of research on the management of disruptions in supply chains, this study addresses an important gap in the literature. It extends and refines current understanding of the buyer-supplier relational determinants that facilitate supply chain robustness. It extents and elaborates the RV perspective in a disruption management

context and provides insights on contextual governance structures needed in supply chain disruption management.

5.6.1 Theoretical Implications

This study is the outcome of the interaction between theory, literature and the empirical context at hand. The framework explains the interplay of the identified four relational determinants. It draws on the RV and modifies some of its aspects to reconcile with the idiosyncrasies of dyadic disruption management, providing five propositions to explain a buying-firm's supply chain robustness through the use, modification and governance of supplier relations.

The group exercises and case studies suggested that buying and supplying-firms possess complementary disruption management capabilities that if combined can increase a buying-firm's supply chain robustness. For example, experience has shown that suppliers can use their complementary knowledge, acquired through their upstream position in the supply chain, to avoid downstream disruptions for the buying-firm; and powerful buying-firms can use their capabilities to assist the supplier in managing its upstream processes. Further, the exchange of knowledge is also suggested to be another important determinant in supply chain disruption management. However, the "the more the merrier" approach of knowledge sharing as proposed in Dyer and Singh (1998) is not supported. Rather, it is shown that the benefit of knowledge exchange in disruption management has indeed a limit. Contrary to the RV, the relationship between knowledge sharing and the performance construct (i.e a buying-firm's supply chain robustness) seems to follow a concave rather than a linear slope. Disruptions that are caused by misaligned processes in particular do not linearly benefit from the prolonged exchange of knowledge, as the partners will eventually build up tacit knowledge for the joint processes.

Further, disruptions that are induced by the supplier were found to usually hail from a lack of trust in the relationship or the preference for short term business with other buying-firms. Only those buying-firms that effectively manage to demonstrate the value of the relationship to the supplier, through relation-specific investment and exchanging relational knowledge (e.g. the strategic importance of the supplier's products for the buying-firm), can effectively reduce these disruptions and increase supply chain robustness. Extending the RV, the data also indicates a positive relationship between industries with heightened product complicatedness and the need for formal governance structures.

5.6.2 Managerial Implications

The findings suggest how managers use, modify and actively govern their business connections to avoid and resist supply chain disruptions. The identified relational determinants can provide guidance on the management of a broader range of disruptions (above and beyond the five disruption causes discussed in the group exercises).

The propositions in the previous sub-chapter may allow for the development of firm-specific standard procedures for the dyadic management of disruptions. While some of the proposed mechanisms might induce costs, managers should keep in mind that firms who are successful in increasing supply chain robustness will be able to reduce safety stocks and capital costs.

It needs to be emphasized that it is not the author's intention to disregard or reject intra-organizational approaches in disruption risk management that have been discussed in other studies (e.g. multiple sourcing, inventories). Neither intra- nor inter-organizational strategies are inherently "good" or "bad". As Bode *et al.* (2011, p. 845) put it, "[e]ither of the two or a combination may be effective, depending on the specific context." Both approaches are not mutually exclusive, as a firm, for example, may decide to look for complementary partners and build up stock to hedge for unexpected events at the same time.

5.6.3 Final Remarks

There are some limitations of this study which should be considered when interpreting the results. In general, the findings of this study could possibly be flawed, if what the participants reported does not reflect the firms' main concerns and strategies. Nevertheless, the author believes that this study can be considered representative, supported by the methodological efforts taken to guarantee anonymity during the methodological development. Furthermore, as a vast majority of the participants stem from the upper echelons of the management hierarchy, it is reasonable to assume that these managers command sufficient knowledge to be aware of the main concerns and strategies within their firms.

Since the group exercise consisted of an above average proportion of large firms, the author cannot rule out the possibility that firm size plays a role in the identified strategies. Larger firms may have more power to force their suppliers into inter-organizational disruption management approaches. However, the data gathered from the smaller firms in the sample have not cast any doubts as to the external validity of

the findings. Therefore, the author is confident that medium- and small-sized firms can also benefit from the findings of this paper.

The unit of analysis within this study sets the limitations of the framework developed. The author acknowledges that the general behavior described in this study has merely been examined from a buying-firm's perspective. The exogenous variable of the framework takes account of this limitation. However, the fact that firms from different positions in the supply chain have participated in the study may heal this limitation to a certain extent.

These limitations, as well as the highlighted importance of identifying ways to motivate the supplier to be part of a successful inter-organizational disruption management, should spark further research.

In this chapter, the study had to restrict itself to a subset of disruptions. As of now, the author therefore cannot claim that the identified underlying procedures hold true for all kind of disruptions. However, the inductive study approach of this chapter already provides encouraging signs that the identified relational determinants may facilitate dyadic disruption management on a broader range of disruption causes. The following chapter will now seek to build on the findings of this study, following a deductive approach in order to test the relationships proposed and generate more insights on the generalizability of the findings.

6 The Relational View Perspective and Supply Chain Robustness: A Hypothetico-Deductive Model

The previous chapter responded to the third research objective through "*theorizing on what determinants in buyer-supplier relationships can be used by buying-firms to increase its supply chain robustness*." The chapter has indicated the applicability of the RV in a dyadic disruption management context, and proposed four relational determinants that facilitate supply chain robustness for the buying-firm. At this point, a rigorous testing of the four relational determinants and their facilitation of dyadic disruption management performance is still missing. This chapter therefore seeks to conduct rigorous quantitative testing of such relationships in order to derive more reliable managerial and theoretical implications.

The reminder of the present chapter is structured as follows: Sub-chapter 6.1 briefly reviews literature related to supply chain disruption management, providing the theoretical backdrop to the proposed model and showing the need for this research; Sub-chapter 6.2 develops the corresponding hypotheses; Sub-chapter 6.3 explains the research methodology. The findings are presented in sub-chapter 6.4, followed by a subsequent discussion (sub-chapter 6.5). Finally, sub-chapter 6.6 provides limitations and future research potentials as well as some concluding remarks.

6.1 Motivating Research on the Relational View in Inter-organizational Disruption Management

The management of supply chain disruptions has been at the focus of our attention for more than a decade now. Supply chain disruptions are still one of the major concerns of supply chain managers and a major threat to the world economy. For example, PricewaterhouseCoopers recently reported that more than 60 percent of 209 firms surveyed reported a drop in their performance indicators by three percent or more as a result of increasing supply chain disruptions (Strom *et al.*, 2013).

During the past 20 years, researchers in SCM have increasingly focused on buyer–supplier relationships as a source of competitive advantage,[6] yet this focus has broadly been neglected in the supply chain disruption management field. SCM scholars that focus on buyer-supplier relationships have often drawn on the RV perspective to explain value creation in dyads. The RV suggests that resources that make for

[6] The interested reader is referred to the supplier development literature (e.g. Krause *et al.*, 2000, 2007) or the supply chain integration literature (e.g. Gimenez and Ventura, 2005; Marquez *et al.*, 2004).

competitive advantage of a firm may extend beyond the firm's boundaries into its net-network. In other words, firms are theorized to gain a competitive advantage from being embedded in a network of firms. A central proposition in the RV is that when firms in a vertical relationship invest in relation-specific assets, implement knowledge sharing routines, provide complementary capabilities and find effective means of governance a supernormal profit can be derived. Dyer and Singh (1998) term these four constructs "determinants of relational rent". The supplier development literature, for instance, has shown that the direct involvement of suppliers through activities such as training and education of a supplier's personnel has a positive impact on business performance (Krause *et al.*, 2000). Looking upstream the supply chain, Gimenez and Ventura (2005) found that external integration contributes to achieving stock-out and lead-time reduction. Both, stocks and lead-times are closely linked with conditions of product unavailability and supply chain disruptions.

These findings provide initial indication that a well-developed supplier relationship can reduce both probability and severity of supply disruptions and finally improve supply chain robustness. That is why, it is surprising to discover that only a few authors in the field of disruption management have yet considered Dyer and Singh's (1998) theoretical idea in their research. This is even more surprising, bearing in mind that supply chain disruptions (e.g. inferior quality, delivery failures, plant fires etc.) have long been defined as inter-organizational phenomena that involve at least two vertically linked firms (Bode *et al.*, 2011; Wagner and Bode, 2008). To the best of the author's knowledge, Wieland and Wallenburg (2013) are the only authors who have yet made explicit reference to the RV when researching the relationship between relational competencies and effective risk mitigation. However, their research provides little clarity as to how all determinants of relational rent can facilitate a buying firm's inter-organizational disruption management – Bode *et al.* (2011) call a buying-firms inter-organizational disruption management "bridging", in contrast to "buffering", i.e. intra-organizational measures (e.g. inventory, operational slack).

Applying structural equation modelling with data from 229 manufacturing firms this chapter sets out to research all determinants of the RV in a dyadic disruption management context. A model will be developed and tested to evaluate their impact on disruption management performance. Drawing on Bode et al. (2011), d*yadic disruption management* performance is defined as avoidance and resistance of supply chain disruptions through boundary-spanning actions using, modifying and governing supplier relationships.

In line with Lavie (2006) and Rai's (2013) stance on assessing value creation, this study distinguishes two forms of disruption management performance, arguing that firms can simultaneously be involved in and benefit from a partnership. That is, disruptions can be successfully managed within the partnership ("Buyer Dyadic Disruption Management Performance (abbr. DyDMPerf)") while learning benefits may be available in other partnerships of the buying-firm ("Buyer Re-deployable Disruption Management Performance (abbr. Re-deplDMPerf)") (Khanna *et al.*, 1998; Mesquita *et al.*, 2008). Therefore, DyDMPerf refers to such performance benefits that are partnership exclusive benefits, whereas Re-deplDMPerf are those benefits that a buying-firm can earn unilaterally by re-deploying disruption management capabilities acquired from the partnership specific activities to its other supplier relationships (Khanna *et al.*, 1998).

Thereafter the "so what" question will be investigated. That is, if the determinants are in fact factors that facilitate disruption management performance in buyer-supplier relationships, what governmental mechanisms can and should be employed by buying-firms to make best use of them?

This research acts in concert with recent calls for more empirical research in the area of supply chain risk management (Gurnani *et al.*, 2011; Sodhi *et al.*, 2012). It is the first study to research the application of the RV in the context of buyer-supplier disruption management performance.

6.2 Theoretical Perspectives on the Relational Management of Disruptions

Dyer and Singh (1998) propose four primary sources of supernormal returns within the dyad: relation-specific assets, knowledge sharing routines, complementary capabilities and effective governance. In developing the theoretical foundation of this study each determinant and its relationship with this thesis's performance dimensions will be individually discussed in the context of dyadic disruption management (see Figure 8). Thereafter, it will be discussed as to what governance mechanisms are really most effective and should be used to positively moderate the hypothesized relationships between the exogenous constructs (relational determinants) of knowledge sharing routines, complementary capabilities and the endogenous performance constructs. Contextual differences will then be analyzed between high and low complicated product industry sectors.

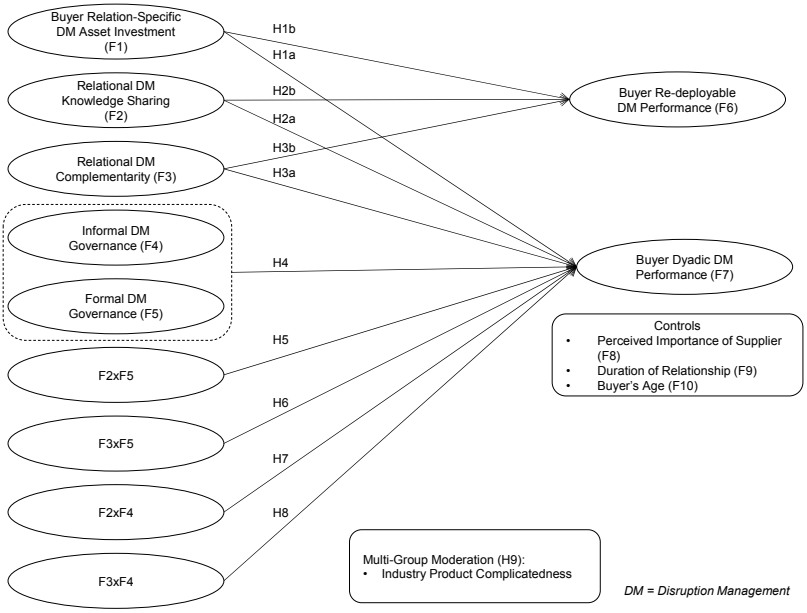

Figure 8 Hypothetico-Deductive Model

Current research still often looks at supply chains as a network of *black boxes* called "suppliers", "buyers" and "consumers". Firms are said to have adopted a supply chain orientation when all its activities are explicitly the result of an emphasize of its employees on upstream and downstream partners (Lengnick-Hall *et al.*, 2013). Hence, this study will depart from this line, and choose the employees of industrial buying-firms and their relationship with the employees of one of its suppliers as the unit of analysis.

6.2.1 Buyer Relation-Specific Disruption Management Asset Investment and Disruption Management Performance

Relation-specific investments have received intensive attention in SCM research (Zhao and Wang, 2011), and long been argued as a necessary condition for relational rent (Amit and Schoemaker, 1993). Relation-specific asset investments have also started to attract authors in the realm of supply chain disruption management (e.g. Bakshi and Kleindorfer, 2009; Wieland and Wallenburg, 2013). Without explicitly researching on it, Wieland and Wallenburg (2013) suggest relation-specific investments as a necessary strategy to successfully cope with disruptions. In this study, Buyer Relation-Specific Disruption Management Asset Investment (abbr. DMAssetInvest) refers to investments

made into human and physical capital that are dedicated to the management of supply chain disruptions within a particular relationship.

It is reasonable to assume that firms, just as human beings, have idiosyncrasies that make them unique in their way they operate (Micheli, 2008). This may be an advantage at times, but also requires supply chain partners to align its processes. In the context of supply chain disruptions, this alignment requires DMAssetInvest in order to modify disruption management skills and adapt commonly learned procedures.

The researched construct resembles the specific know-how that has been generated by the buying-firm's employees through conducting relation-specific trainings, exchanges and learnings with this supplier (e.g. trained disruption management experts, who learned the procedures and idiosyncrasies of the supplier). Further examples of such investments in disruption management include (1) physical approximation of partners, (2) joint inventory planning or (3) supplier trainings.

Following transaction cost economics, investments are relation-specific to the extent that they generate greater value in a given relationship than in their next-best "reservation" use (Williamson, 1985) or by implication that investments can only to a limited amount be tied to the specific relationship. This study thus postulates that a buying-firm's employees will be able to increase DyDMPerf through such relation-specific investments, but will also be able to re-deploy the acquired knowledge across other supplier relationships.

A buyer's relation-specific disruption management asset investment positively associates with the buyer's…

Hypothesis 1a: *… dyadic disruption management performance.*

Hypothesis 1b: *… re-deployable disruption management performance.*

6.2.2 Relational Disruption Management Knowledge Sharing and Disruption Management Performance

Dyer and Singh (1998) suggest in their conceptual work that knowledge sharing in inter-organizational buyer-supplier relationships plays a significant role in enhancing relational benefits. Alliance partners are seen as an important source of know-how and information. They conclude that buyers and suppliers can jointly "*generate rents by developing superior inter-firm knowledge sharing routines*" (Dyer and Singh, 1998, p. 665).

In the context of supply chain disruptions firms typically tend to delay or are reluctant to share knowledge (Hendricks and Singhal, 2005; Tang, 2006). Conducting three longitudinal case studies, Jüttner and Maklan (2011) propose that when firms manage to acquire the required knowledge, a positive impact on supply chain resilience can be expected. Sharing disruption management related knowledge in a supply chain is said to support event preparation as it increases visibility (Brandon-Jones *et al.*, 2014), shortens the time for detecting disruptions (Manuj and Mentzer, 2008) and improves decision making (Christopher and Lee, 2004).

In this study, Relational DM Knowledge Sharing (abbr. DMKnowSharing) refers to the frequent sharing of disruption management know-how and information between buyers and suppliers. Specifically, the construct refers to routines established between the employees of the supply chain partners that are aimed at exchanging supply chain disruptions management knowledge (e.g. performance feedback, expert knowledge, original ideas etc.).

It is postulated that an increase in the sharing of disruption management knowledge, increases disruption management performance within the relationship under consideration. Further, as knowledge sharing can hardly be limited to the sharing of relationship specific knowledge, this study suggested that benefits acquired from sharing knowledge can also be re-deployed across other partners, leading to Re-deplDMPerf.

Relational disruption management knowledge sharing positively associates with the buyer's…

Hypothesis 2a: *… dyadic disruption management performance.*

Hypothesis 2b: *… re-deployable disruption management performance.*

6.2.3 Relational Disruption Management Complementarity and Disruption Management Performance

Research has long recognized the synergies that may arise from different, complementary resources of supply chain partners (Milgrom and Roberts, 1995). The RV proposes that buyer-supplier relations are most effective when firms can provide such complementary (Dyer and Singh, 1998). Lambe *et al.* (2002, p. 144) defines complementarity as "*the degree to which firms in an alliance are able to eliminate deficiencies in each other's portfolio of resources […] by supplying distinct capabilities*."

The proportion of complementarity between alliance partners is argued to increase the degree to which alliance partners can earn relation rents (Dyer and Singh, 1998).

In the context of supply chain disruption management, it is assumed that supply chain partners lack certain capabilities to successfully manage disruptions independently and are thus dependent on their supply chain partner. For example, events such as new exporting-laws in the supplier's home country, sub-supplier issues or supplier equipment failure can only be managed by the supplier itself.

Value from complementarity is said to be achieved through two dimensions: accumulating similar capabilities and combining distinct ones (Larsson and Finkelstein, 1999). As Varadarajan and Cunningham (1995, p. 293) noted, "*a firm entering into a strategic alliance may either seek partners whose abilities augment its strengths or ameliorate its weaknesses*". Therefore the Relational DM Complementarity construct (abbr. DMComplementarity) is operationalized in terms of both strategic similarity and strategic supplementation. Practical examples of the construct include (1) buyer's capability to proactively influence market demand better than the supplier and (2) the suppliers capability to better manage sub-suppliers, (3) each firm's endowment of resources capital that allows to hedge supply disruptions or simply (4) a partner's proprietary access to information that gives both firm's a head start to avoid disruptions to the supply chain.

This study argues that the disruption management skills a buying-firm can learn from complementary suppliers will not remain within the boundaries of the particular relationship; they can be unilaterally appropriated by the buying-firm's employees and redeployed across other suppliers, leading to Re-deplDMPerf.

Relational disruption management complementarity positively associates with the buyer's…

Hypothesis 3a: *… dyadic disruption management performance.*

Hypothesis 3b: *… re-deployable disruption management performance.*

6.2.4 Ambidextrous Governance: Interplay of Formal and Informal Disruption Management Governance Mechanisms

On the supposition that the hypotheses posed above hold true, this chapter seeks to explore what managers should do from a governance perspective to make the most out of these relationships. Beyond simply arguing that the determinants of relational rents can increase a firm's disruption management performance, it is important to

understand how a buying-firm can leverage such information through appropriate forms of governance.

As stated in Dyer and Singh (1998, p. 669), an appropriate form of governance fosters the "*willingness of alliance partners to engage in value-creation initiatives*." Two different governance mechanisms are proposed, formal (e.g. contractual agreements, pledges, etc.) and informal (e.g. norms, social mechanisms etc).

This sub-chapter develops six hypotheses that theorize the value of each governance mechanism and its moderating effect on the relationship between the exogenous variables of DMKnowSharing and DMComplementarity and the endogenous variable of DyDMPerf. It will than make a conjecture for contextual differences in these relationships for two industry clusters.

6.2.4.1 Formal and Informal Disruption Management Governance

Empirical literature on supply chain disruption management often focuses on discussing informal governance mechanisms (Bode *et al.*, 2011), while the alternative or even complementary vehicle, formal governance, is often underrepresented (Lei *et al.*, 2012). It is not new that formal governance usually builds upon the principles taught in transaction costs economics, where contract partners seek to limit opportunisms and foster compliance through explicit agreements about duties and consequences. Following this notion, formal disruption management governance (abbr. FormalDMGov) in this study is defined as "*the extent to which the buyer has specific, customized, and detailed contractual agreements with the supplier*" (Poppo and Zenger, 2002, p. 358) that are specifically designed to the management of disruptions.

Formal agreements in disruption management are usually designed to achieve compliance with the partner to defined disruption management targets. Trowbridge (2015) argues that today's challenges in supply chains, such as an increased complexity of outsourcing structures, require firms to increase reliance on strong written agreements in order to cope with disruptions. Handshakes or trusted relationships are claimed to no longer suffice existing environmental factors. Formal agreements are proposed as a necessary means to maintain the buying-firm's control over what occurs at the supplier.

Other scholars argue that contracts, as formal governance mechanism, are often incomplete and cannot take account of all future scenarios (Dekker *et al.*, 2013). Also, formal governance may lead to the expectation that relationships are terminated,

discouraging suppliers to take additional efforts to reduce supply disruptions for the buying-firm. Informal governance provides more flexibility to the supplier, assuming that the supplier independently takes protective actions. The existence of informal, trustful relationships has been reported to facilitate joint planning and problem solving (Claro *et al.*, 2003).

This study defines informal governance as the reliance on personal relations of disruption management reputations as a governance mechanism. In keeping with the literature, informal disruption management governance (abbr. InformalDMGov) will be measured as "goodwill trust" (Pulles *et al.*, 2014). It is measured as the positive expectation the buying-firm has about the other party's disruption management actions (Yu *et al.*, 2006). In the event of supply chain disruptions, it may be beneficial to rely on the supply chain partner. InformalDMGov ensures both partners of the ongoing of the relationship. Something Durach *et al.* (2015) propose to be a key enabler of more robustness in supply chains.

Considering the diversity of arguments, this thesis follows Poppo and Zenger (2002) as well as Pilbeam *et al.*'s (2012) conceptual work arguing that both governance mechanisms, formal and informal, make a valuable contribution.

Hypothesis 4: *Both formal and informal disruption management governance are positively associated with the buyer's dyadic disruption management performance.*

6.2.4.2 The Moderating Effect of Governance Mechanisms

Through appropriate governance mechanisms firms can guide that the right knowledge is shared. It is only when the right knowledge is shared that one can benefit from it. As Ha and Tong (2008) report it is not just the mere knowledge sharing that provides value to the relationship, but the value of the knowledge shared. They suggest that the value of knowledge shared is highly dependent on the contract type chosen.

Previous research has discussed coordination issues in the situation of disrupted supply chains (Cao, 2014; Cao *et al.*, 2015). Zhang *et al.* (2015) for example suggest that through the introduction of certain contract parameters the buying-firms can better manage a disrupted supply chain as a detailed contract can improve coordination with its supplier. Researching on Toyota's supply chain coordination mechanisms after the devastating Tohoku earthquake in 2011, Matsuo (2015) concludes that Toyota's formal control over its first-tier suppliers helped to alleviate supply chain disruption impacts. Egri and Váncza (2013) conclude that contracts help to coordinate knowledge sharing

and overcome information asymmetry. Considering this, it is proposed that For-FormalDMGov positively moderates the relationship postulated in H2a.

Hypothesis 5: *Formal disruption management governance strengthens the positive relationship between relational disruption management knowledge sharing and the buyer's relational disruption management.*

It is further suggested, that through FormalDMGov one can also gain better access to the complementary capabilities of its supply chain partner and experience an increased benefit from its complementarity capabilities. Huang *et al.* (2013) conducted an analytical study to identify how supplying and buying-firms decide how to best allocate capacities taking into account different capabilities of the firms. They conclude that formal governance can best provide the coordination mechanisms needed. Barnes-Schuster *et al.* (2002) proposed that certain suppliers may be capable of providing contractual options that increase the buyer's ability to deal with downstream supply chain issues, increasing channel performance.

This suggests that in disruption management formal governance can provide the necessary coordinative mechanism to better benefit from the complementary capabilities of the supply chain partners.

Hypothesis 6: *Formal disruption management governance strengthens the positive relationship between relational disruption management complementarity and the buyer's dyadic disruption management performance.*

In line with Pilbeam *et al.*'s (2012) conceptual framework on supply chain governance, this study further argues that during disruptions, the coordinative mechanisms discussed above cannot be provided by the reliance on informal governance. This suggests that an increased reliance on InformalDMGov actually dampens the aforementioned relationships.

It is therefore postulated that the value of DMKnowSharing and DMComplementarity to the DyDMPerf is always positive but will be dampened through the increased reliance on InformalDMGov.

Hypothesis 7: *Informal disruption management governance dampens the positive relationship between relational disruption management knowledge sharing and relational disruption management.*

Hypothesis 8: *Informal disruption management governance dampens the positive relationship between relational disruption management complementarity and relational disruption management.*

6.2.4.3 The Moderating Effect of Complicated Product Industries

Organizational theorists who have long argued that complicated-product industries tend to be characterized by a high degree of reciprocal interdependence (Pfeffer and Salancik, 1978). Campbell (1985), for example, incorporated product complexity as a key dimension in his buyer-seller interaction model, proposing that the higher the product complexity the higher the interdependence between buyer and seller. Novak and Eppinger (2001) found a positive link between product complexity and vertical integration, as greater product complexity gives rise to coordination challenges. In his seminal article, Fisher (1997) advocated that firms should match their supply chain strategy to certain product characteristics. Inman and Blumenfeld (2014) built on this concept when discussing the link between product complexity and supply chain design in the presence of supply chain disruptions. Analyzing 32 cases, Kotteaku *et al.* (1995) found evidence for product complexity to be a major influencing factor on the structure of the purchasing function.

All of these studies have in common that they use the number of product components as one key element in their complexity definition. Analyzing data from over 700 supply chain managers, Handfield *et al.* (2013) depict different forms of complexity and highlight the aspect of product complexity in terms of product variety and part numbers. In line with Vachon and Klassen (2002), this thesis will use the term complicatedness as a more appropriate term to describe the number of parts or components needed to build an average product within a certain industry. The term is often used interchangeably with product complexity, while complexity actually includes additional dimensions, such as differentiation, technical complexity or component interaction (Kotteaku *et al.*, 1995; Novak and Eppinger, 2001).

Kotteaku *et al.* (1995) found that purchases of high complex products – one dimension being product complicatedness – are often associated with high formalization scores at all phases of purchasing. Complex product firms often use formal rules and written documents to describe all tasks of the supplier in detail; at the same time such firms still recognize the need for some degree of flexibility. Paulonis and Norton (2008) reported survey results indicating that managers see product complicatedness amongst the top factor influencing supply chain strategy. The more parts in a product,

the greater the risk of disruption; as such industries with more complicated products are much more sensitive to supply chain disruptions. Coordination plays a key role in the purchasing function in order to deal with supply chain disruptions, suggesting that the higher the complicatedness of the product in certain industry sectors, the more purchasing managers in such sectors will have to rely on formal governance to achieve an effective coordination between the supply chain partners. Vachon and Klassen (2002) have observed a strong linkage between delivery performance and complicatedness of the product; suggesting that high complicated product industries do benefit more from the reliance on formal governance to coordinate their supply chain disruption management approach, than low complicate product industries. Therefore, the following hypothesis is suggested on the moderating role of industry product complicatedness.

Hypothesis 9: *The positive relationship between formal disruption management governance and buyer relational disruption management benefit is stronger in high complicated product industries than in low complicated product industries.*

6.3 Research Methodology and Analysis

The study in this chapter follows prescriptions in Mesquita *et al.* (2008) on collecting and analyzing inter-organizational processes applying structural equation modelling to test the developed hypotheses.

6.3.1 Sample and Procedure

A mailing list was compiled of 2,388 manufacturing firms from Austria, Germany and Switzerland. The informants (purchasing personnel) were addressed directly and asked to fill out the survey focusing on a particular supplier. In line with Mesquite *et al.* (2008), they were asked to assess all items related to “this” supplier, defined as a supplier they see as representative for their firm’s set of suppliers. An online questionnaire was sent out, with three follow-ups, yielding 229 usable responses and an effective response rate of 9.6 percent, which is comparable to other recent surveys in the area of SCM (e.g. Devaraj *et al.*, 2007; Wagner and Bode, 2014).

The average work experience of the respondents at their respective firm was 15.6 years. Seventy-nine percent of the individuals primarily held positions of Area Director, Department Director or higher (see also sample characteristics in Table 17 and Table 21).

Table 17 Sample Characteristics

	Freq.	Percent
Number of Employees		
< 10	2	0.9
11 - 50	17	7.4
51 - 250	48	21
251 - 500	25	10.9
501 - 2000	34	14.8
2001 - 5000	14	6.1
> 5000	89	38.9
Total		**100**
Revenue in €		
< 10m	17	7.4
10m - 50m	32	14
50m - 100m	19	8.3
100m - 250m	18	7.9
205m - 500m	55	24
500m - 1bn	12	5.2
1bn - 5bn	24	10.5
> 5bn	52	22.7
Total	**229**	**100**

6.3.2 Measurement Items and Survey Instrument

A preliminary version of the questionnaire was developed adapting reflective construct items used in previous literature. The final survey items are reported in Appendix F.

Following the process suggested by Marin and Marin (1991) a double back translation of the original English construct items was conducted to adequately translate them into German. A pretest was then conduct to assess the interrater agreement on content validity. Two different sets of five and seven raters were requested to complete the following tasks (Moore and Benbasat, 1991). The first group of raters consisted of three academics that are specialized in SCM, and two academics that are not specialized in the field. The group was provided with definitions of the constructs and was asked to assign the items uniquely to one of the constructs. The items were given to them in a random order. Fleiss' (1971) κ was computed to be 0.78 (substantial agreement, Landis and Koch, 1977). The second group, consisting of seven supply chain and logistics academics, was then asked to assess the adequacy of each item by rating the degree to which it adequately measures the construct (Zaichkowsky, 1985). The raters were asked to rate each item on a 7-point Likert-scale. A rating of “1” indicated very low adequacy, a rating of “7” indicated very high adequacy. The average adequacy and

standard deviation was calculated from those ratings. Indicators for removing or adjust-adjusting the items were an average score of less than 4.5 or a standard deviation of greater than 1.5 (Rai, 2013). No item had to be removed from the original list.

6.3.2.1 Dependent Variables

Following the concept in Rai (2013) on dimensions of value creation in an inter-organizational context, DyDMPerf was measured drawing on Rai (2013) and Bode *et al.* (2011) and Re-deplDMPerf was measured adapting items from Rai (2013), Bode *et al.* (2011) and Mesquita *et al.* (2008). The respondents were asked to indicate their agreement on a 7-point Likert-scale. Unless noted otherwise, all measures in this study used a 7-point Likert scale anchored at "totally disagree = 1" and "totally agree = 7" and were coded so that higher values represent greater amounts of the construct.

6.3.2.2 Independent Variables

DMAssetInvest was measured with items adapted from Klein *et al.* (1990) and Shervani *et al.* (2007). Items for DMKnowSharing were adapted from Gee-Woo Bock *et al.* (2005) and Chen *et al.* (2004). DMComplementarity included items adapted from Lambe *et al.* (2002) and Deitz *et al.* (2010).

The constructs of the two governance mechanisms are used as both independent variables and continuous moderators. Construct items for InformalDMGov were adapted from Whipple *et al.* (2013) and Pulles *et al.* (2014), and FromalDMGov items were adapted from Li *et al.* (2010) and Rai *et al.* (2012).

6.3.2.3 Control Variables

In order to extract possible confounding effects, this paper included three control variables. First, the *Perceived Importance of the Supplier* for the buying-firm was controlled for with a single item value on a 7-point Likert-scale (anchored at "very little = 1" and "very high = 7"). The importance of the supplier for the buying-firm might affect the way the buying-firm interacts with this it. It could increase dependence and eventually impact relational performance. Second, the *Duration of the Relationship* was included, as a proxy for relation-specific experience, which may account for tacit knowledge in the relational management of supply chain disruptions between both firms. Third, the *Buyer's Age* was included as a proxy for knowledge and experience. Older firms may have more expertise in managing and benefiting from relationships than younger firms. The observed performance gains may be partly explained by this factor.

6.3.3 Data Screening, Validity and Model Analysis

In screening the data unengaged respondents and respondents with more than eight percent of item values missing in one data set were removed. Missing item values were estimated through Expectation Maximization Algorithm. All observed variables were examined for skewness and kurtosis (i.e. the absolute values were below 1.4 for skewness and below 1.6 for kurtosis). No issues were detected by visual inspection. To test for non-response bias, the means of all construct items were compared via t-tests between the first and last third of responses (Armstrong and Overton, 1977). No statistically significant differences between these groups could be detected.

Exploratory factor analysis (EFA) showed fairly high cross loadings for items F3_5 and F3_6. It was decided that removing these items will have no substantial impact on content validity. Hence, they were erased. Thereafter, the assumption of unidimensional factors was supported, i.e. no discriminant validity concern could be detected on an item level as cross loadings were below a 0.19 level (see Table 18). Seventy percent of total variance could be explained through the extracted constructs. Two items showed comparatively low loadings (F2_4, F7_2), but the author decided to retain these to ensure construct validity.

Confirmatory factor analysis (CFA) using Amos 20 was conducted to estimate composite reliability. In the CFA, F6_3 had to be removed due to its high covariance with F7_3.

Addressing the potential for common method variance (CMV), several ex-ante strategies were followed (Chang *et al.*, 2010). Complete anonymity was ensured to the respondents in order to address social desirability effects. In order to reduce the likelihood that respondents are guided by a cognitive map, only general information needed to fill out the survey was given to the respondents, but no clues about its objective or relationships. The order of the items was randomized and different for each respondent. The constructs were further mixed with construct items unrelated to this study.

Table 18 Results from Confirmatory Factor Analysis: Standardized Factor Loadings, Cronbach Alpha

	Factor							
	F1	F2	F3	F4	F5	F6	F7	Marker
Cronbach alpha	**0.909**	**0.856**	**0.928**	**0.920**	**0.923**	**0.949**	**0.885**	**0.913**
F1_4	**0.869**	-0.056	-0,086	0,008	-0,033	0.001	0.125	-0.032
F1_3	**0.865**	0.030	-0.088	0.067	0.084	-0.013	-0.025	-0.003
F1_1	**0.859**	0.119	-0.079	-0.017	-0.047	-0.068	0.077	0.014
F1_2	**0.823**	-0.003	0.047	0.049	0.076	0.036	-0.114	0.059
F1_6	**0.714**	-0.048	0.019	-0.129	-0.017	0.010	0.021	-0.005
F1_5	**0.663**	-0.086	0.159	0.046	-0.054	0.068	-0.170	-0.016
F2_5	0.137	**0.818**	-0.015	-0.050	-0.102	0.089	-0.021	-0.045
F2_1	0.100	**0.777**	0.074	-0.107	-0.022	0.018	0.004	-0.019
F2_2	-0.066	**0.708**	-0.055	0.054	0.089	0.036	0.025	-0.018
F2_3	-0.130	**0.678**	-0.017	0.098	0.073	-0.052	-0.010	0.026
F2_4	-0.029	**0.524**	0.161	0.170	0.030	-0.103	-0.014	0.073
F3_3	-0.056	-0.030	**0.941**	0.052	0.011	-0.054	0.003	-0.023
F3_1	-0.020	0.072	**0.921**	-0.024	-0.016	0.012	-0.061	0.014
F3_2	0.055	-0.072	**0.799**	0.038	0.030	0.039	0.052	-0.018
F3_4	0.016	0.133	**0.677**	-0.023	-0.044	0.056	0.118	0.015
F4_6	0.032	-0.013	-0.047	**0.939**	-0.060	0.010	0.014	-0.041
F4_5	-0.040	0.021	-0.008	**0.860**	-0.107	0.103	-0.080	-0.091
F4_2	0.061	-0.017	0.044	**0.821**	0.045	-0.066	-0.012	-0.005
F4_1	-0.105	-0.076	0.046	**0.814**	0.022	0.082	0.005	0.067
F4_4	0.003	-0.001	0.078	**0.696**	0.045	-0.010	0.031	0.001
F4_3	0.084	0.133	-0.078	**0.683**	0.043	-0.098	0.094	0.066
F5_1	0.015	0.061	-0.012	-0.043	**0.911**	0.004	-0.040	0.009
F5_3	-0.056	-0.070	-0.024	-0.057	**0.902**	0.031	0.076	-0.025
F5_2	0.022	0.036	0.070	0.011	**0.883**	0.019	-0.095	-0.005
F5_4	0.029	0.030	-0.041	0.073	**0.705**	-0.025	0.047	-0.016
F6_1	-0.014	-0.037	0.087	-0.028	0.007	**0.956**	-0.070	0.011
F6_2	0.068	-0.060	-0.008	0.087	0.006	**0.882**	0.001	0.031
F6_4	-0.004	0.008	0.043	-0.052	0.033	**0.882**	-0.016	0.007
F6_5	0.052	0.004	-0.028	0.010	0.021	**0.823**	0.056	0.003
F6_3	-0.056	0.115	-0.110	0.026	-0.039	**0.787**	0.136	-0.033
F7_5	0.008	0.028	-0.005	0.047	-0.021	-0.078	**0.874**	-0.030
F7_4	-0.040	0.029	-0.014	-0.034	-0.115	0.089	**0.761**	-0.002
F7_3	-0.025	-0.005	0.032	0.072	0.063	-0.008	**0.754**	0.029
F7_1	-0.107	-0.059	-0.025	-0.013	0.074	0.159	**0.734**	0.026
F7_2	0.189	-0.034	0.157	-0.049	0.050	0.053	**0.551**	-0.030
Marker_2	0.000	0.049	-0.057	0.009	-0.037	0.037	0.021	**0.933**
Marker_1	0.006	-0.030	0.019	-0.028	-0.018	-0.035	0.025	**0.915**
Marker_3	0.005	-0.026	0.024	0.002	0.020	0.020	-0.046	**0.808**

Extraction Method: Maximum Likelihood.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

For an ex-post diagnosis of CMV, the common latent factor method in AMOS and the confirmatory factor analysis marker technique (Richardson *et al.*, 2009; Williams *et al.*, 2010) were followed. “Job satisfaction” was *a priori* chosen as a marker variable as it is theoretically unrelated to the theoretical model. The marker was measured with items develop in Janssen (2001). The common latent factor method indicated no significant common method bias in the model; estimated item-construct correlations did not change much as a result of this test and statistical significance was retained. The same applied for the marker test, providing no indication for CMV. Further calculation in this study was conducted with common latent factor adjusted values.

Discriminant validity on a construct level was tested using the Fornell-Lacker test (Fornell and Larcker, 1981) and the heterotrait-monotrait (HTMT) ration of correlations (Henseler *et al.*, 2014) as suggested in Voorhees *et al.* (2015). The values in Table 19 and the $HTMT_{0.85}$ values in Table 20 indicated no validity concerns.

Table 19 Correlation Matrix of the Latent Variables with Composite Reliability, Average Variance Extracted, Maximum Shared Variance and Average Shared Variance

	CR	AVE	MSV	ASV	F1	F2	F3	F4	F5	F6	F7	Marker
F1	0.907	0.624	0.251	0.110	0.790							
F2	0.841	0.515	0.453	0.253	0.501	0.718						
F3	0.929	0.766	0.453	0.235	0.277	0.673	0.875					
F4	0.918	0.653	0.285	0.124	0.514	0.514	0.534	0.808				
F5	0.917	0.690	0.248	0.133	0.287	0.498	0.464	0.211	0.831			
F6	0.943	0.805	0.428	0.183	0.430	0.484	0.481	0.221	0.377	0.897		
F7	0.887	0.612	0.428	0.245	0.403	0.569	0.620	0.470	0.438	0.654	0.782	
Marker	0.915	0.783	0.010	0.004	-0.090	0.010	0.041	0.042	-0.079	-0.098	-0.050	0.885

Table 20 Matrix of Heterotrait-Monotrait Ration of Correlations

	F1	F2	F3	F4	F5	F6	F7	Marker
F1								
F2	0.459							
F3	0.298	0.668						
F4	0.056	0.507	0.537					
F5	0.268	0.478	0.475	0.228				
F6	0.351	0.46	0.495	0.660	0.489			
F7	0.392	0.549	0.634	0.456	0.451	0.671		
Marker	-0.096	0.020	0.040	0.032	-0.056	-0.101	-0.058	

Curve estimation was than conducted for all the relationships in the model. All relationships were sufficiently linear to be tested in a covariance based structural equation model algorithm. However, the relationships between DMKnowSharing and the dependent variables showed similarly high and significant F-values for linear estimations as well as for logarithmic estimations. While linearity was significant, further attention will be paid to these relationships in the analysis und discussion phase. Subsequently, multi-collinearity was tested and found to be no issue among the independent variables.

6.3.4 Multi-Group Moderation Testing for High and Low Complicated Product Industries

In the online survey, all 229 respondents stated their industry sector. This information was subsequently verified with secondary data available on the firms' homepages. In order to conduct a multi-group moderation the dataset was split along the values of the categorical variable of industry sector.

Following a Q-sort exercise (the reader is referred to Ellingsen *et al.*, 2010), four researchers were asked to independently categorize the different industry sectors according the average complicatedness of its products. The result showed a unanimous agreement over the group classifications. The author acknowledges that the industry sector is just a proxy and not a perfect metric for the average product complicatedness; however, the Q-sort showed unanimity, and it has precedent in the literature as discussed in sub-chapter 6.2.4.3. Table 21 shows the two industry groups identified. Firms that stated to be from "miscellaneous manufacturing industries" were individually assessed. All 21 were sorted to group 1.

Table 21 Complicated Product Industry Grouping Based on Q-methodology

	US-SIC	ISIC	Freq.
Low Complicated Product Industries			
Food and kindred products	20	15	43
Tobacco products	21	16	2
Textile mill products	22	17	2
Apparel and other finished products made from fabrics and similar materials	23	18	6
Paper and allied products,	26	21	2
Printing, publishing, and allied industries	27	22	3
Rubber and miscellaneous plastics products	30	25	7
Fabricated metal products, except machinery and transportation equipment	34	28	24
Furniture and fixtures	25	36	4
Stone, clay, glass, and concrete products	32	None	3
Miscellaneous manufacturing industries*	39	None	21
	Sum Group 1		**117**
High Complicated Product Industries			
Chemicals and allied products	28	24	23
Industrial and commercial machinery and computer equipment	35	30	14
Electronic and other electrical equipment and components, except computer equipment	36	32	35
Measuring, analyzing, and controlling instruments; photographic, medical and optical goods; watches and clocks	38	33	6
Manufacture of motor vehicles, trailers and semi-trailers	37	34	29
Manufacture of other transport equipment	-	35	5
	Sum Group 2		**112**
		Total	**229**

**classified as noted in the text*

Measurement invariance was tested between both groups. No significant differences in how the constructs were being measured across the two groups could be identified.

6.4 Results

The data analysis followed the multi-step approach proposed in Anderson and Gerbing (1988). This approach allows testing for whether any model that is less constrained or nested within the theoretical model proposed would give a better representation of the data and hence provide an enhanced understanding of the theoretical model. Table 22 provides the results for the direct effects as well as the interaction and multi-group effects.

Table 22 Standardized Parameter Estimates and Goodness of Fit Indices for the Three Models

S.E.	**Model 1** (Measurement Model)				**Model 2** (Theoretical Model)				**Model 3** (Best Model)			
DVs	DyDMPerf (F6)		Re-deplDMPerf (F7)		DyDMPerf (F6)		Re-deplDMPerf (F7)		DyDMPerf (F6)		Re-deplDMPerf (F7)	
	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
Controlls												
F8	0.141**	0.106**	0.086	0.079	0.146**	0.099**	0.098	0.061	0.146**	0.109**	0.098	0.061
F9	-0.078	0.051	0.067	-0.049	-0.079	-0.088	0.067	0.036	-0.080	0.076	0.067	-0.088
F10	0.076	-0.019	0.008	0.161**	0.076	-0.004	0.004**	0.201	0.073	-0.004	0.007	0.201**
IVs												
DMAssetInvest (F1)	0.255**	0.171**	0.311**	0.209**	0.249**	0.188**	0.297**	0.252**	0.239**	0.187**	0.297**	0.252**
DMKnowSharing (F2)	-0.066	0.052	-0.014	0.270**	-0.048	0.065	0.028	0.302**	-0.066	0.076	0.028	0.302**
DMComplementarity (F3)	0.522***	0.273**	0.393***	0.267**	0.530***	0.253**	0.410***	0.213*	0.524***	0.239**	0.410***	0.213*
InformalDMGov (F4)	0.248**	0.126	0.026	-0.145	0.237**	0.180**			0.259***	0.172**		
FormalDMGov (F5)	0.075	0.241***	0.060	0.155**	0.049	0.184**			0.044	0.189**		
Interaction Terms												
F2xF5	-0.062	-0.021***			-0.062	-0.210**			-0.084	-0.229**		
F3xF5	0.145*	0.302			0.146*	0.302***			0.137	0.337***		
F2xF4	-0.142*	0.107			-0.142*	0.107						
F3xF4	0.031	-0.354**			0.031	-0.354**			-0.067	-0.273***		
Goodnes of Fit Indices												
GFI	0.975				0.972				0.971			
χ^2/df	1.147				1.196				1.197			
RMSEA	0.018				0.021				0.021			
SRMR	0.049				0.049				0.050			
CFI	0.997				0.995				0.995			
χ^2	86.015				96.898				100.516			
df	75				81				84			
p	0.181				0.110				0.106			

Notes: *** p-value < 0.01; ** p-value < 0.05; * p-value < 0.10

6.4.1 Two Step Modeling Approach

For assessing the structural model three models were built. Model 1 is the measurement model and relates all independent and dependent constructs to one another (not including relationships between interaction terms and Re-deplDMPerf). Model 2 is the theoretical model and nested within Model 1. Model 3 is the most parsimonious model and nested within Model 2.

The lower part of Table 22 displays a list of various fit indices for the models. The χ^2-value assesses the magnitude of discrepancy between the sample and fitted covariance matrices. For all three models, a good model fit was indicated with an insignificant result at a p-value of 0.05 (Barrett, 2007). In keeping with the traditional analysis structure of structural equation modelling articles (Shah and Goldstein, 2006), further model fit indices were calculated. The Goodness-of-fit index (GFI) is a standalone index indicating the absolute model fit. Values above 0.9 usually indicated an acceptable model (Baumgartner and Homburg, 1996). For χ^2/df-values below 3 are commonly acceptable, and below 2 are ideal. The root mean square error of approximation (RMSEA), which denotes root mean square of the residuals, should usually be less than 0.08 to indicate a reasonable fit and 0.05 or less to indicate a close fit (Rigdon, 1996). However, this measure has been criticized for tending to over reject models (Shah and Goldstein, 2006). The standardized root mean square residual (SRMR) was thus calculated as another absolute measure that reflects the residual differences between the input and implied matrices, indicating how well matrix covariance terms are predicted by the model. Values as high as 0.08 are deemed acceptable (Hu and Bentler, 1999). Confirmatory fit index (CFI) was calculated as a comparative fit index. The rule of thumbs says that values above 0.95 indicate a model that fits well (Rigdon, 1996).

For Model 1, all indices are within an acceptable range indicating an acceptable model fit. The theoretical model, Model 2 is nested within Model 1 and only includes the hypothesized relationships. All goodness of fit indices indicate that Model 2 can also be accepted. The same holds true for Model 3.

Conducting a χ^2-difference test between the measurement model and the theoretical model ($\chi^2_{M2} - \chi^2_{M1} = 10.883;\ df_{M2} - df_{M1} = 6; p = 0.092$) reveals no statistically significant difference between the two models for a significance level of 0.05 (Anderson and Gerbing, 1988). That is, the null hypothesis that M2-M1 = 0, that is trimming the Model 1 to Model 2 has significantly reduced the Models ability to resemble the data, is

rejected. Following Anderson and Gerbing (1988) the more parsimonious Model 2 is accepted.

As a last step in developing the model, insignificant parameter estimates from the theoretical model were trimmed off. The marginal cut off was a p-value above 0.05 in both groups. Henceforth, F2xF4→F7 was deleted, while F2→F7 was retained due to the significant effect of the interaction moderation F2xF5→F7. Following Mesquita *et al.* (2008), all paths for the control variables were also retained. Comparing the more constrained Model 3 with Model 2 ($\chi^2_{M3} - \chi^2_{M2} = 4.514;\ df_{M3} - df_{M2} = 6; p = 0.607$) shows no significant difference between the models. Hence, Model 3 is accepted, because it is the most parsimonious structural model of the three hypothesized alternatives and because it provides an adequate representation of the estimated constructs' covariance.

Regarding the explanatory value (Squared Multiple Correlations: R^2) of Model 3, 60.7 percent of the variance in DyDMPerf and 38.0 percent of the variance in Re-deplDMPerf can be explained through this model.

All three models far exceed the recommended threshold for statistical power of 0.80 for both endogenous variables (MacCallum *et al.*, 1996). Thus, one can reasonably conclude that the sample size is adequate and the model has sufficient power to detect global model misspecification.

6.4.2 Hypotheses Test

The following analysis refers to the results of Model 3, which has been identified as the best model.

The effect of DMAssetInvest on both dependent variables is positive and significant for both industry groups, supporting H1a and H1b. Contrary to H2a, knowledge sharing has no significant effect on DyDMPerf. H2b was supported for industry group 2, while it was not supported for industry group 1. Supporting H3a and H3b, a strong positive relationship between DMcomplementarity and the dependent variables could be detected for both industry groups. A significant group difference (z = -1,797) could be detected for H3a with a significance level of $p < 0.1$ for non-standardized path coefficients (see Table 23). This shows that DMComplementarity has a stronger impact on DyDMPerf in low complicated product industries (S.E. +0.524; $p < 0.01$) than high complicated product industries (S.E. +0.239; $p < 0.05$). H4 is largely being supported by the model with the exception that FormalDMGov does not have a significant effect

on DyDMPerf for industry group 1. As this difference is significant (z = 1.784) with a significance level of p < 0.1, H9 is being supported as well.

Table 23 Significance of Group Differences in Model 3

			IndCode1		IndCode2		
DV		**IV**	**Estimate**	**p-value**	**Estimate**	**p-value**	**z-score**
F6	**<---**	**F1**	0,283	0,001	0,320	0,002	0,269
F6	**<---**	**F3**	0,430	0,000	0,260	0,053	-0,964
F6	**<---**	**F2**	0,035	0,824	0,398	0,014	1,622
F6	**<---**	**F8**	0,105	0,211	0,069	0,397	-0,311
F6	**<---**	**F10**	0,000	0,920	0,006	0,005	1,998**
F6	**<---**	**F9**	0,007	0,390	-0,013	0,222	-1,491
F7	**<---**	**F5**	0,027	0,485	0,133	0,003	1,784*
F7	**<---**	**F1**	0,192	0,004	0,194	0,006	0,020
F7	**<---**	**F3**	0,463	0,000	0,239	0,009	-1,797*
F7	**<---**	**F4**	0,270	0,000	0,170	0,021	-0,937
F7	**<---**	**F3xF4**	-0,076	0,270	-0,210	0,000	-1,475
F7	**<---**	**F3xF5**	0,119	0,119	0,343	0,000	1,981**
F7	**<---**	**F2xF5**	-0,082	0,347	-0,219	0,003	-1,204
F7	**<---**	**F8**	0,132	0,025	0,101	0,052	-0,395
F7	**<---**	**F10**	0,002	0,228	0,000	0,949	-0,904
F7	**<---**	**F9**	-0,007	0,216	0,004	0,550	1,255
F7	**<---**	**F2**	-0,068	0,592	0,082	0,450	0,898

Notes: *** p-value < 0.01; ** p-value < 0.05; * p-value < 0.10

In order to retain the full information contained in the continuous moderator variables of this study, the moderated variable effects were modeled as multiplicative interactions. The interaction moderation test surprisingly rejected H5. While no significant interaction effect could be detected for industry group 1, the interaction effect for industry group 2 was significant to a p < 0.05 level with S.E. -0.210, contradicting H5.

The two-way interaction moderation (Figure 9) for industry group 2 reveals a downward slope for the relationship between DMKnowSharing and DyDMPerf, when FormalDMGov is high. Meaning, that FormalDMGov actually dampens the positive relationship between DMKnowSharing and DyDMPerf. However, the figure also reveals that FormalDMGov almost always outperforms low FormalDMGov, while this difference decreases when DMKnowSharing increases. Indicating, that high FormalDMGov is still largely preferable to low FormalDMGov, only when DMKnowSharing is very high, it shows inferior value.

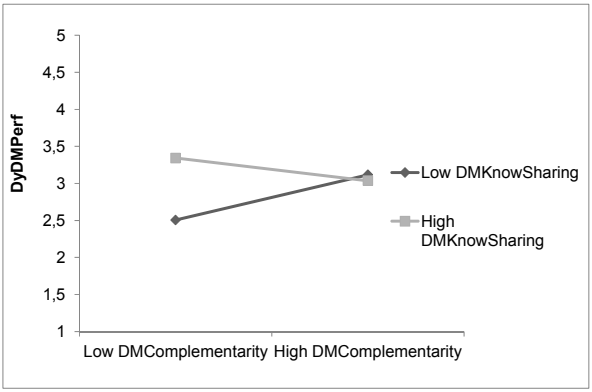

Figure 9 Two-Way Interaction Effects for Unstandardized Variables for H5 (Industry Group 2)

H6 is being supported showing significant interaction effects for industry group 2. The two-way interaction moderation (Figure 10) reveals a steep slope for the relationship between relational DMComplementarity and DyDMPerf, when FormalDMGov is high. The figure also reveals that for low levels of DMComplementarity, a low level of FormalDMGov creates a slightly higher degree of DyDMPerf. That is, if a supplier has a lot of DMComplementarity, it should rely on FormalDMGov to increase performance enhancements stemming from complementarity, while for a lower level of DMComplementarity one only needs a low level of FormalDMGov to benefit from the relationship.

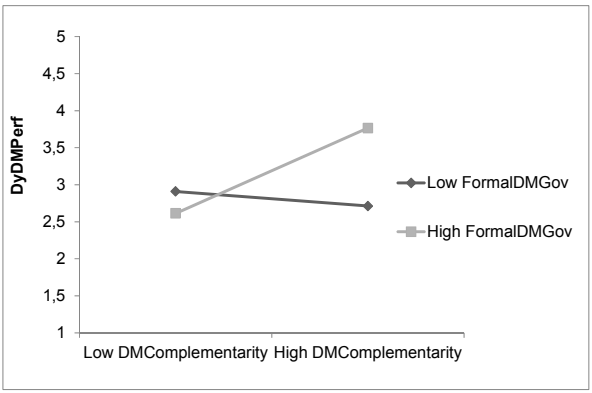

Figure 10 Two-Way Interaction Effects for Unstandardized Variables for H6 (Industry Group 2)

In developing the most parsimonious model (Model 3) to best represent the data, H7 was only supported to a significance level of $p < 0.1$ and was consequently deleted; providing no further support for H7.

H8 is supported by the model for industry group 2, showing no significant effects for industry group 1. The difference between the estimates for both industry groups is significant with $z = 1.981$ and $p < 0.05$. For industry group 2, Figure 11 shows that a high level of InformalDMGov dampens the positive relationship between DMComplementarity and DyDMPerf. Intuitively, the figure shows that for low levels of DMComplementarity, high InformalDMGov generates high DyDMPerf, while this benefit diminishes when DMComplementarity increases.

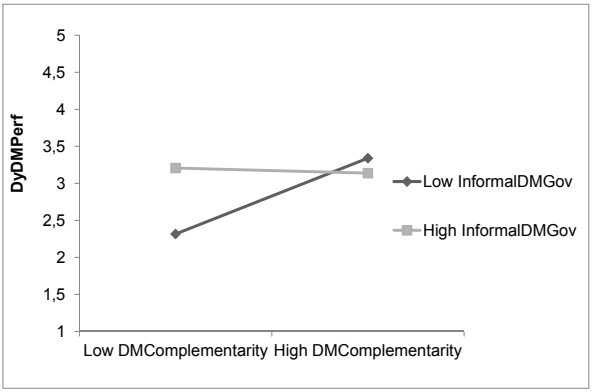

Figure 11 Two-Way Interaction Effects for Unstandardized Variables for H8 (Industry Group 2)

6.5 Discussion

This chapter investigated the RV as a theoretical perspective in dyadic disruption management. In particular it sought to identify to which extend the determinants of the view enhance a buying firm's dyadic (i.e. partnership exclusive) and re-deployable (i.e. replicable across other supplier relationships) disruption management performance. The constructs that are advocated by Dyer and Singh (1998) as the determinants of relational rent were researched from an employee's perspective. It was theorized that in the context of supply chain disruption management, buyer relation-specific disruption management investments, relational disruption management knowledge sharing, relational disruption management complementarity and an effective form of supplier governance positively impact a buying-firm's disruption management performance. It was than researched what governance approaches are best suitable given certain

product characteristics in various industry sectors. The empirical test with 229 manu-manufacturing firms from Austria, Germany and Switzerland largely confirmed the hypothesized relationships.

As far as managerial practice is concerned, this study offers a useful picture about the value of dyads in disruption management, and provides a picture of the impact of different relational determinants in working with the supplier. Theoretically and empirically, this approach represents a significant departure from previous literature. The results highlight the importance of the RV perspective in disruption management, showing that disruption management can and should also be approached from an inter-organizational perspective. It could be shown that the benefits of dyadic disruption management cannot just be tied to a single relationship but that they show use in other supplier relationships as well. It is thereby reasonable to assume that the ratio of relational to re-deployable disruption management performance will be higher when the buying-firm has more opportunities to apply what it learns to its suppliers outside of the scope of the particular relationship (Khanna *et al.*, 1998). Since re-deployability is at the heart of performance spillover (Mesquita *et al.*, 2008), this study may even inform knowledge management and organizational learning literature, in which the aspect of performance spillover (in contrast to knowledge spillover) is still a fairly new debate (e.g. Xue *et al.*, 2013).

Looking at each determinant of the relation view individually, several results can be derived. One can learn that a buyer's relation-specific disruption management asset investment does not just serve the particular relationship, but can be re-deployed over other relationships with suppliers.

The study also busts the myth of the unambiguous usefulness of knowledge sharing in supply chain disruption management. Clearly, knowledge sharing is incorporated in any relationship, and it is an important part of general SCM. Following Dyer and Singh's (1998) proposition this study measured the amount of routines of knowledge sharing. The model hence tested for whether changes in this construct will result in linear changes in the dependent variables. Surprisingly, the data showed no statistical support for this hypothesis. This could be interpreted multiple ways: First, the construct does not account for the quality of and the need for the disruption management knowledge shared. That is, firms that seek to prepare for disruptions may see no additional value in an increased sharing of knowledge, as the right information at the right time might just be enough to appropriately implement mitigation measures.

Second, a structural model assumes linear relations between the endogenous and exogenous variables. However, this assumption is unreasonably to be expected to fit perfectly. As aforementioned, the relationship between DMKnowSharing and the outcome variable in this study was significant for linear as well as logarithmic estimates (see sub-chapter 6.3.3). Drawing on the economic concept of utility, one could argue that the value of sharing knowledge in disruption management follows a very steep quasi-concave shape of the utility function, finally reaching a level where there is no or hardly any value in sharing additional disruption management knowledge. That is, sharing knowledge has a greater value when the buying-firm has a lower amount of it, and hardly any value when it has much of it. If this proposition holds true, one should not interpret the results of this study as knowledge sharing has no value in disruption management, but as more knowledge sharing does not necessarily mean more disruption management benefit. The findings at least counter the assumption of "a lot helps a lot" as proposed in Dyer and Singh (1998). Third, one could simply argue that DMKnowSharing that takes place in direct involvement of the supplier may be more conducive to sharing tacit knowledge. This is probably the most likely interpretation, considering that DMKnowSharing was still found to have a significant positive impact on Re-deplDMPerf in high complicated product industries. The relationship between DMKnowSharing and DyDMPerf was also found to be significantly dampened by FormalDMGov as a moderator (rejecting H5). This provides an indication that in the context of dyadic disruption management formal governance does not provide the mechanisms needed to share knowledge in such manners that allow an appropriate planning for disruptions. Rather the contrary. Formal governance mechanisms seem to be too rigid to actually allow for sharing appropriate knowledge, providing further support for the third interpretation attempt.

The study further shows that DMComplementarity is a very strong, still under researched antecedent of a successful disruption management. The data shows an exceptionally strong relationship between DMComplementarity and the performance constructs, making this construct an interesting research object for further research endeavors. In the context of both industry groups, it could be shown that this relationship is significantly stronger for low complicated product industries. The finding may be a valuable contribution to the supplier selection literature, where, to the best of the author's knowledge, complementarity has not yet been regarded as a selection criterion (e.g. Govindan *et al.*, 2015; Ho *et al.*, 2010). The study also dissents with the research from Priscila *et al.* (2014) who argued that relational complementarity cannot

be measured individually in structural equation models but should be considered as part of relational governance mechanisms. The study data could show a clear difference between these constructs in the context of disruption management. Discriminant validity could be established on an item and on a construct level.

The study then went on to research what firms have to do from a governance perspective to increase the benefits from the hypothesized relationships. It could be shown that both industry groups benefit from InformalDMGov in their disruption management. However, as industry groups may differ in their requirement for coordination mechanisms in their supply chains, a contextual background of the usefulness of FormalDMGov was hypothesized. It could be shown, that industry sectors that deal with highly complicated products should rely much more on formal disruption management governance structures, than industry sectors with less complicated products. In other words, literature may have somewhat exaggerated the exclusive value of relational governance mechanisms (e.g. Bello and Bovell, 2012; Li *et al.*, 2015) as formal governance mechanisms are still a valuable means to coordinate the supply chain partners' actions.

6.6 Final Remarks

Previous research has shown that disruption management issues are often researched in an intra-organizational context (Durach *et al.*, 2015), assuming the supply chain to be the source of disruption rather than the source of disruption mitigation. Drawing on the RV, this research argued and showed that the dyad can be a source of disruption management performance enhancements. A surprising finding in this study was that relational disruption management knowledge sharing was not found to have a direct positive relationship with a buyer's dyadic disruption management performance; challenging the "a lot helps a lot" perception in the RV. It was shown that one has to differentiate between the relational benefits of dyadic disruption management and re-deployable benefits. Indicating, that in the context of supply chain disruption management it is difficult to only generate value for a particular relationship, as the generated know-how provides value across other buyer-supplier relationships as well. Further, this model provides and answers as to whether formal or informal disruption management governance is better suited to optimize dyadic disruption management. Complicated product industries have been shown to benefit more from an ambidextrous governance form, while low complicated product industries benefit more from informal governance.

Despite these interesting results, the study has its limitations which may provide directions for future research. First, this study's analysis has focused on buyer's asset investments, leaving the effects of supplier's asset investments open for future research attempts. Second, the dependent variables have looked at the relational and re-deployable performance enhancements of the buying-firm, while future research could also try to integrate the suppliers' perspectives.

As discussed in the previous sub-chapter, no significant linear positive relationship between knowledge sharing and relational performance could be identified. The multiple ways of interpreting this finding as provided above, may hopefully spark subsequent research efforts to investigate both, the inter-personal knowledge sharing investigated in this article, and the impersonal types such as information technology.

Finally, the author acknowledges that industry sector codes are just a proxy and not a perfect metric for the average product complicatedness. Future research efforts could and should have a closer look into the moderating effects of this context, as further valuable managerial and practical insights are likely to be gained from such efforts.

This chapter has empirically shown the applicability of the RV perspective in dyadic disruption management. The community is now a step closer to proposing an original schema for realizing supply chain robustness on an inter-organizational level. The following chapter will now tie the findings from chapter 3 to 6 together to propose the recapitulatory schema of this thesis.

7 The Recapitulatory Contextual Schema

The previous chapter has researched the fourth and final objective of this thesis, which was *to "test the value of the constructs proposed in the relational view theory in a dyadic disruption management context and identify what governmental mechanisms can be employed by buying-firms to make best use of their supplier relationships*."

This study can now tie the main findings and frameworks from chapters 3, 4, 5 and 6 together and propose a recapitulatory contextual dyadic disruption management schema. The contextual schema addresses two industry clusters that are recommended to employ the identified relational determinants differently in order to most efficiently facilitate a successful buyer-supplier disruption management.

7.1 The Recapitulatory Contextual Schema to Facilitate Supply Chain Robustness

7.1.1 Schema Characterization

The recapitulatory schema, as portrayed in Figure 12, draws on the findings of chapters 4, 5, and 6 as well as the methodological footing developed in chapter 3. Chapter 4 has contributed the overall structure of the schema by showing that antecedents to achieve supply chain robustness can be grouped into intra- and inter-organizational categories. With a focus on inter-organizational robustness, chapter 5 elaborated on the usefulness of the RV theory as a theoretical lens to facilitate successful inter-organizational (dyadic) disruption management. Dyadic disruption management is defined as the management of supply chain disruptions by appropriately using, modifying and governing supplier relationships. The propositions made in chapter 5 provided the theoretical foundation of the hypothetico-deductive model proposed in chapter 6. This model tested and validated the statistical significance of all four relational determinants of the RV in a dyadic disruption management context.

The recapitulatory schema takes account of the different effect sizes of each relational determinant of the RV. All paths between the determinants and the performance construct that have been identified as statistically significant are depicted with solid arrows (see Figure 12). The "+/-" signs indicate the strength of the respective relationship providing initial guidance for practitioners. For example, triple plus (+++) is a clear indication for practitioners to devote particularly many resources in this relational determinant, as the prospective returns are high.

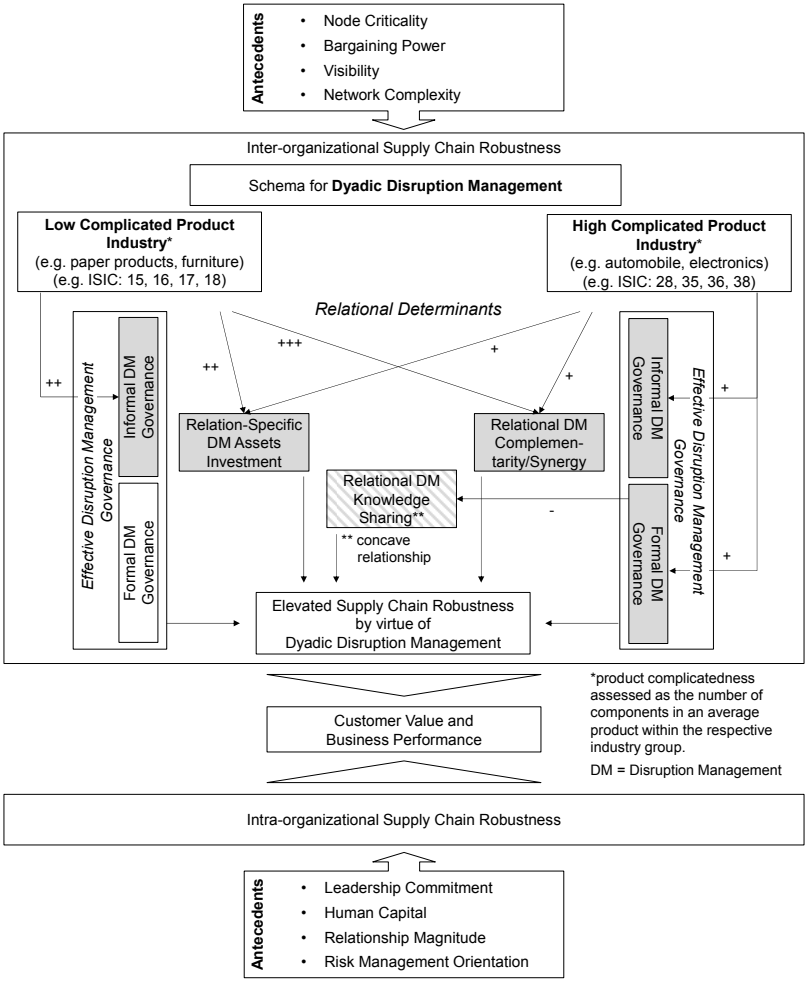

Figure 12 Recapitulatory Contextual Schema of Buyer-Supplier Relational Determinants to Facilitate Supply Chain Robustness

The unit of analysis of the recapitulatory schema is the manufacturing buying-firm and its relationship with a supplier. It demonstrates that supply chain robustness can be achieved through both intra- and inter-organizational robustness approaches. Both robustness elements are supported by a set of four antecedents that enable the effective implementation of robustness measures.

Drilling down into inter-organizational robustness, four buyer-supplier relational determinants to facilitate dyadic disruption management are proposed. In developing these determinants the thesis drew on the determinants of the RV perspective as proposed in Dyer and Singh (1998).

The RV proposes that when firms in a vertical relationship invest in relation-specific assets and knowledge sharing routines, and combine synergistic resources and capabilities a supernormal profit can be derived. These three determinants should be paralleled with a fourth determinant, i.e. an effective form of governance to make the best out of existing relationships. Chapter 5 has theorized how all four determinants can be transferred to the field of dyadic disruption management, and indicated that they are exhaustive. Thereafter, chapter 6 has quantitatively validated their individual impact on the dyadic disruption management performance of firms.

The schema now shows that relation-specific investments, complementary suppliers with synergistic capabilities and an effective form of governance are indeed three fundamental pillars of an effective dyadic disruption management. However, the relational determinant of relational disruption management knowledge sharing was found to be only of limited value in dyadic disruption management. That is, the linear, "the more the merrier" approach of knowledge sharing, as proposed in the RV, is not supported by the hypothetico-deductive model. The thesis argues that the marginal benefit of knowledge sharing is always higher for non-routine tasks than for routine tasks and decreases with the extent of knowledge exchanged. The relationship between knowledge sharing and the performance construct (i.e. a buying-firm's dyadic disruption management performance) seems to follow a concave rather than a linear slope. In particular, disruptions that are caused by misaligned processes do not linearly benefit from the prolonged sharing of knowledge, as partners will eventually build up tacit knowledge for their joint processes. The determinant of knowledge sharing has therefore been marked in light grey upward lines (see Figure 12). But note, it has still been shown that suppliers can use their complementary knowledge, acquired though their upstream position in the supply chain, to avoid downstream disruptions for the buying-firm; and powerful buying-firms can use their capabilities to assist the supplier in managing its upstream processes.

Table 24 summarizes the definitions of all four relational determinants as used in this thesis and as depicted in the recapitulatory schema.

Table 24 Definitions of Buyer-Supplier Relational Determinants to Facilitate Dyadic Disruption Management

Relational Determinant	Definition
(Buyer) Relation-Specific Disruption Management Asset Investment (DMAssetInvest – F1)	Investments in human and physical capital that are dedicated to the management of supply chain disruptions within a particular relationship.
Relational Disruption Management Knowledge Sharing (DMKnowSharing – F2)	The frequent sharing of disruption management related know-how and information between buyers and suppliers which they have acquired or created.
Relational Disruption Management Complementarity (DMComplementarity – F3)	The degree to which firms in an alliance are able to eliminate disruption management deficiencies in each other's portfolio of resources by supplying distinct or similar capabilities.
Effective Disruption Management Governance (InformalDMGov – F4/ FomalDMGov - F5)	All processes of informally or formally governing the supplier.

In keeping with the literature, the relational determinant of effective disruption management governance has been split into two forms of governance, formal governance (i.e. contracts, written agreements etc.) and informal governance (i.e. social norms, maxims etc.). The quantitative research approach in chapter 6 has shown that there is not just a different disruption management value of the use of these two governance forms, but that a surprising moderating effect exists when looking at the average product complicatedness of different industry sectors. It turned out that the factor of product complicatedness[7] significantly influences the relationships between the relational determinants and the performance construct. That is, firms operating in high complicated product industries (e.g. automobile, electronics) show a significantly increased benefit from relying on ambidextrous governance approaches, through balancing formal and informal disruption management governance; whereas firms from low complicated product industries (e.g. paper products, furniture) merely benefit from an informal supplier governance.

[7] Product complicatedness in the structural equation model (chapter 6) was assessed as the number of components in an average product within the respective industry group. However, a more subtle approach could be thought of, such as the one discussed further down, using horizontal, vertical and spatial product complicatedness factors.

This finding refines Trowbridge's (2015, p. 38) remark that "*handshakes and good intentions and long-term trusted relationships may have sufficed in earlier times, but in today's frenetic […] environment leave businesses exposed to significant risks*" through adding a contextual factor to it. His proposition seems to hold true in high complicated product industries, such as the automotive industry; though, low complicated product industries, such as the paper industry, seem to still require higher degrees of flexibility in their disruption management, and therefore benefit from the reliance on informal governance structures.

This finding can be interpreted in such ways that the number of unique parts in a product defines appropriate supply chain disruption responses. Complicated products usually require much more coordination efforts as the number of direct suppliers involved is considerably higher. Industries that manufacture more complicated products eventually have to manage a more complex supply network.

In their seminal research, Bode and Wagner (2015) quantitatively researched the relationship between network complexity and the frequency of supply chain disruptions. They differentiated between three types of complexity – horizontal, vertical and spatial supply chain complexity. This thesis has focused on horizontal complexity looking at the sum of individual components of products; nevertheless, researchers and managers may in the future link complicated products with all three dimensions types of supply chain complexity. Horizontal complexity refers to the number of direct suppliers, or in the case of products, to the number of components that are directly supplied to the buying-firm by different suppliers. Vertical complexity refers to the length of the supply chain, or in the case of products, to the number of sub-suppliers involved in producing all individual parts of the product. Spatial complexity refers to the global expansion of the supply chain, or in the case of products, to the local content of the product under consideration.

Bode and Wagner (2015) managed to identify a positive relationship between all three of these complexity dimensions and disruption frequency. Vertical complexity was identified to have a linear relationship with disruption frequency. Horizontal and spatial complexity was even found to have an above linear relationship. The effect size of horizontal complexity (similar to the factor regarded in this thesis) was thereby found to have by far the largest effect on the frequency of disruptions. Hence, their findings may directly support the findings of this thesis and substantiate the usefulness of product complexity as a (proxy) moderating variable in the proposed schema.

7.1.2 Normative Implications for Supply Chain Managers

Breaking away from the somewhat rigid discussion of the four relational determinants of dyadic disruption management, as proposed in Figure 12, one will rightfully ask for some normative guidance for practitioners. In this sub-chapter a non-exhaustive, normative description will be given for each of the two industry groups.

Managers from *less complicated product industries* should learn from the schema that there is a limited value of having ironclad disruption management contracts with their suppliers. Firms in this group are usually characterized by only having to orchestrate a handful of suppliers in order to manufacture a product. These firms should not seek to detail every aspect of their suppliers' disruption management actions or consequences. Quite the contrary, the present thesis detects that leading firms show a heightened benefit from relying on interpersonal agreements in their disruption management. Hence, those firms that manage to follow a more cooperative approach with their suppliers will be more successful in avoiding and resisting disruptions.

Less complicated products usually mean fewer supplier relationships that need to be managed. If feasible, the best option for firms is to have their purchasing personal develop close personal relationships with their counterparts. If they manage to do so, a quick, non-formal adjustment in case of disruptions is more likely and changing processes can be better aligned. It will also allow both partners to better line up their everyday processes to adequately avoid disruptions. As a result of closer relationships, punishments, in situations of non-conformance of the supplier, can be handed down to the supplier on a personal level, making a stronger and more sustainable impact.

Managers in this industry group should also learn that more disruption management flexibility can be and should be given to the supplier. Especially in less complicated supply chain structures, it is of heightened importance to find suppliers that are not just passively receiving disruption management targets, but to find suppliers which show commitment to the relationship and are willing to be independently pro-active (e.g. quick adjustment of transportation routes, product adjustments to changing market regulations etc.). Such suppliers, and in particular their employees, should not narrow-mindedly focus on fulfilling their contractual obligations, but be willing to become actively engaged in cooperative disruption management actions. Buying-firms should nurse this commitment by showing the supplier the importance of the relationship to the buying firm.

To meet these requirements of buyer-supplier relationships in low complicated product industries, the process of finding suppliers is potentially much more challenging than one would wish for. However, as this thesis demonstrates, the disruption management benefit form finding the right supplier is exceptionally high.

The above normative guidance for managers from low complicated product industries has built upon the assumption that it is usually easier for managers to control what occurs in their supply chain if the supply chain structure is relatively simple. As the number of supplier relationships increases, more relationships have to be orchestrated in order to manufacture a product. The simplicity of orchestration vanishes and firms will have to increasingly rely on building detailed agreements in order to coordinate what happens in their supply chain.

High complicated product industries are characterized by many suppliers that have to be coordinated. More relationships also imply less value and time to manage the individual relationship. Therefore, detailed contractual agreements are needed that detail each suppliers' disruption management obligations and consequences in case of non-conformance. This requires a coordinated approach from all managers in such firms.

Managers in this industry cluster should learn from this thesis that they have to take a much more strategic approach in handling their supplier relationships. Today, managers still often look anew at the content of each contract with each supplier. However, it could be shown that leading firms have procurement groups that partner with their companies' legal and risk management teams in order to provide best supply chain orchestration and disruption management protection. Managers who haven't done this yet should immediately start sharpening and harmonizing their supplier contracts.

Unsurprisingly, companies from *all industry groups* equally benefit from investing in their buyer-supplier disruption management assets (e.g. joint [technical/social] trainings, employee exchanges, seminars etc.). And these investments are well-invested even in short-lived supplier relationships. It could be shown that employees' learnings derived from such investments can be easily reused across other supplier relationships. That is, even from supplier specific trainings, employees are capable of extracting important knowledge and capabilities and re-deploy those with other suppliers.

Managers from both industry clusters should also understand that all factors discussed in this sub-chapter foster a constant exchange of important knowledge. Though, the benefit of explicitly installing knowledge sharing routines to manage disruptions seems to wear off very quickly. Leading companies therefore have installed mechanisms that allow for an unstructured yet timely exchange of knowledge on disruptions, rather than following a schedule of constant meetings.

Before adhering to the normative guidance of this sub-chapter, managers will have to assign themselves to one of the two industry g. They will thereby have to consider the nature of their product. Low complicated products are usually characterized by little differentiation, as the quality of such products usually only differs slightly between producers. Such products are hardly complex in a sense that not a lot of parts have to be assembled in making the product, and production processes are rather straightforward. The local content of such products is comparatively high with lower levels of re-current risks, as usually experienced in international supply chains. High complicated products on the other hand are those products requiring complex supply chain structures.

Yet, it is agreeably difficult to devise hard cut-off limits for high and low product complicatedness. Managers interviewed during the case studies have shown a basic sense of whether their products are rather complicated. For managers who are rather unsure, the ISIC or US-SIC codes as proposed in chapter 6 should give practical guidance. Alternatively, a positivistic table in Appendix G could provide another guiding hand for managers. The table is a suggestion based upon data solicited from the case studies.

Sub-chapter 7.1 has summarized the findings from chapters 3, 4, 5 and 6. The following sub-chapter will now provide some concluding thoughts on how robustness improvements through managerial interventions (as it could be the consequence of the scientific findings of this thesis) and/or the current state of supply chain robustness could be calculated, taking a single firm's perspective.

7.2 Thoughts on Measuring Supply Chain Robustness and Intervention Outcomes

This sub-chapter proposes some brief ideas on how to measure status quo of supply chain robustness from a single firm's perspective and improvements in supply chain robustness following managerial interventions. Measuring supply chain robustness

means measuring disruptions that are hoped to never occur. In particular, it requires detailed metrics for the probability and the impact of disruptions on existing supply chain structures.

Developing such metrics for a single firm poses several challenges. First, network interdependencies require tracking disruptions not just to the supplier, but to the sub-suppliers and even the sub-supplier's supplier and so on. Second, today's supply chains are often characterized by high degrees of outsourcing and broad supplier bases. It is therefore not just the depth of the network at hand but the breadth as well that needs to be taken into consideration. Third, disruption types are diverse, interdependent and usually require situational analysis approaches (Käki *et al.*, 2015).

One could therefore rightfully argue that measuring status quo of supply chain robustness from a single firm's perspective or measuring improvements in supply chain robustness can only be conducted in retrospect. The author acknowledges that attempting to develop such metrics has in itself the potential for a whole new dissertation project. Yet in the following he would like to share some thoughts on this to encourage further research.

It is reasonable to assume that the proposition of a new strategic management schema, such as the one proposed in this thesis, will motivate decision makers to intervene in their current set of strategies. Having proposed a new schema for supply chain robustness in the previous chapters, the author would now like to ignite a future discussion on basic tools that could be developed for practitioners to assess the robustness of their networks pre- and post-managerial interventions.

The quantitative approach taken in chapter 6 has already shown the practical and theoretical value of the proposed schema, as over 60 percent of the variance of the endogenous variable could be explained through the proposed exogenous variables. However, this benefit is not generalizable to all firms, and the statistical approach taken is not suitable for a single firm's internal assessment. Initial attempts to measure proneness of single firms to risks have been conducted by Käki *et al.* (2015), a.o. They used the probabilistic risk assessment approach to measure risks firms are exposed to by identifying the probability of disruption at the focal firm. Their proposed probability approach, however, is complicated as it depends upon the status of other nodes in the network. It is therefore only partially suitable for managerial practice.

The approach that will be proposed in this sub-chapter is intended to be more appealing for managerial practice, yet it will face the trade-off of being more sensitive to measurement errors. Recall, chapter 4 has defined robustness as "resist" and/or "avoid" supply chain disruptions. That means, the less disruptions happen, the less their impact and/or the less the probability of their occurrence (see also chapter 5.1), and in turn the higher the supply chain robustness. This implies that there are three variables relevant for measuring both, a relative value to resemble the improvements achieved through an intervention that seeks to increase robustness, and an absolute value that resembles the status quo of robustness of the supply chain under consideration.

In the following, the author proposes a simple formula that shows how these figures can be calculated. Similar to the methodological approach followed in chapter 5, the formula considers all potential disruptions that may occur at a single firm. It draws on quantitative data regarding probabilities (*p*) and impacts (*i*) of the potential disruptions in order to calculate an overall score. While the sum over the products *p*×*i before the intervention* build the numerator, the denominator is built by the sum over the same products *after the invention*. See chapter 5 for a more elaborate discussion on probability and impact of disruptions.

The complete notation and symbols used are listed below:

n: *Number of identified disruptions (assuming no interdependencies)*[8]*;*

$\widehat{p_b}$: *Pre-intervention estimates of probability of the disruption to occur,* $[0 \leq \widehat{p_b} \leq 1]$; $\widehat{p_b} \in \mathbb{R}^{\geq 0}$,

$\widehat{\imath_b}$: *Pre-intervention estimates of the impact of the disruption,* $[0 \leq \widehat{\imath_b} \leq 1]$; $\widehat{\imath_b} \in \mathbb{R}^{\geq 0}$,

$\widehat{p_a}$: *Post-intervention estimates of probability of the disruption,* $[0 \leq \widehat{p_a} \leq 1]$; $\widehat{p_a} \in \mathbb{R}^{\geq 0}$,

$\widehat{\imath_a}$: *Post-intervention estimates of the impact of the disruption,* $[0 \leq \widehat{\imath_a} \leq 1]$; $\widehat{\imath_a} \in \mathbb{R}^{\geq 0}$,

$\hat{p}$: *Estimates of probability of the disruption to occur,* $[0 \leq \hat{p} \leq 1]$; $\hat{p} \in \mathbb{R}^{\geq 0}$,

$\hat{\imath}$: *Estimates of impact of the disruption,* $[0 \leq \hat{\imath} \leq 1]$; $\hat{\imath} \in \mathbb{R}^{\geq 0}$,

Ro_{rel}: *Relative robustness figure, and*

[8] Note, the formula is highly sensitive to the experts' ability to identify all potential disruptions. Missing out on some disruptions will inevitably impact the robustness figures (see the discussion on the need of a sensitivity measure below).

Ro_{abs}: *Absolute robustness figure.*

Given an intervention has taken place, the robustness improvement achieved through this intervention can be calculated as follows (with *k = 1, …, n*).

$$Ro_{rel} = \frac{\sum_{k=1}^{n}(\widehat{p_b}(k) \times \widehat{i_b}(k))}{\sum_{k=1}^{n}(\widehat{p_a}(k) \times \widehat{i_a}(k))} \qquad (I)$$

As long as the following condition is met

$$\sum_{k=1}^{n}(\widehat{p_a}(k) \times \widehat{i_a}(k)) > 0$$

the resulting figure from equation (I) can be interpreted as:

Ro_{rel} < 1; *robustness has worsened;*

Ro_{rel} = 1; *no change;*

Ro_{rel} > 1; *robustness has improved;*

Ro_{rel} >> 1; *robustness has substantially improved.*

In case $\sum_{k=1}^{n}(p_a(k) \cdot i_a(k)) = 0$ one has achieved an optimum in generating an absolutely robust supply chain; a theoretical results that most likely bears no practical relevance.

In order to calculate Ro_{abs}, so as to determine the current state of supply chain robustness, the following formula is proposed.

$$Ro_{abs} = \frac{1}{\sum_{k=1}^{n}(\hat{p}(k) \times \hat{\imath}(k))} \qquad (II)$$

Under the following condition

$$\sum_{k=1}^{n}\left(\hat{p}(k) \times \hat{\imath}(k)\right) > 0$$

Ro_{abs} figures allow both within firm robustness comparisons across different supply chains, and within supply chain comparisons over different periods of time. Using equation (II), higher Ro_{abs} scores can be interpreted as higher levels of supply chain robustness.

Typically, disruption risk data needed to solve equations (I) and (II) should be elicited from experts. The processes of assessing probability and impact of disruptions as proposed in chapter 5 provides a principal methodological approach that could be followed in managerial practice. Data generated through methodological processes such as the NGT can then be used to compare pre-intervention and post-intervention robustness metrics (see equation (I)) and quantify robustness improvements. As the estimates of the likelihood of disruptions are generated through historical data and practical experience, one should allow for enough time to elapse between the intervention and the collection of new data in order to calculate the denominator of equation (I). The same approach can be followed to calculate Ro_{abs} as proposed in equation (II).

It should be noted that applying the proposed methodology in everyday business is still challenging, as quantification of both disruption probabilities and impact can be an arduous task. The approach should also always be paralleled with a sensitivity analysis, in order to measure the robustness of the Ro_{rel} and Ro_{abs} measures.

Therefore, as a next logical step – leaving the scope of this sub-chapter – one would need to assess the robustness of the robustness measures themselves. In developing the ideas proposed in this sub-chapter further, a sensitivity measure would need to be introduced to capture the maximum change in Ro_{rel} (and Ro_{abs}) for individual disruptions occurring with absolute certainty (probability = 1.0) instead of their estimated probabilities

$$\Delta = Ro_{rel} - \max_{k}\{Ro_{rel}|p_k = 1.0\}$$

and

$$\Delta = Ro_{abs} - \max_{k}\{Ro_{abs}|p_k = 1.0\}\,.$$

Note, this measure would not take into consideration “correlated” changes in disruption probabilities. The measure can still help to understand how sensitive the robustness metric is with regard to the uncertainty of single disruption probabilities.

8 Overall Summary and Outlook

8.1 Synopsis and Contribution Value

The overall aim of this cumulative thesis was to develop a conceptual framework of supply chain robustness, and construct a schema of buyer-supplier relational determinants which supports managers in making their supply chain relationships more effective so as to facilitate supply chain robustness.

The present thesis culminates in such a contextual recapitulatory schema, depicting relational determinants crucial to increase a buying-firm's supply chain robustness through the use, modification and governance of supplier relationships. The recapitulatory schema is the outcome of the interaction between theory, literature and the empirical context at hand, thereby following the scientific endeavor of theory building and theory testing. Despite a multitude of research on the management of disruptions in supply chains, this study addresses an important gap in the literature. It extends and refines current understanding of what relational determinants exist on a buyer-supplier level so as to avoid and resist supply chain disruptions and increase supply chain robustness.

Chapters 2, 3 and 4 set the scene for this thesis. Chapter 2 briefly delimited the present thesis within the field of supply chain risk management. Chapter 3 then provided a refinement of the SLR methodology in order to support the research community in rigorously exploring the literature body of SCM. The chapter analyzed procedural approaches that have been taken in reviews published since 2009, linking these approaches with a previous meta-review in the field. The developed methodological guidelines build on a sample of 37 articles that apply the SLR methodology, along with discussions and shared insights from experienced SLR researchers and librarians. A refined six-step procedure of conducting literature reviews in SCM could be developed.

The findings in chapter 3 demonstrate that a proper application of systematic review principles can help researchers improve rigor and objectivity. Most of the analyzed reviews were found to still not provide enough information to make them independently replicable, raising the risk that their conclusions might not be valid. It could also be shown that remarkably little research today has included outside practitioners or researchers to better sharpen their research question or reduce researcher bias.

Chapter 4 then drew on this refined methodological guidelines and explored dimensions and antecedents of supply chain robustness. By screening 1,482 studies,

94 relevant publications on supply chain robustness could be identified. From such publications a conceptual framework of supply chain robustness was developed. To increase the soundness of the framework, academicians, practitioners and librarians were involved to identify, analyze and synthesize the articles. The newly developed framework identifies eight antecedents of supply chain robustness, categorizing them into intra- and inter-organizational robustness antecedents. Drawing on the identified dimensions of supply chain robustness, the chapter also proposes a formal definition of the construct.

Chapter 4 complements prior research on dimensions and antecedents of supply chain agility and provides a vital building block for better understanding the foundation of the two fundamental strategies (agility and robustness). It turns out that even though four of the eight identified antecedents are inter-organizational in nature, hardly any research in supply chain disruption management has yet looked at what relational determinants actually facilitate supply chain robustness on an intra-organizational level.

Chapter 5, therefore, sought to fill this gap by an elaboration of the RV perspective as an inter-organizational theoretical lens with which to explain a successful dyadic disruption management. Drawing on group exercises with 42 practitioner and five case studies, the chapter modified some of the RV aspects to reconcile with the idiosyncrasies of the disruption management context. The chapter culminated in providing five propositions that explain a buying-firm's supply chain robustness through the use, modification and governance of supplier relations.

The findings suggest the usefulness of the four relational determinants of the RV in order to explain increased robustness in dyads. It is being proposed that buying and supplying-firms possess complementary disruption management capabilities and assets that if, combined, can increase a buying-firm's supply chain robustness. Instances have shown that suppliers can use their complementary information, acquired through their upstream position in the supply chain, to avoid downstream disruptions to the buying-firm; and powerful buying-firms can use their capabilities to assist the supplier in managing its upstream processes. The qualitative approach of chapter 5 also indicated that disruptions that are induced by the supplier itself commonly stem from a lack of trust in the relationship or the preference for short term business with other buying-firms. Only those buying-firms that effectively manage to demonstrate the value of the relationship to the supplier, through relation-specific investment and sharing of relational knowledge (e.g. the strategic importance of the

supplier's products for the buying-firm) can effectively reduce these disruptions and increase supply chain robustness.

However, the "the more the merrier"-approach of knowledge sharing as proposed in Dyer and Singh (1998) is not supported by the qualitative method of this chapter. The benefit of knowledge sharing in disruption management seems to have a clear limit. Contrary to the RV perspective, the relationship between knowledge sharing and dyadic disruption management performance seems to follow a concave rather than a linear slope. Especially disruptions that are caused by misaligned processes do not seem to linearly benefit from the prolonged knowledge sharing, as partners will eventually build up tacit knowledge for the joint disruption management processes.

Chapter 6 then followed a deductive research approach, using the RV perspective to formulate hypotheses evolving around the four determinants of relational rent, and their value to function as buyer-supplier relational determinants to facilitate dyadic disruption management. The set of hypotheses was subsequently tested through structural equation modelling with data collected from 229 informants from manufacturing industries in Austria, Germany and Switzerland. In particular, it could be shown that successful dyadic disruption management should in deed focus on the proposed four relational determinants. About 60 percent of the variance in the endogenous performance construct can be explained through these determinants.

Further, and probably most interesting, a contextual difference in the usefulness of the determinants in different industry sectors could be affirmed. Firms in high complicated product industries have been shown to be more successful in managing disruptions on a dyadic level when they rely on both formal and informal disruption management governance, while firms from low complicated product industries mainly benefit from the reliance on informal governance structures (e.g. social norms, maxims etc.). The value of disruption management complementarity was also found to be significantly higher in low complicated product industries; indicating that such firms should especially focus on finding synergistic suppliers.

Chapter 6 also explored the extent to which the dyadic benefits in disruption management cannot just be tied to a particular relationship, but can be reused across other supplier relationships. A paper by Mesquita *et al.* (2008) has already shown that suppliers can in-deed redeploy the knowledge they have acquired from trainings that have been paid for by the buyer with some of their rivals (i.e. free riding); a finding that is rather discouraging for the buyer, and may deter firms from making future relation-

specific investments. This thesis tried to take a more positive stance on this issue, and sought to identify whether buyers who make relation-specific investments can redeploy the potential benefit from the relationship across other supply chain partners. That is, even though the buying-firm invests transaction-specific, at the same time it learns from this investment and can redeploy its learning with other suppliers.

The present thesis is a valuable contribution to supply chain risk management practice, theory and methodology. From a practical perspective, the frameworks and findings developed in this thesis should and will force purchasing managers to reconsider their strategic approaches in supply chain disruption management. Managers should learn from this thesis the value of taking a strategic approach in handling their supplier relationships. The elaborate normative discussion provided in the sub-chapter 7.2 intends to make managers reassess their current approaches. The sub-chapter shows practical implications for managers that will help them to make their inter-organizational disruption management more effective. It could be shown that successful firms, which have to handle fewer supplier relationships in order to manufacture a product, should seek to find more collaborative disruption management terms with their suppliers. Firms that have to deal with more complicated supplier structures, on the other hand, will have to rely on ironclad contractual agreements in order to achieve an optimal orchestration of their relationships. The interplay of sharing strategic knowledge and making relation-specific investments can thereby function as a useful enabler to achieve increased relational commitment on the supplier side. The demonstrated benefit of a strategic management of supplier relationships, along with the identified relational determinants, may even lead managers to develop new metrics in their supplier selection processes.

The thesis also makes a theoretical contribution by discussing the RV perspective in the context of supply chain disruption management; contributing new perspectives to literature streams which research supplier relationships. Supplier relationship investments have to be understood as a strategic move to maximize long-term profit. It should be the goal of every manager to increase the net present value of relation-specific investments. Yet, what one can often see in practice today is that some managers still follow a myopic return-on-investment thinking. In this sense, this thesis supports the supplier development literature as it shows how an effective management of supplier relationships can provide a complementary or even alternative strategy in disruption management. However, it needs to be emphasized that neither intra- nor inter-organizational strategies are inherently “good” or “bad”. Both approaches are not

mutually exclusive, as a firm, for example, may decide to look for complementary part-partners and build up stock to hedge for unexpected events at the same time (Bode *et al.*, 2011).

Further, this thesis is not just a practical and theoretical but also a methodological contribution to the SCM field. Future research is encouraged to deploy the refined methodology guidelines for conducting SLRs, as proposed in chapter 3. They can serve as a review protocol to increase efficiency and transparency in presenting all necessary review steps. The guidelines are also intended to provide a useful tool for reviewers and editors to better assess the rigor of the applied research methodology.

The community is now a step closer to understanding the relational mechanisms that facilitate more supply chain robustness in dyads. Managers should learn from the present thesis how the use, modification and governance of their business connections can help to avoid and resist supply chain disruptions. The nature of this research does not, however, allow us to derive general management guidelines for all types of disruptions; yet, the identified patterns of relational determinants, along with the facilitating sub-processes discussed in chapter 5, should provide clear guidance on the inter-organizational management of a broader range of disruptions. That is, the mechanisms identified in this thesis may allow for the development of firm-specific standard procedures for the effective dyadic management of disruptions. While some of the proposed mechanisms might induce costs, managers should keep in mind that firms who are successful in increasing supply chain robustness will also be successful in reducing safety stocks and capital costs.

8.2 Limitations and Future Research

As with any other piece of research, the present thesis is subject to a number of limitations, some of which can serve as extensions for future research. Chapters 3, 4, 5 and 6 have already highlighted and discussed potential restrictions that need to be taken into account when seeking to interpret the individual findings. This sub-chapter will now briefly summarize the main points and provide avenues of future research.

This thesis's findings are limited by its qualitative and quantitative methods applied. The literature reviewed in chapter 4 commonly focused on goods supply chains, although no explicit restriction was made on this, leading the inductive and deductive parts of the thesis (chapters 5 and 6) to focus on goods supply chains as well. Therefore, the value of the developed frameworks and the contextual schema to service supply chains remains uncertain.

Service supply chain research is still in its infancy, as compared to research on goods supply chains. Service supply chains will certainly provide a fruitful field for new supply chain risk management research efforts, similar to the one taken in this thesis. This thesis may therefore both inspire the research community to look deeper into the value of supply chain relationships in the context of supply chain disruptions and simultaneously encourage the community to move this thesis's findings onto a service level.

The unit of analysis within this study sets the limitations of the developed schema. The author acknowledges that the general behavior described in chapters 5 and 6 has only been examined in buyer-supplier relationships. A supply chain is a network made up of nodes and links. The dyad is the smallest unit that consists of both of these elements. Though, it cannot be ignored that calls have been made for research to extend concepts in dyad perspectives to the triad (Choi and Wu, 2009b), for example by looking at buyer-supplier-supplier relationships. Future research will therefore certainly benefit from looking further downstream or upstream the supply chain when elaborating on the basic mechanisms proposed in this thesis.

Supply chain risk management literature has extensively relied on the resource-based theory but there is scant research that examines the orchestration of inter-organizational resources. This thesis is amongst the first to apply the RV in supply chain risk management. However, it has to be acknowledged that the RV perspective originally postulates a win-win situation for both partners of a dyad. Despite the fact that this thesis has provided strong indications that benefits can be expected for both partners, it could eventually not be determined. However, the empirical data collected and analyzed in chapters 5 and 6 came from firms occupying different positions along the supply chain; a fact that might partly diminish this limitation. Future research could and should pick up at where this thesis left of and also analyze the dyadic disruption management from a supplier's point of view.

The author also would like to point out that while this research was limited to manufacturing firms, value of the application of the developed schema can well be expected in retail industries. Future research might look deeper into the supplier relationships of retail industries. Idiosyncrasies of these industry types (e.g. switching cost, contract duration, or relationship length) might require some adjustments of the proposed schema, and could provide an interesting object of study.

Furthermore, while this thesis has controlled for the perceived importance of suppliers to buying-firms in its analysis, it cannot yet have a final say as to the effectiveness of the proposed schema with different supplier groups. On might rightfully argue that the proposed schema is only applicable in close business relationships. It is most likely difficult (or impossible) to deploy it in spot-market transactions. However, it should be considered that the resulting schema is to be seen as a new and genuine design element for business relationships in the context of supply chain disruptions. It is meant as a guiding hand for managers, while managers may still want to decide for themselves as to the need for applying it with particular suppliers. Nevertheless, the identified pattern of relational determinants and their disruption management value should not go unheeded.

Lastly, the conceptual framework developed in chapter 4 (Figure 5), which provided the literature backdrop of this thesis, remains a conceptual one. While aspects of it have been subject of further qualitative and quantitative research in this thesis, multiple aspects of it still deserve quantitative testing. The thesis is therefore also a call for researchers to conduct further rigorous quantitative testing of the conceptual framework of supply chain robustness in order to derive further reliable practical implications. The focus of such research should be to test the existence of and identify differences in the strength of, the proposed relationships and assess the moderating effect of uncertainty; a research effort that will certainly meet with a unanimous positive response from both researchers and practitioners.

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Annex

A Reviewed Literature (37): Chapter 3

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B Study Participants: Chapter 4

Academics

Name	***Research Area (not exhaustive)***	***Institute***	***Country***
Bode, Christoph	Risk and disruption management strategies in supply chains and logistics	Universität Mannheim	Germany
Choi, Tsan-Ming	Global fashion supply chain management	The Hong Kong Polytechnic University	Hong-Kong
Handfield, Robert B.	Supply Chain Management	North Carolina State University	USA
Jüttner, Uta	Marketing and supply chain management	Lucerne University of Applied Sciences/Cranfield University	Switzerland/UK
Manuj, Ila	Global supply chain risk management	University of North Texas	USA
Tang, Christopher S.	Global supply chain management, retail operations, and social business operations	University of California Los Angeles	USA
Zeng, Amy Z.	Risk and disruption management strategies and tactics in supply chains	Worcester Polytechnic Institute	USA
Zsidisin, George A.	Purchasing and supply management	Bowling Green State University	USA

Industry Professionals

Name	***Organization***	***Position***	***Industry Type***	***Country***
Elias, Hans-Gunnar	Bernstein AG	Head of SCM and Logistics	Electrical equipment and components	Germany
Grubbert, Michael	Centrotherm Thermal Solutions GmbH & Co. K	Vice President Procurement	Manufacturing Industry	Germany
Barrett, Simon	Intel Corporation (UK)	Global Logistics Strategist	Computer equipment	UK

Bai, Hua	Siemens Factory Automation and Engineering Ltd.	Manager Supply Chain Management	Industrial and commercial machinery	China
Parker Aust, Ashley	Hasbro Inc.	Manager Supply Chain Management and Logistics	Toys, games, media and entertainment	USA

Librarians

Name	***Position***
Guba, Beate	Director of the Library, Business & Management, Technische Universität Berlin
Loch, Michael	Field Specialist, Business & Management, Technische Universität Berlin

D Coding Sheet: Chapter 4

		Intra-Organizational Antecedents				Inter-Organizational Antecedents				Moderator
Paper	IF	Human Capital	Intra-Org. Relationship Magnitude	Risk Management Orientation	Leadership	Node Importance	Bargaining Power	Visibility	Network Complexity	Uncertainty
(van Landeghem & Vanmaele, 2002)	4.400									x
(Speier, Whipple, Closs, & Voss, 2011)	4.400				x			x	x	
(Williamson, 2008)	3.320						x			
(Sawik, 2013)	3.024						x			
(Schmitt, 2011)	2.944			x						
(Lin & Wang, 2011)	2.944			x						x
(Lavastre, Gunasekaran, & Spalanzani, 2012)	2.201		x		x			x		x
(Vlajic, van der Vorst, & Haijema, 2012)	2.081	x	x	x				x		x
(Reiner & Trcka, 2004)	2.081					x				
(Klibi, Martel, & Guitouni, 2010)	2.038								x	x
(Cruz & Liu, 2011)	2.038							x		x
(Hazra & Mahadevan, 2009)	2.038						x			
(Baghalian, Rezapour, & Farahani, 2013)	2.038									x
(Klibi & Martel, 2012)	2.038									x
(Schönlein, Makuschewitz, Wirth, & Scholz-Reiter, 2013)	2.038									
(Zsidisin & Wagner, 2010)	2.020	x		x						x

(Blackhurst, Dunn, & Craighead, 2011)	2.020	x		x				x	x	
(Ouyang & Daganzo, 2006)	1.859							x		
(Tomlin, 2006)	1.859			x						
(Wieland & Wallenburg, 2012)	1.826			x						
(Shukla, Lalit, & Venkatasubramanian, 2011)	1.826					x				x
(Meepetchdee & Shah, 2007)	1.826							x	x	
(Deane, Craighead, & Ragsdale, 2009)	1.826							x		x
(Wieland & Wallenburg, 2013)	1.826							x		
(Peck, 2005)	1.826	x			x					x
(Norrman & Jansson, 2004)	1.826		x	x				x		x
(Christopher & Lee, 2004)	1.826							x		
(Wang, Gilland, & Tomlin, 2010)	1.712			x						
(Fernández, Salomone, & Chiotti, 2012)	1.709									x
(Hofmann, 2011)	1.684						x			
(Jüttner & Maklan, 2011)	1.684			x				x		
(Leat & Revoredo-Giha, 2013)	1.684							x		x
(Xuan, Du, Li, & Wu, 2011)	1.674								x	
(Gaonkar & Viswanadham, 2007)	1.674							x		x
(Rothenberg & Ettlie, 2011)	1.667									x
(Abercrombie, 2007)	1.519						x	x		
(Craighead, Blackhurst, Rungtusanatham, & Handfield, 2007)	1.484					x		x	x	
(Whipple & Roh, 2010)	1.463							x		

(Hall, Skipper, Hazen, & Hanna, 2012)	1.463				x			x		
(Dynes, Johnson, Andrijcic, & Horowitz, 2007)	1.463	x								
(Christopher & Peck, 2004)	1.463			x	x	x				
(Yadav, Mishra, Kumar, & Tiwari, 2011)	1.460									
(Thun, Druke, & Hoenig, 2011)	1.460						(x)		x	x
(Nair & Vidal, 2011)	1.460					x			x	x
(Blackhurst, Craighead, Elkins, & Handfield, 2005)	1.460									
(Grötsch, Blome, & Schleper, 2013)	1.460				x			x		
(Chen, Sohal, & Prajogo, 2013)	1.460		x					x		x
(Wagner & Bode, 2006)	1.458						(x)	x		x
(Chopra & Sodhi, 2004)	1.413								x	
(Azadegan, Patel, & Parida, 2013)	1.315			x						
(Xia, Ramachandran, & Gurnani, 2011)	1.287							x		
(Xue, Zhang, Ling, & Zhao, 2013)	1.262						x			
(Zhao, Kumar, & Yen, 2011)	0.893					x			x	
(Crone & Watts, 2002)	0.753							x	x	
(Chopra, Reinhardt, & Mohan, 2007)	0.692									
(Wei, Dong, & Sun, 2010)	0.656					x				
(Bhattacharya, Geraghty, Young, & Byrne, 2013)	0.600									x
(Figueira, Machado, & Nunes, 2012)	0.513	x								
(Ratick, Meacham, & Aoyama, 2008)	0.500			x						
(Tang, 2006)	0.400			(x)		x			x	

(Shao, 2013)	0.500							x		
(Xiao, Yu, & Gong, 2012)	0.250							x		
(Shulman, Corr, & Ibañes, 2010)	0.083									
(Slowinski, Latimer, & Mehlman, 2013)				x						
(Houlton, 2009)									x	
(Neureuther & Kenyon, 2009)						x			x	x
(Stecke & Kumar, 2009)		x		x				x	x	x
(Faisal, Banwet, & Shankar, 2006)		x			x			x		
(Zhang & Wang, 2011)								x		
(Wildgoose, Brennan, & Thompson, 2012)						x				
(Glendon, 2013)								x		
(Kessler, McGinnis, Bennett, Bello, & Bovell, 2012)								x		x
(Willoughby, 2006)										
(Wan & Beil, 2009)							x			
(Tinham, 2007)								(x)		
(Snell, 2011)		x	x					x		
(Silva & Reddy, 2011)				x						
(Shah, 2009)				x						
(Sarathy, 2006)								x		
(Rowbottom, Buntrock, & Hannesson, 2011)				x		x				x
(Reddy, 2004)						x				
(Pezzini, 2012)								x		
(McKenna, 2008)									x	
(Lassar, Haar, Montalvo, & Hulser, 2010)				x						
(Khan, Khan, & Jarman, 2009)								x	x	
(Jorgensen, 2012)								x		

(Giuntini, 2012)				x				x		
(Fisher *et al.*, 2007)		x		x						
(Feuling, 2010)										x
(Ellinor, 2006)							x			
(Eckert & Hughes, 2010)		x			(x)					
(Dutton, 2005)				x		x		x		
(Davis & Zank, 2008)										x
(Bednarz, 2006)								x		
SUM		**11**	**5**	**22**	**7**	**13**	**8**	**38**	**17**	**35**

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E Main Case Study Interview Questions: Chapter 5

General Information

(Note: all information regarding firm profile has been collected before the firm was invited for an interview)

(1) Please provide us with the following information on your main product in order to allow us to better understand your supply chain structures (Excerpt: supply chain position, frequency of disruptions, main disruption causes, outage costs, lead time, production approach etc.)

(2) Does your firm actively manage supply chain disruptions? If yes, please specify.

Dyadic management of disruptions

(1) Choose one of your suppliers you know very well. How well has the relationship with this supplier been in terms of delivery reliability?

(2) What component is the supplier supplying to you? What's the strategic importance of this component?

(3) Choose three disruptions that are of major concern to you, and that you mitigate with the use of the relationship with this supplier. How do you approach these disruption risks with this supplier in order to avoid or resist disruptions stemming from it?

(4) Are these strategies part of any contractual agreement with this supplier?

(5) Please explain how and why all aforementioned approaches could be useful to increase robustness in your supply chain. That is, why did you choose these approaches?

(6) What is your main problem in dealing with this supplier?

(7) How dependent are you on this supplier? How dependent is this supplier on you? How does this affect your behavior?

Thinking back

(1) Is there anything that we didn't talk about that appears relevant? Do you want to add something to the answers?

F Measurement Items and Scales: Chapter 6

Job Satisfaction (from Janssen, 2001)

How satisfied are you with... ? (1: totally disagree – 7: totally agree)

Marker_1 …your work performance

Marker_2 …the quality of your performance

Marker_3 …the way you perform your tasks

Buyer Relation-Specific DM Asset Investment (adapted from Klein *et al.*, 1990; Shervani *et al.*, 2007)

Specifically for 'this' supplier, we employees have made large efforts…

(1: totally disagree – 7: totally agree)

F1_1 …to learn the necessary capabilities to avoid supply disruptions.

F1_2 …to learn the necessary soft skills (i.e. social competencies) to deal with supply disruptions.

F1_3 …to learn the necessary hard skills (i.e. technical qualifications) to deal with supply disruptions.

F1_4 …to adjust our usual way of dealing with supply disruptions to the employees of 'this' supplier.

F1_5 It is very difficult for other companies to learn the specific way our employees do disruption management with 'this' supplier's employees.

F1_6 To be effective in managing supply disruptions with 'this' supplier's employees, our employees had to invest a lot of time.

Relational DM Knowledge Sharing (adapted from Chen *et al.*, 2004; Gee-Woo Bock *et al.*, 2005)

We employees and 'this' supplier's employees…

(1: totally disagree – 7: totally agree)

F2_1 …constantly exchange expert knowledge on dealing with supply disruptions.

F2_2 …always give each other feedback about each other's performance when dealing with supply disruptions.

F2_3 …provide each other with any information about the status of current supply disruptions.

F2_4 …exchange information about potential supply disruptions frequently and in a timely manner.

F2_5 …exchange many new ideas about avoiding supply disruptions.

Relational DM Complementarity (adapted from Deitz *et al.*, 2010; Lambe *et al.*, 2002)

We employees and 'this' supplier's employees …

(1: totally disagree – 7: totally agree)

F3_1 …contribute capabilities to manage supply disruptions that greatly complement each other.

F3_2 …possess distinct opportunities to avoid supply disruptions that greatly complement each other.

F3_3 …possess distinct opportunities to fix supply disruptions that greatly complement each other.

F3_4 …bring to the table management concepts to avoid supply disruption that greatly complement each other.

F3_5 If one of our employees despairs while managing a supply disruption, our supplier's employees can almost ever assist (and vice versa!).

F3_6 Strategically, you couldn't ask for a better fit between our employees and this supplier's employees to proactively manage disruptions.

Informal DM Governance (adapted from Pulles *et al.*, 2014; Whipple *et al.*, 2013)

Though not required by our formal agreement with 'this' supplier, our organization can always be confident that…

(1: totally disagree – 7: totally agree)

F4_1 …in case of supply disruptions, it would immediately seek to fix the problem.

F4_2 …in case of supply disruptions, our organization could always depend on it to treat us fairly.

F4_3 …it always takes all initiatives possible to prevent supply disruptions.

F4_4 …it would make huge sacrifices to fix supply disruptions.

F4_5 …it will always be honest when responding to our organization's inquiries about potential supply disruptions.

F4_6 Our organization trusts this supplier, because it is always sincere with us when dealing with disruptions.

Formal DM Governance (adapted from Li *et al.*, 2010; Rai *et al.*, 2012)

Our organization has formal agreements with 'this' supplier that precisely detail…

(1: totally disagree – 7: totally agree)

F5_1 …its obligations to avoid supply disruptions.

F5_2 … its procedure to deal with supply disruptions.

F5_3 … consequences in case it causes a supply disruption.

Based on the formal agreements regarding supply disruptions, 'this' supplier knows exactly…

F5_4 …which expectations have to be fulfilled.

F5_5 …which goals our organization associates by working with it.

Buyer Re-Deployable DM Performance (adapted from Bode *et al.*, 2011; Mesquita *et al.*, 2008; Rai, 2013)

The value that has been generated by our employees' cooperation with 'this' supplier's employees has helped to…

(1: totally disagree – 7: totally agree)

F6_1 …better protect ourselves against supply disruptions from our other supplier.

F6_2 …improve our dealing with supply disruptions with our other suppliers.

F6_3 …reduce the likelihood of supply disruptions with our other suppliers.

F6_4 …reduce the impact of supply disruptions with our other suppliers.

F6_5 …reduce the duration of supply disruptions with our other suppliers.

Buyer Dyadic DM Performance (adapted from Bode *et al.*, 2011; Rai, 2013)

Because of our employees' cooperation with 'this' supplier's employees we have managed to…

(1: totally disagree – 7: totally agree)

F7_1 …much better protect ourselves against supply disruptions from 'this' supplier.

F7_2 …develop many new strategies to deal with supply disruptions.

F7_3 …heavily reduce the likelihood of supply disruptions from 'this' supplier.

F7_4 …heavily reduce the impact of supply disruptions from 'this' supplier.

F7_5 …heavily reduce the duration of supply disruptions from 'this' supplier.

G Positivistic Product Industry Classification Data from Case Studies: Chapter 7

	Low product complicatedness	**High product complicatedness**
Vertical parts range	< 6	> 10
Horizontal parts range	< 50	> 60
Local content	> 95 %	< 30 %

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