

RE-THINKING SUPPLIER RISK MANAGEMENT WITH CASE STUDIES AND AGENT-
BASED SIMULATION

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ABSTRACT

This mixed method research uses a series of case studies and an agent based simulation to investigate how firms *do* and *should* acquire information to manage risks inherent in supplier processes. Managing this risk born from supplier non-compliance is important because it can not only threaten a firm's reputation and bottom line, but it can also affect various stakeholders. Current literature on supplier risk management recommends that firms acquire comprehensive information on potential triggers of supplier non-compliance to mitigate this risk in an effective manner. Nevertheless, the literature fails to acknowledge that firms often choose not to obtain such information. In fact, the results from multiple case studies indicate that firms seek to acquire comprehensive information on potential triggers of supplier non-compliance only when they do not see other alternatives to address the risks of supplier non-compliance. The sampled firms reduce their need for comprehensive information on supplier processes because of close relational ties with suppliers or the presence of powerful external stakeholders, such as regulatory agencies, monitoring supplier processes. The agent-based simulation then reveals conditions under which firms should rely on the relational ties and powerful stakeholders to reduce the supplier risks they face.

TABLE OF CONTENTS

Abstract	ii
Table of Contents	iii
List of Tables	iv
List of Figures	v
Chapter One: Introduction	1
Chapter Two: Literature Review	5
The value of supply chain transparency	5
The role of information in supplier risk management	7
The effect of supplier governance	13
The effect of supply chain complexity	16
Chapter Three: Multiple Case Studies	19
Case study description	19
Case study results	57
Chapter Four: Agent-Based Simulation	66
Simulation description	68
Simulation results	79
Chapter Five: Discussion	101
A decision to mitigate supplier risks	102
A decision to avoid supplier risks	104
A decision to tolerate supplier risks	109
Limitations	110
Chapter Six: Conclusion	112
Bibliography	116
Appendix A. Related Concepts and Systematic Literature Review	131
Appendix B. Case Study Protocol	135
Appendix C. Case Description	138
Appendix D. Simulation Code	160

LIST OF TABLES

Table 1. Definitions of supply chain transparency	6
Table 2. Data collected for each case.....	25
Table 3. Description of case groups.....	44
Table 4. Description of factors common among firms in each case group.....	45
Table 5. Simulation notation.....	69
Table 6. Four approaches to manage supplier risks.....	77
Table 7. Summary of simulation results	80
Table A1. Definitions of supply chain traceability and supply chain visibility.....	131

LIST OF FIGURES

Figure 1. Sampling matrix	21
Figure 2. Initial theoretical model.....	26
Figure 3. Final theoretical model for case analysis.....	28
Figure 4. Paths determining firm’s approach to supplier risk.....	58
Figure 5. Flowchart of simulation algorithm	71
Figure 6. ‘Select suppliers’ sub-process	73
Figure 7. ‘Non-compliant suppliers attempt corrective action’ sub-process	75
Figure 8. The role of stakeholder’s capability in determining the likelihood of supplier non-compliance under stakeholder enabled risk avoidance.....	82
Figure 9. The role of a firm’s supply base size in determining the likelihood of supplier non-compliance under stakeholder enabled risk avoidance.....	83
Figure 10. The role of a firm’s supply base size in determining the likelihood of supplier non-compliance under relationship enabled risk avoidance	85
Figure 11. The role of a firm’s capability in determining the likelihood of supplier non-compliance under relationship enabled risk avoidance in small and large supply bases.....	85
Figure 12. The role of a firm’s capability and its selection standard in determining the likelihood of supplier non-compliance under risk mitigation in small and large supply bases	87
Figure 13. The role of a firm’s supply base size in determining the likelihood of supplier non-compliance under risk mitigation	88
Figure 14. The role of a firm’s supply base size in determining the likelihood of supplier non-compliance under risk tolerance	90
Figure 15. The role of a firm’s capability in determining the likelihood of supplier non-compliance under risk tolerance in small and large supply bases	91
Figure 16. The role of a firm's capability in determining the likelihood of supplier non-compliance under risk tolerance vs. under relationship-enabled risk avoidance.....	94
Figure 17. The role of a firm’s supply base size in determining the likelihood of supplier non-compliance under risk tolerance vs. under relationship-enabled risk avoidance.....	95
Figure 18. The role of a firm’s capability in determining the likelihood of supplier non-compliance under risk mitigation vs. under relationship-enabled risk avoidance in small and large supply bases	97
Figure 19. The role of a firm’s selection standard in determining the likelihood of supplier non-compliance under risk mitigation vs. under relationship-enabled risk avoidance.....	97
Figure 20. The role of a firm's capability in determining the likelihood of supplier non-compliance under risk mitigation vs. under stakeholder-enabled risk avoidance in small and large supply bases	99

Figure 21. The role of a firm’s selection standard in determining the likelihood of supplier non-compliance under risk mitigation vs. under stakeholder-enabled risk avoidance in small and large supply bases 99

CHAPTER ONE: INTRODUCTION

A firm's operational, environmental, and social performance to a great extent depends on the ability of its suppliers to comply with order requirements (Krause et al. 2009; Lambert, 2008). Yet, firms often lack information to ensure that their suppliers remain compliant. Identifying possible supplier non-compliance is important because it can threaten the firm's reputation, bottom line and survival, while also affecting its customers and other stakeholders.

To ensure supplier compliance, the literature recommends creating transparent supply chains (e.g., Awaysheh and Klassen, 2010; Lamming et al., 2001; New, 2010; Skilton and Robinson, 2009; Tse and Tan, 2012). In transparent supply chains, firms have comprehensive information on supplier processes. The firms can thus easily ensure that suppliers follow product quality requirements, do not cause supply delays or other operational disruptions, and do not engage in socially irresponsible practices (Marucheck et al., 2011; New, 2010).

While the literature clearly articulates that firms should create transparent supply chains, it is yet to explain how to do so. In particular, it remains unclear what barriers firms face when they attempt to acquire comprehensive information on supplier processes and how the firms overcome these barriers. Without such knowledge, it is difficult to determine how firms should acquire comprehensive information on supplier processes. To address this gap in the literature, I use a combination of multiple case studies and an agent-based simulation to explore how firms *do* and *should* acquire comprehensive information on supplier processes to ensure compliance.

Using a series of case studies, I first investigate *how firms acquire the information required to ensure supplier compliance*. The collected case studies offer a number of empirical contribu-

tions. First, they clarify that firms approach the issue of transparent supply chains from the risk management perspective. Only firms that face significant risk of supplier non-compliance strive to acquire comprehensive information on supplier processes to mitigate this risk, i.e., to take actions aimed at reducing the likelihood of supplier non-compliance. Furthermore, the cases show that firms that seek to acquire comprehensive information on supplier processes focus their efforts on the first-tier suppliers, and not the entire supply chain. Finally, the case studies reveal that many firms choose not to acquire comprehensive information on supplier processes. Instead, they depend either on close relational ties with their suppliers or on powerful external stakeholders, such as regulatory agencies, to manage the risk of supplier non-compliance.

I use these unexpected empirical findings as the foundation for an agent-based simulation that explores how a firm's decisions influence the likelihood of supplier non-compliance. Manipulating a firm's decision-making in a simulation helps compare the empirically observed behavior with the behavior recommended by the literature. Hence, the simulation addresses the second research question: *What decisions should firms make to reduce the likelihood of supplier non-compliance?*

The prescriptive results of the agent-based simulation complement the descriptive results of the case studies. Combined, the case studies and the agent-based simulation offer a number of contributions to the literature on supplier risk management. First, while the literature recommends risk mitigation for all firms (e.g., Sodhi et al., 2012), this research clarifies that only firms with a high capability to assess and monitor suppliers' processes should favor risk mitigation. Firms that lack this capability should instead seek to avoid the risk of supplier non-compliance. These firms are better off not acquiring comprehensive information on supplier processes to en-

gage in risk mitigation, because they are unable to use this information to substantially reduce the likelihood of supplier non-compliance.

This research reveals two paths firms may take to avoid, rather than mitigate, the risk of supplier non-compliance that have been neglected by the supplier risk management literature. One path to avoid the risk of supplier non-compliance is to form close relationships with suppliers. Firms relying on close relational ties with their suppliers do not collect information on supplier processes because they believe the relationships provide strong incentives for suppliers to comply, allowing them to avoid the risk. Despite some authors warning against close, trust-based relationships in supplier risk management (e.g., Harland et al. 2003), this research indicates that this approach may be suitable, especially for firms that lack the capability to fully assess supplier processes. Another path to avoid the risk of supplier non-compliance exists in industries where a powerful external stakeholder is involved in controlling the suppliers. A number of authors have warned that firms can be in a vulnerable position when they know less about their supplier risks than their stakeholders do (e.g., New, 2010; Scherer et al., 2013). Yet, this research shows that firms benefit from having an external stakeholder that monitors supplier processes and incentivizes their suppliers to remain compliant. Finally, this research also shows that some firms choose to tolerate supplier risks, an approach largely omitted in the supplier risk management literature (Hajmohammad and Vachon, 2016). These more tolerant firms manage non-compliances only if they materialize. In doing so, they contradict the literature that focuses on prevention and risk minimization.

This research offers important managerial implications. First, it shows that firms should make a decision to mitigate the risk of supplier non-compliance not only by considering the source of the risks, the processes of their suppliers, but also by taking into account whether they possess a

high capability to assess and monitor supplier processes. Second, this research shows that firms that rely on close relationships to avoid the risk of non-compliance face a threat of overestimating a supplier's ability to comply. It then reveals that a small supply base that is selected using strict criteria and faces termination for non-compliance, diminishes this threat. Third, this research provides a recommendation for firms that operate in highly regulated industries and have an external stakeholder involved in controlling their suppliers. These firms should view such a stakeholder involvement as a beneficial arrangement. Whenever these firms believe that the stakeholder lacks capability to ensure supplier compliance, they should complement the stakeholder's efforts by having stricter selection standards and sourcing from fewer suppliers. Finally, this research clarifies the value of monitoring supplier processes. Supplier monitoring is required to ensure low likelihood of non-compliance in large supply bases. In many industries with complex production, firms have to source from a large number of suppliers. This research shows that these firms can assure supplier compliance only if they, or an involved stakeholder, oversee supplier processes.

The cases allowed for a detailed exploration of what firms did. The simulation offered a detailed exploration of what they should do. Combined they offer meaningful new insight into supplier risk management and help to elaborate on the conditions when acquiring comprehensive information on supplier processes is appropriate.

CHAPTER TWO: LITERATURE REVIEW

The existing literature recognizes that firms are vulnerable to supplier non-compliance (e.g., Marucheck et al., 2011; Sodhi et al., 2012). This risk can not only damage the firms' reputation and bottom line but also threatens the society at large (Madsen, 2009; New, 2010). To address this risk, the literature recommends creating transparent supply chains (e.g., Lamming et al. 2001; Skilton and Robinson, 2009; Tse and Tan, 2011; New, 2010; Awaysheh and Klassen, 2011). In transparent supply chains, firms have comprehensive information on supplier processes and thus can mitigate the risk of supplier non-compliance in an effective manner (Roth et al. 2008; Williams et al., 2013).

In addition, the systematic literature review on supply chain transparency conducted prior to the collection of case data (Appendix A) revealed that two theoretical themes, governance mechanism and the complexity of a firm's supply chain, are related to the process of creating transparent supply chains. Specifically, the reliance on relational governance makes it more likely that firms will gain access to comprehensive information on supplier processes (e.g., Jiang, 2009; Peck, 2005). The complexity of supply chains can substantially inhibit firms' efforts to collect this information (e.g., Mena et al., 2013; Speier et al., 2011).

The value of supply chain transparency

The systematic review of supply chain transparency literature (Appendix A) reveals a large number of studies that refer to the notion of supply chain transparency. Yet, only a few of them offer a formal definition (Table 1). Some authors note that supply chain transparency is associated with a firm's ability to acquire information on supplier processes (e.g., Lamming et al. 2001; Roth et al. 2008). Others argue that the supply chain transparency is determined by the extent a firm shares this information with its external stakeholders (e.g., Awaysheh and Klassen, 2010;

Carter and Easton, 2011; Skilton and Robinson, 2009). I employ the former approach and define supply chain transparency as the extent to which a firm is able to acquire comprehensive information on supplier processes. I chose the perspective of the focal firm, and not on of its stakeholders, because the focus of this research is on the firm’s own efforts to acquire information on supplier processes.

Citation	Definition
Lamming et al. (2001)	“the two-way exchange of information and knowledge between customer and supplier” (p. 4)
Skilton and Robinson (2009)	“the extent to which information about sources, processes and relationships is readily accessible to counterparties in an exchange, and to outside observers” (p. 41)
Roth et al. (2008)	“the lack of secrecy, or the systematic provision of product and processing information under informal and formal agreements” (p. 23)
Angeles and Nath (2001)	“[the] ability to share and exchange information needed to complete transaction sets and to fulfill requirements of shared business applications” (p.112)
Inkpen and Crossan (1995)	“the openness and willingness of the partner firm to share its embedded knowledge” (p. 613)
Hamel (1991)	“openness of the firm to its partner” (p. 85)
Awaysheh and Klassen (2010)	“the extent to which information is readily available to end-users and other firms in the supply chain” (p. 1249)
Carter and Easton (2011)	“proactively engaging and communicating with key stakeholders and having traceability and visibility into upstream and downstream supply chain operations” (p. 49)

Table 1. Definitions of supply chain transparency

Despite the disagreements in definitions, the literature agrees that firms benefit from supply chain transparency, with many authors arguing that firms should strive to create transparent supply chains (Blackhurst et al., 2011; Christopher and Lee, 2004; Co and Barro, 2009; Hora et al., 2011; Kleindorfer and Saad, 2005; Lamberti and Lettieri, 2009; Lamming et al., 2001; Maruchek et al., 2011; New, 2010; Neiger et al., 2009; Vlajic et al., 2012; Tse and Tan, 2012). To create transparent supply chains, firms are required to have an objective understanding of supplier processes and therefore need to ensure that the suppliers do not conceal any issues pre-

sent in their operations (Roth et al. 2008; Williams et al., 2013). Roth et al. (2008) explain that in transparent supply chains there exists mutual openness and “a lack of secrecy” (p. 23) between the firms with their suppliers. Overall, supply chain transparency is necessary to identify “disruptions from normal activities” (Kleindorfer and Saad, 2005: 53) that have potential for great negative impact on a firm and its stakeholders. These disruptions from normal activities are supplier risks. They include product safety violations and the use of socially irresponsible practices (Blackhurst et al., 2011; Kleindorfer and Saad, 2005; Lamberti and Lettieri, 2009). Supply chain transparency then is required to identify and manage potential triggers of supplier risks.

The role of information in supplier risk management

Supplier risks: Definition and drivers

Supplier risks vary from labor strikes in supplier facilities to supply delays to procurement of counterfeit components. This research focuses on process-based risks and hence defines supplier risk as a supplier non-compliance that can disrupt a firm’s operational processes and, as a result, can harm its reputation (Harland et al., 2003; Jüttner et al., 2003; Jüttner, 2005; Marucheck et al., 2011; Narasimhan and Talluri, 2009). The literature distinguishes two characteristics of supplier risks. The first is their likelihood, which is associated with the presence of risk triggers, i.e. deviations from a firm’s requirements, in supplier processes (Ellis et al., 2011; Harland et al., 2003). The likelihood of supplier non-compliance is high when the triggers are present in the supplier’s daily operations. In contrast, this likelihood is low when the triggers appear only in extraordinary circumstances. The second characteristic of supplier risks is their impact; what a firm will face if these risks materialize (Hora and Klassen, 2013; Lewis, 2003). The impact of supplier non-compliance is high when the non-compliance has the potential to create long-term damage to the

firm, or even put it out of business. The impact is low when supplier non-compliance causes short-term disruptions and losses, but does not threaten the firm's survival (Harland et al., 2003).

In some buyer-supplier relationships, a supplier that fails to comply with a firm's requirements will share the negative impact of its non-compliance with the firm (Manuj and Mentzer, 2008; Kleindorfer and Saad 2005). Jüttner (2005) empirically shows that firms prefer sourcing from such suppliers. Manuj and Mentzer (2008) point out that firms usually benefit from situations when they share risk impact with their suppliers. However, some suppliers may remain unaffected by their non-compliances and may knowingly cause a non-compliance, threatening a buying firm's viability (Gümüs et al., 2012).

Drivers to ensure supplier compliance

The supplier risk management literature highlights both internal and external driving forces that push firms to create transparent supply chains to ensure supplier compliance. The internal driving force is a firm's own vulnerability to supplier risks. A firm's performance – operational, environmental, and social – depends on its suppliers (Lambert, 2008). A supplier may threaten a firm's performance if it uses poor practices, inferior raw materials or improper packaging (Marucheck et al., 2011). Marucheck et al. (2011) claims that manufacturing and pharmaceutical firms are often forced to oversee how their suppliers design and produce components, because suppliers can significantly undermine product security and safety. Leaders in sustainability trace the origins of their products to ensure that their suppliers take steps to limit the impact on the environment and society (Pagell and Wu, 2009). Thus, only in transparent supply chains firms can ensure that the suppliers operate in a way that does not inhibit their performance (Christopher and Peck, 2004; Marucheck et al., 2011; Mena et al., 2013).

The external force driving firms to create transparent supply chains to ensure supplier compliance is stakeholder pressure. Stakeholders can pressure a firm when supplier non-compliance not only has a negative impact on the firm, but also on society at large (Awaysheh and Klassen, 2010; Christmann, 2004; Doorey, 2011; Madsen, 2009; New, 2010). This can occur when suppliers compromise product safety or pollute surrounding communities. Various stakeholders use different means to pressure firms. Government agencies rely on legislation; for instance, E.U. legislation requires firms in many industries to ensure supplier compliance with product safety standards and trace the origins of product components (Alfaro and Rábade, 2009; Viaene and Verbeke, 1998; Wagner and Bode, 2006). Customers can express their demands through product preference. Park-Poaps and Rees (2010) empirically demonstrate that American consumers prefer products with labeling that guarantees good working conditions in supplier facilities. Industry initiatives also often motivate firms to ensure their suppliers comply with codes of conduct (Egels-Zanden, 2014).

Powerful stakeholders, such as NGOs and government agencies, may seek to gain access to supplier information and discover potential risk triggers in firms' supply bases (Awaysheh and Klassen, 2010; Scherer et al., 2013). Many large firms react to such stakeholder actions by transferring questionable practices to offshore divisions (Surroca et al., 2013). Christmann (2004) empirically shows that firms cease such activities if their stakeholders are likely to cooperate with each other to investigate the firms' operations. Many authors argue that firms should instead proactively identify and manage the risks associated with their suppliers before their stakeholders become aware of them (e.g., Awaysheh and Klassen, 2010; Madsen, 2009; New, 2010). In particular, New (2010) notes that firms should address potential supplier risks by helping their suppliers improve working conditions and limit pollution levels.

In addition, firms should proactively address stakeholder pressure by engaging with various stakeholder groups (e.g., Parmigiani et al., 2011; Carter and Rogers, 2008; Wu and Pagell, 2011; Alvarez et al., 2010) to ultimately ‘convert’ stakeholder pressure into a source of knowledge (Roome and Wijen, 2006; Griesse, 2007). External stakeholders may help identify what specific information a firm should acquire to ensure supplier compliance. The stakeholders may also clarify the extent to which a firm is responsible for its supply chain (Carter and Rogers, 2008). As Sloan and Oliver (2013) argue, ultimately a firm should change its relationship with external stakeholders from power-based – when the stakeholders push the firm to address their demands – to trust-based. The authors, however, note that most firms do not share values with their stakeholders and consequently find it difficult to establish trust-based relationships with the stakeholders.

Finally, firms often face both internal and external driving forces to ensure supplier compliance. However, one driving force is likely to dominate over the other. For instance, a manufacturer of industrial machinery may be concerned about eliminating potential threats to product quality in its supply chain because the dependability of its products requires having suppliers that follow strict order requirements (the internal driver). In contrast, a chain of coffee shops may strive to ensure good working conditions at coffee farms, from which it procures its coffee beans, to demonstrate the supply chain-wide commitment to the goals of sustainability (the external driver).

Why effective risk management requires information on supplier processes

Agency theory has been central to creating a better understanding of how firms should manage supplier risks (e.g., Hajmohammad and Vachon, 2016; Whipple and Roh, 2010; Zsidisin and

Ellram, 2003). Agency theory focuses on a relationship between a principal (e.g. a firm) and an agent (e.g. a firm's supplier). When the principal assigns a task to the agent, it faces the threat of the agent failing to complete the task successfully. This threat exists because the agent's goals may not align with the principal's, the principal did not observe how the agent completed the task, or the principal may have misjudged the agent's ability to complete the task successfully (Anderson and Oliver, 1987; Eisenhardt, 1989A; Fayezi et al., 2012).

The principal can ensure successful task completion by controlling inputs, behavior, or outputs. Input control focuses on ensuring that the agent has the required skills and incentives prior to assigning the task (Hajmohammad and Vachon, 2016; Ouchi, 1979). That is, input control is oriented towards ensuring goal alignment between the agent and the principal (Fayezi et al., 2012; Ketchen and Hult, 2007). Behavioral control is associated with verifying whether agent behavior satisfies the requirements the principal established for successful task completion (Eisenhardt, 1989A; Zsidisin and Ellram, 2003). Finally, output control focuses on assessing agent performance after task completion (Eisenhardt, 1989A).

The supplier risk management literature notes that under certain circumstances, firms can rely on input control to avoid supplier risks (Hajmohammad and Vachon, 2016). Specifically, firms can avoid risks by sourcing from suppliers operating in environments where causing a non-compliance is unacceptable (Jüttner et al., 2003). For example, a firm can avoid the risk of slave labor if it does not source from manufacturers with facilities located in countries known for weak labor laws, poor work and safety practices, and frequent violations of human rights. Nevertheless, the literature assumes that the instances when a firm can ensure that it has avoided all supplier risks are rare.

Agency theory recommends behavioral control when a principal faces high uncertainty associated with how an agent completes the task (Zsidisin and Ellram, 2003). This suggestion is based on assumption that the principal is “flawless” and that it has the capability to accurately assess the agent’s behavior: a “questionable” assumption (Fayezi et al., 2012: 565) that also underpins the supplier risk management literature on risk mitigation via behavioral control.

The supplier risk management literature presupposes the existence of the uncertainty associated with supplier processes and for that reason focuses predominantly on using behavioral controls to mitigate supplier risks. Risk mitigation refers to a firm’s actions aimed at reducing the likelihood of supplier non-compliance (Harland et al., 2003; Jüttner et al., 2003; Kleindorfer and Saad, 2005). The majority of articles to date view risk mitigation as the essential component of supplier risk management (Sodhi et al., 2012). Finally, because the literature focuses on preventing risks from materializing rather than on responding to materialized supplier risks, output control is generally absent in the literature (Sodhi et al., 2012).

The supplier risk management literature contends that risk mitigation depends on a firm’s ability to acquire comprehensive information on potential risk triggers (Christopher and Lee, 2004; Jüttner et al., 2003; Marucheck et al., 2011; Neiger et al., 2009). In other words, only in transparent supply chains can the firms mitigate supplier risks. Neiger et al. (2009: 156) highlight the importance of acquiring timely information for “real-time assessment, evaluation, treatment and monitoring of risks”. Marucheck et al. (2011: 717) also discuss the need for “real-time monitoring of processes across a global supply chain that allows companies to manage supplier behavior”. Christopher and Lee (2004: 390) further emphasize the importance of comprehensive information on supplier processes, warning against situations “when one member of a supply chain has no detailed knowledge of what goes on in other parts of the chain”. Speier et al. (2011)

warn that acquiring comprehensive information on potential risk triggers requires substantial effort and resources. Behavioral controls, in the guise of gathering comprehensive information to mitigate risks, have been the primary focus of the supplier risk management literature.

The effect of supplier governance

A firm's effort to create transparent supply chains and hence to engage in risk mitigation requires cooperation from suppliers. A firm is more likely to have access to comprehensive information on supplier processes if it builds collaborative, trust-based relationships with its supplier (Jiang, 2009; Lamming et al., 2001; Peck, 2005). Thus, the way a firm governs its relationships with suppliers determines if the firm requires comprehensive information on supplier processes and influences how it acquires this information (e.g., Poppo and Zenger, 2002; Whipple and Roh, 2010). Supplier governance refers to a set of mechanisms a firm employs to coordinate and control exchanges with its suppliers (Mahapatra et al., 2010). The supplier governance literature distinguishes among behavior-based contractual, outcome-based contractual and relational governance mechanisms.

Under relational governance, a firm relies on interpersonal relationships and "implicit and explicit understandings" (Bensaou and Anderson, 1999: 462). Relational governance emphasizes the importance of bonds between a firm and its suppliers (Nyaga et al., 2010; Poppo and Zenger, 2002; Wathne and Heide, 2004). Rather than relying on a contract, "mutual respect, trust, and close interaction that exists between the partner firms" (Cousins et al., 2006: 853) empower this governance mechanism. A firm is likely to use relational governance if it believes that its suppliers are trustworthy and thus motivated to comply with its requirements (Joshi and Campbell, 2003; Poppo and Zenger, 2002). When the firm relies on this governance mechanism it assumes that its suppliers value relationship continuity (Jiang, 2009; Joshi and Campbell, 2003; Nyaga et

al., 2010). That is, the focus is on creating relational ties that “influence or restrain a [supplier’s] actions” (Palmatier, 2008: 77). At the same time, Poppo and Zinger (2002) emphasize that close relational ties do not presuppose that no formal contract exists between a firm and a supplier; instead, the ties enable the relationships.

Relational ties enable behavior control since they encourage suppliers to share information on their processes with buying firms (Barratt and Oke, 2007; Johnston et al., 2004; Speier et al., 2011). For instance, a supplier is more likely to disclose the social and environmental aspects of its operations if its relationship with a buyer is candid and long-term oriented (Bendixen and Abratt, 2007; Roth et al., 2008). Jiang (2009) empirically shows that suppliers are more likely to commit to supplier codes of conduct if a buying firm relies on relational governance. Cousins et al. (2006: 856) argue that close social ties are associated with such benefits as “lower costs, improved delivery, fewer quality problems, early insights into new technologies, on-time product launches, and others.” Firms are likely to employ relational governance in industries with complex production (Jiang, 2009; Mahapatra et al., 2010; Poppo and Zenger, 2002), because they require frequent interactions with suppliers, and close relationships enable more effective communication.

Yet, under some circumstances relational governance can fail to lead to desired outcomes. Villena et al. (2011) emphasize that a firm’s excessive reliance on cooperation and trust can lead to opportunistic supplier behavior. Telser (1980: 27) highlights the fragile nature of relational ties and argues that the ties last as long as “each party believes to be better off by continuing the agreement than [it] would be by ending it”. Poppo and Zenger (2010) argue that for firms with large supply bases, fostering close relationships is a resource intensive practice. Link and Marxt

(2004) highlight that cooperative relationships often suffer from irregular and fragmented exchange of information between partners.

Under contractual governance a firm relies on a legally binding agreement to guide its exchanges with suppliers. This agreement focuses either on the supplier behavior or on the outcomes they need to achieve (Mahapatra et al., 2010). The key principle behind behavior-based contractual governance is to source from suppliers with processes that satisfy a firm's requirements (Heide et al., 2007; Whipple and Roh, 2010). Since suppliers may choose to ignore these requirements, a firm relying on this governance mechanism needs to engage in behavioral control by “[gathering] information about supplier behavior and then influencing that behavior, thus achieving higher supplier compliance” (Selviaridis and Norrman, 2014: 156). Nevertheless, some suppliers may not allow the firm to oversee their processes, because they have serious operational issues they wish to conceal (Gümüs et al., 2012) or they are concerned that allowing a buyer to oversee their processes may lead to opportunistic behavior such as a buyer using the information to leverage its bargaining power (Saeed et al., 2005). In contrast, outcome-based contractual governance focuses on specifying the performance requirements suppliers need to achieve (Heide et al., 2007; Selviaridis and Norrman, 2014; Whipple and Roh, 2010). Firms relying on this governance mechanism do not oversee supplier processes. Instead, they assume that proper processes are in place if outcome goals are met (Eisenhardt, 1989A; Selviaridis and Norrman, 2014). At the same time, the effectiveness of outcome-based contractual governance depends on a supplier's willingness to achieve the required outcomes. In addition, this governance mechanism can fail if a supplier lacks capabilities to perform at the level that a contract prescribes (Simpson et al., 2012; Delmas and Montes-Sancho, 2010). As a result, firms tend to use this governance mechanism when the uncertainty of suppliers achieving the outcomes is low,

e.g., when they source relatively simple products. Firms also rely on outcome-based contractual governance if they prioritize cost minimization in procurement (Jiang, 2009; Mahapatra et al., 2010).

In summary, governance mechanism influences whether a firm can create transparent supply chain. Under relational governance, a firm's supplier may grant access to comprehensive information on supplier processes because the relationships with the firm are mutually open. Under behavior-based contractual governance, a firm can choose suppliers that agree with having such a requirement in a contract. Finally, under outcome-based contractual governance, a firm is unlikely to seek comprehensive information on supplier processes.

The effect of supply chain complexity

Many modern supply chains are complex networks that consist of multiple tiers with a large number of suppliers in each tier (Skilton and Robinson, 2009). The complexity of supply chains increased as the firms started dealing with “[higher] number of suppliers in the supply base, [greater] level of supplier interaction, and [an increasing] degree to which these suppliers vary in terms of organizational culture, size, location, technology, and so on” (Choi and Krause, 2006: 638). With the increased complexity of supply chains, it becomes harder and costlier to ensure supplier compliance (Fawcett et al., 2012; Mena et al., 2013; Speier et al., 2011). In such supply chains, firms often face fragmented information flows: information sources are harder to identify and incoming information is often unreliable (Pathak et al., 2007).

In global supply chains, firms face the additional challenge of managing relationships with suppliers of diverse cultural and national backgrounds (Awaysheh and Klassen, 2010). The choice of country, from which firms choose to source, may impair the ability to gain reliable in-

formation from their suppliers (Awaysheh and Klassen, 2010; Bhattacharyya et al., 2010). In many developing countries, the flow of information is restricted, and governmental institutions tend to overlook various issues ranging from human rights violations to poor product security. This institutional environment inhibits firms' ability to ensure that their suppliers adhere to the imposed requirements (Kostova and Zaheer, 1999). Furthermore, the trend towards global sourcing has inhibited firms' ability to establish the origins of their product components. This issue is especially salient in industries with high product safety concerns, such as baby food industry (Lamberti and Lettieri, 2009). Finally, Fine (2013) offers a general critique of current global sourcing practices. He notes that the trend towards global sourcing was a cost cutting initiative that had exposed firms to greater levels of supplier risks. Fine argues for a more "intelligent" approach to sourcing that takes into account both potential returns and risks.

While we still lack a full understanding of how to manage complex supply chains, a number of important findings have emerged in the literature. Ellis et al. (2011) highlight the benefits of closer proximity to suppliers, as distance tends to increase uncertainty. A number of authors argue that the only way to manage lower-tier suppliers is via direct interaction (Mena et al., 2013; Wagner, 2010; Wagner and Silveira-Camargos, 2012). This last measure also helps to increase the reliability of the information acquired from the supply chain (Speier et al., 2011)

In summary, the literature agrees that high complexity of supply chain inhibits a firm's ability to create transparent supply chains to ensure compliance. In general, the simpler the structure of the supply chain is, the easier it is for a firm to acquire information on supplier processes. At the same time, it is not clear what aspects of modern supply chains play the most important role in hindering a firm's ability to acquire this information. Moreover, manufacturers of complex products often cannot significantly reduce complexity of their supply chains. Yet, we lack under-

standing on how these firms should ensure supplier compliance despite having complex supply chains.

CHAPTER THREE: MULTIPLE CASE STUDIES

The literature has long acknowledged that firms are both internally and externally driven to acquire comprehensive information to ensure supplier compliance (e.g., New, 2010; Marucheck et al., 2011; Christopher and Lee, 2004). Furthermore, we understand that a firm's supplier governance mechanism and complexity of its supply chains are likely to influence the firm's efforts to acquire this information. At the same time, we still do not fully understand how firms do it. This gap in the literature calls for an empirical investigation.

Qualitative methods are highly desirable for emergent research topics (Yin, 2014). The use of field data can provide a more in-depth understanding of organizational processes (Eisenhardt, 1989B; Pagell et al., 2014). Operations management scholars favor multiple case studies over a single case study, due to greater generalizability and easier replication (Barratt et al., 2011). Thus, the first stage of the research is a series of case studies of firms that are actively engaged in acquiring information required to ensure supplier compliance.

Case study description

Sampling strategy

Multiple case study research designs benefit from theoretical sampling, because it allows the incorporation of existing knowledge by taking into account themes emphasized by the literature (Eisenhardt, 1989B; Miles and Huberman, 1994) and ultimately makes the results more generalizable and replicative (Pagell et al., 2014). Thus, to develop a better understanding of how firms acquire comprehensive information on supplier processes, I used the relevant literature to construct a 2×2×2 sampling matrix. The first dimension of the matrix captures a driver pressuring firms to acquire information on supplier processes to ensure compliance. The literature high-

lights two drivers: a firm's own vulnerability to supplier risks and the stakeholder pressure. The former is an internal driver and the latter is an external driver. It was difficult to determine the dominant driver *a priori*. For that reason, I had instead identified whether for a firm a certain driver was present; that is, I sampled firms that were at least to some extent internally driven and firms that were at least to some extent externally driven. Namely, the performance of the four internally driven firms in the sample can be significantly undermined by supplier non-compliance and for that reason they are driven to acquire information on supplier processes. In contrast, the four externally driven firms in the sample are expected to acquire information on supplier processes to satisfy stakeholder demands.

The second dimension captures how a firm governs relationships with its suppliers. The literature shows that a firm's supplier governance affects whether a firm can access comprehensive information on supplier processes (e.g., Jiang, 2009; Poppo and Zenger, 2002). Since I could not easily identify how a firm governs its relationships with suppliers *a priori*, I used firm size as a proxy. I chose this proxy because small firms often lack power over their suppliers and are more likely to engage in relational governance than their larger counterparts (Lepoutre and Heene, 2006). Firm size corresponds to the number of full-time employees. Firms with 500 or more employees are considered to be large and firms with fewer than 500 employees are considered to be small (Tether, 1998).

The third dimension is supply chain complexity. The literature agrees that high supply chain complexity inhibits a firm's ability to acquire comprehensive information on supplier processes to ensure compliance (e.g., Awaysheh and Klassen, 2010; Bhattacharyya et al., 2010). Similarly to the other dimensions, the complexity of a firm's supply chain could not be assessed *a priori*. Therefore, I used a firm's product complexity as a proxy for supply chain complexity. I opera-

tionalized product complexity via three dimensions: difficulty to produce and develop products due to product design architecture, number of distinct components in a purchased product, and level of interaction between these components (Closs et al., 2008; Mahapatra et al., 2010; Novak and Eppinger, 2001).

Sample

Eisenhardt (1989B) recommends sample size for multiple case studies to be between four and ten cases, but notes that data collection should continue until researchers have reached the point of theoretical saturation, when “incremental learning is minimal because the researchers are observing phenomena seen before” (p. 545). I reached that point after collecting the seventh case. Yet, the data collection continued until an eighth case to confirm that theoretical saturation has been reached and to have two firms in each cell of the sampling matrix.

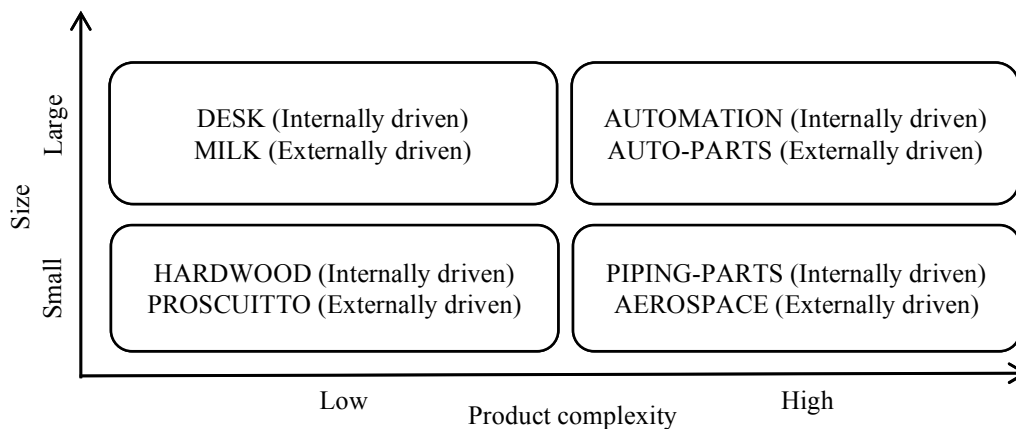


Figure 1. Sampling matrix

The eight collected cases are firms from eight different industries, all based in Canada. During early contacts with the sampled firms, their representatives confirmed that their firms were actively engaged in acquiring information needed to ensure supplier compliance. Figure 1 shows the allocation of the eight cases along the three dimensions of the sampling matrix. Firms that

fall under low product complexity produce relatively simple products and, as a result, source mainly raw materials from their suppliers: DESK is a large manufacturer that produces office furniture. MILK is a large company that produces a variety of dairy products. HARDWOOD is a small plant that processes North American woods. Finally, PROSCUITTO is a meat processing plant that manufactures frozen and dried pork products. Firms that fall under ‘high product complexity’ category have more complex products than those in ‘low product complexity’ category. AUTOMATION is a large company that manufactures engineer-to-order equipment. AUTO-PARTS is a large retailer that sells a variety of automotive products such as car mats and wiper blades. Finally, both PIPING-PARTS and AEROSPACE are mechanical component manufacturers.

DESK and HARDWOOD rely on business models easily affected by supply disruptions, such as supply delays. For that reason, they are internally incentivized to prevent supplier non-compliance. AUTOMATION and PIPING-PARTS prioritize high product quality and thus are internally driven to ensure that their suppliers comply with their quality requirements. MILK, PROSCUITTO, and AEROSPACE operate in highly regulated industries and are externally driven to assure high product quality of their purchases. Finally, AUTO-PARTS is under external pressure from its customers to ensure that its products have a low defect rate.

Level of analysis

Each case focuses on the firm’s supply base for a specific product family. The level of analysis is the supply base, but since the aim of the multiple case studies is to understand how a firm gains information on supplier processes, the unit of observation is the firm. Three of the firms, DESK, HARDWOOD and PIPING-PARTS have two distinct supply bases that provide the same

inputs: one where the firm perceives that it faces a negligible likelihood of non-compliance and a second where it faces a high likelihood of non-compliance. Consequently, for each of these firms there were two supply bases: DESK.R and DESK.UN, HARDWOOD.R and HARDWOOD.UN, PIPING-PARTS.R and PIPING-PARTS.UN, where *R* stands for the reliable supply base and *UN* for unreliable supply base.

Data collection

In each case, I collected data from multiple sources in order to ensure construct validity (Yin, 2014). The main data sources were interviews. I used semi-structure interviews, as recommended for studies where concepts are underdeveloped (Miles and Huberman, 1994). The interview protocol appears in Appendix B. For each firm, I interviewed the manager responsible for procurement, which is a key organizational function for this research. I also interviewed a manager responsible for customer or stakeholder relations to gain a better understanding of the role of customers and other external stakeholders in a firm's ability to acquire information on supplier processes. In addition, I interviewed a manager who provided insights on the firm's operations. In all four large firms, I interviewed three managers; while in small firms, responsibility for procurement, customer relations, and operations often overlapped or fell on one person. In small firms, I interviewed two managers, with the exception of AEROSPACE where the owner provided information on all three organizational functions. Most interviews lasted 45 to 60 minutes. In addition, I toured the production facilities of six out of eight sampled firms. I also asked for relevant documentation, and collected online information. For AEROSPACE, MILK and PROSCUITTO, I collected detailed documentation on how external stakeholders were involved in controlling the firm's suppliers. Table 2 summarizes the data collected for each case.

To ensure reliability, the case study protocol guided data collection (see Appendix B). Furthermore, I and another person familiar with the topic of supply chain management collected the case data. Each person took notes during the data collection process and all interviews were recorded and then transcribed (Yin, 2014). Moreover, a researcher with expertise in supply chain management who was not involved in data collection verified the subsequent coding.

Case	Firm description	Firm size	Driver	Collected data
AEROSPACE	Aerospace component manufacturer	Small	Stakeholder pressure	Interview with the company owner Firm's documentation on supplier processes requirements Industry certifications' documentation on supplier compliance requirements Field notes taken during interview and facility tour Information on the firm and its products retrieved from the firm's website
AUTO-PARTS	Automotive component retailer	Large	Stakeholder pressure	Interview with VP logistics Interview with a senior procurement manager Interview with product quality assurance manager Field notes taken during interviews Information on the firm and its products retrieved from the firm's website
AUTOMATION	Manufacturer of engineer-to-order automated equipment	Large	Firm's vulnerability to supplier risks	Interview with supply chain and quality manager Interview with the head of engineering unit Interview with supply chain management coordinator Field notes taken during interviews and facility tour Information on the firm and its products retrieved from the firm's website
DESK	Furniture manufacturer	Large	Firm's vulnerability to supplier risks	Interview with VP purchasing Interview with VP manufacturing Interview with director of sustainability programs Firm's documentation on supplier processes requirements Field notes taken during interviews Information on the firm and its products retrieved from the firm's website
HARDWOOD	Hardwood producer	Small	Firm's vulnerability to supplier risks	Interview with the company owner Interview with the sales and purchasing manager Field notes taken during interviews and facility tour Information on the firm and its products retrieved from the firm's website
MILK	Dairy producer	Large	Stakeholder pressure	Interview with VP Supply Chain Management Interview with VP of Sales and Marketing Interview with VP Operations Regulatory agency's documentation on supplier compliance requirements Field notes taken during interviews and facility tour Information on the firm and its products retrieved from the firm's website
PIPING PARTS	Piping component manufacturer	Small	Firm's vulnerability to supplier risks	Interview with Chief Operating Officer Interview with purchasing manager Field notes taken during interviews and facility tour Information on the firm and its products retrieved from the firm's website
PROSCUITTO	Italian meats producer	Small	Stakeholder pressure	Interview with the company owner Interview with quality assurance manager Sample of the firm's supplier's letter of guarantee Regulatory agency's documentation on supplier compliance requirements Field notes taken during interviews and facility tour Information on the firm and its products retrieved from the firm's website

Table 2. Data collected for each case

Case coding and within-case analysis

Case coding was an iterative process (Miles and Huberman, 1994). The first few iterations of coding were based on the initial theoretical model (Figure 2). This model was based on a systematic review of relevant literature. Appendix A describes how I conducted the literature review. The initial theoretical model consisted of the following theoretical constructs: (1) the extent of supply chain transparency (i.e., the extent to which a firm is able to acquire comprehensive information on supplier processes); (2) enablers; (3) drivers; (4) barriers. Following this model for each case study, I coded what information the firm acquired about supplier processes and what practices enabled the firm to do it. I also identified what drove or who pressured the firm to acquire this information, along with contextual factors that inhibited the firm's ability to acquire this information. Later, during the within-case analysis, I elaborated the theoretical model (the process is described below) and revised the coding scheme.

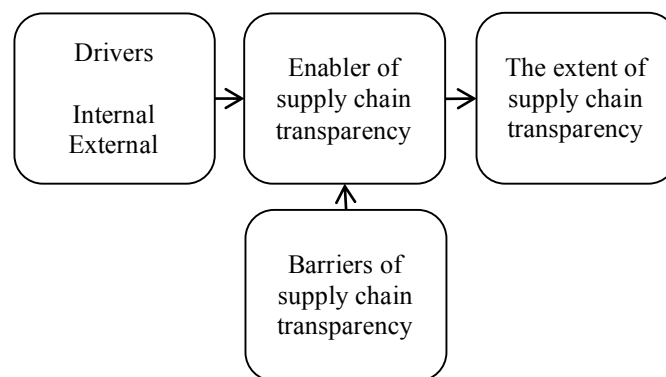


Figure 2. Initial theoretical model

Within-case analysis was another iterative process (Miles and Huberman, 1994) aimed at describing and explaining the collected data. During the within-case analysis, I constructed a number of displays to explain the data. Ultimately, the within-case analysis included a context chart and an analytic text. The processes of creating the context chart and writing the analytic text were performed in parallel to help shape each other. The context chart displayed key theoretical

concepts found in each case, while the analytic text provided a detailed description of these concepts.

During the analysis, the theoretical model considerably changed. Figure 3 depicts the final theoretical model. The model significantly differs from the initial model because the case data revealed new theoretical constructs relevant to the research question. The key change is related to the concept of supply chain transparency, which was the focus of the initial theoretical model. The collected data revealed that firms that choose to create transparent relationships with their suppliers do not attempt to increase transparency of the entire supply chain, instead they focus on acquiring comprehensive information on the processes of their first-tier suppliers. Furthermore, the sampled firms approach supply chain transparency strictly from the perspective of supplier risk management. For these reasons, I omitted the concept of supply chain transparency from the final theoretical model and instead focused on how firms acquire comprehensive information to manage supplier risks.

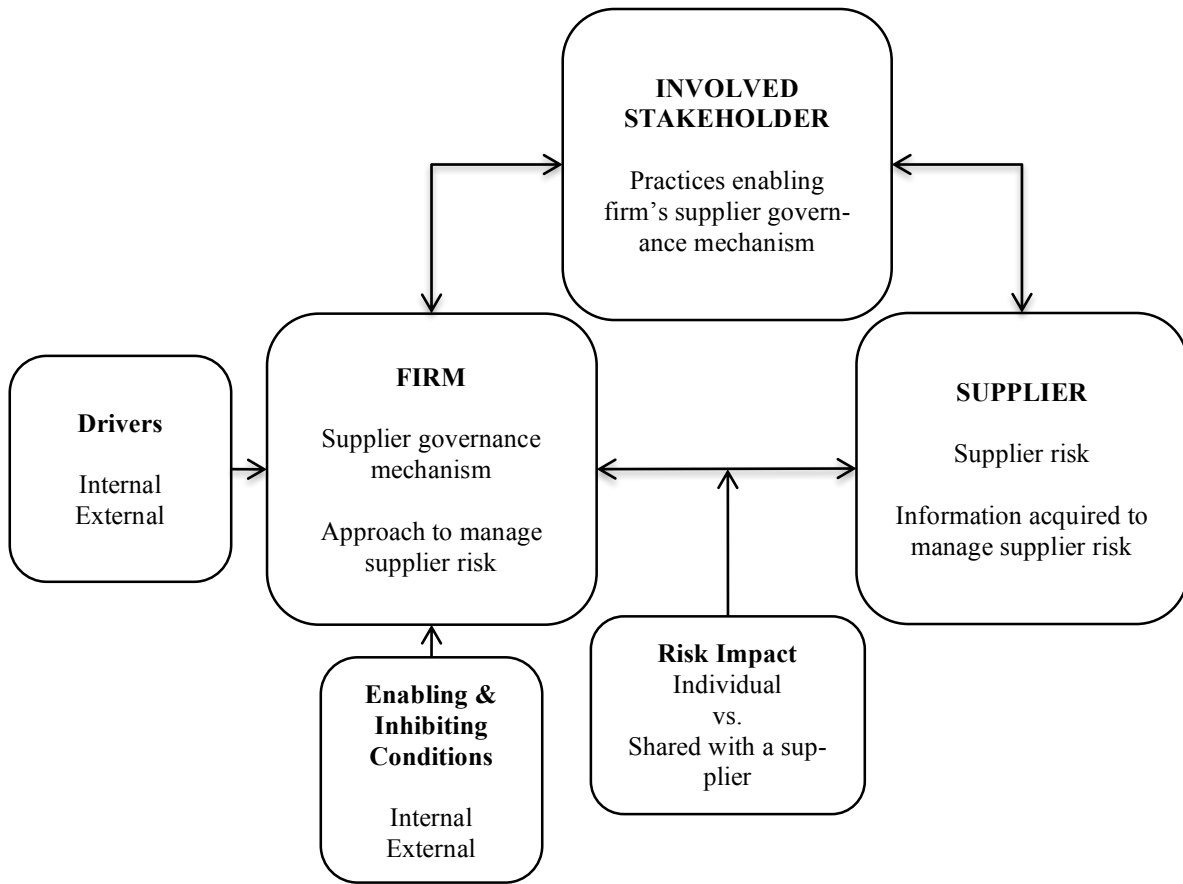


Figure 3. Final theoretical model for case analysis

Second, the data indicated that firms use different approaches to manage supplier risks. These approaches, in turn, relate to what information the firms acquire about suppliers. Third, the data show the importance of distinguishing between cases where supplier non-compliance, if materialized, affects the focal firm and the non-compliant supplier, and cases where it affects only the focal firm. For that reason, in the revised theoretical model I added a construct specifying whether a supplier shares the negative impact of a materialized risk. Fourth, I made a firm's supplier governance mechanism an explicit part of the model. Fifth, in the initial theoretical model I used the word 'enabler' to describe practices that help a firm's efforts to acquire comprehensive information on supplier processes. The cases data clarified that enablers are contextual factors. For that reason, I added 'enabling conditions' along with 'inhibiting conditions' in the part of the

model that describes the contextual factors. Finally, in three cases, the firms rely on a third party, a powerful external stakeholder, that is involved in controlling and regulating the firms' suppliers. These firms then learn about supplier processes indirectly by knowing what requirements the involved stakeholder imposes on their suppliers. Below I briefly describe each case and provide a more detailed description in Appendix C.

AEROSPACE (small firm; high product complexity; externally driven)

AEROSPACE is a small manufacturer of customized mechanical components in the aerospace defense industry. This industry is characterized by stable relationships among supply chain partners. As a result, AEROSPACE does not have many competitors, but at the same time it cannot easily find new customers. Customized mechanical components are a niche market where product quality is the main priority. AEROSPACE relies on a number of critical-to-quality suppliers that provide such services as casting, anodizing, and grinding. These suppliers are a potential source of the firm's main supplier risk, the risk of its suppliers undermining product quality.

The risk of a supplier undermining product quality is a high impact supplier risk. The firm's final customers – producers of aerospace and defense machinery – face the threat of operational catastrophe if non-compliant mechanical components are installed in their products. For that reason, the final customers endorse supply-chain-wide adoption of industry certifications, AS9100 and NADCAP (National Aerospace and Defense Contractors Accreditation Program). These certifications specify requirements for various types of production processes and oversee how firms in this industry adhere to these requirements.

Overall, AEROSPACE's management believes that due to the involvement of the certification organizations it is unlikely that one of its suppliers would undermine the quality of its products.

In addition, the presence of these certifications influences how the firm governs its suppliers. AEROSPACE engages in behavior-based supplier governance, but outsources to the certifying organizations monitoring of supplier processes. In addition, these organizations incentivize the suppliers to comply with the imposed requirements.

AEROSPACE chooses not to acquire comprehensive information on processes of its critical-to-quality suppliers. The firm relies on the certifying organizations to control and regulate its suppliers and trusts that the certification auditors properly assess the suppliers' production capabilities. Therefore, AEROSPACE manages the risk of a supplier undermining product quality by avoiding it. The firm is convinced that its suppliers ensure that any non-compliant components, if ever produced, are destroyed and would never reach the firm or its customers.

AUTO-PARTS (large firm; high product complexity; externally driven)

AUTO PARTS is a large retailer that specializes in automotive consumer products. Its target consumers are young families that prefer buying inexpensive but relatively reliable products. The firm faces the risk of its suppliers failing to produce products at an acceptable quality level. The firm is externally driven to address this risk as customer satisfaction is easily affected by poor product quality. Overall, it is a low impact risk as having defective products in stock can lead to financial and reputational losses but the losses are unlikely to be significant.

The firm has a large supply base located mostly offshore. AUTO-PARTS's priority is to source from suppliers that can produce high volumes of products at a low cost. The product quality plays a secondary role: only once potential suppliers are chosen, the firm ensures that these suppliers can achieve the required quality level. As a result, the risk of a supplier failing to achieve acceptable quality level has high likelihood.

The firm interacts with its suppliers mostly during the supplier selection process. Its quality team visits supplier facilities to assess their manufacturing capability. If the firm selects a supplier, a sample of the supplier's products undergoes prototype testing. Once the supplier starts mass production the firm controls product quality via random testing.

AUTO-PARTS relies on outcome-based supplier governance. The firm sources from suppliers that can achieve the needed outcomes: producing high volumes of low-cost products of acceptable quality. Overall, the firm assumes that suppliers are able to achieve the needed outcome levels, unless there are indications of non-compliance. As a result, AUTO-PARTS is willing to tolerate a certain level of the supplier risk and tends to address the risk only if it materializes and only if the costs associated with the non-compliant supplier are significant.

AUTOMATION (large firm; high product complexity; internally driven)

AUTOMATION is a large company that manufactures engineer-to-order equipment. The firm's customers, OEMs, put significant cost pressures and choose to source from AUTOMATION because of its ability to achieve the required product quality level despite the cost pressures. The firm is forced to source from suppliers that can provide low-cost components of acceptable quality facing a high-likelihood risk of its suppliers failing to achieve the required product quality level.

The firm is internally driven to address this risk. It strives to protect its reputation as a firm known for its ability to provide acceptable quality products despite the high cost pressures. Yet, this is a low impact risk. The firm's customers accept that some of the components the firm procures can lead to a product failure.

For each engineer-to-order project the firm selects component suppliers on the open market. On a regular basis, AUTOMATION deals with between 80 to 120 external component suppliers. The firm relies on outcome-based supplier governance seeking suppliers that can provide the needed outcomes: low cost components of an acceptable quality level. To ensure that its suppliers can produce products of acceptable quality, the firm engages its engineers when it selects suppliers. The engineers assess the manufacturing capabilities of a potential supplier. If there is evidence that the supplier is able to provide acceptable quality, the firm requests a sample order for destructive testing to further confirm that the supplier has the required quality system in place.

AUTOMATION has a certain tolerance for the supplier risk and hence chooses not to work with customers who are more risk adverse. Moreover, the firm is prepared that over time some of its suppliers will fail to achieve the required product quality becoming non-compliant. It is only when the risk of supplier non-compliance materializes that does the firm increase control of the non-compliant supplier or finds a new supplier.

DESK.R (large firm; low product complexity; internally driven)

DESK.R is a contract furniture manufacturer that specializes in customized office furniture. The firm's final customers include law firms, universities, and Fortune 500 companies. The contract furniture market segment faces increasing customer expectations. The firm's ability to meet customer requirements while remaining efficient internally makes the firm one of the few large furniture manufacturers with production facilities located in Canada.

As a contract manufacturer, DESK.R does not produce products to stock and hence faces short lead times. As a result, the firm's main supplier risk is a supplier non-compliance that can

delay orders and negatively affect their reputation among their customers. This is a low impact supplier risk: while supplier non-compliance will delay the firm's fulfillment of a particular customer order, it is unlikely to severely affect its reputation.

The firm works with 80 main suppliers. Most of its suppliers produce commodity products and raw materials. The firm's management believes that these suppliers have sufficient capabilities as well as incentives to fulfill orders following the firm's requirements. With these suppliers, the firm relies on relational governance. Over time, the firm developed close ties with its suppliers investing significant resources in supplier development and helping them adapt to the increasing industry requirements. Furthermore, DESK.R does not require the suppliers to have cost reduction initiatives, thus limiting cost pressures on its suppliers. The firm also ensures that its suppliers have sufficient capabilities to produce the needed amount of product within a short time window following the firm's requirements for product and processes.

Overall, the firm is convinced that its suppliers have both sufficient capabilities and incentives to fulfill orders following the firm's requirements. The firm's management believes that when they procure from these suppliers the likelihood of supplier non-compliance is low. In fact, close relational ties make it unnecessary to acquire comprehensive information on supplier processes as relational governance allows the firm to avoid the risk of supplier non-compliance.

DESK.UN (large firm; low product complexity; internally driven)

This case focuses on the same firm sourcing the same inputs as in DESK.R but considers how this firm sources from a supply base consisting of unreliable suppliers. This supply base is of considerably smaller size than the firm's supply base of reliable suppliers. The firm sources from unreliable suppliers, because it faces short lead times and thus has to procure the majority of its

raw materials locally. Some of its local suppliers tend to lack production capabilities and, as a result, over time are likely to cause a non-compliance.

These are mostly small local suppliers of raw materials. They tend to struggle to adapt to emerging industry requirements and do not have sufficient knowledge of new trends in the industry. These factors necessitate the firm to have a greater level of oversight of processes of these suppliers.

Specifically, with these suppliers, DESK.UN engages in behavior-based contractual governance. First, the firm makes sure that the suppliers agree to adhere to its terms and conditions. However, because of low capabilities the suppliers may fail to comply with the firm's order requirements. For that reason, the firm assigns employees to remain in facilities of these suppliers and ensure that the suppliers engage in processes that comply with the firm's requirements. Acquiring information on supplier processes enables the firm's governance mechanism and allows it to mitigate the risk of supplier non-compliance. If any of these suppliers sufficiently improve their processes, the firm starts to rely on the relational governance mechanism and stops directly acquiring comprehensive information on supplier processes.

HARDWOOD.R (small firm; low product complexity; internally driven)

This case focuses on a small hardwood producer. The firm seeks to procure timber of high quality and carries a diverse inventory that its competitors choose not to stock. HARDWOOD.R is in a weak market position: some of the firm's current customers seek to procure directly from its suppliers and some of its largest suppliers are its main competitors.

The firm's suppliers are sawmills located in the United States and Canada. On a regular basis, the firm sources from 30 to 50 saw mills. The firm faces supplier non-compliances both in terms of wood quality or delivery time. This supplier risk has low potential impact. If materialized, this risk will cause short-term financial losses and disrupt the firm's processes, but is unlikely to have lasting negative effects on the firm. HARDWOOD.R is internally driven to address this supplier risk and prefers working with suppliers it believes to be reliable. The firm's management believes that these suppliers are associated with low likelihood of non-compliance. Over time these suppliers have demonstrated their ability to provide a reliable supply of high quality timber.

The firm relies on relational governance to manage these suppliers. It trusts the suppliers and does not directly oversee how the suppliers prepare the ordered wood. Instead, the firm's management fosters close relational ties with these suppliers. In addition, some of these suppliers are dependent on the firm's expertise in wood grading. Overall, long-term relationships, trust, and mutual dependence enable the firm's governance mechanism.

HARDWOOD.R seeks to avoid the supplier risk when it sources from suppliers it views as reliable. The firm expects that these suppliers will remain responsive to its requirements for wood quality and delivery times. It chooses not to oversee how the suppliers fulfill its orders and instead believes that relational ties allow it to avoid risk.

HARDWOOD.UN (small firm; low product complexity; internally driven)

This case considers the same firm as in HARDWOOD.R but sourcing timber from a different supply base. This supply base consists of suppliers that the firm views as being unreliable. The firm's supply chain has been consolidated, and as a result, the firm cannot be as selective about

dealing only with suppliers with proven reliability. For that reason, the firm is willing to procure from suppliers that are known for supplying wood of inferior quality or delaying shipments.

These suppliers are not motivated to comply with the firm's requirements, and the firm is forced to control supplier processes by engaging in behavior-based contractual governance. The firm ensures that these suppliers comply with its order requirements by having an employee located close to suppliers' facilities who controls how suppliers fulfill the firm's orders. The employee travels to the suppliers' facilities and oversees how they prepare wood for the shipment.

With its unreliable suppliers, HARDWOOD.UN cannot avoid the risk of supplier non-compliance. For that reason, with these suppliers the firm focuses on mitigating the likelihood of supplier non-compliance by relying on behavior-based contractual governance. It employs an agent who oversees supplier processes and ensures that suppliers do not trigger a non-compliance.

MILK (large firm; low product complexity; externally driven)

MILK is a large Canadian dairy firm that produces a variety of dairy products. The firm's top priority is high product quality. In fact, the firm is able to attract many of its customers because of its reputation as a quality-focused firm.

The product quality depends on sourcing from farms that eliminate any potential triggers of milk contamination. The risk of its suppliers supplying contaminated milk is the main supplier risk MILK faces. If materialized, this supplier risk will have high impact on the firm: it would disrupt its supply chain processes but more importantly would have long-term negative effect on its reputation. The firm faces significant external drivers to ensure high quality of the procured

milk. Its large customers put significant pressures on the firm to control the risk of product contamination and impose strict policies for quality assurance measures.

The firm procures fresh milk from Ontario milk farmers via Dairy Farmers of Ontario (DFO), a governmental agency that controls milk supply in the province. The DFO acts as an intermediary supplier between milk farms and milk processing plants. The firm is not allowed to procure milk from any other sources. At the same time, Ontario farms are constrained by regulation to having the DFO as their only customer.

In general, hazards that have potential to trigger milk contamination are present in daily operations of milk farms. However, the aim of the DFO quality program that the farmers adhere to is to eliminate potential food safety hazards. Due to the DFO's role in the supply chain, the likelihood of farm supplying contaminated milk is low.

The involvement of the DFO allows MILK to rely on behavior-based contractual governance. The firm outsources to the DFO the efforts to assure that suppliers have the required processes in place. This stakeholder oversees on an ongoing basis whether practices of licensed farms comply with the established requirements. In addition, the DFO conducts its own testing of milk and ensures traceability of milk to a particular farm. In other words, it is the DFO that ensures that suppliers have needed process in place.

Because of the DFO's involvement, the firm does not participate in supplier selection and does not allocate resources towards acquiring information on supplier processes. MILK addresses the risk of a supplier producing contaminated milk by avoiding it. The firm is fully dependent on the DFO's ability to ensure compliance of the milk farms. It does not oversee production of these farms nor does it know from which farms each milk truck comes from.

PIPING-PARTS.R (small firm; high product complexity; internally driven)

PIPING-PARTS.R is a small pipeline component manufacturer that sources semi-finished components from four North American suppliers. The firm sells its products to piping companies in the oil and gas industry. This industry is sensitive to product defects. For that reason, to attract customers the firm emphasizes its high product quality. Its customers do not monitor production of the firm or of its suppliers but expect that the firm will operate according to its reputation.

High product quality requires procuring defect-free semi-finished components from suppliers. Therefore, the firm's main supplier risk is a supplier producing a defective component. This supplier risk has high potential impact. If installed in a pipe, a defective component may later crack under pressure and cause an operational disaster. The firm is internally driven to address this risk as its market presence depends on maintaining its reputation of a firm that prioritizes quality.

From its four North American suppliers, PIPING-PARTS.R sources non-standard products in small volumes or when a customer requests a rush order. The firm believes that when it procures from these suppliers the likelihood of procuring a non-compliant component is low. The reason is that these suppliers follow a business model similar to the firm's: they attract customers because they are known for their emphasis on product quality. The firm management believes that it does not need to oversee processes of these suppliers because of their organization culture that emphasizes high product quality. Aligned vision on the importance of product quality makes it possible for the firm to rely on relational governance. Overall, the firm trusts that these suppliers would perform according to the firm's expectations and requirements.

With these suppliers, PIPING-PARTS.R focuses on risk avoidance. It believes that the viability of these suppliers depends on maintaining their reputation and therefore they are unlikely to

produce defective components. The firm chooses not to acquire comprehensive information on their production processes. Instead, it trusts that over time the suppliers will remain compliant.

PIPING-PARTS.UN (small firm; high product complexity; internally driven)

This case considers the same firm as in PIPING-PARTS.R sourcing the same type of products (semi-finished components) but from a different supply base. This supply base consists of 18 offshore suppliers. From them the firm procures components of standard design in high volumes. These suppliers are associated with the same supplier risk of high potential impact as in PIPING-PARTS.R: a supplier producing a defective component. Unlike its North American supply base, these suppliers are associated with a high likelihood of supplier risk. The firm believes that its offshore suppliers lack capabilities to assure that no defects are introduced to the components. In addition, these suppliers are known for their cost-cutting organizational culture and for prioritizing profits over product quality.

PIPING-PARTS.UN does not trust that the offshore suppliers can produce high quality products on consistent basis. For that reason, the firm relies on behavior-based contractual governance. The firm agrees to source from these suppliers only if they follow detailed requirements for critical-to-quality production processes. In addition, to ensure compliance the firm has an off-site team that monitors the processes and remains in the suppliers' facilities until the produced products are shipped out to the firm. The firm's management believes that the off-site team should control production even of its long-term offshore suppliers.

With its offshore suppliers, the firm engages in behavior-based contractual governance. Its management believes that these suppliers cannot sufficiently avoid the risk of manufacturing de-

fective components. For that reason, the firm oversees each step of production to be able to mitigate potential supplier non-compliances.

PROSCUITTO (small firm; low product complexity; externally driven)

PROSCUITTO is a small meat processing plant that produces cured, cooked, and frozen Italian meat products. The firm is a plant with a federal license, the highest standard in the meat processing industry. Being a federal plant gives the firm a right to sell across Canada and to export but at the same time puts it under the highest level of regulatory control.

The only meat ingredient the firm uses in its products is pork. It is the firm's main expense in procurement and its critical-to-quality purchase. The firm mainly procures meat from a single federal slaughterhouse. The main risk PROSCUITTO faces is sourcing from a supplier that produces contaminated meat. This is a high-impact supplier risk. The firm is under significant external pressure from the federal regulator to avoid product contamination. The firm will be held responsible even if the contamination is originated in the supplier's slaughterhouse.

At the same time, the firm believes that the likelihood of the supplier supplying a contaminated product is low. In general, food safety hazards are present in daily operations of slaughterhouses. However, to ensure that federal slaughterhouses eliminate the hazards their processes are controlled and regulated by a powerful external stakeholder, the Canadian Food Inspection Agency (CFIA). CFIA inspectors are on the staff of federal slaughterhouses; they ensure that production processes comply with the regulatory requirements.

CFIA's involvement influences how the firm governs its meat suppliers. The firm relies on behavior-based contractual governance, with the key aspects of this governance mechanism ena-

bled by the CFIA. The agency assigns inspectors to oversee all aspects of the slaughterhouse's production from purchasing to slaughtering to shipping. In addition, CFIA incentivizes the slaughterhouse to eliminate any potential triggers of product contamination.

The firm does not allocate resources towards acquiring comprehensive information on supplier processes and outsources these efforts to the CFIA. It relies on behavior-based relational governance with the supplier processes controlled by the involved stakeholder and not the firm. The firm avoids the supplier risk of procuring contaminated meat to the extent largely determined by the effectiveness of the CFIA involvement.

Cross-Case Analysis

Based on Miles and Huberman's (1994) guidelines, the cross-case analysis began with constructing tables with the cases ordered in various ways based on the concepts identified during the within-case analysis. This process took a number of iterations. Some variables that the supply chain management literature predicted to have explanatory power failed to sufficiently explain how firms acquire information on supplier processes. For instance, both firm size and complexity of its products were used to create the sampling matrix for this research (Figure 1), as the literature highlights the importance of these variables in this context. However, neither variable could suggest how firms acquire information on supplier processes to ensure supplier compliance. In fact, these two variables could explain the logic of only two cases, AUTOMATION and AUTO-PARTS. In both cases, large firms have products that fall under the 'high product complexity' column of the sampling matrix. The firms are also similar in how they acquire information to ensure supplier compliance. Yet, these two variables could not explain the logic of the remaining cases.

Next iterations in the analysis revealed that the more promising approach was to focus on variables related to supplier risk. I first ordered the cases based on the potential risk impact. This approach revealed a number of unexpected patterns. For instance, it showed that the three cases with the supply bases controlled by external stakeholders – AEROSPACE, MILK, and PRO-SCUITTO – faced high impact supplier risk. In fact, high impact risk helps to explain why the firms in these cases rely on involved powerful stakeholders: these stakeholders are perceived to eliminate the triggers of supplier non-compliance. Also, in the two cases, AUTO-PARTS and AUTOMATION, where the firms tolerate supplier risks, both were associated with a low impact risk. The low impact of the supplier risk explains why these firms tolerate supplier non-compliances: if materialized, supplier non-compliance is unlikely to have a lasting negative impact on the firms' reputation and financial standing. The risk impact, however, failed to sufficiently explain the logic in the remaining six cases.

The next iteration focused on approaches each firm takes to address the risk of supplier non-compliance. In this iteration, I was able to explain the logic in all the cases. Based on the risk management literature, I identified three approaches to supplier risk management relevant to this study. PIPING-PARTS.UN, HARDWOOD.UN, and DESK.UN engage in *risk mitigation*. The firms oversee their suppliers' operations because they believe that their suppliers, if not monitored, are associated with high likelihood of non-compliance. This group includes cases with supplier risks of both high and low impact. By acquiring information on supplier processes, these firms can identify potential triggers of non-compliance and hence mitigate their likelihood. AUTOMATION and AUTO-PARTS form another group. In these two cases, the supply bases are associated with high likelihood of non-compliance but the risk has low impact on the firms. In

this group, the firms choose to engage in *risk tolerance* and address supplier risks only if they materialize.

In the remaining cases, the firms find ways to avoid supplier non-compliance by taking two different paths to achieve *risk avoidance*. AEROSPACE, MILK, and PROSCUITTO engage in *stakeholder enabled risk avoidance*. They rely on powerful external stakeholders that are involved in controlling and regulating their suppliers. All three cases have supply bases with potential to have high impact on the focal firms. Simultaneously, due to stakeholder involvement the firms perceive that the likelihood of non-compliance is low. As a result, the focal firms outsource to the involved stakeholders the efforts of acquiring comprehensive information on supplier processes to ensure supplier compliance. PIPING-PARTS.R, HARDWOOD.R, and DESK.R engage in *relationship enabled risk avoidance*. This group includes cases with both high and low impact supplier risks. These firms are convinced that their suppliers have both sufficient capabilities and motivation to comply with order requirements. As a result, they have established close relational ties with these suppliers and believe that the suppliers are likely to remain compliant. Overall, the process of ordering cases by an approach firms take to address supplier risks revealed four distinct case groups (Table 3).

Then I analyzed what other factors cases in each group had in common. Table 4 summarizes these factors and the section below provides a more detailed overview of each group. In particular, this analysis revealed that the four case groups differ not only in their approaches of addressing supplier risks, but also in their supplier governance mechanisms. Finally, I created a path diagram that compares the four identified case groups. Shown in Figure 4, the diagram reveals how different supply chain characteristics shape the approach to supplier risks and how the supplier governance mechanism enables this approach.

Case group	Case	Firm description	Firm size	Product complexity	Risk impact	High supplier capabilities	Likelihood of non-compliance	Description of firm's supply base
1	AEROSPACE	Aerospace component manufacturer	Small	High	High	Yes	Low	Approx. 15 local suppliers providing critical-to-quality manufacturing services. Some are integrated. All suppliers are certified by industry certification agency.
	MILK	Dairy producer	Large	Low	High	Yes	Low	3,000 local milk suppliers. A regulatory agency distributes milk in the industry and manages milk suppliers. The suppliers are licensed by the agency and adhere to agency's production requirements
	PROSCUITTO	Meat products manufacturer	Small	Low	High	Yes	Low	Single local meat supplier licenced by a regulatory agency. The agency monitors supplier operations on a daily basis and manages non-compliances.
2	DESK.R	Furniture manufacturer	Large	Low	Low	Yes	Low	The firm procures in total from 80 raw material suppliers. The suppliers are mostly local. They have production capabilities sufficient to cope with increasing customer requirements.
	HARDWOOD.R	Hardwood producer	Small	Low	Low	Yes	Low	The firm procures in total from 30 suppliers. Geographically clustered consolidated supply base of sawmills. Suppliers have close relationship with the firm and some rely on the firm to grade the wood.
	PIPING-PARTS.R	Piping component manufacturer	Small	High	High	Yes	Low	Three North American suppliers of semi-finished components. Suppliers have demonstrated their reliability and the reputation of quality-focused firms.
3	DESK.UN	Furniture manufacturer	Large	Low	Low	No	High	Firm procures in total from 80 raw material suppliers. The suppliers are mostly small and local. The suppliers lack capabilities to cope with increasing customer requirements. Many face bankruptcy.
	HARDWOOD.UN	Hardwood producer	Small	Low	Low	Yes	High	Firm procures in total from 30 suppliers. Geographically clustered supply base of sawmills. Mostly large suppliers that are also the firm's main competitors
	PIPING-PARTS.UN	Piping component manufacturer	Small	High	High	No	High	18 suppliers in India with potential to be compliant but lack production capabilities and incentives.
4	AUTO-PARTS	Automotive component retailer	Large	High	Low	No	High	Offshore supply base of approx. 500 suppliers. Many suppliers of seasonal and slow-moving products.
	AUTOMATION	Manufacturer of engineer-to-order equipment	Large	High	Low	No	High	Approximately 80 component suppliers. Some are local. The firm selects new suppliers for each engineer-to-order project.

Table 3. Description of case groups

Group	Case	Supplier shares risk impact	Acquiring information on supplier processes	Focus on stable supply base	Cost pressures	Focus of communication with suppliers	Governance mechanism	Approach to supplier risk
1	AEROSPACE	Yes	Periodic; by stakeholder	Stakeholder enabled	Low	Compliance to stakeholder requirements	Stakeholder-enabled behavior-based contractual governance	Risk avoidance
	MILK	Yes	Direct; by stakeholder	Stakeholder enabled	Stakeholder regulated	No	Stakeholder-enabled behavior-based contractual governance	Risk avoidance
	PROSCUITTO	Yes	Direct; by stakeholder	Stakeholder enabled	High	Compliance to stakeholder requirements	Stakeholder-enabled behavior-based contractual governance	Risk avoidance
2	DESK.R	Yes	None	Strong	Low	Relationship & compliance to firm's requirements	Relational governance	Risk avoidance
	HARDWOOD.R	Yes	None	Strong	Low	Relationship & compliance to firm's requirements	Relational governance	Risk avoidance
	PIPING-PARTS.R	Yes	None	Strong	Low	Compliance to firm's requirements	Relational governance	Risk avoidance
3	DESK.UN	Yes	Direct	Strong	Low	Compliance to firm's requirements	Behavior-based contractual governance	Risk mitigation
	HARDWOOD.UN	No	Direct	Strong	NA	Compliance to firm's requirements	Behavior-based contractual governance	Risk mitigation
	PIPING-PARTS.UN	No	Direct	Strong	Low	Compliance to firm's requirements	Behavior-based contractual governance	Risk mitigation
4	AUTO-PARTS	No	None	Weak	High	Outcomes	Outcome-based contractual governance	Risk tolerance
	AUTOMATION	No	None	Weak	High	Outcomes	Outcome-based contractual governance	Risk tolerance

Table 4. Description of factors common among firms in each case group

Overview of Four Case Groups

Case Group 1: Stakeholder enabled risk avoidance

This group includes MILK, PROSCUITTO and AEROSPACE. The first two firms are in the food industry and the last one is in the defense industry. The impact of supplier non-compliance is high for all of them. The involvement of powerful external stakeholders in each of these firms' supply bases is the reason they form a separate group. For these supply bases, external stakeholders participate in selecting suppliers, acquiring information on supplier processes, and incentivizing suppliers to comply with necessary requirements for their production processes. As a result, of the stakeholder's involvement, these firms believe they can avoid supplier non-compliance.

MILK and PROSCUITTO face the risk of a supplier producing contaminated ingredients. To eliminate potential triggers of contamination, government agencies regulate and control their supply bases. These regulatory agencies license potential suppliers, set the requirements for supplier processes and then ensure that licensed suppliers conform to these requirements. AEROSPACE faces the risk of its suppliers, undermining the quality of the mechanical components it sells. It thus only selects licensed suppliers that have gained a third-party certification from aerospace certifying organizations. These third party certifying organizations ensure that suppliers have sufficient capabilities to maintain high product quality by acquiring information on these suppliers and assessing if they conform to the process requirements developed for their specific types of production.

Case Group 1 firms rely on behavior-based contractual governance with key elements of this governance mechanism enabled by the powerful stakeholders. Specifically, they source only from suppliers that have been licensed by the stakeholders, which in turn only license those with

the potential to comply with industry-specific production process requirements. Losing the license threatens suppliers' viability and so motivates them to remain compliant. An executive from MILK explained that the involvement of the regulatory agency incentivizes milk suppliers to avoid product contamination:

“The farmers know their requirements and I've never seen a load that has been refused for antibiotics or something because the farmers know better because they know it will have a very significant impact on [them]. So, the farmers expect very high level of quality so they don't take risk at that because it is their family business.”

Case Group 1 firms also outsource information acquisition on supplier processes to the external stakeholders. As one of the owners of AEROSPACE explains:

“I could tell you that if the company is approved [by the external stakeholder], I don't even need to think about them. I know that their process will be in place there. I will gain nothing by going for an audit.”

Specifically, for MILK and PROSCUITTO, representatives of the external stakeholder have access to suppliers' production facilities and oversee supplier processes on an ongoing basis. The President of PROSCUITTO explained the importance of having stakeholder representatives at suppliers' facilities:

“They [stay in production facilities] enough so you cannot allude them forever... They come enough, the smart ones ask the right questions... Believe it or not, inspectors will come and ask something, observe something downstairs, ask one of the workers, will come up... and ask [a manager] the same question. And then compare stories. They are

almost like the police, they have badges, and if they want they can go in any established place of business or anywhere that they think has ties to good safety. They show their badge and they can go in. You cannot stop them, they are federal agents”.

In contrast, in AEROSPACE the stakeholder representatives monitor suppliers’ facilities periodically, either once a year or every three years. Therefore, in this case the firm faces a threat of supplier processes containing potential triggers of non-compliance. This firm differs from the firms in the other two cases in its much closer relational ties with its suppliers. The focus on close relationships complements the efforts the stakeholder takes to ensure supplier compliance.

Case Group 1 firms do not directly acquire information on supplier processes and thus have no means to mitigate the likelihood of non-compliance. They instead acquire information at the supply-base level by being aware of the stakeholders’ requirements, which represent a threshold to avoid supplier risks. When asked about potential supplier non-compliance, one of executives in AEROSPACE referred to stakeholder requirements guiding supplier processes:

“If [suppliers] have a product that is discrepant and non-conforming, it must physically be destroyed. No chance... There are requirements you must destroy it.”

Overall, the involvement of external stakeholders allows Case Group 1 firms to avoid supplier risks. Nevertheless, by outsourcing the monitoring of supplier compliance to external stakeholders, these firms depend on the suppliers adhering to these process requirements each time they fulfill an order.

Case Group 2: Relationship enabled risk avoidance

This group consists of DESK.R, HARDWOOD.R and PIPING-PARTS.R. Firms in this group build close relationships with their supply bases that consist of suppliers proven to be reliable and trustworthy. That is, these suppliers have high production capabilities and are motivated to comply. Case Group 2 suppliers strive to protect their reputation of being reliable, as expressed by the Chief Operating Officer of PIPING-PARTS.R,

We rely on their reliance to quality, that quality is key to their reputation, for our own peace of mind with them... We don't [monitor them] because these guys are much better at keeping us [with] the updates... we do trust more than the other mills that they are ensuring that things are going well... Really, it is a bit of a different corporate culture and yeah... I would chuck that up to be the biggest reason... They just take us seriously; they take their product seriously.

The goals of the firms in Case Group 2 are aligned with the goals of these suppliers to ensure compliance. If the suppliers fail to comply, they are expected to suffer substantial reputational and financial losses. The supply bases of Case Group 2 are all located in North America, although DESK.R not only sources locally but also from some offshore suppliers for certain materials/components unavailable locally. These firms thus share similar institutional environment with their suppliers.

This Group includes cases with both high and low impact supplier risks, although all firms in this group believe that the processes of their suppliers contain few if any possible risk triggers. These firms provide incentives for their suppliers to remain compliant and foster long-term relationship with suppliers. DESK.R, the only large firm in this group, takes an additional step to

ensure relationship continuity by investing significant resources in supplier education, which helps the suppliers conform to increasing industry requirements. One of its executive managers explains,

In very simplistic terms kind of the rules of engagement that if we're going to partner, and I like partners, I don't want to be looking for new suppliers. As an organization, we're very loyal to our supplier base. We don't change suppliers for a nickel. Some of our suppliers have been literally here since day one, 30 years.

Another of its executive noted:

I think [some of our competitors] learnt the hard lesson where they kind of beat the crap out of their suppliers: beat on their price, beat on everything else and they went through this whole thing where there's no supply chain... You can't take that approach. You got to work with them. It's long-term. Short-term fine we'll improve our margins, but 5 years, 10 years down the road we're onto another supplier, because he's out of business...So let's work together, their engineers work with your engineers. We engage them early in the process...

Furthermore, DESK.R and PIPING-PARTS.R do not put significant cost pressures on their suppliers, while HARDWOOD.R relies on trust when it comes to cost negotiations. The firm, a hardwood manufacturer, grades incoming wood from its suppliers (because suppliers lack expertise in wood grading) and these suppliers trust that the grading is done objectively and the cost is appropriately set. The firm's owner emphasized the importance of approaching relationships in this manner:

When [a supplier] ships us they know we will pay for everything and we will have to determine the grade. And hopefully they have confidence in us that we grade it properly. They just cut the wood and ship it. Their wood is very good. Their quality is very good. And they are very good people to deal with... These people are a pleasure to deal with...

Both DESK.R and HARDWOOD.R also emphasized the importance of personal relationships between the members of their sourcing teams and their suppliers' employees. They highlight the importance of informal meetings that encourage closer relationships with the suppliers. For instance, the supply chain director of DESK.R describes:

[For our primary members that have performed very well] I'll pop to say thanks for everything...I was in Cambridge [, ON] this week with a supplier and there's one operator at this facility who is notorious for giving us good product. [For instance,] she'd come in when she's sick. I won't get into a long story but I wanted to meet her personally. Her name is Anna and she's a line operator at this [facility]... I wanted to personally meet her and thank her for everything.

HARDWOOD.R managers prefer not to source from suppliers when they cannot establish personal relationships with their salesforce:

You got some guys that are just, they just don't click with us. They don't like us, we don't like them. Just personality.

Moreover, if a supplier's salesforce changes, the firm's managers take steps to rebuild personal relationships with the new salesforce:

I had known this guy for years and I got to meet him and really I probably get a lot of their production because of him. If he was to leave or [his company] get bought [with] the new guy I couldn't have bought [from]. So, yeah, the real importance is who[m] you are involved with. That's why generally when we lose someone... you really have got to reconnect ... once someone new takes over you're starting over. You pretty much have got to rebuild.

Overall, the firms in Case Group 2 gain confidence over time that their suppliers possess high production capabilities. In addition, the firms take steps to ensure that their suppliers are motivated to comply. They trust that strong relational ties help them avoid non-compliance each time a supplier fulfills an order.

Case Group 3: Risk mitigation

This group consists of DESK.UN, HARDWOOD.UN and PIPING-PARTS.UN. These cases cover the same firms as Case Group 2 buying the same type of inputs. But the supply bases are managed differently because they consist of suppliers that the firms believe lack production capabilities and/or incentives to comply with order requirements on a consistent basis. Consequently, Case Group 3 firms believe that these suppliers have a high likelihood of non-compliance and do not trust that they can eliminate potential triggers of non-compliance in their processes. These firms do not rely on relational governance for their unreliable supply bases, but instead engage in behavior-based contractual governance and monitor supplier processes to ensure compliance. This governance mechanism then allows the firms to mitigate the supplier risks. Interestingly, this group includes cases with supplier risks of both high and low impact.

These three firms apply the following principle to supplier risks in these supply bases: They seek to have information on supplier processes to identify potential triggers of supplier risks before the risks materialize. Nevertheless, these firms somewhat differ in how they monitor supplier processes. DESK.UN procures raw materials from suppliers that struggle to comply with increasing industry requirements. These suppliers are motivated to comply, but they lack capabilities. The firm assigns its engineers to oversee the suppliers' production processes. The firm's intention is to educate the suppliers enough to decrease control over time. In contrast, PIPING-PARTS.UN's suppliers lack both production capabilities and incentives to comply. As a result, the firm does not foresee a way to build trust-based relationships and acknowledges that it needs to constantly keep the same level of control over its suppliers. The firm's COO explained:

I mean I trust them with our people on the ground... Obviously, it is a sliding scale depending on suppliers. Some of them yeah I would but in any regard, it really would only be a matter of time till I did not trust all the mills if our inspection team was not there.

DESK.UN and PIPING PARTS.UN do not put significant cost pressures on the suppliers to further reduce the odds of non-compliance. They clarify their requirements by engaging in regular communications, where they explain how the suppliers' processes conform to their requirements. HARDWOOD.UN, on the other hand, has been forced to source from suppliers that have caused previous supply disruptions by supplying wood of inferior quality or delaying shipments. These suppliers lack the motivation to comply with the firm's requirements, as their viability does not depend on doing business with it. To monitor their processes, HARDWOOD.UN employs a person who specifically oversees supplier compliance. This employee has significant experience in the industry and is located in close proximity to the suppliers' facilities to control how they fulfilled orders.

Overall, the firms in Case Group 3 engage in behavior-based contractual governance and acquire comprehensive information on supplier processes to ensure compliance from these supply bases. These firms assign employees who directly oversee supplier compliance and thus ensure they have the ability to identify the presence of possible triggers of supplier risks and mitigate the risks before they materialize. They make this process less resource-intensive by selecting either local suppliers or suppliers located in close proximity to each other. These firms also strive to retain the same suppliers because it helps to gain a better understanding of their processes.

Case Group 4: Risk tolerance

This last group consists of AUTO-PARTS and AUTOMATION. It differs from the rest of the sample because firms in this group tolerate supplier non-compliance to a certain extent. The firms face the risk of a supplier failing to produce products of acceptable quality, a non-compliance that is considered to have low impact on these firms. The suppliers do have the potential to comply, but may be unable to consistently supply products of acceptable quality. Both firms engage in outcome-based supplier governance and prioritize cost minimization in procurement and, in particular, when they select suppliers. They also tend to interact closely with the suppliers only during their selection process, where the main selection criterion is whether the supplier can maintain product quality at an acceptable level. Once the suppliers have been selected, Case Group 4 firms address supplier risks only when they materialize; that is, when product quality has significantly deteriorated. For instance, AUTO-PARTS uses consumer feedback and product returns to identify non-compliant suppliers.

AUTOMATION favors selecting component suppliers that offer products of acceptable quality at the lowest cost. If a supplier's performance significantly deteriorates, the firm's representative visits the supplier and if no successful corrective action takes place, then the firm stops

sourcing from that supplier. Similarly, AUTO-PARTS focuses on selecting suppliers that can offer acceptable level of product quality at the lowest cost. It has developed standards for assessing a supplier's production system and ability to achieve the required level of quality. The firm's quality team does so under significant time pressure:

It has to be very quick. Our decision-making sometimes could be between a month or two.

Once suppliers are selected, the firm rates them based on defect costs every month and identifies the suppliers that require intervention. Its management admits that when procuring small volumes from a non-compliant supplier, the non-compliance may go unnoticed due to small associated costs.

Although AUTO-PARTS and AUTOMATION attempt to limit the likelihood of supplier risk, the likelihood remains high. They do expect that product quality can deteriorate if some of the suppliers fail to comply with their quality requirements. This is one of the reasons why both firms emphasize the importance of offering a warranty to their customers. For instance, in AUTOMATION case the firm's manager explained:

[We] are open for any communication or any concerns that the customer might have if it gets out of spec or so on and so forth. Or if there is something that's not functioning to how they would like it to be then we are still there. But we normally give out if I'm not mistaken one year warranty in terms of what we have built.

These firms also have a number of practices in common. They put considerable cost pressure on their suppliers and, to limit the likelihood of supplier risks, they regularly monitor the suppli-

ers' performance and communicate with suppliers that fail to meet product quality requirements. They also do have stable supply bases. AUTOMATION manufactures engineer-to-order equipment and selects new suppliers for each new project. As one of its executive explained when discussing particular equipment that they engineered:

So, if we look at [supply base for this product] ... we try to, you can go to anyone, we have pretty much an open mind here. You can go to whomever you want...

AUTO-PARTS' large supply base limits its ability to invest in supplier relationships. As a member of the firm's quality team noted:

But I hope you realize that we have thousands of different products... It is a very complex system to be able to make improvements.

Overall, the firms in Case Group 4 choose not to acquire information on supplier processes; instead, they acquire information about potential supplier risks at the firm level. After providing the suppliers with their compliance requirements during the selection process, they learn about the suppliers' potential to meet these requirements. Case Group 4 firms are aware of the supplier risks they face and choose to address them by having certain tolerance for supplier non-compliance. They do not have the means to mitigate the likelihood of non-compliance and are prepared to face supplier failures.

Case study results

Ways to address supplier risk

The literature on supplier risk management points out that firms can mitigate supplier risks if they monitor supplier processes and identify potential risk triggers in a timely manner (e.g., Finch et al., 2004; Christopher and Lee, 2004; Marucheck et al., 2011; Sodhi et al., 2012). That is, the literature agrees that comprehensive information on supplier processes is necessary to mitigate supplier risks before they materialize. Initially, the aim of collecting case study data was to understand how various firms acquire this information. The results of the collected case studies, however, reveal that many firms choose not to have comprehensive information on supplier processes, despite the recommendations of the supplier risk management literature. Specifically, firms seek to gain an ability to mitigate supplier risks only when they do not have alternative approaches to address the risks.

The firms in two case groups believe that they avoid supplier risks owing to their governance mechanism. In Case Group 1 the firms avoid supplier risks because a powerful external stakeholder regulates and controls their suppliers. Case Group 1 firms engage in behavior-based governance enabled by a powerful external stakeholder. These firms choose to rely on behavior-based governance because the stakeholders, and not these firms, control behavior of their suppliers. Specifically, they outsource the burden of acquiring comprehensive information on supplier processes and identifying possible triggers of non-compliance to these stakeholders.

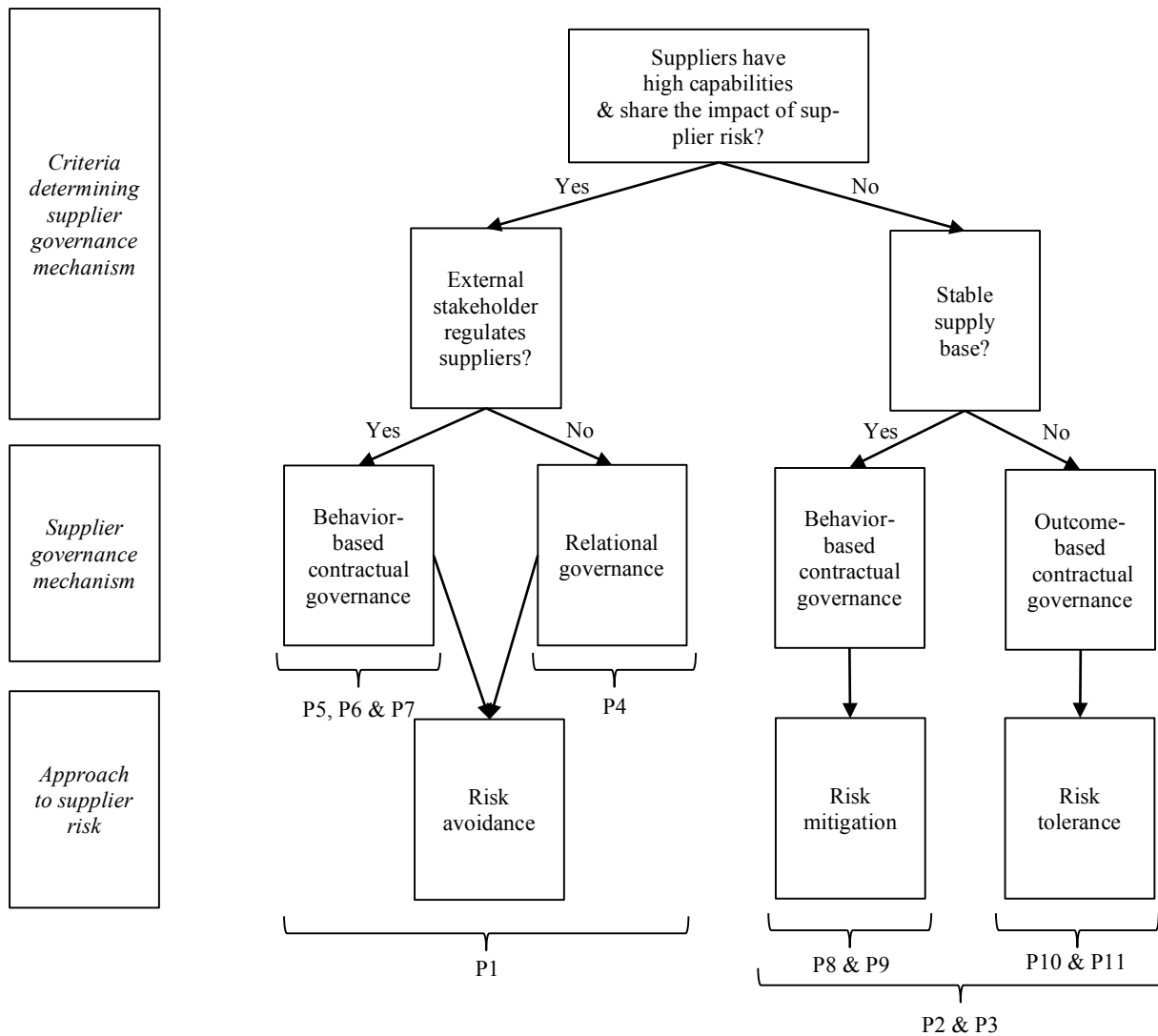


Figure 4. Paths determining firm's approach to supplier risk

Case Group 2 firms do not collect comprehensive information on suppliers because they believe that they can avoid non-compliance via close relational ties with their suppliers. These firms are convinced that relational ties provide sufficient behavioral control to ensure supplier compliance. In other words, they rely on relational governance to foster stable relationships with their suppliers and trust that the suppliers are motivated to remain compliant.

P1. A firm does not seek to have the capability to mitigate supplier non-compliance when it believes its governance mechanism allows it to avoid this risk.

Two criteria determine whether firms seek to acquire comprehensive information on supplier processes to mitigate the supplier risks. The first criterion is whether suppliers have capabilities sufficient to comply with the firms' requirements. The second criterion is whether suppliers share impact of the risks with the firms. If suppliers fail to meet either of these criteria they are associated with high-likelihood supplier risk. Then, unless the firms are willing to tolerate supplier risks, they seek to acquire comprehensive information on supplier processes to mitigate the risk of supplier non-compliance.

The first criterion, supplier capabilities, plays an important role in firms' decision-making because suppliers that lack capabilities are likely to have risk triggers present in their daily operations. As a result, the firms need to invest resources into acquiring information on supplier processes and have an ability to mitigate supplier risks. If the firms fail to do so, they are likely to be affected by materialized supplier risks on a regular basis.

The literature argues that sharing with suppliers potential impact to supplier risks tends to lead to a greater level of information sharing between firms and their suppliers (e.g., Harland et al.,

2003; Jüttner, 2005; Ritchie & Brindley, 2007). The results of the case studies, however, indicate that when firms source from suppliers that share the impact of materialized risks they are less likely to have comprehensive information on supplier processes. Instead, the firms are convinced that their suppliers are motivated to eliminate potential triggers of supplier risks. While agency theory (e.g., Eisenhardt, 1989A; Whipple and Roh, 2010) emphasizes the importance of aligning goals of the principal (i.e., a focal firm) and the agent (i.e., a supplier), the case results show how potential impact of supplier non-compliance contributes to the goal alignment. Specifically, the sampled firms believe that suppliers that will suffer from their own non-compliances have goals aligned with the firms'. In contrast, firms that source from suppliers that are not affected by their non-compliances seek to mitigate the likelihood of non-compliance by acquiring information on supplier processes - or tolerate supplier non-compliances on a regular basis.

P2. Sourcing from suppliers that lack capabilities necessitates a firm to seek comprehensive information on potential triggers of supplier non-compliance - or tolerate the risk.

P3. Sourcing from suppliers that do not share the impact of materialized supplier risk necessitates a firm to seek comprehensive information on potential triggers of supplier non-compliance - or tolerate the risk.

Relying on external stakeholders to avoid supplier non-compliance

The firms from industries, in which a powerful external stakeholder regulate suppliers, choose not to acquire comprehensive information on supplier processes and do not have direct means to mitigate the likelihood of supplier non-compliance. Instead, they outsource the efforts of eliminating potential triggers of supplier non-compliance to the involved stakeholder. That is, these

firms engage in behavior-based contractual governance enabled by the stakeholder involvement and believe that this governance mechanism allows them to avoid supplier non-compliance.

These firms are convinced that the requirements the stakeholders impose on supplier processes are sufficient to ensure supplier compliance. They also know what behavioral control measures the stakeholders take to ensure that the suppliers adhere to these requirements. As a result, the firms believe that their suppliers have the required processes in place and can successfully comply with their order requirements.

The literature has predicted that external stakeholders would play a more important role in coordinating firms' supply bases than in the past (e.g., Bitran et al., 2007). The results show that the stakeholder involvement can go beyond coordination, affecting many aspects of supplier operations. First, in the three collected cases the stakeholders are involved in supplier selection process. As Maruchek et al. (2011) point out, firms need to find a way to incorporate factors associated with managing risks into supplier selection decisions. Interestingly, for these firms it is the external stakeholders - and not the firms - that ensure that selected suppliers can eliminate potential triggers of non-compliance in their processes.

The supplier governance literature argues that behavior-based contractual governance requires having comprehensive information on supplier processes (e.g., Whipple and Roh, 2010; Selviaridis and Norrman, 2014). However, the results of the case studies reveal that the firms engaged in behavior-based governance may not seek the comprehensive information if a powerful external stakeholder regulates and controls their supply base. Specifically, the firms believe that they do not need to know how their suppliers fulfill their orders because the involved stakeholder

has developed strict requirements for supplier processes and oversees that the suppliers adhere to these requirements.

Finally, these stakeholders help align the goals of suppliers with those of the firms (Eisenhardt, 1989A; Whipple and Roh, 2010) by motivating suppliers to remain compliant. Specifically, the survival of suppliers, in these cases, to a great extent depends on their ability to conform to the requirements imposed by the stakeholders. Non-conforming suppliers can lose their license to operate and therefore severe relationships with all of their customers.

P4. When a powerful external stakeholder regulates a firm's suppliers, the firm does not seek comprehensive information on potential triggers of supplier non-compliance.

P5. When a powerful external stakeholder regulates a firm's suppliers, the firm outsources the efforts of monitoring supplier processes to this stakeholder.

P6. When a powerful external stakeholder regulates a firm's suppliers, the firm believes its suppliers have external incentives to remain compliant.

Using relationship to avoid supplier non-compliance

The case results also bring to light the role buyer-supplier relationships play in managing risks, following Marucheck et al.'s (2011) call for a better understanding of this role. Scholars (e.g., Harland et al., 2003; Villena et al., 2011) warn against relying on relationships to manage supplier risks, indicating that from the perspective of risk management, "trust is a risky engagement" (Harland et al., 2003: 55). Nevertheless, three sampled firms use relational governance to manage supplier risks. They foster close relational ties with suppliers that have high production capabilities and share the potential impact of materialized risks. These firms believe that their

suppliers value the relationships and hence are incentivized to eliminate potential triggers of non-compliance.

Furthermore, the supply chain management literature often highlights a higher degree of information sharing among supply chain partners with close relational ties (e.g., Richie and Brindley, 2007). The cases show a different aspect of this approach to buyer-supplier relationships: by building close relational ties with their suppliers, the firms do not seek access to comprehensive information on supplier processes. Instead, they solely rely on the firm-level information: they believe that their suppliers value the relationships with them and are motivated to eliminate potential triggers of supplier risks.

P7. When a firm has close relational ties with its suppliers, the firm does not seek comprehensive information on potential triggers of supplier non-compliance.

Interestingly, the three firms in this study that rely on relational governance bifurcate their supply bases. They prefer this governance mechanism, but rely on it only with suppliers with which they have established close, trust-based relationships. When a supplier's behavior indicates that it either lacks production capabilities or is not motivated to comply with the imposed requirements, the firms instead use behavior-based contractual governance and strive to have comprehensive information on supplier processes.

P8. A firm that prefers using relational governance will revert to behavior-based contractual governance when it believes that a supplier either lacks capabilities or does not share the impact of materialized supplier risk.

Stable relationships with unreliable suppliers

The supplier governance literature emphasizes that effective relational governance depends on having stable supply bases and sharing accrued benefits with suppliers over time (Poppo and Zenger, 2002; Jiang, 2009; Nyaga et al., 2010). These practices foster relationships and help to ensure supplier compliance. In contrast, firms relying on behavior-based contractual governance do not depend on these practices as they ensure supplier compliance by acquiring comprehensive information on supplier processes.

Interestingly, the results of the case studies show that firms that rely on behavior-based contractual governance have stable supply bases and do not put cost pressures on their suppliers. Their suppliers either lack production capabilities and/or do not share the impact of materialized supplier risks. For that reason, the firms cannot establish close, trust-based relationships with them. And yet, they rely on relational practices and choose not to view the relationships with these unreliable suppliers as purely transactional.

The literature has emphasized the value of complementing contractual governance with certain aspects of relational governance (e.g., Poppo and Zenger, 2002). The case results add to this discussion by showing why doing so can be valuable in the context of supplier risk management. Specifically, firms relying on behavior-based contractual governance believe that certain relational practices, including having stable supply bases and limiting cost pressures on their suppliers, can help them further mitigate the likelihood of supplier non-compliance.

P9. A firm relying on behavior-based contractual governance seeks to have a stable supply base to help further mitigate the likelihood of supplier non-compliance.

P10. A firm relying on behavior-based contractual governance limits cost pressures on its suppliers to help further mitigate the likelihood of supplier non-compliance.

Limitations of outcome-based governance in supplier risk management

The results of the case studies also reveal the limitations of outcome-based contractual governance in managing supplier risks. Firms relying on this governance mechanism assess and reward suppliers based on the outcomes suppliers achieve (Eisenhardt, 1989A; Whipple and Roh, 2010). As a result, outcome-based contractual governance shifts the responsibility of identifying potential risk triggers from the firms onto suppliers. The case results show that only firms facing low-impact supplier risks choose to rely on this governance mechanism.

The cases demonstrate that outcome-based governance is ineffective if a firm's goal is to ensure supplier compliance on a regular basis. If a supplier fails to achieve a required outcome, - i.e. it causes a non-compliance – such situation represents a materialized supplier risk. Therefore, firms engaging in outcome-based governance have to tolerate supplier risks.

P11. A firm relying on outcome-based contractual governance is required to tolerate potential impact of supplier non-compliance.

P12. A firm chooses to rely on outcome-based contractual governance when a supplier non-compliance has low impact on the firm.

CHAPTER FOUR: AGENT-BASED SIMULATION

The cases provided important insights into how in practice firms manage the risk of supplier non-compliance. Specifically, they show four distinct approaches firms may take to manage the risk of supplier non-compliance. Yet, these descriptive results do not reveal which of these four approaches a firm should choose to successfully manage the risk of supplier non-compliance. To offer prescriptive results, I complement the case studies with an agent-based simulation. The agent-based simulation derives its assumptions from the results of case studies. Its aim is to investigate a firm's decision-making over time and explore what decisions a firm should make to reduce the likelihood of supplier non-compliance.

Simulation is a theory building methodology found useful in studying emergent phenomena (Davis et al., 2007; Fioretti, 2013). Scholars have used simulations to explore diverse management topics ranging from innovation diffusion to teamwork to organizational learning (Crowder et al., 2012; Davis, et al., 2007; Miller and Lin, 2010; Rahmandad and Sterman, 2008). Many have argued for a more extensive use of simulations in supply chain management research (e.g., Gilbert, 2008; Macal and North, 2005; Van Der Zee and Van Der Vorst, 2005).

In this research, I employed agent-based modeling (Wilensky and Ran, 2015). It is a widely-used approach when the phenomenon under study involves a “collection of autonomous decision-making entities, agents” (Bonabeau, 2002: 7280) such as buyers and suppliers. Agent-based modeling is a bottom-up approach, where agents' rules of behavior are specified to understand the dynamics of an entire system (e.g., a firm's supply base) (Macal and North, 2005), and where agents (e.g., a firm and its suppliers) can possess heterogeneous attributes, uncertain behavior, form networks, and their interactions influence their actions (Bonabeau, 2002; Fioretti, 2013).

Application of agent-based modeling in the context of supply chain management - and especially in the context of supplier risk management - is relatively novel. For that reason, the agent-based simulation in this research is not based on any existing simulation models of supply chains. Instead, it is based on a number of agent-based models from biology and sociology that focus on agent behavior in networks (Wilensky and Rand, 2015). I programmed the simulation in NetLogo, currently the most popular programming environment for agent-based modeling simulations. NetLogo is open-source software with extensive supporting materials available to assist with developing simulations for a particular context (Railsback and Grimm, 2011; Wilensky and Rand, 2015).

A simulation should well mimic the real world, and yet it cannot represent all its aspects in equal degree of detail (Wilensky and Rand, 2015). As Bonabeau (2002: 7287) states, “a model has to serve a purpose; a general-purpose model cannot work”. Fioretti (2013) notes that a study’s research question can give a focus to a simulation determining what aspects of the real world the simulation should model in detail and what aspects it should omit. Davis et al. (2007) argue that a simulation then requires sufficient theoretical understanding of the studied phenomenon. Only then can a researcher ensure that the simulation’s representation of the phenomenon is valid.

In the absence of quantitative data that describe relevant agent and system behaviors, scholars recommend relying on qualitative empirical methods such as case studies (Hughes et al., 2012; Macal and North, 2005). As Midgley et al. (2007:887) point out, empirically grounded simulations tend to be “realistic, at least to some degree of face validity, and ... evidently complex in overall structure”. Following their recommendation, I use the results of the case studies to ground the simulation assumptions.

Model verification is another crucial step that ensures that the conceptual model has been correctly represented in the programming code (Midgley et al., 2007). It establishes “an understanding for the cause of unexpected outcomes and exploring the impact of small changes in rules.” (Wilensky and Rand, 2015: 324-325). In essence, model verification is a debugging of the simulation code. I relied on a number of techniques to verify the simulation model (Midgley et al., 2007; Wilensky and Rand, 2015). First, a researcher not involved in model coding inspected the programming code. Second, I depicted the simulation algorithm in a number of flow charts. These charts provide an intuitive way to analyze the underlying conceptual model. Third, I performed sensitivity analysis to examine how changes in model parameters affect its results and therefore established the robustness of the simulation results. The code of the simulation is available in Appendix D.

Simulation description

This agent-based simulation investigates the behavior of a firm attempting to manage the risk of supplier non-compliance. The case studies show that firms can take different approaches to manage their supplier risks. The simulation then explores how a particular approach to supplier risks impacts the likelihood of supplier non-compliance. The case firms only managed supplier risks associated with their first-tier suppliers. Therefore, the simulation uses a single-tier supply network consisting of two agent types, a focal firm and its suppliers, with each agent being described by two parameters: capability $C \in [0,1]$ and risk impact $I \in [0,1]$. Capability C is defined as an ability to employ internal and external resources to facilitate supply management processes (Wu et al., 2006). Capability C thus determines both the extent to which the focal firm is able to successfully manage its suppliers and the extent to which these suppliers are able to comply with the focal firm’s order requirements. Risk impact I is defined as the potential of supplier

non-compliance to inflict long-term damage to the buyer or supplier. Risk impact I determines the extent to which the focal firm is motivated to ensure supplier compliance and the extent to which these suppliers are motivated to comply with the focal firm's order requirements. Various external conditions such as competitive pressures, change of ownership and the emergence of new technologies can lead to fluctuations in C and I . Therefore, at the end of each time period, and for any agent, the simulation also incorporates a 5% probability for C and I to increase or decrease by a set value of 0.01. The simulation notation is shown in Table 5.

Parameter	Notation	Definition
Focal firm's capability	C^f	The focal firm's ability to ensure supplier compliance
Focal firm's risk impact	I^f	Potential damage inflicted to the focal firm by supplier non-compliance
Focal firm's selection standard	T_c	Threshold for a supplier's capability the focal firm uses during supplier selection
A supplier's capability	C^s	A supplier's ability to comply with the focal firm's requirements
A supplier's risk impact	I^s	Potential damage inflicted to a supplier by its non-compliance
An external stakeholder's capability	C^e	A stakeholder's ability to regulate and control the focal firm's suppliers
A supplier's risk impact imposed by an external stakeholder	I^e	The external stakeholder's potential to inflict damage to a supplier that caused a non-compliance
A supplier's likelihood of non-compliance	P_{NC}^s	The likelihood of non-compliance associated with a supplier s
Highest likelihood of non-compliance	P_{Max}^F	The likelihood of non-compliance associated with a supplier that represents the greatest threat to the focal firm

Table 5. Simulation notation

Figure 5 depicts the algorithm of the simulation. The simulation unfolds as follows: At time $t = 0$ a focal firm selects its suppliers and for each subsequent period $t = 1, 2, 3 \dots$ (corresponding to a month), each supplier produces and sends its products to that firm, with a likelihood P_{NC}^s that any given supplier s fails to comply with the order requirements. The supplier's capability C^s and risk impact I^s determine this likelihood of non-compliance. I use the functional form $P_{NC}^s = a(1 - C^s I^s)$, where a is a scaling parameter ($a = 0.1$ without loss of generality), to capture an interaction between C^s and I^s . In other words, low levels on either a supplier's capability or its risk impact can significantly increase the likelihood of non-compliance. When a non-

compliance actually takes place, it can undermine the focal firm's product quality, lead to significant financial losses or harm that firm's reputation. I thus focus on accounting for the supplier s , among a total of N suppliers, that represents the greatest threat to the focal firm f and record as simulation outcome the highest likelihood of non-compliance in the firm's supply base, $P_{Max}^f =$

$$\max_{s \in \{1, 2, \dots, N\}} (P_{NC}^s).$$

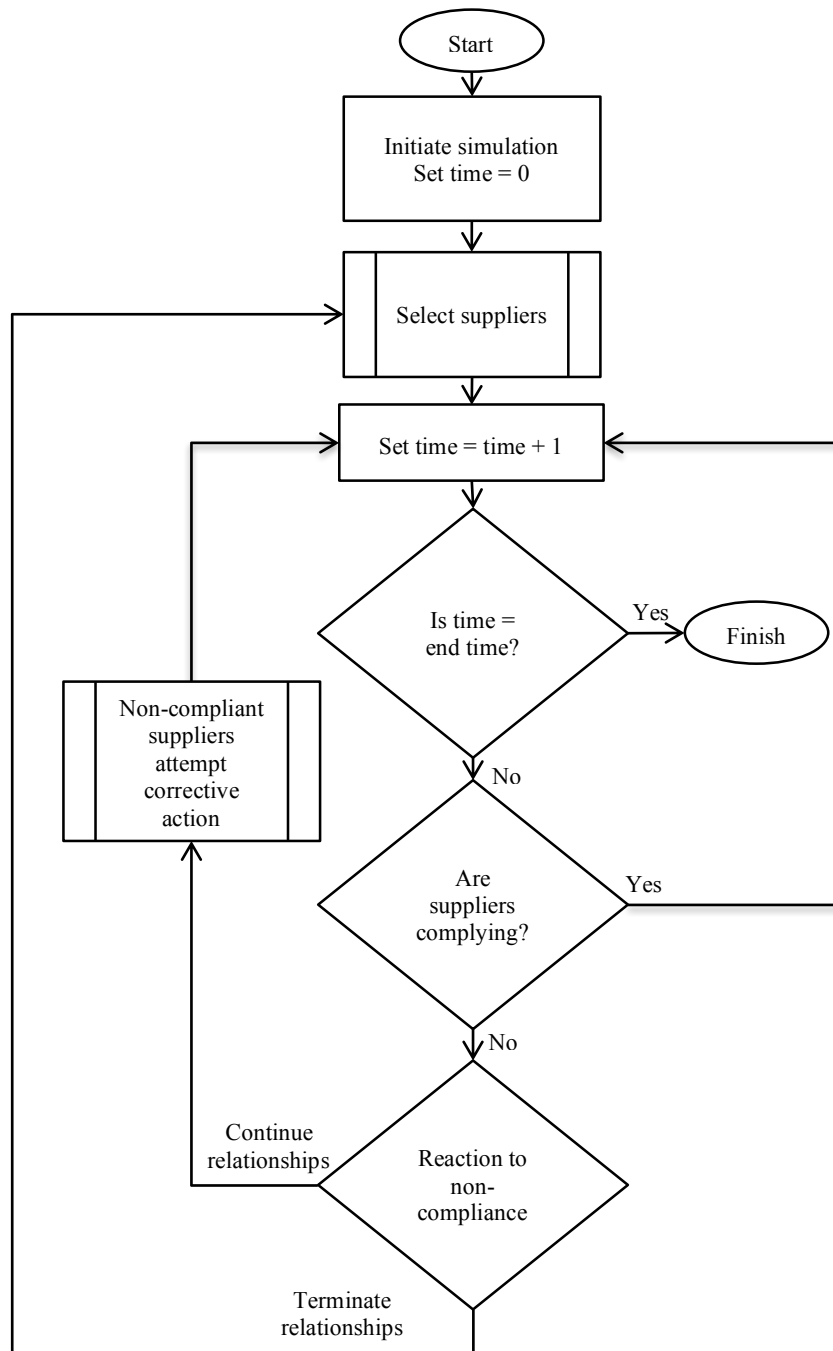


Figure 5. Flowchart of simulation algorithm

As the cases reveal, during the supplier selection process, the focal firm acquires crucial information regarding the likelihood of these suppliers to remain compliant. That information depends on the focal firm's approach to governing supplier risks. Regardless of the selected approach, the focal firm will attempt to select suppliers with a capability sufficient to comply with its order requirements. Consequently, the focal firm tries to select suitable suppliers with a capability C^s that is equal to or exceeds certain selection standards T_c (i.e., $C^s \geq T_c$). Because a subset of selected suppliers may fail to satisfy this selection criteria (Eisenhardt, 1989A; Whipple and Roh, 2010), the simulation incorporates a probability of selecting a suitable supplier that depends on the focal firm's own capability C^f and its risk impact I^f . I use the functional form $P(C^s \geq T_c) = C^f I^f$ to capture the fact that the probability of selecting a supplier that satisfies the focal firm's selection criterion approaches zero when the focal firm itself possesses low capability or faces low risk impact from supplier non-compliance.

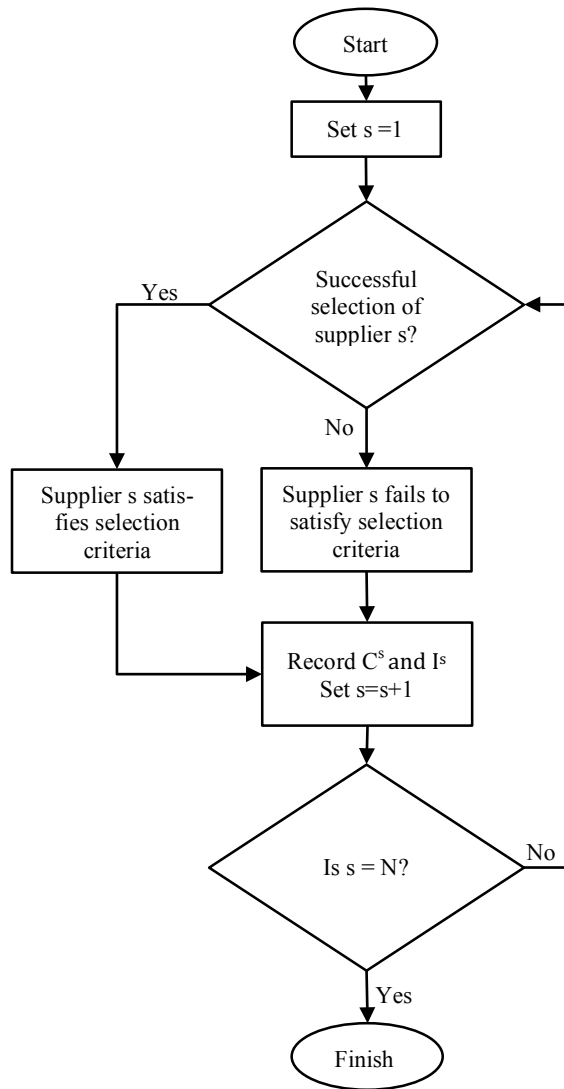


Figure 6. 'Select suppliers' sub-process

When a supplier triggers a non-compliance, the focal firm can either continue or terminate its relationship with that supplier. Terminating a relationship forces the focal firm to select a new supplier by following the same supplier selection process the firm relied on at $t = 0$. On the other hand, continuing a relationship with a non-compliant supplier may require a corrective action, because the focal firm may hope that the supplier improves its capability C^S to a level that satisfies the selection criterion $C^S \geq T_c$. Nevertheless, success is not guaranteed and the supplier's current capability C^S , its risk impact I^S and the focal firm's selection standard T_c determine the probability P of a successful corrective action. I use the functional form $P = \left(C^S/T_c\right)I^S$ to capture the following properties: the lower C^S is relative to T_c , or the lower I^S is (and thus the less the supplier's incentive to improve its capability), the less likely the corrective action will succeed. When the non-compliant supplier already possesses capability that satisfies the focal firm's selection criterion, then no corrective action takes place.

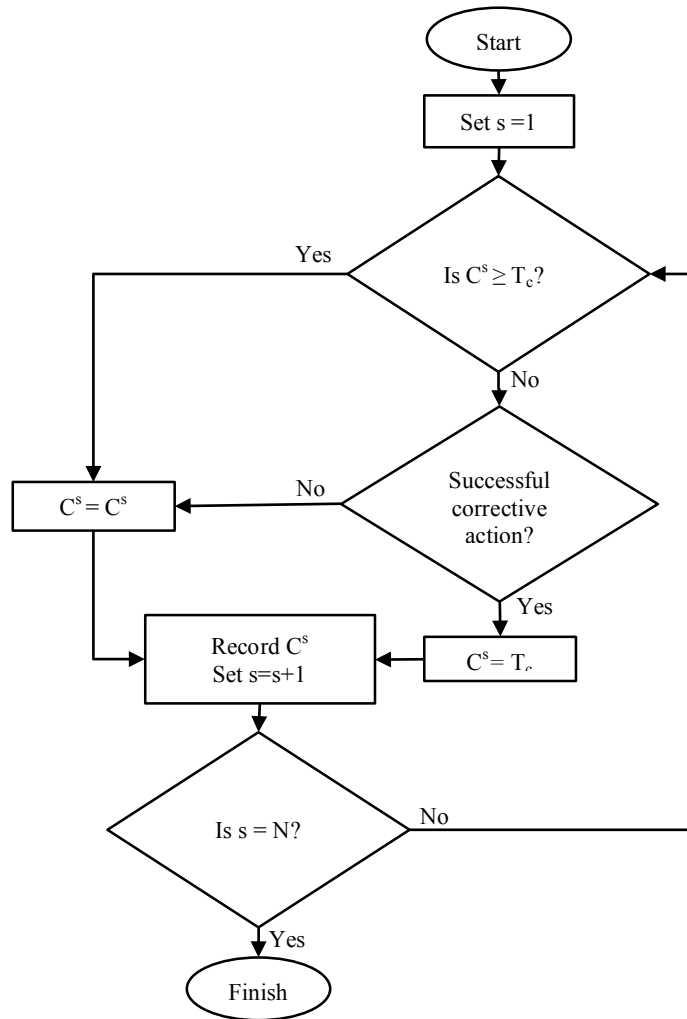


Figure 7. 'Non-compliant suppliers attempt corrective action' sub-process

The four identified approaches to supplier risk management – *risk mitigation*, *relationship-enabled risk avoidance*, *stakeholder-enabled risk avoidance* and *risk tolerance* – differ in terms of (1) how the focal firm selects its suppliers and (2) how it ensures supplier compliance. Table 6 summarizes the differences. A firm engaged in *risk mitigation* strives to have comprehensive information about supplier processes every time it requests an order from a supplier. These firms select suppliers with capabilities that satisfy the selection criterion $C^s \geq T_c$. At the same time, the firm accepts suppliers with any level of I^s because its employees are present in suppliers' facilities to assure supplier compliance. Furthermore, the simulation takes into account that not all firms can mitigate the risk of supplier non-compliance to the same degree. A firm's ability and motivation to identify and remove potential triggers of supplier non-compliance increase as the impact of non-compliance and the firm's supply management capability also increase. As a result, if the firm engages in *risk mitigation* the probability of non-compliance associated with supplier s depends on the supplier's capability and risk impact and the firm's capability and risk impact, $P_{NC}^s = a(1 - C^s I^s)(1 - C^F I^F)$.

A firm engaged in *relationship-enabled risk avoidance* believes its suppliers strive to comply owing to their mutual close relational ties. Hence, the focal firm believes that the selected suppliers can be impacted by their non-compliance, which then incentivizes them to comply with the firm's order requirements. In addition to selecting suppliers with capability that satisfies the selection criterion $C^s \geq T_c$, the focal firm then also selects suppliers that are impacted by their non-compliances at least as much as the focal firm is. In other words, the focal firm considers a second selection criterion, $I^s \geq I^f$. Nevertheless, success is not guaranteed and the focal firm's risk impact I^f determines the probability of selecting a supplier who will be impacted as much as the firm if non-compliance occurs. I use the functional form $P(I^s \geq I^f) = \beta I^f$ ($\beta = 1$ without

loss of generality) to ensure that the greater the focal firm's risk impact is, the greater its incentive to select suppliers that also face high levels of risk impact. By satisfying both selection criteria, the likelihood that any of the focal firm's suppliers fails to comply decreases, since $P_{NC}^S = a(1 - C^S I^S)$ approaches 0 as C^S and I^S increase.

	Risk tolerance	Relationship-enabled risk avoidance	Risk mitigation	Stakeholder-enabled risk avoidance
Supplier selection criteria	$C^S \geq T_c$	$C^S \geq T_c;$ $I^S \geq I^f$	$C^S \geq T_c$	$C^S \geq T_c;$ $I^S \geq I^e$
Likelihood of supplier non-compliance	$P_{NC}^S = a(1 - C^S I^S)$	$P_{NC}^S = a(1 - C^S I^S)$	$P_{NC}^S = a(1 - C^S I^S)(1 - C^f I^f)$	$P_{NC}^S = a(1 - C^S I^S)(1 - C^e)$

Table 6. Four approaches to manage supplier risks

A firm engaged in *stakeholder-enabled risk avoidance* believes that it does not face supplier risks because a powerful external stakeholder is controlling the suppliers. In addition to selecting suppliers with capability that satisfy the selection criterion $C^S \geq T_c$, the focal firm selects from suppliers incentivized to comply by a powerful external stakeholder that sets a lower bound I^e on their risk impact, $I^S \geq I^e$. Not all suppliers are guaranteed to face such risk impact with the probability of selecting a supplier with the required risk impact expressed as $P(I^S \geq I^e) = \gamma I^e$ ($\gamma = 1$ without loss of generality). The greater the risk impact the stakeholder imposes on the suppliers, the more likely suppliers satisfy this selection criterion. Moreover, representatives of the stakeholder in the suppliers' facilities can identify and remove potential triggers of non-compliance. Consequently, a supplier's likelihood of non-compliance, P_{NC}^S , depends not only on its capability C^S and risk impact I^S , but also on the capability of the stakeholder, C^e . I therefore adjust the likelihood of non-compliance by using the functional form $P_{NC}^S = a(1 - C^S I^S)(1 - C^e)$, which captures a reduction in the likelihood of non-compliance owing to a more capable stakeholder controlling a firm's suppliers.

A firm engaged in *risk tolerance* does not invest significant resources in supplier risk management accepting a certain exposure to supplier risks. During supplier selection, the firm focuses on selecting suppliers with sufficient capability level, $C^s \geq T_c$ and accepts suppliers with any level of I^s . Once suppliers are selected, the firm does not seek to have comprehensive information about supplier processes. Instead, it manages supplier non-compliances only if they occur. As a result, the likelihood of non-compliance that its supplier s exhibits is determined by the supplier's capability C^s and its risk impact I^s , $P_{NC}^s = a(1 - C^s I^s)$.

Simulation results

The simulation was set to answer the following research question: *what decisions should firms make to reduce the likelihood of supplier non-compliance?* To answer this question, I first focused on the decision-making of a firm that has chosen a particular approach to managing supplier risks. By doing so, I was able to explore in detail how simulation parameters influence the likelihood of supplier non-compliance a firm faces under each approach. The simulation results reveal that the parameters often interact, thus influencing the extent to which each parameter affects the likelihood of non-compliance. Table 7 summarizes pairwise interactions of parameters under each approach to supplier risk management and shows how each parameter affects the likelihood of non-compliance. Below I focus on the most revealing results.

Approach	Firm reduces the likelihood of non-compliance if...	Steeper likelihood of non-compliance reduction if ...				
		Reaction to non-compliance	Firm's capability	Selection standard	Supply chain size	Stakeholder's capability
<i>Stakeholder enabled risk avoidance</i>	Firm's capability ↑	-		↑	↓	↓
	Selection standard ↑	-	↑		↓	↓
	Supply chain size ↓	-	↑	↑		↓
	Stakeholder's capability ↑	-	↓	↓	↑	
<i>Relationship enabled risk avoidance</i>	Firm's capability ↑	Terminate Relationship		↑	↓	-
	Selection standard ↑	-	↑		↓	-
	Supply chain size ↓	-	↑	↑		-
<i>Risk mitigation</i>	Firm's capability ↑	-		↓	↑	-
	Selection standard ↑	-	↓		-	-
	Supply chain size ↓	-	↓	-		-
<i>Risk tolerance</i>	Firm's capability ↑	Terminate Relationship		-	↓	-
	Selection standard ↑	-	-		↓	-
	Supply chain size ↑	Terminate Relationship	↑	↑		-

↑ - increase, ↓ - decrease

Table 7. Summary of simulation results

The effect of parameters under stakeholder enabled risk avoidance

In many regulated industries, firms rely on a powerful external stakeholder to avoid supplier compliances. The simulation shows that under *stakeholder enabled risk avoidance* the likelihood of supplier non-compliance is largely determined by the stakeholder's capability. As portrayed in Figure 8, when the stakeholder has high capability, the firm faces negligible likelihood of non-compliance and thus avoids this risk. Furthermore, even if the firm lacks capability and uses low selection standards, the likelihood of non-compliance remains low.

Alternatively, when the involved stakeholder has low capability, the firm should seek ways to complement the stakeholder's insufficient efforts to reduce the likelihood of non-compliance. As Figure 8 shows, it should have stricter selection standards. In addition, the firm can reduce the likelihood of non-compliance by sourcing from fewer suppliers. That is, a firm with small supply base is less dependent on the stakeholder's capability. The likely reason is that such a firm faces lower chance of overestimating ability of each of its suppliers to comply with its order requirements. These two decisions have greater effect on the likelihood as the stakeholder's capability decreases. Finally, as expected, when the stakeholder lacks capability, a firm with high capability faces lower likelihood of non-compliance. However, even high-capability firms should have stricter selection standards and source from fewer suppliers.

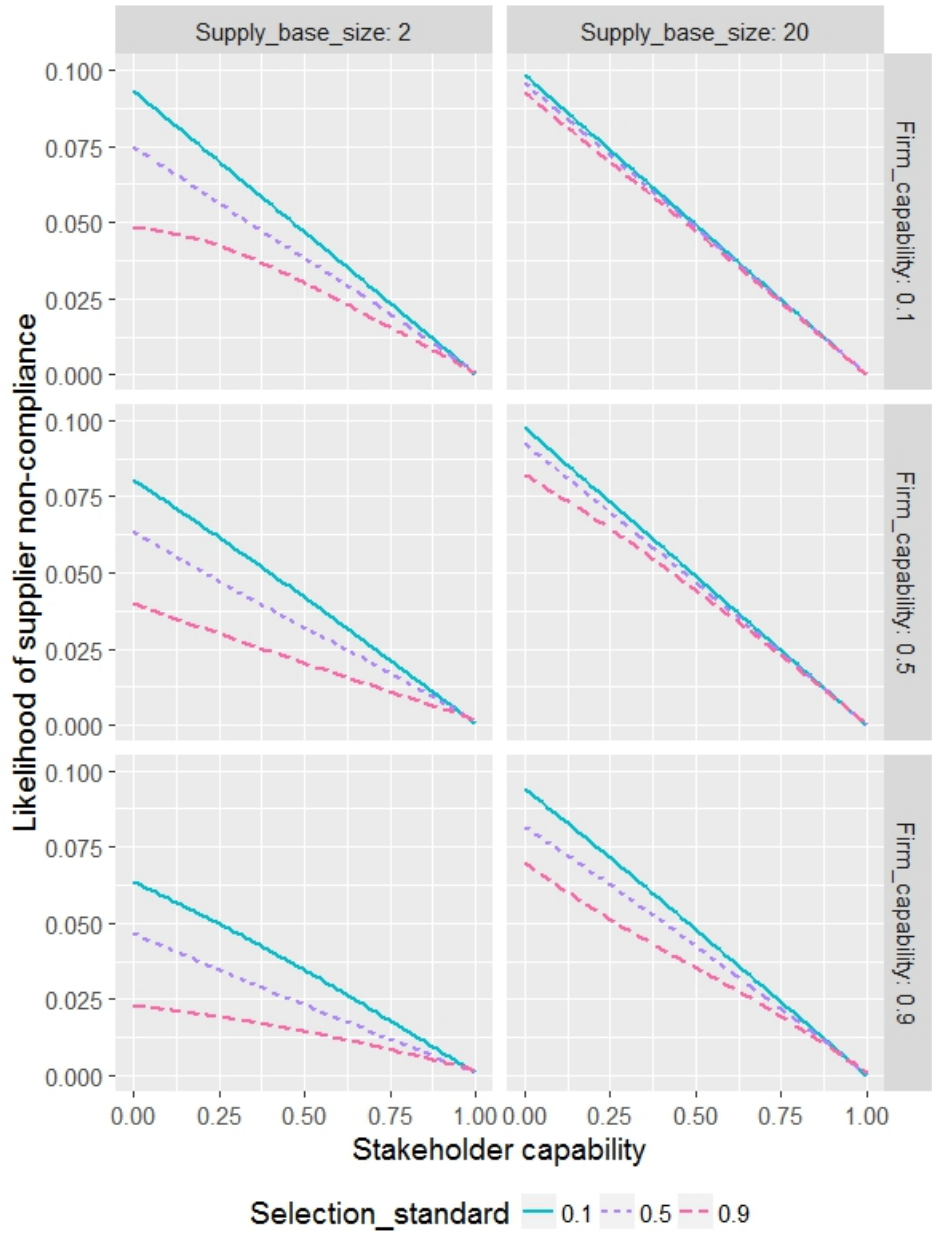


Figure 8. The role of stakeholder’s capability in determining the likelihood of supplier non-compliance under *stakeholder enabled risk avoidance*

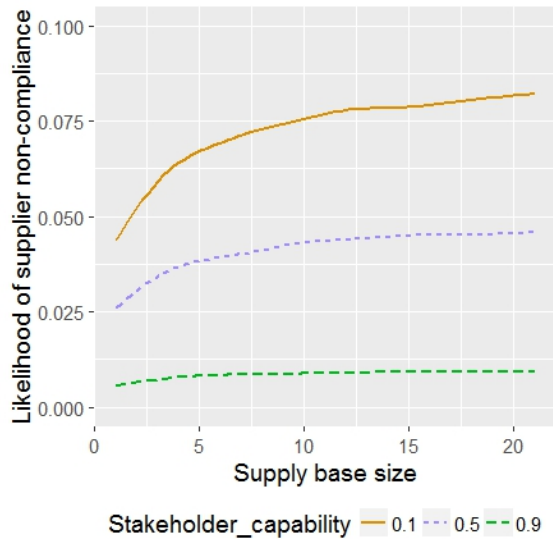


Figure 9. The role of a firm’s supply base size in determining the likelihood of supplier non-compliance under *stakeholder enabled risk avoidance*

The simulation also reveals that under *stakeholder enabled risk avoidance* supply base size has an unexpected role in determining the likelihood of non-compliance. As portrayed in Figure 9, if the involved stakeholder has high capability, a firm will only marginally increase the likelihood of non-compliance if it chooses to increase the size of its supply base. In contrast, if the stakeholder lacks capability the effect of supply base size on the likelihood of non-compliance is non-linear, with the likelihood decreasing at an increasing rate as supply base size decreases.

Conjecture 1. If the involved stakeholder lacks capability, then a firm engaged in *stakeholder enabled risk avoidance* should increase its selection standard to achieve a lower likelihood of non-compliance.

Conjecture 2. If the involved stakeholder lacks capability, then a firm engaged in *stakeholder enabled risk avoidance* should have a small supply base to achieve a lower likelihood of non-compliance.

The effect of parameters under relationship enabled risk avoidance

A firm engaged in *relationship enabled risk avoidance* believes that close relational ties with its suppliers motivate the suppliers to comply with its requirements. For that reason, such a firm deems it unnecessary to acquire comprehensive information on supplier processes to ensure compliance. The simulation shows that under *relationship enabled risk avoidance* the likelihood of non-compliance is highly sensitive to the size of the firm's supply base. In fact, supply base size not only largely determines the likelihood of non-compliance, but it also moderates the effect of other parameters on the likelihood of non-compliance. First, the effect of supply base size on the likelihood of non-compliance is non-linear with the likelihood decreasing at an increasing rate as supply base size decreases (Figure 10). Second, increasing the firm's selection standard leads to a greater reduction in the likelihood of non-compliance when a firm has a small supply base (Figure 10). In addition, a firm engaged in *relationship enabled risk avoidance* rarely benefits from relationship continuity with suppliers that have caused non-compliances. In general, such a firm is better off terminating relationships with non-compliant suppliers, especially if it has a strict selection standard (Figure 10). Finally, supply base size determines the extent to which a firm's capability affects the likelihood of non-compliance (Figure 11). Only if a firm has a small supply base, does improving its capability linearly decrease the likelihood of non-compliance. In contrast, if a firm has a large supply base, then improving its capability will substantially decrease the likelihood only after a certain threshold. As a result, if a firm with average capability chooses to have large supply base, it will face a likelihood of non-compliance similar to that faced by a low-capability firm.

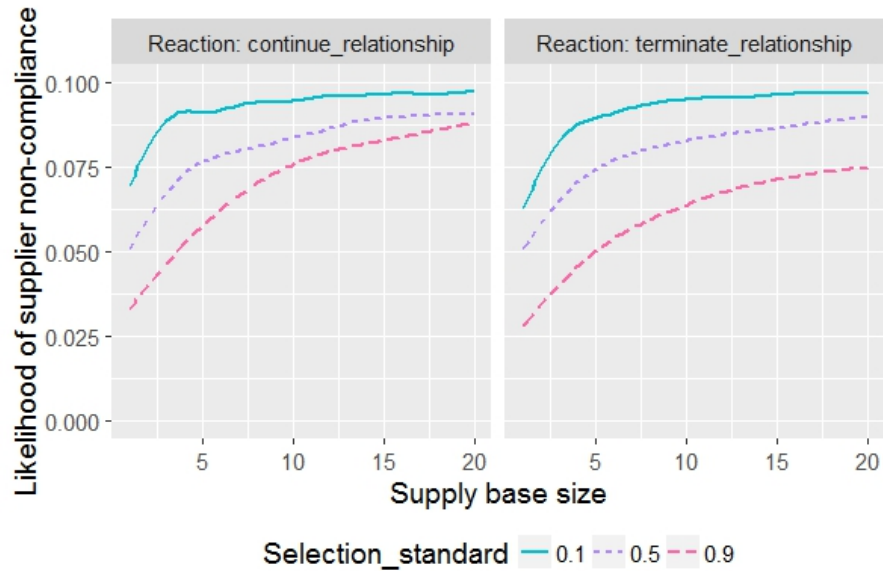


Figure 10. The role of a firm’s supply base size in determining the likelihood of supplier non-compliance under *relationship enabled risk avoidance*

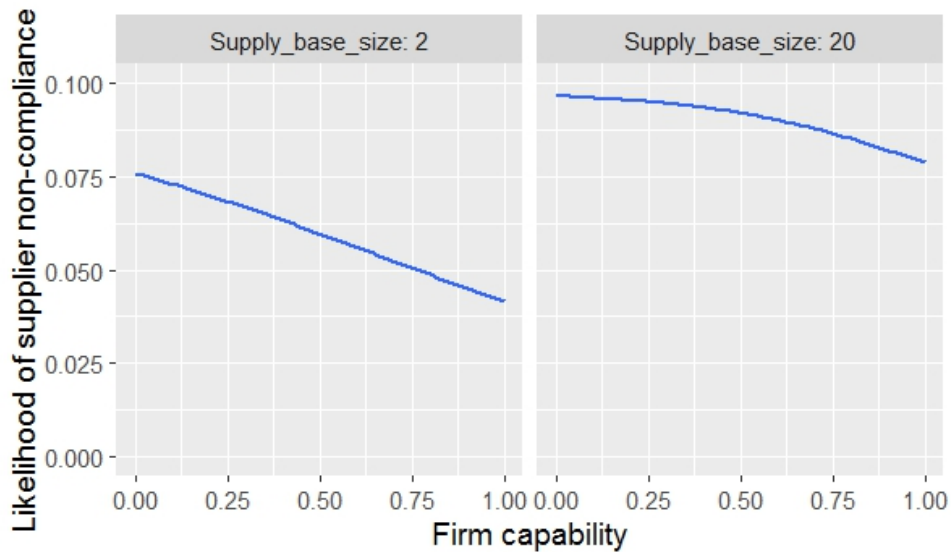


Figure 11. The role of a firm’s capability in determining the likelihood of supplier non-compliance under *relationship enabled risk avoidance* in small and large supply bases

Overall, one of the key decisions for a firm engaged in *relationship enabled risk avoidance* is to have a small supply base, since sourcing from a limited number of suppliers offers a firm more opportunities to decrease the likelihood of supplier non-compliance. While unexpected, the effect of supply base size has an intuitive explanation: these firms choose not to seek comprehen-

sive information on supplier processes and trust that their suppliers have both the potential and the motivation to remain compliant. The more suppliers such a firm procures from, the more likely it is to overestimate the potential of its suppliers to comply.

Conjecture 3. A firm engaged in *relationship enabled risk avoidance* should have a small supply base to achieve a lower likelihood of non-compliance.

Conjecture 4. A firm engaged in *relationship enabled risk avoidance* that has a small supply base can further decrease the likelihood of non-compliance by

- (a) terminating relationships with a supplier that has caused a non-compliance; or
- (b) having greater capability; or
- (c) increasing its selection standard.

Conjecture 5. A firm engaged in *relationship enabled risk avoidance* that has a large supply base faces a capability threshold below which lower capability levels are no longer associated with a higher likelihood of non-compliance.

The effect of parameters under risk mitigation

A firm that seeks to have comprehensive information on supplier processes to engage in *risk mitigation* chooses this approach to manage supplier risks because it believes that supplier processes contain triggers of potential supplier non-compliances. Such a firm then seeks to utilize its internal resources to identify and remove these risk triggers. The simulation shows that the extent to which this firm is able to mitigate the risk of supplier non-compliance largely depends on its capability (Figure 12). In addition, a firm's capability determines whether the firm's decisions on its selection standard and supply base size affect the likelihood of non-compliance. For high-capability focal firms, the impact of the selection standard (i.e., minimum level of capability T_c for each selected supplier) on their likelihood of supplier non-compliance is relatively small (Figure 12). Firms with low-to-average supply chain capabilities can decrease the likelihood of

non-compliance by increasing the supplier selection standard but only if they have small supply bases. The limited role of selection standard shows that in general firms engaged in *risk mitigation* do not require sourcing from reliable suppliers to decrease the likelihood of non-compliance. Finally, as Figure 13 shows, the size of a firm’s supply base affects the likelihood of non-compliance only for firms with low-to-average capabilities. The non-linear effect of supply base size on the likelihood of non-compliance observed under other approaches to supplier risks is present only at lower firm’s capability levels under *risk mitigation*. When a firm has a high capability, it will face only a marginally higher likelihood of non-compliance if it chooses to increase the size of its supply base.

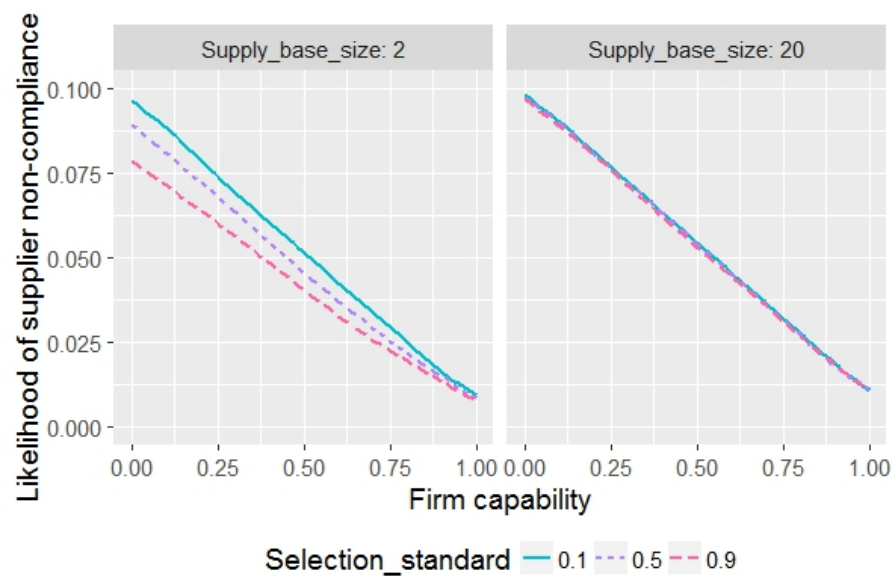


Figure 12. The role of a firm’s capability and its selection standard in determining the likelihood of supplier non-compliance under *risk mitigation* in small and large supply bases

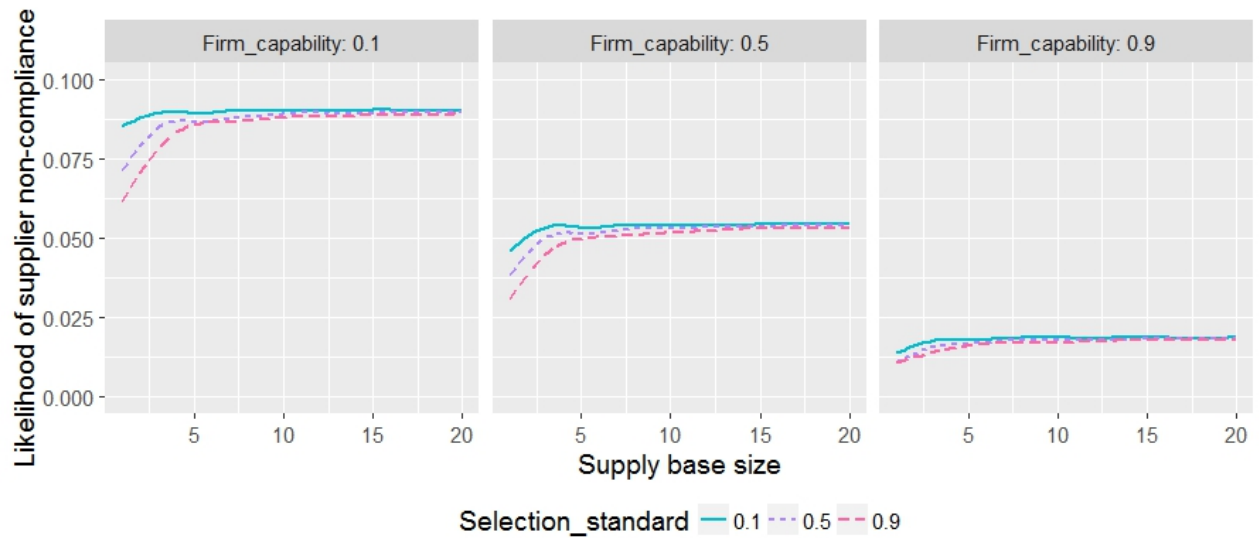


Figure 13. The role of a firm’s supply base size in determining the likelihood of supplier non-compliance under *risk mitigation*

Overall, under *risk mitigation* the likelihood of supplier non-compliance is to a great extent determined by a firm’s own capability rather than by its supply-chain-related decisions. That is, under this approach, the likelihood is shaped by the extent a firm is able to identify and remove potential triggers of supplier non-compliance. Only if a firm lacks capability, then decisions such as supply base size and selection standard affect the likelihood of non-compliance.

Conjecture 6. A firm engaged in *risk mitigation* should seek to increase its capability to achieve a lower likelihood of non-compliance.

Conjecture 7. A firm engaged in *risk mitigation* that lacks capability should increase its selection standard to achieve a lower likelihood of non-compliance.

Conjecture 8. A firm engaged in *risk mitigation* that lacks capability should have a small supply base to achieve a lower likelihood of non-compliance.

The effect of parameters under risk tolerance

Some firms choose not to invest significant resources in managing supplier risks and tolerate possible supplier non-compliance. One would expect these firms to face high level of likelihood of non-compliance. In general, the simulation results provide support for this *a priori* expectation. In addition, the simulation clarifies that just as under *relationship enabled risk avoidance*, under *risk tolerance* the likelihood of non-compliance depends to a greater extent on the size of a firm's supply base. Specifically, the simulation reveals the non-linear effect of supply-base-size on the likelihood of non-compliance, similar to that observed under *relationship enabled risk avoidance*. This similarity between the two approaches is likely because neither approach relies on monitoring supplier processes. However, under *risk tolerance* the non-linear effect is more pronounced and characterized by a threshold. Above this threshold, increasing supply base size no longer increases the likelihood. Below the threshold, decreasing supply base size decreases the likelihood at an increasing rate (Figure 14). The non-linear effect of supply base size reveals an interesting result: a smaller supply base allows a firm engaged in *risk tolerance* to face lower likelihood of non-compliance even if both the firm's capability and its selection standard are low. In addition, if a firm chooses to have a small supply base it can further decrease the likelihood of non-compliance by increasing its selection standard and terminating relationships with non-compliant suppliers (Figure 15). In contrast, if a firm engaged in *risk tolerance* decides to have a large supply base, neither these decisions nor the exact size of supply base affect the likelihood of non-compliance. Furthermore, firms engaged in *risk tolerance* tend to face similar likelihood of non-compliance regardless of their capability (Figure 15). The reason lies in limited efforts to manage supplier risks under *risk tolerance*. Capability determines how effective a firm's efforts are at managing supplier risks. Since under *risk tolerance* these efforts are limited,

the effect of capability on the likelihood of supplier non-compliance is also limited. As Figure 15 shows, the expected positive impact of capability appears only when a firm has a small supply base.

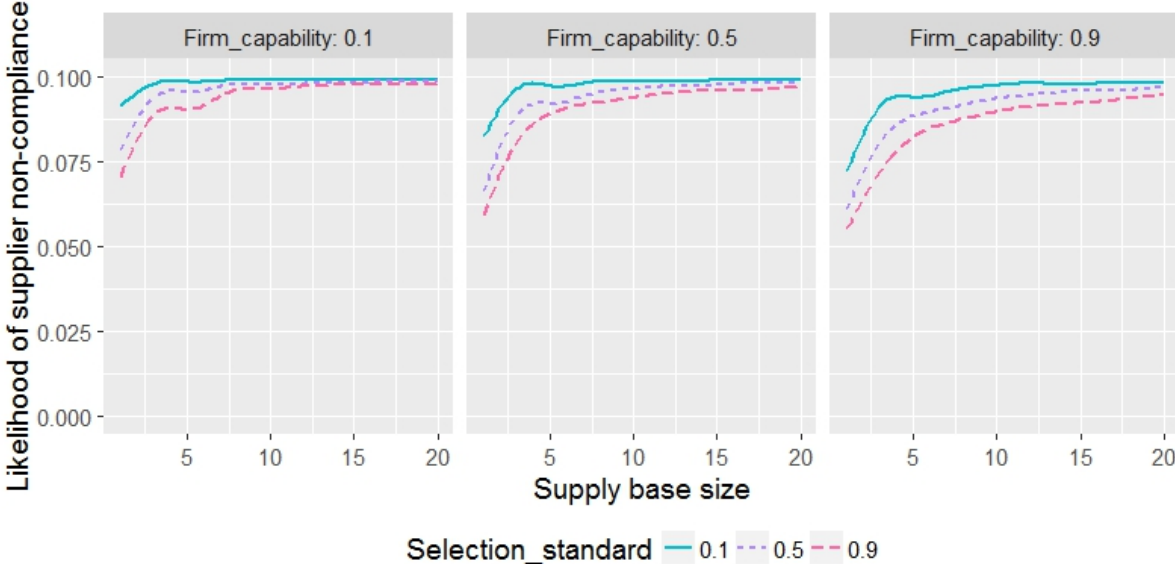


Figure 14. The role of a firm’s supply base size in determining the likelihood of supplier non-compliance under *risk tolerance*

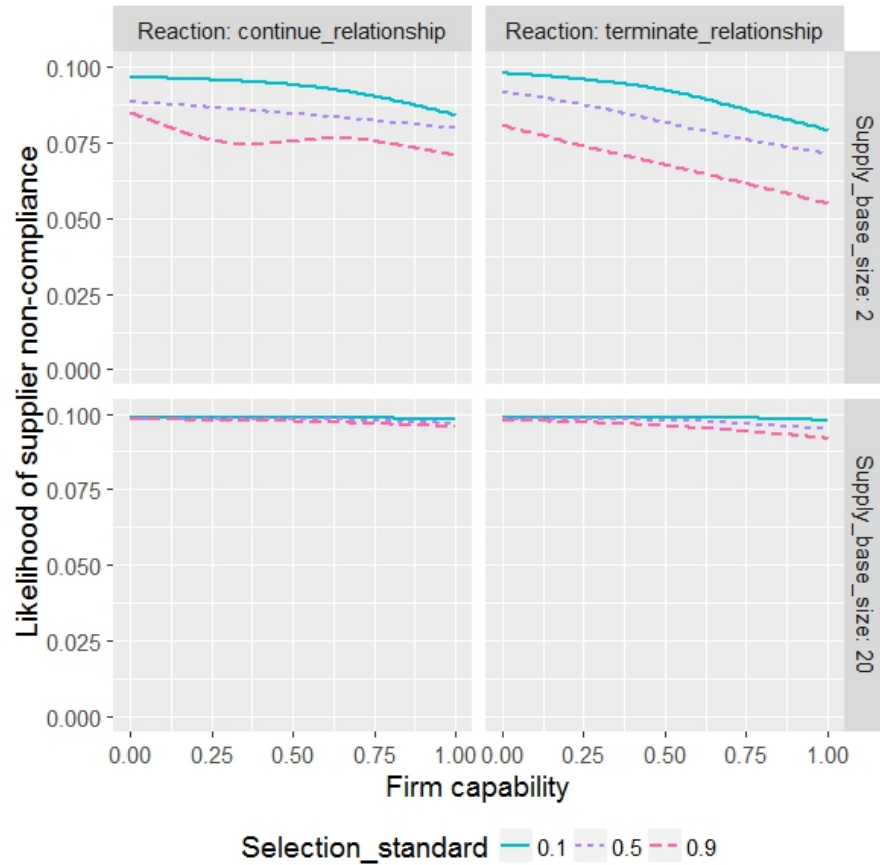


Figure 15. The role of a firm’s capability in determining the likelihood of supplier non-compliance under *risk tolerance* in small and large supply bases

Conjecture 9. A firm engaged in *risk tolerance* should have a small supply base to achieve a lower likelihood of non-compliance.

Conjecture 10. A firm engaged in *risk tolerance* that has a small supply base can further decrease the likelihood of non-compliance by

- (a) terminating its relationships with a supplier that has caused a non-compliance; or
- (b) having greater capability; or
- (c) increasing its selection standard.

Comparing approaches to supplier risk management

The second part of the analysis focuses on comparing the likelihood of non-compliance a firm faces under each of the four approaches to supplier risks. In general, one would expect *risk tolerance* to be associated with the highest likelihood of supplier non-compliance and *risk mitigation* to be associated with the lowest likelihood of supplier non-compliance. However, the impact of engaging in either *relationship enabled risk avoidance* or *stakeholder enabled risk avoidance* on the likelihood of supplier non-compliance is unclear. Consequently, these two approaches to supplier risk management is the focus of the following analysis. First, it remains unclear whether *relationship enabled risk avoidance* resembles *risk tolerance* or *risk mitigation*. On the one hand, similar to *risk tolerance*, *relationship enabled risk avoidance* does not depend on having comprehensive information on potential triggers of supplier risks. On the other hand, firms use *relationship enabled risk avoidance* because they firmly believe that their suppliers are motivated to remain compliant. Second, it is unclear whether *stakeholder enabled risk avoidance* is superior to *risk mitigation*. On the one hand, the involved stakeholder not only monitors supplier processes but also keeps a firm's suppliers accountable for their non-compliances and thus provides external incentives for the suppliers to remain compliant. On the other hand, an involved stakeholder may lack the capability to identify potential triggers of supplier non-compliance.

The analysis described below addresses these questions. First it focuses on comparing *relationship enabled risk avoidance* with *risk tolerance* and *risk mitigation*. Then it compares *stakeholder enabled risk avoidance* with *risk mitigation*. I exclude *risk tolerance* from the latter analysis because the cases in which powerful external stakeholders are involved in controlling firms' suppliers reveal that such a stakeholder involvement exists due to the high potential impact a supplier non-compliance can have not only on the firms, but also on the final customers. There-

fore, due to the high-risk impact, one would not expect firms in these industries to engage in *risk tolerance*.

The simulation results propose that *relationship enabled risk avoidance* tends to allow firms to achieve a lower likelihood of non-compliance than under *risk tolerance* (Figures 16 and 17). Yet, four conditions can reduce the likelihood gap between using *relationship enabled risk avoidance* and *risk tolerance*. First, as portrayed in Figure 16, lower capability level reduces the gap. A low-capability firm engaged in *relationship enabled risk avoidance* faces a likelihood of supplier non-compliance similar to the likelihood under *risk tolerance*. Figure 16 also demonstrates that lowering selection standard increases the likelihood of non-compliance under *relationship enabled risk avoidance*, making it more similar to that under *risk tolerance*. Overall, the impact of having low capability or selection standard on the likelihood of supplier non-compliance points out to the same conclusion: choosing suppliers motivated to remain compliant by selecting suppliers that face high risk impact I^s is insufficient to ensure compliance. *Relationship enabled risk avoidance* is superior to *risk tolerance* in decreasing the likelihood of supplier non-compliance only if a firm addresses the threat of adverse selection. That is, only a capable firm with high selection standard can ensure that it selects capable suppliers and thus eliminates the threat of adverse selection.

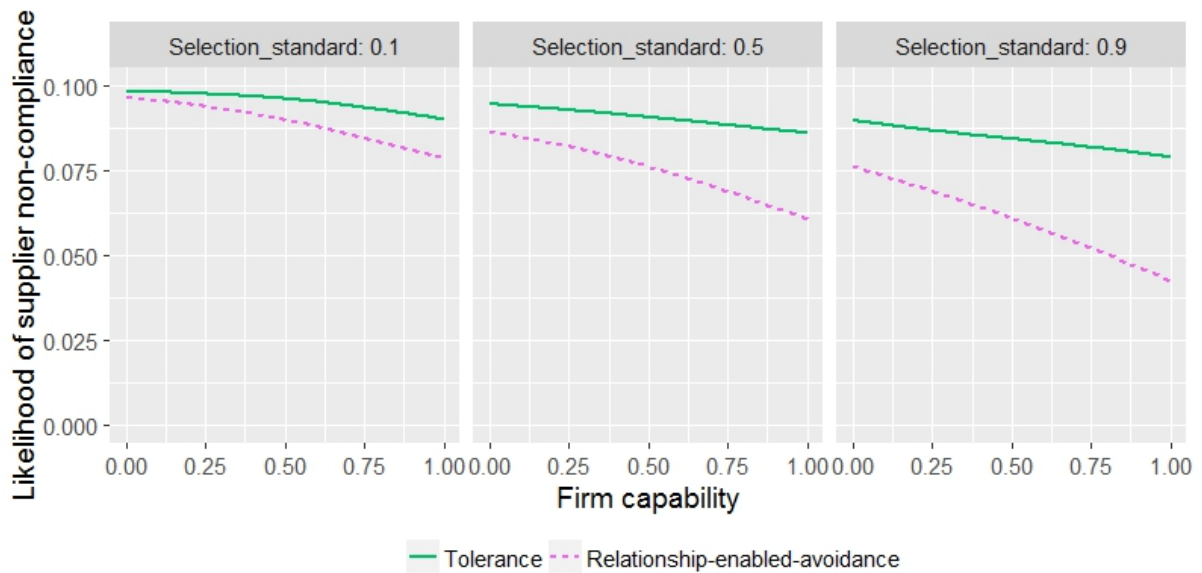


Figure 16. The role of a firm's capability in determining the likelihood of supplier non-compliance under *risk tolerance* vs. under *relationship-enabled risk avoidance*

Third, the likelihood of non-compliance under *relationship enabled risk avoidance* approaches the likelihood under *risk tolerance* when a firm continues relationships with suppliers that have failed to comply (Figure 17). Despite the emphasis on relationship continuity among firms relying on relational governance (Jiang, 2009; Nyaga et al., 2010), from the risk management perspective a firm engaged in *relationship enabled risk avoidance* rarely benefits from continuing relationships with suppliers that have failed to comply. This result provides a support for Vilena et al.'s (2011) warning against over-relying on trust-based relationships. Finally, a firm engaged in *relationship enabled risk avoidance* that chooses to increase its supply base faces an increasing likelihood of supplier non-compliance, thus decreasing the gap with *risk tolerance* (Figure 17). However, the effect of the supply base size on that gap is small because none of these approaches requires comprehensive information on supplier processes, while both face a non-linear effect of supply base size on the likelihood of non-compliance. Therefore, under both ap-

proaches, a firm with a large supply base faces an increasing chance that the threat of adverse selection has materialized.

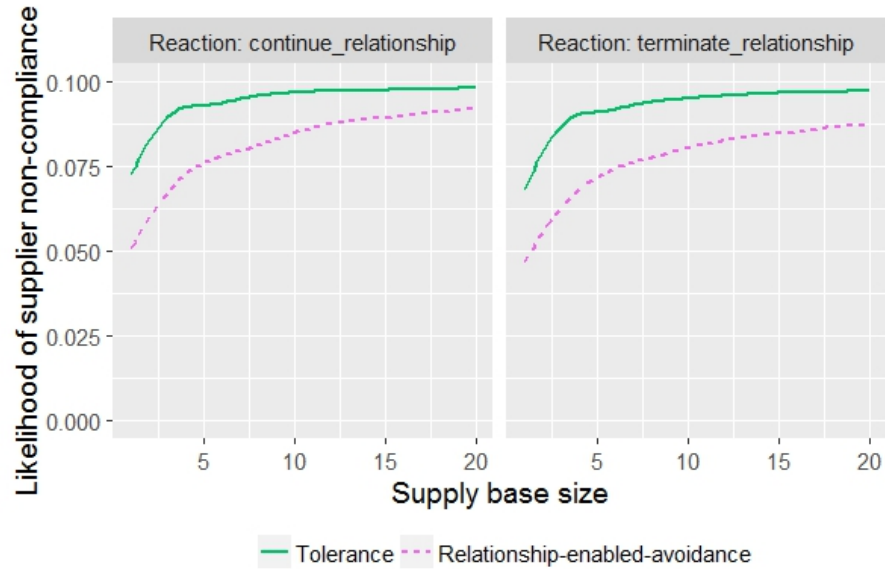


Figure 17. The role of a firm’s supply base size in determining the likelihood of supplier non-compliance under *risk tolerance* vs. under *relationship-enabled risk avoidance*

Conjecture 11. A firm faces a lower likelihood of non-compliance if it engages in *relationship enabled risk avoidance* rather than in *risk tolerance*, but both likelihoods converge if

- (a) it continues relationships with a supplier that has caused a non-compliance; or
- (b) its capability level decreases; or
- (c) it decreases its selection standard; or
- (d) it increases its supply base size.

The simulation further compares *relationship enabled risk avoidance* and *risk mitigation*. The simulation results show that for high-capability firms, *risk mitigation* is the better choice. In contrast, if a firm engaged in *relationship enabled risk avoidance* lacks capability, then it can achieve a likelihood of supplier non-compliance that is similar to that under *risk mitigation*. In

fact, a firm faces a lower likelihood of non-compliance under *relationship enabled risk avoidance* than under *risk mitigation* provided it makes the following supply-chain-related decisions. First, supply base size must be small, with the likelihood of non-compliance decreasing at an increasing rate as the size diminishes (Figure 18). Second, rather than requesting a corrective action from non-compliant suppliers, the firm should terminate the relationships (Figure 19). Third, the firm's selection standard for determining the minimum level of capability for each of its selected suppliers must be as strict as possible, with the likelihood of non-compliance decreasing at an increasing rate as the selection standard increases (Figure 19). The rationale for this finding goes as follows. When a firm believes that its suppliers can ensure compliance without its direct involvement, it faces a threat of overestimating its suppliers' likelihood to comply. A small supply base, that is selected using strict criteria and faces termination for non-compliance, diminishes this threat. High capability firms that make these choices will also reduce the likelihood of non-compliance when using *relationship enabled risk avoidance*. However, high capability firms still have lower likelihood of non-compliance when they use *risk mitigation*.

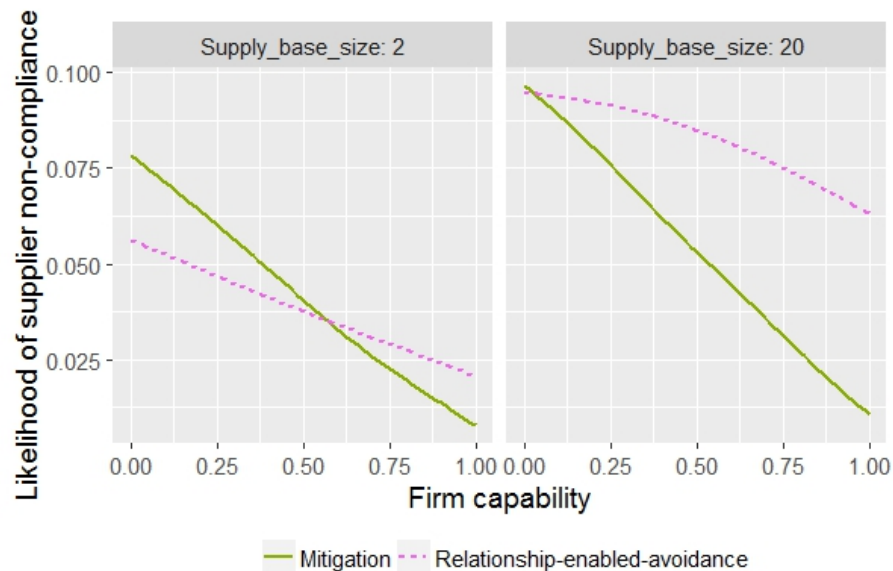


Figure 18. The role of a firm's capability in determining the likelihood of supplier non-compliance under *risk mitigation* vs. under *relationship-enabled risk avoidance* in small and large supply bases (selection standard set at 0.9)

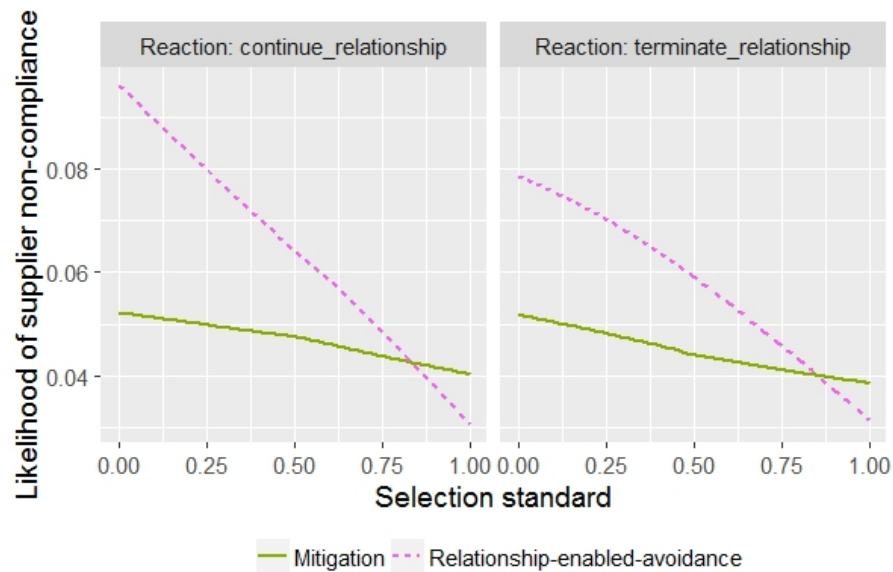


Figure 19. The role of a firm's selection standard in determining the likelihood of supplier non-compliance under *risk mitigation* vs. *relationship-enabled risk avoidance* (firm's capability set at 0.5; supply base set at 2)

Conjecture 12. A firm faces a higher likelihood of non-compliance if it engages in *relationship enabled risk avoidance* rather than in *risk mitigation*, but both likelihoods converge if

- (a) it terminates relationships with a supplier that has caused a non-compliance;
- or
- (b) its capability level decreases; or
- (c) it increases its selection standard; or
- (d) it decreases its supply base size.

Conjecture 13. A firm should favor *relationship enabled risk avoidance* over *risk mitigation* when all conditions in Conjecture 12 are present.

Having a stakeholder regulating suppliers is generally not a firm's choice. Nevertheless, the simulation allows to examine whether firms benefit from such an arrangement in terms of risk

management. The simulation reveals that one should compare a firm's capability and that of the involved stakeholder to understand whether the firm benefits from a powerful external stakeholder regulating its suppliers. In general, a firm should favor *stakeholder enabled risk avoidance* over *risk mitigation*, even when its capability exceeds the stakeholder's capability. The likely reason is the stakeholder's dual role of monitoring and incentivizing suppliers. However, as portrayed in Figure 20, this only holds true as long as the firm's capability does not exceed a certain threshold. Everything else being equal, this threshold is higher when the firm has a smaller supply base. In other words, even when the stakeholder's capability is relatively lower than the firm's capability, a small supply base can enable the firm to prefer *stakeholder enabled risk avoidance* over *risk mitigation* (Figure 20). On the other hand, a firm with a large supply base should prefer *stakeholder enabled risk avoidance* over *risk mitigation* only if the stakeholder's capability is marginally lower than the firm's capability (Figure 20). Having a larger supply base makes it more likely that the firm sources from a supplier that cannot assure compliance, despite the stakeholder involvement. In contrast, under *risk mitigation* the likelihood of non-compliance is less sensitive to the supply base size. Finally, the simulation also suggests a relationship between the selection standards for the suppliers' capability and a firm's likelihood of non-compliance for these suppliers. As portrayed in Figure 21, even when stakeholders possess low capability, the firm should favor *stakeholder enabled risk avoidance* over *risk mitigation* if its supply base is small and its selection standard is high. In other words, to compensate for the stakeholder's insufficient ability to ensure supplier compliance, the firm should source from fewer suppliers and increase their selection standards.

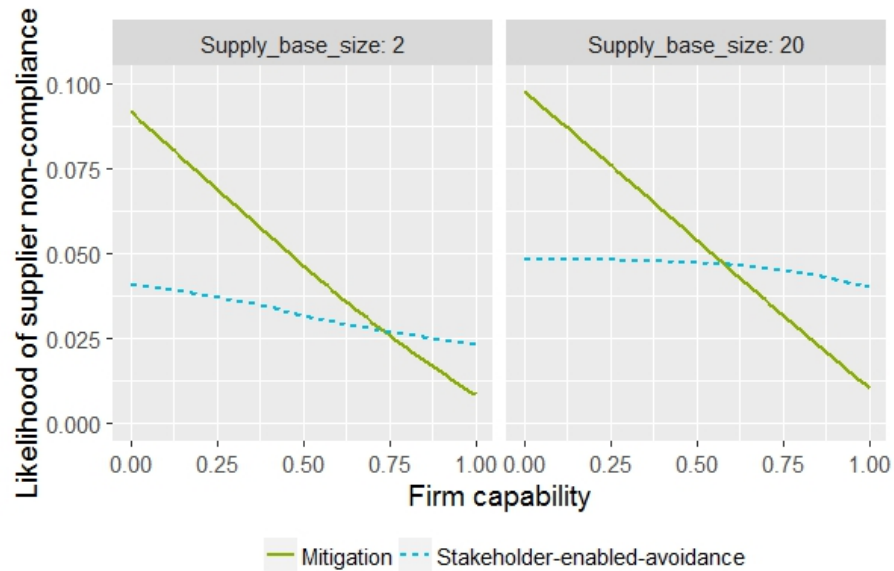


Figure 20. The role of a firm’s capability in determining the likelihood of supplier non-compliance under *risk mitigation* vs. under *stakeholder-enabled risk avoidance* in small and large supply bases (stakeholder’s capability set at 0.5)

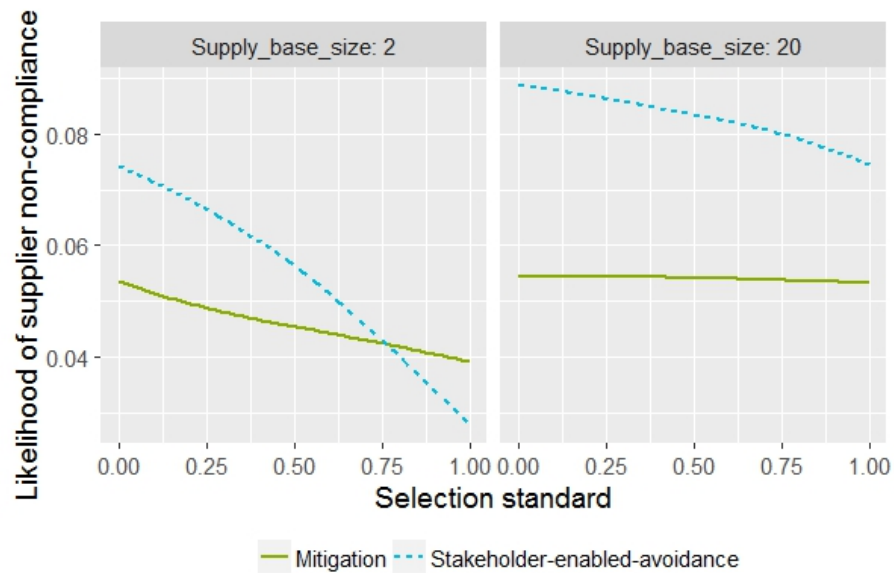


Figure 21. The role of a firm’s selection standard in determining the likelihood of supplier non-compliance under *risk mitigation* vs. under *stakeholder-enabled risk avoidance* in small and large supply bases (firm’s capability set at 0.5; stakeholder’s capability set at 0.1)

Conjecture 14. When the involved stakeholder’s capability is higher than the firm’s, the firm should favor *stakeholder enabled risk avoidance* over *risk mitigation*.

Conjecture 15. A firm with a large supply base should favor *stakeholder enabled risk avoidance* over *risk mitigation* even if the stakeholder's capability is marginally lower than the firm's.

Conjecture 16. A firm with a small supply base and strict selection standard should favor *stakeholder enabled risk avoidance* over *risk mitigation* even when the stakeholder's capability is significantly lower than the firm's.

CHAPTER FIVE: DISCUSSION

The supplier risk management literature posits that effective management of supplier non-compliance requires comprehensive information on supplier processes to engage in *risk mitigation*. This recommendation originates from agency theory, which argues that a principal (i.e., a firm) should rely on behavioral control when facing uncertainty associated with an agent's (i.e., a supplier's) behavior (Eisenhardt, 1989A; Zsidisin and Ellram, 2003). The initial aim of this research was to collect case study data to understand how in practice firms acquire comprehensive information on supplier processes to identify and manage supplier risks and then to build an agent-based simulation to clarify how firms should acquire this information.

The collected cases, however, revealed that many firms believed that they were effectively managing supplier risks without having comprehensive information on supplier processes. Along with *risk mitigation*, the firms in the case studies engaged in three other approaches to supplier risk management: *stakeholder enabled risk avoidance*, *relationship enabled risk avoidance*, and *risk tolerance*. These three approaches do not require comprehensive information on supplier processes and rely on other means to address the risk of supplier non-compliance. The cases, therefore, offered important insights into what firms do to manage supplier risks.

The agent-based simulation incorporated these unexpected empirical findings and was used to determine what firms should do to effectively manage the risk of supplier non-compliance. Specifically, the simulation explicitly considered varying levels of a buying firm's capability, allowed manipulating the firm's supply-base-related decisions and compared the likelihood of supplier non-compliance under the four identified approaches to supplier risk management. In addition, combining the case studies and the simulation allowed juxtaposing some of the deci-

sions the sampled firms made with the simulation findings and thus compared what firms *do* with what they *should* do.

A decision to mitigate supplier risks

The literature is clear that collecting comprehensive information on supplier processes is required but often not done (e.g., Christopher and Lee, 2004; Marucheck et al., 2011; New, 2010). The collected cases reveal that firms choose to do it only when they do not have alternative approaches to address the risk of supplier non-compliance. Specifically, two criteria determine whether firms believe that they need to acquire comprehensive information on supplier processes: (1) whether suppliers have capabilities sufficient to comply with the firms' requirements; (2) whether suppliers will share the negative impact of their non-compliance. The cases are clear that if suppliers fail to meet either of these criteria then the firms will seek comprehensive information on supplier processes to mitigate the risk of supplier non-compliance, or will be willing to tolerate frequent supplier non-compliances. This finding has an important theoretical implication. It clarifies the agency theory's recommendation to use behavioral controls when a principal (i.e., a firm) faces high level of uncertainty (e.g., Zsidisin and Ellram, 2003). In the context of supplier risk management, this uncertainty can be associated not only with an agent's (i.e., supplier's) ability to complete an assigned task, but also with the consequences the agent will face in case it fails to complete the task. The results show that either source of uncertainty is sufficient to push the principal to take behavioral control measures.

Furthermore, the supplier risk management literature suggests that a close relationship between a firm and its supplier is a path to collecting the comprehensive information that *risk mitigation* requires (e.g., Barratt and Oke, 2007; Jonhston et al., 2004). The cases show that when firms engage in *risk mitigation*, it is often because a close relationship is missing and they do not

trust the supplier. This finding then contributes to the supplier risk management literature by showing that while close relationships may be one means of enabling *risk mitigation*, they are neither always required nor always desirable by either the firm or its suppliers.

While the cases reveal when firms follow the literature's recommendation to engage in *risk mitigation*, the simulation shows when firms *should* do so. The simulation results indicate that under *risk mitigation* the risk of supplier non-compliance is largely determined by a firm's capability. For high-capability firms, then, *risk mitigation* is the best approach to manage the risk of supplier non-compliance. Only these firms are able to properly use comprehensive information on supplier processes to identify and remove potential triggers of supplier non-compliance. This simulation result contributes to both agency theory and the supplier risk management literature by elaborating on Fayezi et al.'s (2012) observation that agency theory is built on an assumption of "flawless principal". Specifically, it shows that agency theory's recommendation to engage in behavioral control relies on an assumption that the principal knows how to control an agent's behavior. The supplier risk management literature shares this assumption with agency theory and therefore provides guidance only when this capability does exist.

In addition, the simulation allows examining some decisions made by the sampled firms engaged in *risk mitigation* and hence contributes to practice. For instance, the sampled firms do not use strict selection standards for their suppliers. The simulation shows that under *risk mitigation*, selection standards have a limited impact on the likelihood of non-compliance. Overall, *risk mitigation* depends on a firm's own efforts and resources to ensure compliance and hence does not require sourcing from high-capability suppliers. Second, while supply base size among sampled firms engaged in *risk mitigation* varied, the simulation shows that as long as a firm has a high capability, it will face only a marginally higher likelihood of non-compliance if it chooses to in-

crease the size of its supply base. Finally, the sampled firms engaged in *risk mitigation* have stable relationship with their supply bases. In doing so, the firms follow the literature's recommendation to complement contractual governance with certain aspects of relational governance (e.g., Poppo and Zenger, 2002). These firms consider their suppliers to be unreliable, and yet they believe that this practice helps them further mitigate the likelihood of supplier non-compliance. The simulation shows that whether or not a firm focuses on a stable relationship with an unreliable supplier has little effect on the likelihood of supplier non-compliance.

A decision to avoid supplier risks

Marucheck et al. (2011) called for a better understanding of the role supply chain relationships play in managing supplier risks. This research addresses this call. The case results show that for three of the sampled firms, relational governance offers a way to avoid supplier risks, but these firms rely on it only when they perceive that their suppliers have sufficient capabilities to remain compliant and share the potential impact of materialized risks. The firms believe that fostering close ties with these suppliers motivates them to eliminate potential triggers of non-compliance, since the suppliers value the relationship and would also suffer if something went wrong. Interestingly, despite the warning against relying on relationships to manage supplier risks (e.g., Harland et al., 2003; Villena et al., 2011), firms facing both high and low impact supplier risks engage in *relationship enabled risk avoidance*. This finding contributes to supplier risk management literature by showing that in practice, behavioral control does not constitute the preferred way to manage supplier risks. In fact, the cases indicate that firms prefer relying on an input control, in the guise of sourcing from trustworthy suppliers, to engage in *risk avoidance*. These are the same firms that, when they believe suppliers are unreliable, rely on behavioral con-

trol to mitigate risks. In other words, this is a choice they believe is effective and they are aware of *risk mitigation* as an option.

The simulation further clarifies that firms with low to average capabilities should prefer *relationship enabled risk avoidance* to *risk mitigation*. Specifically, the simulation results indicate that firms without the capability to properly collect and assess this information would be better served by using relational governance to manage a small supply base with strong incentives to comply. While the case studies show that input control may be preferred to behavioral control, this simulation finding offers a contribution to agency theory by showing conditions under which a principal firm should favor input control over behavioral control.

In addition, the simulation contributes to practice by examining a number of decisions made by the sampled firms engaged in *relationship enabled risk avoidance*, particularly those with large supply bases. The simulation indicates that to face low likelihood of supplier non-compliance, these firms should source from a limited number of suppliers. In fact, while the sampled firms emphasized the importance of selecting high-capability suppliers, the simulation reveals that when these firms source from a large number of suppliers, having high selection standards does not significantly reduce the likelihood of non-compliance. Only with a small supply base, can a firm engaged in *relationship enabled risk avoidance* diminish the threat of over-estimating a supplier's ability to remain compliant. Finally, the sampled firms that are engaged in *relationship enabled risk avoidance* seek to have stable supply bases. The simulation indicates, however, that from the perspective of supplier risk management, these firms are better off terminating their relationships with suppliers that have caused a non-compliance. This finding then contradicts the focus on close trusting relationships among the sampled firms.

Scholars argue that firms can be in a vulnerable position when they have less information about their supplier risks than their stakeholders do (e.g., New, 2010; Scherer et al., 2013). The remedy is to promptly identify potential triggers of supplier risks before their stakeholders become aware of them. Nevertheless, the cases reveal that in industries where powerful external stakeholders regulate the suppliers, firms often possess less information than their stakeholders. In fact, the sampled firms choose not to acquire comprehensive information when powerful external stakeholders regulate and control their supply bases. The firms believe that they do not need to know how their suppliers fulfill their orders, because the stakeholders impose strict requirements for supplier processes and then oversee how the suppliers adhere to these requirements. These stakeholders also contribute to aligning the goals of suppliers with those of the firms by providing suppliers with incentives to remain compliant. Specifically, in these industries a supplier's viability depends to a great extent on its ability to conform to the stakeholder's requirements. The stakeholder can deprive a non-conforming supplier of its license to operate and, as a result, sever relationships with its entire customer base, not just this one buyer. These firms believe that relying on behavior-based contractual governance without directly engaging in behavioral control is an effective way to manage the risk of supplier non-compliance. Specifically, these firms are convinced that the requirements the stakeholders impose on suppliers are sufficient to ensure their compliance. This finding contributes to the supplier risk management literature by showing that having a powerful external stakeholder regulating suppliers represents an input control measure that firms can rely on to engage in *risk avoidance*. In fact, under these circumstances firms believe that the input control, in the guise of a powerful external stakeholder regulating suppliers, represents a viable alternative to behavioral control.

This finding also points out that agency theory's focus on a principal-agent dyadic relationships (Eisenhardt, 1989B) limits its explanatory power. The cases show that often an agent has numerous principals with overlapping goals. In these situations, the actions of one principal can shape the actions of other principals. Specifically, if a firm (i.e., one principal) is aware that a powerful involved stakeholder (i.e., another principal) controls behavior of a supplier (i.e., an agent), these behavioral control measures of the stakeholder represent an input control measure for the firm.

In many industries having a stakeholder regulating suppliers is not a choice. Yet, the simulation allows me to examine if firms benefit from such an arrangement in terms of risk management and hence contributes to the supplier risk management literature. Specifically, the simulation compares a firm's likelihood of non-compliance under *stakeholder enabled risk avoidance* with the likelihood the same firm would have faced if it were to engage in *risk mitigation* instead. Interestingly, the results suggest that firms should rely on *stakeholder enabled risk avoidance*, even when the stakeholder does not have high capability. This outcome is likely due to the stakeholder's dual role of monitoring and incentivizing suppliers. So even if the stakeholder is not effective at monitoring supplier processes, the suppliers know that the stakeholder is a gatekeeper to many potential buyers. Therefore, failing to comply with the requirements of one of the buyers will likely mean losing business with many buyers not just the one. In addition, the simulation shows that when a firm believes that a stakeholder significantly lacks capability, yet the stakeholder must be used, the firm should seek ways to complement the stakeholder's insufficient efforts to ensure supplier compliance. Specifically, it should increase selection standards and source from fewer suppliers to reduce the likelihood of non-compliance. While the importance of having stricter selection standards is intuitive, the effect of having a small supply

base is more nuanced. The simulation results show that if the involved stakeholder has high capability increasing supply base size only marginally increases the likelihood of non-compliance. In contrast, if the stakeholder has low capability, a firm faces a non-linear effect of supply base size on the likelihood of non-compliance with the likelihood decreasing at an increasing rate as supply base size decreases.

This non-linear effect of supply base size on the likelihood of supplier non-compliance is observed under *relationship enabled risk avoidance* and *risk tolerance*, approaches that do not have any party monitoring supplier processes. Yet, this effect can disappear under the two approaches to supplier risk management, *risk mitigation* and *stakeholder enabled risk avoidance*, that involve correspondingly a focal firm or an involved stakeholder collecting comprehensive information on supplier processes. Therefore, this research also contributes to the supplier risk management literature by revealing the unexpected effect of monitoring supplier processes. When supplier processes are monitored, the focal firm can increase the size of its supply base without facing a substantial increase in the likelihood of non-compliance. In contrast, two other approaches to supplier management that do not rely on monitoring supplier processes are associated with significantly higher likelihood of non-compliance if the firm chooses to increase its supply base size. This finding then also contributes to practice by showing that in industries with complex production requiring a large supply base, a buying firm can assure supplier compliance only if the firm or an involved stakeholder monitors supplier processes.

The supply bases of the case firms that rely on *stakeholder enabled risk avoidance* vary in size; however, these firms are convinced that their stakeholder is highly capable. In addition, these firms focus on having stable relationships with their suppliers. The simulation then contributes

to practice by clarifying that under *stakeholder enabled risk avoidance* a choice to have stable supplier relationships with suppliers does not affect the likelihood of supplier non-compliance.

A decision to tolerate supplier risks

Finally, this research reveals that some firms do not prioritize addressing the risk of supplier non-compliance and choose to engage in *risk tolerance*. The case firms that engaged in *risk tolerance* face supplier risks of low impact and rely on outcome controls to manage these risks. Specifically, they shift the responsibility of identifying potential risk triggers of non-compliance onto their suppliers and manage non-compliances only if they materialize. These firms, when facing the trade-off between addressing supplier risks and minimizing costs associated with supplier management, choose the latter. In doing so, these firms contradict the supplier risk management literature that emphasizes the importance of minimizing supplier risks (Sodhi et al., 2012). Interestingly, the literature largely omits discussing this supplier risk management approach (Hajmohammad and Vachon, 2016).

The simulation shows that firms engaged in *risk tolerance* are expected to face high levels of supplier non-compliance. It also allows for an examination of some of the decisions of the sampled firms engaged in *risk tolerance*, thus contributing to practice. The sampled firms choose to have large supply bases, do not focus on having stable supply bases and developed detailed standards for supplier selection. The simulation reveals that sourcing from a large number of suppliers not only is associated with high likelihood of supplier non-compliance but also significantly limits the effect of other decisions on the likelihood. Specifically, in large supply bases neither increasing firm's selection standard nor terminating relationships with non-compliant suppliers can significantly lower the likelihood of non-compliance.

Limitations

This research has a number of limitations. First, the collected case data contains only eight firms, limiting the ability to generalize to other firms. Second, the collected cross-sectional data does not allow examining firm behaviour across time. Only longitudinal data can help gaining a more in-depth understanding of how firms identify, manage, and react to supplier non-compliances. In addition, the simulation reveals the importance of considering firm's capability in the context of supplier risk management; yet, the collected case data cannot provide an objective assessment of a firm's capability. Only in-depth longitudinal data can give an insight in how capable firms are at managing supplier risks. Another limitation of the collected data is related to the three cases, where external stakeholders were involved in regulating firms' suppliers. While the data included extensive documentation on the stakeholders' practices, it did not contain any interviews with the stakeholders' representatives.

The agent-based simulation is based on the case studies and allows exploring decisions across time, yet this simulation is a considerable simplification of the observed firm behaviour. In fact, I limited the simulation complexity because Wilensky and Rand (2015) recommended doing so when the application of agent-based simulations in a certain context is relatively new, as is the case with supplier risk management. In particular, the simulation considers only a firm's relationships with its first-tier suppliers. The decision to consider single-tier supply networks was, in part, based on how the case firms managed their suppliers, but clearly some supplier risks have origins beyond the first tier of suppliers. Managing such risks might require different means of control or have different outcomes.

There are also a number of limitations associated with the specifics of the simulation algorithm. First, built from the supplier risk management perspective, the simulation does not take

into account other criteria that can influence a firm's decisions. For instance, the literature acknowledges that both *relationship enabled risk avoidance* and *risk mitigation* are resource intensive approaches to supplier risk management (e.g., Poppo and Zenger, 2002; Selviaridis and Norrman, 2014). Yet, the simulation analyzes only how a decision to engage in either *relationship enabled risk avoidance or risk mitigation* affects the likelihood of non-compliance, without considering any associated costs. In particular, the simulation does not consider the cost associated with collecting comprehensive information on supplier processes, nor does it take into account coordination costs associated with increasing the size of a firm's supply base. In addition, the simulation focuses on a supply chain of a single firm, and yet suppliers rarely have only one buyer. The simulation, however, does not capture how actions of other buyers may affect supplier behaviour or the actions of the focal firm. Finally, I started building the simulation after the case data collection had been completed. Approaching the simulation in such a way revealed an important limitation: the process of simulation building offered a number of important insights into how firms may manage the risk of supplier non-compliance, and yet I could not use these insights to influence what case data was collected.

CHAPTER SIX: CONCLUSION

This research began with the literature's supposition that firms benefit from having transparent supply chains. The first stage of this research, case studies, clarified that firms saw benefit in having transparent relationships with their first-tier suppliers, and not the entire supply chain. These firms acquired comprehensive information on the processes of their first-tier suppliers to have an ability to mitigate the risk of supplier non-compliance. The case studies also indicated that many firms did not follow the literature's recommendation to create transparent supply chains, as they relied on other means to address the risk of supplier non-compliance. The second stage of the research, an agent-based simulation, then showed the conditions when firms should follow the literature's recommendation and when they should not. Combining a simulation with qualitative studies has offered an opportunity to both describe what firms *actually do* and to examine whether they make appropriate decisions, that is, what they *should do*. It has thus enabled me to offer contributions to theory and practice that would not have been possible using either approach alone.

This research showed how various firms should address the risk of supplier non-compliance. Only firms that possess high capability to assess and monitor supplier processes should favor mitigating the risk of supplier non-compliance, which is the approach the supplier risk management literature recommends for all firms. Firms that lack this capability are better off not acquiring comprehensive information on supplier processes to engage in risk mitigation, because they are unable to use this information to substantially reduce the likelihood of supplier non-compliance. Instead, they should seek to avoid the risk of supplier non-compliance.

This research highlighted two paths firms may take to avoid, rather than mitigate, the risk of supplier non-compliance. The first path is to rely on close relationships with suppliers. The sam-

pled firms that chose to rely on that path did not seek to collect comprehensive information, because they believed that a close relationship could provide incentives for suppliers to comply, thus making the risk of non-compliance negligible. These were the same firms that, when they believed suppliers were unreliable, did collect such information. Therefore, this was an approach they believed was effective in avoiding the risk of supplier non-compliance. The second stage of this research, simulation, then showed that this approach might be suitable, especially for low-capability firms. An alternative path to avoid supplier risks exists in industries where a powerful external stakeholder is involved in controlling the suppliers. Due to the stakeholder's dual role of monitoring and incentivizing suppliers, firms in these industries can benefit from the stakeholder's involvement, even when their capability to assess supplier processes is higher, often significantly higher, than that of the stakeholder.

This research also contributed to agency theory by addressing the theory's assumption of a "flawless" principal that has the capability to accurately assess an agent's behavior (Fayezi et al., 2012). The results showed that a principal might lack the ability to effectively control agent behavior, which can in turn shape what approach the principal should take to ensure that the agent successfully completes an assigned task. Specifically, a principal that lacks capability is more likely to successfully control the agent if it chooses input control (i.e., selecting a highly incentivized agent) over behavioral control (i.e., verifying how an agent completes an assigned task). The results then stress the importance of considering the decision-making of flawed principals in agency theory, both within and outside the realm of supplier risk management.

Despite a growing number of calls for the use of agent-based simulation in supply chain management (e.g., Gilbert, 2008; Macal and North, 2005; Van Der Zee and Van Der Vorst, 2005), studies that employ this method are still scarce. This research answered these calls by revealing

the ability of agent-based simulations to offer a valid representation of a complex supply chain management phenomenon. As the nature of agent-based modeling allows for extending already developed simulations, my simulation framework provides a starting point to continue this research in the context of more complex supply networks. A first natural extension is to focus on sustainability risks (Hajmohammad and Vachon, 2016) and explore how firms should manage these risks in complex supply networks. One of the difficulties firms face when they seek to address sustainability risks in their supply chains is that unlike supply delays or poor product quality, sustainability risks can remain unidentified over long periods of time. Managing sustainability risks beyond first-tier suppliers represents an even more challenging task. Research based on an agent-based model can thus contribute to the supply chain management literature by showing how firms should manage these risks.

Another fruitful avenue for future research lies in further investigating the involvement of external stakeholders in supply chains and, more specifically, in exploring how firms rely on external stakeholders to ensure sustainability compliance of their suppliers. Unlike product-quality compliance, sustainability compliance is harder to ensure, as the standards to measure it remain largely undefined (Shevchenko et al., 2016). Hence, outsourcing the efforts to ensure sustainability compliance to an external stakeholder is likely to require a greater level of cooperation between the firm and the stakeholder. Focusing on an industry with stakeholder involvement and using qualitative methods to gather in-depth data will shed more light on how the stakeholders ensure supplier compliance to their requirements, and how firms and their suppliers react to the stakeholder involvement. In the Canadian paper industry, for instance, the Forest Stewardship Council (FSC, 2017), a powerful NGO, plays an active role in assuring sustainability of wood sourcing. Research focused on this industry can contribute to the supply chain management liter-

ature by showing how firms cooperate with an external stakeholder to adapt to changing requirements for suppliers' sustainability compliance.

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APPENDIX A. RELATED CONCEPTS AND SYSTEMATIC LITERATURE REVIEW

The supply chain management literature employs three concepts that are related to the notion of a firm acquiring information on supplier processes. The most commonly used concept is supply chain transparency. Two other concepts are supply chain traceability and supply chain visibility. Table A1 shows their definitions.

Concept	Citation	Definition
Traceability	Pagell and Wu (2009)	"an internal practice of sharing information among chain members about materials and methods (toxins, use of child labor, type of solvents used and so on) to optimize noneconomic chain performance and minimize risks" (p. 44)
Traceability	Khabbazi et al. 2011)	"the ability to retain the identity of the product and its origin and its use nowadays concerns both government and business" (p. 732)
Traceability	Wang et al. (2009)	"the ability to trace and follow food, feed, and ingredients through all stages of production, processing and distribution" (p. 2866)
Traceability	Roth et al. (2008)	"assurance of expected quality through close identification of producer, branding or certification" (p. 26)
Visibility	Barratt and Oke (2007)	"the extent to which actors within a supply chain have access to or share information which they consider as key or useful for their operations and which they consider will be of mutual benefit" (p. 1218)
Visibility	Wang and Wei (2007)	"the degree to which supply chain partners have on-hand information related to demand and supply for planning and control management" (p. 662)
Visibility	Williams et al. (2013)	"the access to high quality information that describes various factors of demand and supply.. in order for information to be of high quality, it must be accurate, timely, complete, and in usable forms" (p. 545)
Visibility	Co and Barro (2009)	"the practice of "capturing and analyzing supply chain data that informs decision-making, mitigates risk, and improves processes"" (p. 592)
Visibility	Dentchev, (2004)	"the extent to which internal and external stakeholders can observe and recognize [corporate social performance]" (p. 400)

Table A1. Definitions of supply chain traceability and supply chain visibility

The concept of supply chain traceability is closely related to supply chain transparency. In fact, Pagell and Wu's (2009) definition of traceability is similar to how others refer to supply chain transparency. Many define traceability as a product-level construct that shows an extent to which a buying firm has identified the origins of its product components (Roth et al. 2008; Khabbazi et al., 2009; Wang et al., 2009). Overall, one can view traceability as a special case of supply chain transparency that focuses on the product, its components and origins.

Finally, supply chain visibility is focused on the information essential for matching supply and demand on a day-to-day basis. For instance, Wang and Wei (2007: 652) in their study on supply chain visibility focus on the information required "for planning and control management". Barratt and Oke (2007: 1218) argue that supply chain visibility allows supply chain partners to "have access or share information which they consider as key or useful for their operations". On a day-to-day basis many firms strive to acquire various information about supplier processes including suppliers' inventory levels and promotions, changes in product line, and lead time (Williams et al., 2013; Wang and Wei, 2007; Co and Barro, 2009). That is, supply chain visibility is focused on ensuring that a firm has information to achieve sufficient coordination between supply and demand.

Overall, these three concepts - supply chain transparency, traceability, supply chain visibility – are related to the notion of a firm acquiring information on supplier processes. They tend to differ in the underlying reason why the information is acquired. Supply chain transparency is about ensuring that supplier processes would not have significant negative impact on the firm or its stakeholders. Traceability is focused on the information needed to identify the origins of a firm's purchases. Finally, supply chain visibility is concerned with acquiring information needed to match supply and demand. To have a better understanding of what supply chain management

literature knows about how firms acquire information on supplier processes I conducted systematic literature review based on these three concepts.

The relevant literature was selected using systematic review through Google Scholar database (www.scholar.google.com). The main advantage of the systematic review is that it helps to ensure that the process of selecting articles is unbiased and its results are replicable (Carter and Easton, 2011). To have a wider scope I chose journals from a range of management areas, including supply chain management, management science, strategy, and business ethics. The complete journal list consisted of the following 23 journals:

Academy of Management Journal

Academy of Management Review

Administrative Science Quarterly

Decision Science Journal

IEEE Transactions

International Journal of Operations & Production Management

International Journal of Physical Distribution and Logistics Management

International Journal of Production Research

International Journal of Production Economics

Journal of Business Ethics

Journal of Business Venturing

Journal of Business Logistics

Journal of Cleaner Production

Journal of Management Studies

Journal of Operations Management

Journal of Supply Chain Management

Management Science

Omega

Organization Science

Production and Operations Management

Strategic Management Journal

Supply Chain Management: An International Journal

These journals were searched through Google Scholar database using the following key terms: supply chain transparency, supply chain traceability, supply chain visibility. The results of the search initially produced 504 articles, out of which 154 articles were relevant to the topic of this research.

APPENDIX B. CASE STUDY PROTOCOL

Overview of the case study

Mission and goals

The goal of this study is to understand how firm acquire information required to identify supplier non-compliance. It is a first stage of a two-stage research project, and its results will be used to inform the second stage of the project, an agent-based simulation model.

Theoretical framework

Based on the existing literature, two theoretical themes were identified to form a sampling matrix. These themes are relationship with suppliers (firm size is used as a proxy) and a driver to ensure compliance. The sampling matrix is shown in Figure 1 in the main body of the manuscript.

Research questions

General research question:

- How do firms acquire information required to identify supplier non-compliance?

Specific research questions:

- What role do buyer-supplier relationships play in the process of acquiring information required to identify supplier non-compliance?
- What are the most important supplier risks a firm seeks to mitigate?

- What role do a firm's external stakeholders play in the process acquiring information required to identify supplier non-compliance?

Data collection procedure

Fieldwork

The case study data will be collected by two persons to ensure the reliability of the results of the study. The interviews will be recorded and then transcribed. Relevant documentation will be collected on site and online.

Data collection plan

This study will have multiple cases. Ultimate the final number of case studies will be determined when the data collection process will reach theoretical saturation (Eisenhardt, 1989B).

Preparation for the fieldwork

For the purposes of the study, we will identify companies that actively pursue the goal of ensuring supplier compliance. The study will cover multiple industries. We will sample both small and large firms that ensure compliance both because of their own vulnerability to supplier risks and because of stakeholder pressure.

Data collection questions

- What is your role in the company?
- Can you describe your previous work experience and education?
- How many employees are in the company?

- How many are employed in production?
- Why do customers buy your products?
- Who are your main competitors?
- Can you describe the structure of your company's supply chain?
- What kind of information do you obtain from your suppliers?
- Can you describe the process of gathering information about your suppliers?
- How are you involved in this process?
- How do you use the information about your suppliers?
- What do your customers want to know about your suppliers?
- Do you trust your supply chain partners? How so?
- What are the other important stakeholders of the company?
- What do stakeholders want to know about supply chain?
- How do you share the information with stakeholders?

Case study report

Audience for the results

The audience of the results of this study includes management scholars and practitioners interested in the subject of the study.

Further steps in the study

The results of case study will be used in the build an agent-based simulation. The simulation aims to answer the following research question, how should firms acquire information required to identify supplier non-compliance?

APPENDIX C. CASE DESCRIPTION

AEROSPACE

This case focuses on a small component manufacturer in the aerospace industry that faces the risk of its suppliers undermining the quality of its components. The firm manufactures customized mechanical components in small volumes for approximately 20 military and aerospace OEMs. These OEMs procure from the firm because of its high engineering capability, its advanced production processes that ensure high product quality, and its responsiveness to customer requirements.

The aerospace industry is characterized by stable relationships among supply chain partners. There are two main reasons behind such relationships. First, the industry has undergone significant consolidation across all supply chain tiers. Second, the final customers and the regulators impose significant sourcing restrictions. As a result, firms in this industry do not have many competitors but at the same time cannot easily find new customers.

Aerospace components are a niche market where product quality is the main priority. To compete the firm needs to have a supply base that can provide products of high and consistent quality without an opportunity to repeatedly improve the products. AEROSPACE relies on a number of critical-to-quality suppliers that provide such services as casting, anodizing, and grinding. These suppliers are a potential source of the firm's main supplier risk. The risk is that one of its service suppliers lacks capabilities and would undermine product quality. The risk is exacerbated by the small volumes the firm tends to order, making it hard to identify non-compliant components.

The risk of a supplier undermining product quality is a high impact supplier risk. The firm's final customers – producers of aerospace and defense machinery – face the threat of operational catastrophe if non-compliant mechanical components are installed in their products. If this supplier risk materializes, it will significantly harm the firm's reputation, severe its relationships with its existing customers, and undermine its position in the industry. Overall, AEROSPACE faces significant external drivers to ensure that its critical-to-quality suppliers can assure high product quality.

Due to high potential risk impact, the final customers strive to ensure that even at lower tiers of their supply chains firms have needed processes in place. For that reason, they endorse industry certifications, AS9100 and NADCAP. These certifications had been developed to provide objective ways to assess all aspects of production. They specify requirements for various types of production processes and oversee how firms in this industry adhere to these requirements. Having these certifications became an order qualifier for the industry members. Overall, AEROSPACE's management believes that due to the involvement of the certification bodies it faces a low-likelihood supplier risk.

If a service supplier undermines the quality of the firm's mechanical components it is expected to share the impact of its non-compliance. First, a non-compliant supplier can lose its NADCAP and/or AS9100 certifications and, as a result, its current customers in the aerospace industry. Second, AEROSPACE keeps its suppliers financially responsible for any non-compliance via contractual obligations.

The presence of NADCAP and AS9100 certifications influences how the firm governs its suppliers. Overall, because of this stakeholder involvement the firm engages in behavior-based

supplier governance. The certification bodies enable two essential aspects of this governance mechanism. These organizations periodically monitor suppliers to ensure that they have sufficient production capabilities to maintain high product quality and incentivize the suppliers to comply with the requirements for production processes.

As a result, AEROSPACE chooses not to acquire comprehensive information on processes of its critical-to-quality suppliers. The firm relies on these certifications to control and regulate its suppliers and trusts that the certification auditors properly assess the suppliers' production processes. At the same time, the firm has developed close relationship with its service suppliers and invests resources in supplier education. Moreover, it had integrated some of these suppliers and had moved them to the facilities in a close proximity to its own facility. The firm can directly observe how NADCAP and/or AS9100 conduct monitoring as the firm and its integrated suppliers have these certifications.

AEROSPACE manages the risk of a supplier undermining product quality by avoiding it. The firm believes that its suppliers ensure that, if ever produced, any non-compliant components are destroyed and would never reach the firm or its customers. It relies on NADCAP and AS9100 certifications to verify that its suppliers have sufficient capabilities to produce products of high quality. In their oversight of the firm's suppliers, the certifying organizations assess suppliers' production processes to ensure their compliance with the requirements established in the aerospace/defense industry.

AUTO-PARTS

AUTO PARTS is a large retailer that specializes in automotive products. It carries a large inventory of such products ranging from car mats to automotive batteries to wiper blades. The tar-

get consumer group for these products is young families that prefer buying inexpensive but relatively reliable products.

The supplier risk the firm faces is a supplier failing to produce products at an acceptable quality level. The firm is externally driven to address this risk as customer satisfaction is easily affected by poor product quality. In fact, the market for automotive products is associated with low brand loyalty: customers dissatisfied with a product quality are likely to buy automotive products elsewhere. In addition, stocking defective products leads to financial losses.

Overall, this is a low impact risk. If the firm's supplier fails to achieve acceptable product quality, the materialized risk is likely to lead to financial losses and to poor customer satisfaction. However, the firm offers a large variety of products sourced from hundreds of suppliers and one non-compliant supplier is unlikely to have a lasting negative effect on the firm.

The firm has a large supply base. It sources automotive products from more than 500 suppliers. Its supply base for the automotive products is located in China. These suppliers are clustered in coastal areas close to Shanghai and Hong Kong. Many of these suppliers are SMEs.

AUTO-PARTS's priority is to source from suppliers that can produce high volumes of products at a low cost. The product quality plays a secondary role: only once potential suppliers are chosen, the firm's quality team ensures that these suppliers can achieve an acceptable level of product quality. Furthermore, the firm believes that many of their suppliers have corner-cutting culture and might be unable to provide consistent level of product quality during mass production. Therefore, the risk of a supplier failing to achieve acceptable quality level has high likelihood.

Because the firm's suppliers face the pressures to produce high volumes of products at a low cost, they do not have sufficient incentives to ensure that the products they manufacture can consistently meet the required quality standards. Suppliers do not share the impact of this risk with the firm, and therefore only the firm is negatively affected if the risk is materialized.

The firm interacts with its suppliers mostly during the supplier selection process. The firm's quality team conducts an initial visit focusing on a supplier's processes and its manufacturing capability. In particular, it assesses how the supplier controls incoming materials and how it tests its products. Once the firm selects a supplier, a sample of the supplier's products undergoes prototype testing in one of 3rd party testing laboratories. After prototype testing, the firm asks the supplier to start mass production and from that point controls product quality via random testing.

On a monthly basis, AUTO-PARTS rates its products based on the defect cost and identifies non-compliant suppliers. It uses consumer feedback and product returns as additional sources of information about any issues with product quality. Low-rated suppliers go through more frequent product testing and their products are audited more frequently before shipping.

AUTO-PARTS relies on outcome-based supplier governance. The firm sources from suppliers that can achieve the needed outcomes: producing high volumes of low-cost products of acceptable quality. Overall, the firm assumes that suppliers are able to achieve the needed outcome levels, unless there are indications of non-compliance.

Overall, AUTO-PARTS tolerates certain level of the supplier risk. Because the impact of the supplier risk is low the firm accepts its high likelihood. The size of its supply base would make extremely resource intensive to acquire information on supplier processes and mitigate supplier non-compliances across its entire supply base. For that reason, the firm tends to address the risk

only if it materializes and only if the costs associated with the non-compliant supplier are significant.

AUTOMATION

AUTOMATION is a large company that manufactures engineer-to-order equipment. The firm's products range from material handling systems for assembly lines to control cabinet for factory automation to pneumatic cylinders. The firm expects to increase customer base for these products in the upcoming years growing at a double-digit rate.

The firm's Canadian office works with approximately 80 OEMs on a regular basis. Their customers range from medical equipment producers to laboratory automation providers to automobile tier 1 manufacturers. The key to increasing its market share is building close relationship with its customers and satisfying their increasing requirements. Their customers put significant cost pressures and choose to source from AUTOMATION because of its ability to ensure the required product quality level despite the cost pressures. The firm strives to protect its reputation of a quality-focused company. For instance, it does not take on contracts that can make it impossible to ensure acceptable product quality and can compromise its R&D efforts.

At the same time, given the cost pressures the firm faces, it cannot source from suppliers with highest manufacturing capabilities and instead selects suppliers that can provide low-cost components of acceptable quality. For that reason, AUTOMATION faces the risk of its suppliers failing to achieve acceptable quality level. This supplier risk has high likelihood. The firm's suppliers are under considerable cost pressures and do not have sufficient incentives to ensure that the products they manufacture consistently meet the requirements for the product quality level. That is, the suppliers do not share the impact with the firm if the risk materializes.

The firm is internally driven to address this risk. First, it protects reputation as a firm known for its ability to produce products of acceptable quality under high cost pressures. Second, the firm strives to further develop its reputation in order to increase the market share for its engineer-to-order equipment products.

Overall, this is a low impact risk. The firm accepts that some of the components it procures can lead to a product failure. It is one of the reasons why after the firm ships products to its customers it gives a year of warranty during which customers can communicate regarding any issues with the product.

For each engineer-to-order project the firm selects component suppliers. Its procurement team finds suppliers on the open market. On a regular basis, AUTOMATION deals with between 80 to 120 external component suppliers. Many of these suppliers are local. Due to high cost pressures from their customers, the firm prioritizes cost minimization in procurement and, in particular, when it selects suppliers. For that reason, the firm sources from suppliers that can provide the needed outcomes: low cost components of acceptable quality level. In other words, the firm relies on the outcome-based supplier governance. Its decisions regarding a particular supplier are guided by supplier ability to provide needed outcomes.

To ensure that its suppliers can produce products of acceptable quality the firm engages its engineers during supplier selection process. The engineers assess manufacturing capabilities of a potential supplier and its ability to comply with the firm's quality requirements. Once the firm's engineers have evidence that the supplier is able to provide acceptable quality, the firm requests a sample order for a destructive testing to further confirm that the supplier has the required quality system in place.

Selected suppliers tend to provide products of acceptable quality but some may not be able to do so consistently. As long as supplier meets the outlined performance requirements the firm does not intervene to control supplier processes. If a supplier becomes non-compliant, the firm's representatives visit this supplier to assess the non-compliance. Failing to successfully take a corrective action makes it likely that the firm would stop sourcing from such supplier.

AUTOMATION has a certain tolerance for the supplier risk and hence chooses not to supply to customers who are more risk adverse. After the firm selects suppliers that demonstrate an ability to produce products at the acceptable quality level the firm does not take measures to oversee and control their processes. Moreover, the firm is prepared that over time some of its suppliers fail to achieve needed outcomes in terms of product quality becoming non-compliant. In fact, only when the risk of supplier non-compliance materializes, the firm increases control of its suppliers or finds a new supplier for the component.

DESK.R

DESK.R is a contract furniture manufacturer that specializes in customized office furniture. Its products include office desks, chairs, filing cabinets, and cubicle walls. The firm works with dealers, architects and designers to fulfill orders of such final customers as law firms, large North American universities, and Fortune 500 companies.

The contract furniture market segment faces increasing customer expectations. To keep up with them, the firm established an internal continuous improvement program and encourages such programs among its suppliers. Its ability to meet customer requirements while remaining efficient internally makes the firm one of the few large furniture manufacturers with production facilities located in Canada.

As a contract manufacturer, DESK.R does not produce products to stock. As a result, the firm constantly faces short lead times for its customized products. This constraint pushed the firm to become more integrated and to source predominantly locally. Because of short lead times, the firm's main supplier risk is a supplier non-compliance that can delay orders and negatively affect their reputation among their customers. To address this risk, the firm needs to ensure that its suppliers have sufficient capabilities to produce the needed amount of product within a short time window following the firm's requirements for product and processes. This is a low impact supplier risk: a supplier non-compliance will delay the firm's fulfillment of a particular customer order but is unlikely to inflict a long-term damage on the firm's supply chain processes or severely affect its reputation.

The firm works with approximately 300 suppliers, of which 80 are its main suppliers. Most of its suppliers produce commodity products and raw materials including wood, metals, glass, and textiles. A number of factors allow the firm to ensure that these suppliers are incentivized to remain compliant. First, the firm is one of the few large Canadian furniture manufacturers that actively seek working with local suppliers. Second, the firm invests significant resources in supplier development, offers long-term relationships to its suppliers, and assists its better suppliers with adapting to increasing requirements. Furthermore, a supplier that causes a supply disruption will share the negative impact of this risk. Specifically, the firm is able to specify in its terms and conditions that suppliers would be held responsible for non-compliances charging them "massive penalties".

The firm's management believes that when they procure from these suppliers the likelihood of supplier non-compliance is low. These suppliers have sufficient capabilities as well as incentives to fulfill orders following the firm's requirements. With these suppliers, the firm relies on rela-

tional governance. It fosters close relational ties with its suppliers by helping them improve their operations and educating them about new products and emerging trends in the industry. Furthermore, DESK.R does not put substantial cost pressures and if it finds a way to internally save on certain aspects of a product it shares savings with the relevant suppliers. In general, the firm's management believes it is essential to have long-term supplier relationships and let good suppliers develop. As a result, the management believes that the close relational ties make it unnecessary to acquire comprehensive information on supplier processes.

DESK.R believes that its suppliers are reliable. As a result, the firm relies on relational governance to avoid the risk of supplier non-compliance. The firm is convinced that these suppliers have both capabilities and sufficient incentives to meet the firm's expectations and requirements and therefore it does not need to mitigate this risk.

DESK.UN

This case focuses on the same firm as in DESK.R but considers how this firm sources from a supply base consisting of unreliable suppliers. This supply base is considerably smaller than the firm's supply base of reliable suppliers. The firm sources from unreliable suppliers because it is forced to procure the majority of its raw materials locally. Some of its local suppliers lack production capabilities and, as a result, over time are likely to cause a non-compliance.

These local suppliers of raw materials tend to be small firms. These suppliers adhere to the firm's terms and conditions and can face significant penalties for non-compliances that end up disrupting the firm's processes. Therefore, if they become non-compliant they will share the impact of this materialized risk. At the same time, they tend to lack production capabilities, often struggle to adapt to emerging industry requirements and do not have sufficient knowledge of new

trends in the industry. These factors necessitate the firm to have a greater level of oversight of processes of these suppliers.

Specifically, with these suppliers, DESK.UN engages in behavior-based contractual governance. First, the firm makes sure that the suppliers agree to adhere to its terms and conditions. However, because of lacking capabilities suppliers may fail to comply with the firm's order requirements. For that reason, the firm assigns employees to remain in facilities of these suppliers and ensure that the suppliers engage in processes that comply with the firm's requirements. In other words, having the firm's representatives that acquiring information on supplier processes enables this governance mechanism.

With these suppliers, the firm has gained an ability to mitigate the supplier risk before it materializes. Specifically, the firm assigns its employees to remain in supplier facilities to assure compliance. If these suppliers sufficiently improve their processes, the firm starts to rely more heavily on relational governance mechanism and stops directly acquiring comprehensive information on supplier processes.

HARDWOOD.R

This case focuses on a hardwood producer that sources lumber from a number of saw mills, with which it has established trust-based relationships. HARDWOOD.R is a small firm that specializes in North American lumber, mostly maple, ash, and oak. The firm seeks to procure timber of high quality. Also, it carries diverse inventory that its competitors choose not to stock. One of the main reasons for prioritizing high quality and diverse inventory is its weak market position. Some of its current customers seek to procure directly from its suppliers and some of its largest

suppliers are its main competitors. It deals mainly with overseas customers from China, UK, Japan, and Germany.

The firm's suppliers are sawmills located in Ohio, Pennsylvania, Ontario, and Quebec. The North American hardwood industry has undergone significant consolidation and many saw mills merged or went out of business. On a regular basis, the firm sources from 30 to 50 saw mills.

The firm faces supplier non-compliances both in terms of wood quality or delivery time. This supplier risk has low potential impact. If materialized, this risk will cause short-term financial losses but will be unlikely to have lasting negative effects on the firm. To ensure that a supplier remain compliant the firm needs to assure that the suppliers are capable of fulfilling their orders following the agreed requirements for timber quality and delivery times.

A number of internal drivers incentivize the firm to address this supplier risk. First, it has limited human resources for managing suppliers. Second, both receiving timber of poor quality and managing delayed deliveries are disruptive to its daily operations. Second, because of long production process of hardwoods and significant credit risk the firm needs to ensure dependable supply of wood.

HARDWOOD.R prefers working with suppliers it believes to be reliable. The firm's management believes that these suppliers are associated with low likelihood of non-compliance. Over time these suppliers have demonstrated their ability to provide a reliable supply of high quality timber. The firm relies on relational governance to manage these suppliers. Because of the firm trusts the suppliers, it does not directly oversee how the suppliers prepare the ordered wood. Instead, the firm's management fosters close relational ties with owners and member of sales force of these suppliers via regular calls, meetings, and visits. Some of these suppliers are

dependent on the firm's expertise in wood grading. That is, these suppliers let the firm grade the wood, which then determines how much the firm pays the suppliers for the shipment. Long-term relationships, trust, and mutual dependence incentivize these suppliers to be responsive to the firm's requirements. If one of these suppliers fails to comply, it will sever its relationship with the firm. Therefore, the supplier will be negatively affected if the risk is materialized.

With its focus on relational governance, HARDWOOD.R is able to avoid the supplier risk when it sources from suppliers it views as reliable. The firm expects that these suppliers remain responsive to its requirements for wood quality and delivery times. It chooses not to oversee how the suppliers fulfill its orders and instead believes that relational ties allow avoiding the risk.

HARDWOOD.UN

This case considers the same firm as in HARDWOOD.R but sourcing timber from a different supply base. This supply base consists of suppliers that the firm views as being unreliable. The firm's supply chain has been consolidated, and as a result, the firm cannot be selective about suppliers it relies upon. For that reason, the firm is willing to procure from unreliable suppliers.

These unreliable suppliers tend to be large sawmills located in the United States. Many of them are the firm's direct competitors. Moreover, these suppliers are known for supplying wood of inferior quality or delaying shipments. For instance, one of these suppliers is known for selling wood it has not got in stock (i.e., has not received wood from loggers). Another supplier had tried to bypass the firm and sell its timber directly to one of the firm's customers. Overall, these suppliers do not depend on the firm and if they fail to comply they will not be affected by their non-compliance.

Because these suppliers are not motivated to comply with the firm's requirements, the firm takes measures to control their processes, engaging in behavior-based contractual governance. The firm ensures that these suppliers comply with its order requirements by having an employee located close to suppliers' facilities who controls how suppliers fulfill the firm's orders. The employee travels to suppliers' facilities and oversees how supplier prepares wood for the shipment. He has more than 25 years of experience in the industry and is employed by the firm specifically to conduct such informal monitoring of supplier processes.

With its unreliable suppliers, HARDWOOD.UN cannot avoid the supplier risk to the required extent and faces high likelihood of supplier non-compliance. For that reason, with these suppliers the firm focuses on mitigating the likelihood of supplier non-compliance by relying on behavior-based contractual governance. It employs an agent who oversees supplier processes and ensures that suppliers do not trigger a non-compliance.

MILK

MILK is a large Canadian dairy firm that produces a variety of dairy products and then sells them via different channels: under its own brands in retail stores, as co-pack products, as private label products produced for large retail chains, and as ingredient products produced for manufacturers of other food products. The firm's top priority is high product quality. It established a robust quality assurance system. The firm continuously improves the system and invests resources into developing product packaging and new testing methods. In fact, the firm is able to attract many of its customers because of its reputation of quality-focused firm.

The product quality depends on sourcing from farms that eliminate any potential triggers of milk contamination. The risk of its suppliers producing contaminating milk is the main supplier

risk MILK faces. If materialized, this supplier risk will have high impact on the firm: it would disrupt its supply chain processes but more importantly would have long-term negative effect on its reputation.

The firm faces significant external drivers to ensure high quality of the procured milk. Its large customers put significant pressures on the firm to control the risk of product contamination and impose strict policies for quality assurance measures. If the firm uses contaminated milk in its products, it is likely to sever the firm's relationships with these key customers.

Fresh milk is 80% of the firm's purchasing cost, with the rest spent mostly on packaging materials. The firm procures fresh milk from Ontario milk farmers but it does so via Dairy Farmers of Ontario (DFO), a governmental agency that controls milk supply in the province. The DFO acts as an intermediary supplier between milk farms and milk processing plants: the firm sends order to the DFO, which procures milk from 3,000 Ontario milk farms and then ships it to the firm. The firm is not allowed to procure milk from any other sources. At the same time, Ontario farms are constrained by regulation to having the DFO as their only customer. In particular, the farms cannot bypass DFO and sell milk abroad or even directly to the firm.

Overall, the farms are incentivized to avoid milk contamination. If an Ontario farm sells contaminated milk, it would be negatively affected by this materialized risk: the DFO would hold the farm financially responsible and even may revoke its license. Without an ability to sell milk to the DFO the farm is likely to go out of business. In MILK's experience farms almost never supply contaminated milk, as they are aware of the requirements and potential consequences for non-compliance.

In general, hazards that have potential to trigger milk contamination are present in daily operations of milk farms. However, the aim of the DFO quality program that the farmers adhere to is to eliminate potential food safety hazards. Due to the DFO's role in the supply chain, the likelihood of farm producing contaminated milk is low.

The involvement of the DFO allows MILK to rely on behavior-based contractual governance. The firm outsources to the DFO the efforts to assure that suppliers have the required processes in place. This stakeholder oversees on an ongoing basis whether practices of licensed farms comply with the established requirements. These requirements are based on Hazard Analysis Critical Control Point (HACCP) and cover all aspects of milk production from feeding to milking to shipping cattle. Moreover, the program establishes a plan for corrective actions, prescribes farmers to actively involve veterinarians, and requires keeping detailed records about any materialized non-compliances (drug treatment, broken needles, etc.) and taken corrective actions. Finally, the DFO conducts its own testing of milk and ensures traceability of milk to a particular farm. In other words, it is the DFO that ensures that suppliers have needed process in place.

Because of the DFO's involvement, the firm does not participate in supplier selection and does not allocate resources towards acquiring information on supplier processes. Moreover, it does not have information about particular Ontario farms its milk comes from. Instead, the firm's management is only aware of the requirements DFO places on the farmers.

The risk of a supplier producing contaminated milk has high impact and – due to DFO's presence in the industry - low likelihood. The firm addresses this risk by avoiding it. MILK is able to avoid this risk because of the DFO involvement in its milk supply chain. In fact, the firm is fully dependent on the DFO's ability to ensure compliance of the milk farms. It does not oversee pro-

duction of these farms nor does it know which farms each milk truck comes from. Therefore, the DFO practices determine the extent to which the firm is able to avoid non-compliances in its supply chain.

PIPING-PARTS.R

PIPING-PARTS.R is a small pipeline component manufacturer that sources semi-finished components from four North American suppliers. The firm sells its components (various types of flanges and fittings) to piping companies in the oil and gas industry. It carries a diverse inventory of semi-finished components, which it customizes according to customers' order specifications.

The piping industry is sensitive to product defects. For that reason, to attract customers the firm emphasizes its high product quality. Its customers do not monitor production of the firm or of its suppliers and expect that the firm will operate according to its reputation and will assure high quality of its products.

High product quality requires procuring defect-free semi-finished piping components from suppliers. Therefore, its main supplier risk is a supplier producing a defective component. Most likely, a component can become defective when a supplier heat-treats it in a furnace. Once the component is heat treated, defects are hard to identify.

This supplier risk has high potential impact. If installed in a pipe by one of the firm's final customers, the defective component may later crack under pressure and cause an operational disaster such as an oil spill. If this risk materializes it can lead to significant financial losses and can have a lasting negative effect on the firm's reputation. As a result, the firm is internally driven to address this risk. The firm's presence on the market depends on its reputation of a firm that prior-

itizes quality. In particular, it positions itself as an intermediary firm that guarantees control of its suppliers making it unnecessary for its customers to monitor its suppliers.

From its four North American suppliers, PIPING-PARTS.R sources non-standard products (e.g., based on an unusual alloy) in small volumes or when a customer requests a rush order. The firm believes that when it procures from its North American suppliers the likelihood of procuring a non-compliant component is low. The reason is that these suppliers follow a business model similar to the firm's: they attract customers because they are known for their emphasis on product quality. If one of these suppliers manufactures a defective product that later leads to an operational catastrophe, the materialized risk will severely affect both the reputation of the firm and of the supplier responsible for the defect. In other words, the North American suppliers will share the impact if the risk materializes.

Aligned vision on the importance of product quality makes it possible for the firm to rely on relational governance. These suppliers have demonstrated their adherence to complying with the firm's order requirements. They communicate about their products and disclose how they approach the critical stages of production. The firm management believes that it does not need to oversee processes of these suppliers because of their organization culture that emphasizes high product quality. Overall, the firm trusts that these suppliers would perform according to the firm's expectations and requirements.

With these suppliers, PIPING-PARTS.R focuses on risk avoidance. It believes that the viability of these suppliers depends on maintaining their reputation and therefore these suppliers are unlikely to produce defective components. The firm has visited facilities of these suppliers and evaluated their responsiveness to its requirements and chose not to acquire comprehensive in-

formation on their production processes. Instead, it trusts that over time the suppliers will remain compliant.

PIPING-PARTS.UN

This case considers the same firm as in PIPING-PARTS.R sourcing the same type of products (semi-finished components) but from a different supply base. This supply base consists of 18 offshore suppliers. From them the firm procures components of standard design in high volumes. These suppliers are associated with the same supplier risk of high potential impact: a supplier producing a defective component. Unlike its North American supply base, these suppliers are associated with the supplier risk of high likelihood. The firm believes that its offshore suppliers lack capabilities to assure that no defects are introduced to the components. In addition, these suppliers do not strive to protect their reputation to the extent the PIPING-PARTS.UN does. They are known for their cost-cutting organizational culture and for prioritizing profits over product quality. Moreover, the suppliers operate in an institutional environment, where corruption is common. As a result, they do not share the negative impact of the risk and lack incentives to ensure that products they manufacture for the firm are defect-free.

PIPING-PARTS.UN does not trust that the offshore suppliers can produce high quality products on consistent basis. For that reason, the firm relies on behavior-based contractual governance. The firm agrees to source from these suppliers only if they follow detailed requirements for critical-to-quality production processes. At the same time, the firm believes that even if the suppliers are aware of the requirements they might not comply with them. For that reason, to ensure compliance the firm has an off-site team that monitors the processes and remains in the suppliers' facilities until the produced products are shipped out to the firm.

The firm's off-site team consists of engineers. Their function is to remain in suppliers' facilities and control each stage of the production process including the selection of raw materials the suppliers use to manufacture the firm's components. Most importantly, the off-site team monitors heat treatment of the components. It is a critical production stage, during which a product can become fragile and later crack under pressure. The firm's management believes that the off-site team should control production even of its long-term offshore suppliers. To make it possible for the off-site team to oversee production of all its offshore suppliers the firm has chosen suppliers located in close proximity to each other.

With its offshore suppliers, the firm engages in behavior-based contractual governance. Its management believes that these suppliers cannot sufficiently avoid the risk of manufacturing defective components. For that reason, the firm oversees each step of production and hence is able to mitigate potential supplier non-compliances.

PROSCUITTO

PROSCUITTO is a small meat processing plant that produces cured, cooked, and frozen Italian meat products. The firm is a plant with a federal license, the highest standard in the meat processing industry. Being a federal plant gives the firm a right to sell across Canada and to export. Its products are sold mostly in independent grocery stores but also in a few large grocery retail chains. At the same time, the federal license puts it under the highest level of regulatory control and requires sourcing meat only from federal slaughterhouses.

The only meat ingredient the firm uses in its products is pork. It is the firm's main expense in procurement and its critical-to-quality purchase. The firm mainly procures meat from a single federal slaughterhouse. The main risk PROSCUITTO faces is sourcing from a supplier that pro-

duces contaminated meat. This is a high-impact supplier risk, and the firm is under significant external pressure to address it. The federal regulation keeps the firm responsible for any product contamination even if the contamination is originated in the meat supplier's facility. In addition, if the firm uses contaminated meat in its products and then ships it to one of its customers, it would need to issue a recall, and recalls are associated with significant financial and reputational losses.

At the same time, the firm believes that the likelihood of the supplier producing a contaminated product is low. In general, food safety hazards are present in daily operations of slaughterhouses. However, to ensure that federal slaughterhouses eliminate the hazards, their processes are controlled and regulated by a powerful external stakeholder, Canadian Food Inspection Agency (CFIA). CFIA inspectors are on staff of federal slaughterhouses; they ensure that production processes comply with the regulatory requirements and with the Hazard Analysis Critical Control Point (HACCP) program. The HACCP program is used throughout the Canadian meat processing industry to ensure that firms in the industry control potential food safety hazards. Overall, the CFIA's direct control of the supplier's operations makes the risk of a supplier producing a contaminated product a low-likelihood supplier risk.

The firm's meat supplier will share the impact if this risk materializes. If it produces contaminated meat and ships it to the firm, the slaughterhouse would share legal responsibility in the case of a product recall. Moreover, if the supplier contaminates its product it faces a threat of CFIA suspending or even revoking its federal license. Therefore, the slaughterhouse has incentives to comply with the CFIA's requirements minimizing the likelihood of product contamination.

CFIA's involvement influences how the firm governs its meat supplier. The firm relies on behavior-based contractual governance, with the key aspects of this governance mechanism enabled by the CFIA. The agency assigns inspectors to oversee all aspects of the slaughterhouse's production from purchasing to slaughtering to shipping. The inspectors have a right to detain non-compliant product, stop production, order the slaughterhouse to recall its products, and even initiate the process of revoking its license.

For that reason, the firm believes that the processes of the slaughterhouse do not contain potential triggers of product contamination and follow the requirements of the CFIA. As a result, the firm does not allocate resources towards acquiring comprehensive information on supplier processes and outsource these efforts to the CFIA. In fact, its management believes that it would not gain any important information by directly overseeing the processes of the supplier.

Overall, PROSCUITTO does not strive to have comprehensive information on its supplier's processes. It relies on behavior-based relational governance with the supplier processes controlled by the involved stakeholder and not the firm. The firm avoids the supplier risk of procuring contaminated meat to the extent largely determined by the effectiveness of the CFIA involvement in controlling and regulating the supplier.

APPENDIX D. SIMULATION CODE

```
globals [N_r]
breed [firms firm]
breed [risks risk]
directed-link-breed [chains chain]
firms-own [level capability impact risk_caused P_R fired]
risks-own [level origin location previous-location time_created]
```

```
to setup
```

```
ca
```

```
ask patches [set pcolor white]
```

```
set N_r 0
```

```
random-seed 100
```

```
create-random-tree (Supply_Base_Size + 1) Supply_Base_Size
```

```
reset-ticks ;;Reset time
```

```
end
```

```
to create-random-tree [number-of-nodes #-direct]
```

```
set-default-shape firms "circle"
```

```
create-firms 1 [
```

```
set level 0
```

```
set capability Firm_capability
```

```
set impact Firm_risk_impact
```

```
set risk_caused 0
```

```
set size 2.5
```

```
set color grey ]
```

```
create-firms (#-direct) [
```

```
set level 1
```

```
set size 2
```

```
set risk_caused 0
```

```
set color grey]
```

```
ask firms with [level = 1] [ create-chain-to one-of firms with [level = 0] ]
```

```
layout-radial turtles chains one-of turtles with [level = 0]
```

```
ask firms with [level > 0] [ set capability random-float 1 set impact random-float 1 ]
```

```
ask firms [ set capability precision capability 2 set impact precision impact
```

```
set color impact * 9 set size capability * 3 ]
```

```
end
```

```
to supplier_selection
```

```
ask firms with [level = 1] [
```

```
if (Approach = "Mitigation") or (Approach = "Tolerance") [
```

```
ifelse ( [capability] of one-of out-chain-neighbors )*( [impact] of one-of out-chain-neighbors ) >  
random-float 1
```

```
[set capability Selection_Threshold + random-float (1 - Selection_Threshold) ]
```

```
[set capability random-float Selection_Threshold ]]
```

```
if Approach = "Relationships-enabled-Avoidance" [
```

```
ifelse ( [capability] of one-of out-chain-neighbors )*( [impact] of one-of out-chain-neighbors ) >  
random-float 1
```

```
[set capability Selection_Threshold + random-float (1 - Selection_Threshold) ]
```

```
[set capability random-float Selection_Threshold ]
```

```
ifelse ( [impact] of one-of out-chain-neighbors ) > random-float 1
```

```
[set impact [impact] of one-of out-chain-neighbors + random-float (1 - [impact] of one-of out-  
chain-neighbors) ]
```

```
[set impact random-float [impact] of one-of out-chain-neighbors ] ]
```

```
if Approach = "Stakeholder-enabled-Avoidance" [
```

```
ifelse ( [capability] of one-of out-chain-neighbors )*( Stakeholder_Impact ) > random-float 1
```

```

[set capability Selection_Threshold + random-float (1 - Selection_Threshold) ]
[set capability random-float Selection_Threshold ]
ifelse ( Stakeholder_Impact ) > random-float 1
[set impact Stakeholder_Impact + random-float (1 - Stakeholder_Impact) ]
[set impact random-float Stakeholder_Impact]]]

```

```

ask firms [ set capability precision capability 2 set impact precision impact 2
set color impact * 9 set size capability * 3 ]
end

```

```

to go

```

```

let count_suppliers 1

```

```

let P_nc 0

```

```

while [count_suppliers <= count firms with [level = 1] ] [

```

```

ask firm count_suppliers [

```

```

if Approach = "Mitigation"

```

```

[ set P_nc alpha * (1 - capability * impact ) * (1 - [capability] of one-of out-chain-neighbors *
[impact] of one-of out-chain-neighbors )

```

```

set P_R P_nc ]

```

```

if Approach = "Stakeholder-enabled-Avoidance"

```

```

[ set P_nc alpha * (1 - capability * impact ) * (1 - Stakeholder_Capability )

```

```

set P_R P_nc ]

```

```

if Approach = "Relationships-enabled-Avoidance"

```

```

[ set P_nc alpha * (1 - capability * impact )

```

```

set P_R P_nc ]

```

```

if Approach = "Tolerance"

```

```

[ set P_nc alpha * (1 - capability * impact )

```



```

set P_R P_nc ]]

if P_nc > random-float 1
[ create-risks 1 [
set time_created ticks
set location firm count_suppliers
set origin [who] of location
move-to location ]
set N_r N_r + 1 ]
set count_suppliers count_suppliers + 1
set P_nc 0]

ask firms with [any? risks-here] [ set risk_caused risk_caused + 1]
ask risks [
let new-location one-of [out-link-neighbors] of location
move-to new-location
set previous-location location
set location new-location]

ask firms [ if capability < 0.01 [ set capability 0.01 ] if capability > 0.99 [ set capability 0.99 ] ]
ask firms [ if impact < 0.01 [ set impact 0.01 ] if impact > 0.99 [ set impact 0.99 ] ]

ask firms [
if capability < 1 and capability > 0
[ if fluctuations > random-float 1 [ let c one-of [0.01 -0.01] set capability capability + c ]]
if impact < 1 and impact > 0 and level > 0
[ if fluctuations > random-float 1 [ let c one-of [0.01 -0.01] set impact impact + c ]]]

ask firms [ set capability precision capability 2 set impact precision impact 2
set color impact * 9 set size capability * 3
set label-color red set label precision P_R 3]

```

```

if Reaction = "terminate_relationships" [
ask firm 0 [
if any? in-chain-neighbors with [risk_caused > 0 ] [
ask in-chain-neighbors with [risk_caused > 0 ] [
set fired true]]]

ask firms with [fired = true] [
if (Approach = "Mitigation") or (Approach = "Tolerance") [
ifelse ( [capability] of one-of out-chain-neighbors ) * ( [impact] of one-of out-chain-neighbors )
> random-float 1
[set capability Selection_Threshold + random-float (1 - Selection_Threshold) ]
[set capability random-float Selection_Threshold ]
set impact random-float 1 ]

if Approach = "Relationships-enabled-Avoidance" and level = 1 [
ifelse ( [capability] of one-of out-chain-neighbors ) * ( [impact] of one-of out-chain-neighbors )
> random-float 1
[set capability Selection_Threshold + random-float (1 - Selection_Threshold) ]
[set capability random-float Selection_Threshold ]
ifelse ( [impact] of one-of out-chain-neighbors ) > random-float 1
[set impact [impact] of one-of out-chain-neighbors + random-float (1 - [impact] of one-of out-
chain-neighbors) ]
[set impact random-float [impact] of one-of out-chain-neighbors ] ]

if Approach = "Stakeholder-enabled-Avoidance" [
ifelse ( [capability] of one-of out-chain-neighbors ) * ( Stakeholder_Impact ) > random-float 1
[set capability Selection_Threshold + random-float (1 - Selection_Threshold) ]
[set capability random-float Selection_Threshold ]
ifelse ( Stakeholder_Impact ) > random-float 1
[set impact Stakeholder_Impact + random-float (1 - Stakeholder_Impact) ]

```

```

[set impact random-float Stakeholder_Impact]]]
ask firms with [fired = true]
[ set fired false set risk_caused 0 set capability precision capability 2 set impact precision impact
2 set size capability * 3 set color impact * 9 set label-color red set label precision P_R 3]]

if Reaction = "continue_relationships" [
ask firm 0 [
if any? risks-here [ ask risks-here [
ask previous-location [
if capability < Selection_Threshold    [ if ( ( capability / Selection_Threshold ) * impact ) >
random-float 1
[ set capability Selection_Threshold ]]]]]]

ask firms [ set capability precision capability 2 set size capability * 3 set label-color red set label
precision P_R 3]]
ask risks [ if [level] of location = 0 [die ]] ;; removing materialized risks from the system
tick
end

```