Improving Sustainability Performance in a Two-Tier Supply Network: An Agency Perspective

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ABSTRACT

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Equity owners are often blamed for the unsustainable behaviors of other supply chain members. Recent events show that focal firms may face reputational and financial damages when such misconducts are exposed. However, controlling sub-suppliers can be challenging due to the high supply chain complexity, lack of contractual relation, and the large distance between the supply chain members. Focal firms adopt different governance strategies to improve sustainability performance, but it is unclear how the behavioral and contextual contingencies affect the sustainability performance of sub-suppliers. To explore this issue, the current study employs agentbased modeling and uses agency theory as an interpretive lens. The results shed light on how sustainability performance of sub-suppliers is impacted by (1) risk-aversion of supply chain members, (2) the cost of monitoring and the cost of undertaking sustainability practices, (3) varying information asymmetry between the focal buyer, intermediary supplier, and focal supplier, (4) stakeholder pressure, (5) and supply chain power.

Keywords: sustainability performance, sub-supplier, agent-based modeling, sustainable supply chain

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1. Introduction

Outsourcing business operations to suppliers no longer means outsourcing risks associated with it. Leading companies learned this lesson over the last two decades when they were blamed for the misconducts of their supply chain partners. The recall of over 18 million toys due to excessive lead by Mattel, the collapse of Rana Plaza housing sub-suppliers of clothing giants like Primark and JC Penny, the BP oil spill resulting in a penalty of 4.5 million, Foxconn's struggle with human right violation, and successful Greenpeace campaign against Nestle for working with suppliers involved in deforestation are few of the events that drew global attention. Therefore, companies can be only as sustainable as their suppliers (Krause, Vachon & Klassen, 2009), since they are accountable for unsustainable behaviors of their direct or indirect suppliers (Hartmann & Moeller, 2014). This implies that to be truly sustainable, firms need to extend sustainability practices to their supply network.

In addition to these events, almost three-quarters of the greenhouse gas emissions originate in the extended supply chain of a firm (GHG Protocol, 2011). Further, social and environmental violations are likelier in second-tier and third-tier suppliers who are ill-equipped to deal with such issues (Sedex, 2013). When such misconducts of the suppliers are exposed, focal firms are vulnerable to customer boycotts, governmental penalties, and poor stock market performances (Dam & Petkova, 2014; Locke, Qin & Brause, 2007; Plambeck & Taylor, 2015). Increasing pressure in terms of media scrutiny, governmental regulation, and activism implies that focal firms need to ensure improvement in the sustainability performance in sub-suppliers (Tong, Lai, Zhu, Zhao, Chen & Cheng, 2018b). Selective improvement in the environmental and social performances of a few first-tier suppliers is inadequate to mitigate the sustainability risks existing among the lower-tier suppliers (Rauer& Kaufmann, 2015). Collectively, these issues

highlight the importance of focal firms controlling the level of the sustainability performance of their supply chain partners.

To understand this phenomenon, research on sustainable supply chains has shifted over the last decade from focal buying firm level to suppliers (Bai &Sarkis, 2010) and recently to subsuppliers (Grimm,Hofstetter&Sarkis, 2014; Wilhelm,Blome, Wieck& Xiao, 2016b). Extant literature indicates that lower-tier suppliers are hard to govern since they are geographically far away and are indifferent towards improving their sustainability performance. Exploring how focal firms coordinate with suppliers and sub-suppliers, studies have primarily focused on governance mechanisms (Mena, Humphries & Choi, 2013; Hofstetter, 2018), practices linked to these governance mechanisms (Tachizawa& Wong, 2014), contextual factors that determine the strategies used by focal firms (Wilhelm et al, 2016b), and the diffusion of codes of conduct (Jia, Orzes, Sartor&Nassimbeni, 2017; Hofmann, Schleper&Blome, 2018). While the extant literature discussed different governance mechanisms, the effectiveness of these strategies is doubtful (Sancha, Giminez& Sierra, 2016).

It is common knowledge that focal buyers and intermediaries[1] monitor sub-suppliers to ensure improvements in the level of sustainability performance. However, there is compelling evidence that suppliers often misrepresent their actual conditions to pass an audit and continue business as usual (Plambeck& Taylor, 2015). To understand how focal firms can improve the level of sustainability performance in multi-tier suppliers, previous studies have explored how varying contextual contingencies (like supply chain complexity, industry pressure, etc.) can determine the choice of governance strategy. Having said that, it is relatively unclear how behavioral variables (like risk-aversion) and contextual contingencies (like stakeholder pressure)

[1] The words intermediaries and first-tier suppliers have been used interchangeably in this paper. I have used the word intermediary in the model but it bears the same meaning as first-tier supplier.

can affect the level of sustainability performance over time. Therefore, the research question that I pose is as follows: *How do the behavioral factors of supply chain members and contextual contingencies affect the level of sustainability performance in a two-tier supply network?*

Grounding on the central constructs of agency theory and using evidence from prior multi-tier supply chain literature, this study develops a model to explore the improvements in the level of sustainability performance in a two-tier supply network. This model has four supply chain members: focal buyer, intermediary, the focal supplier, and the stakeholder. The level of sustainability performance refers to the sustainability performance of the focal supplier. The focal buyer is described by three parameters: risk-aversion, cost of monitoring, and monitoring efficiency. The intermediary is described by four parameters: risk-aversion, cost of monitoring, monitoring history, and relationship history. The focal buyer is described using three parameters: risk-aversion, cost of sustainability practice, and relationship history. Finally, the model also includes a stakeholder which is described by the parameter monitoring efficiency. These variables are the inputs to the agent-based model and evolve based on a set of logic that influences the behavior of the supply chain members, thus affecting the level of sustainable performance in a multi-tier supply chain network over time.

This study responds to the call for research to look beyond the dyadic relationship and considers the complexities of the multi-tier supply chain (Tachizawa& Wong, 2014). Besides, this study lends a better perspective to the sparse research that uses quantitative modeling in the multi-tier supply chain (Jabbour, Jabbour&Sarkis, 2018). Finally, the agent-based simulation model explores how supply chain members behave over time, thus overcoming the typically static viewpoint adopted by previous literature (Gong, Jia, Brown &Koh, 2018). The results from the agent-based modelprovide a predictive tool to understand the improvement of sustainability performance over time in a two-tier supply network. In particular, the results shed light on how

sustainability improvement can be impacted by (1) risk aversion of supply chain members; (2) the cost of monitoring and the cost of undertaking sustainability practices; (3) varying information asymmetry between the focal buyers, intermediary and focal supplier; (4) stakeholder pressure and (5) supply chain relational power.

This paper has six sections after this. Section 2 reviews the literature on multi-tier supply chain sustainability and the use of agency theory in sustainable supply chain literature, followed by developing a theoretical framework. Section 3 outlines the model assumption, parameters, and simulation design used in the study. After that, Section 4 reports the results of the simulation and develops six propositions. In section 5, the results are discussed in the context of the extant literature, while Section 6 highlights the theoretical, methodological, and managerial contributions of the study. Finally, Section 7 talks about the limitations of the study.

2. Literature Review & Theoretical Framework

2.1. Sustainability in Multi-tier Supply Chain

A multi-tier supply chain consists of direct and indirect suppliers of a focal firm. Indirect suppliers (or sub-suppliers) are all those firms that are in the supply chain network of a focal firm but not contractually connected to the focal firm. Prior literature claims that monitoring subsuppliers is particularly challenging due to the large number of sub-suppliers, lack of contractual agreements, power asymmetry, and high cost (Choi & Linton, 2011; Awaysheh&Klassen, 2010; Wilhelm et al, 2016b; Villena&Gioia, 2018). Further, first-tier suppliers are often unwilling to reveal the identity of the second-tier suppliers fearing that will undermine their position in the relationship (Grimm et al, 2014). Even if focal companies identify the second-tier suppliers, it is hard to improve the performance of these second-tier suppliers mainly because they operate in countries with fewer regulations and do not face the pressures of the end consumers (Homburg, Wilczek& Hahn, 2014).

The limited improvement in the sustainability performance of sub-suppliers is also because focal firms struggle to engage extensively in sub-supplier management. The high cost involved, low capability, and inadequate top management support (Grimm et al, 2014) contribute to the limited efforts in multi-tier sustainability. While auditing and certifying sub-suppliers have emerged as mainstream ways to improve the conditions, they come with their limitations as well. Bribing auditors and mock compliances mean that these efforts do little to change the prevailing conditions (AnisulHuq, Stevenson &Zorzini, 2014). Other unique challenges to improving subsupplier sustainability management are heterogeneous criteria of assessment, data availability, and lack of standardized tools. (Hofstetter& Grimm, 2019;Jia, Gong & Brown, 2019).

An early effort to understand multi-tier supply chain management was made by Mena et al (2013), using case studies built on three-tier data. Observing the structural arrangements of

buyers, suppliers, and sub-suppliers, they proposed three types of multi-tier structures, namely, open, closed, and transitional. In an open structure, there is no direct connection between the buyer and the sub-supplier. In a closed structure, there is a formal link among the buyer, supplier, and sub-supplier. Finally, in a transitional structure, the link between the buyer and the subsupplier is being established. Grounded on this typology, Tachizawa& Wong (2014) stated that focal firms belonging to a particular structure adopted sustainability governance practices best suited to that structural arrangement. These practices were classified into four categories: direct, indirect, working with 3rd parties, and don't bother.

Direct governance practices mainly consist of supplier assessment, monitoring system, and supplier collaboration (Formentini&Taticchi, 2016; Sancha et al, 2016; Liu et al, 2019). Continuous assessment of sustainability performance and monitoring are not only costprohibitive but also can be less effective since focal firms are not sure what information is needed and how to make sense of it (Hofstetter, 2018). However, in this approach, if focal firms detect violations, they may impose a penalty or discontinue the relationship with the sub-supplier (Meinlschmidt, Schleper&Foerstl, 2018). In contrast to the monitoring approach, focal firms can also decide to build the capability of the sub-suppliers with resources and sustainability knowledge so that they can comply with the sustainability requirements of the focal firms (Grimm et al, 2014).

The challenge of directly managing endless suppliers makes indirect governance the most popular form of governance today (Hofstetter, 2018). In indirect governance practices, the focal firm depends either on their suppliers to diffuse the sustainability requirements among the subsuppliers or use certification systems to ensure improvement in the standard of sustainability performance (Kauppi& Hannibal, 2017; Ciliberti, de Groot, de Haan&Pontrandolfo, 2009; Wilhelm et al, 2016b). Naturally, the role of the first-tier suppliers is crucial here, as they not

only have to improve their sustainability performance but also motivate their suppliers to embrace the requirements of the focal firms.

"Working with the third party" means that the focal firms may collaborate with NGOs or an industry association. This approach typically involves building a relationship with a nonbusiness actor who acts as a bridge between the buyer and the sub-supplier to improve the level of the sustainability performance of the sub-supplier (Alvarez,Pilbeam& Wilding, 2010). The role of these non-traditional actors has grown in importance lately, as these NGOs and industry associations are effective in improving the sustainability performance of suppliers and subsuppliers. Finally, in the “don’t bother” approach, the focal firm assumes the sustainability risk because they have no information about these sub-suppliers or do not care about them.

Other than the discussed structural arrangements, contextual and relational contingencies also play an important role in determining the approach and success in sustainability performance in a multi-tier supply chain(Wilhelm et al, 2016b; Dou, Zhu &Sarkis, 2018). For example, the organizational culture and top management of the focal firms are important factors influencing the attitude and engagement in improving sustainability performance among the subsuppliers (Grimm et al, 2014; Jia et al, 2019). Industry pressures, stakeholder salience, product criticality, and geographic location are other factors that can determine the strategies adopted by the focal firms for managing lower-tier suppliers (Formentini&Taticchi, 2016; Shukla,Khor&Lockey, 2018). Finally, relational variables like behavioral uncertainty, power, and level of trust between focal firms and first-tier suppliers can also affect the sustainability performance in a multi-tier supply network (Wilhelm et al, 2016b; Dou et al, 2018).

Besides the governance perspective, a few recent studies have notably enriched the multi-tier supply chain literature in a sustainability context. First, Hoffman, Schleper&Blome (2018)

recently focused on how firms are responding to sustainability risks associated with conflict mineral. Introducing a holistic concept of supply chain due diligence, they found that based on the varying level of pressure, a few firms commit to this problem and proactively collaborate with the supply chain partners. As a result, they achieve better financial results, form strategic partnerships, and enjoy a superior reputation. Second, countering Tachizawa& Wong's (2014) claims of a relationship between supply chain structural arrangements and practices adopted, Gong et al (2018) invoked supply chain learning and resource orchestration theory to propose that firms may use their discretion in applying a direct or indirect governance irrespective of their awareness of the lower-tier suppliers. Third, grounded on leadership theory, Jia et al, (2019) found that focal firms leading sustainability initiatives could dynamically change supply chain structure to suit the preferred form of learning and governance. Recent studies also point out a few unresolved challenges in multi-tier sustainable supply chain management. For example, there is a limited understanding of how sub-supplier management benefits the focal firms thus making the business case for multi-tier sustainable supply chain weak (Hofstetter& Grimm, 2019). Finally, from a researcher's perspective, incorporating all three dimensions of sustainability and exploring a sub-supplier's perspective may be a viable route to further the body of research.

2.2. Agency Theory & its Application in Sustainable Supply Chain Management

Agency theory has been scarcely applied in supply chain management research (Ciliberti,De Haan,De Groot, Pontrandolfo,2011). An agency relationship is established when a principal delegates a particular task to an agent (Eisenhardt, 1989). Since a supply chain is a

complex network of buyers (principals) and suppliers (agents), it is naturally suited to agency theory (Fayezi, O'Loughlin &Zutshi, 2012). The central assumptions of agency theory are that principals and agents are self-interested, have varying risk preferences, and partially conflicting goals (Eisenhardt, 1989; Jensen &Meckling, 1976). It is assumed that the agents (suppliers) can choose an action from several alternatives that affect the outcome of both the agents and the principals. In such situations, agency theory gives guidance to safeguard the principal's interest by inducing favorable agent behavior at the least effort. Agency theory has been used as an interpretive lens to tackle defaulting suppliers (Prosman, Scholten& Power, 2016), managing supplier-related risks (Hajmohammad&Vachon, 2016), supply chain quality management (Zu&Kaynak, 2012; Whipple &Roh, 2010), and implementation of codes of conduct in the supply chain (Cilberti et al, 2011).

Anecdotal evidence in sustainable supply chain management literature suggests that focal firms and suppliers have divergent goals and varying preferences towards sustainability (Busse, Schleper, Niu& Wagner, 2016; Koplin, Seuring&Mesterharm, 2007; Wilhelm et al, 2016b). Contrary to the assumption of agency theory, suppliers are riskier than buyers, in the context of sustainability (Delbufalo, 2018). This is because the suppliers are less visible, less intimidatedbymedia scandals, and usually located far from the point of sales where consumer pressure is high (Foerstl, Azadegan, Leppelt& Hartmann, 2015). Other factors to hinder improvement in sustainability performances include lack of capability, poor knowledge of sustainability, and low regulatory pressure (Meinlschmidt et al, 2018; Grimm et al, 2016; Wilhelm,Bloome, Bhakoo&Paulraj, 2016a).

Thus, eliciting favorable reactions from the suppliers, and more so from the subsuppliers, is a challenge. Grounding on agency theory, Wilhelm et al (2016a) and Shukla et al (2018)

further explored this problem. In doing so, they highlighted the critical role of the firsttier suppliers in the context of a multi-tier sustainable supply chain. They found that in a multitier context, the direct suppliers are agents to the focal buyers and principals to the second-tier suppliers. Hence, in addition to the traditional agency role, these suppliers fulfill the lead buyer's sustainability requirement in their supplier's activities. Based on agency and contextual factors, the studies proposed the conditions under which first-tier suppliers will champion this new role. In a similar vein, Cilibertiet al (2011) highlighted that principals have two fundamental issues while dealing with suppliers. One is to know whom to select as a supplier and next is how to monitor thereafter (adverse selection and moral hazard in agency theory terms). Based on four case studies, they showed that adoption of code of conduct, like SA8000, could attenuate information asymmetry in a supply chain and solve these two problems.

2.3. Theoretical Framework

In this part, the decision framework and the central constructs of the model are discussed. The decision framework represents a typical process of monitoring in a multi-tier supply chain environment with four members, namely, focal buyer, intermediary, focal supplier, and stakeholder. The focal buyer, intermediary, and stakeholder may monitor the focal supplier at each period. However, monitoring the level of sustainability performance poses a few challenges. Practices like slavery and the use of minerals from conflict zones are difficult to observe *ex-post* (Gold, Trautrims&Trodd, 2015). However, other performances, such as greenhouse gas emission, quality, and ecological footprint, can be benchmarked. Hence, following Vachon and Klassen (2006), I consider both behavior control and output assessments to be part of supplier monitoring. This means that supplier monitoring consists of direct observation as well as assessing performance against a set of pre-specified criteria. The stakeholder can be a typical

non-business entity like an NGO or government that is always monitoring the focal supplier. However, the other two members, that is the focal buyer and intermediary, are rational agents having two choices each time, to monitor or not.

The decision to monitor depends on behavioral and contextual variables. These are the risk-aversion, cost of monitoring, and relationship history. First, risk-aversion is a central construct in agency theory and characterizes an individual's behavior under uncertainty (Eisenhardt, 1989; Zu&Kaynak, 2012). That means all other factors remaining the same, a focal buyer with higher risk-aversion is likelier to monitor the focal supplier than its counterpart with a lower risk-aversion. Second, the cost of monitoring refers to the resources needed to monitor a particular agent (Grimm et al, 2014). Third, the relationship history applies to the intermediary and refers to past incidents in the supply network. This means that, if the focal buyer catches the intermediary not doing its duty, it punishes the intermediary in the next period (Meinlschmidt et al, 2018). One more condition central to the framework is monitoring efficiency. Since monitoring does not imply successfully detecting violations, each supply chain member monitoring the focal supplier has an imperfect monitoring efficiency (Plambeck& Taylor, 2015).

The decision to improve the level of sustainability performance lies with the focal supplier in this framework. The first variable is the risk-aversion of the sub-supplier that indicates its risk preference towards improving the level of sustainability performance (Tong, Chen, Zhu & Chen, 2018a). Second is the cost of sustainability practice. A supplier, especially in developing countries, can be discouraged by the cost of sustainability practices (Tong et al, 2018b). Third, the history of the relationship also influences the sub-supplier. This means that, if any supply chain member caught the sub-supplier in the previous time, the sub-supplier will be more cautious

the next time. Finally, the improvement in the level of sustainability performance encompasses all dimensions of sustainability (Tong et al, 2018a).

Relying on agency theory and prior literature , the research framework represents a popular governance approach in multi-tier supply chain literature.Despite its simplicity, it represents a dynamic environment considering the behavioral adaptation of the supply chain members, longitudinally.Figure 1 and Figure 2 represent the timeline of the actions and the relation between monitoring and risk-aversion for each supply chain member used in the experimental design, respectively.

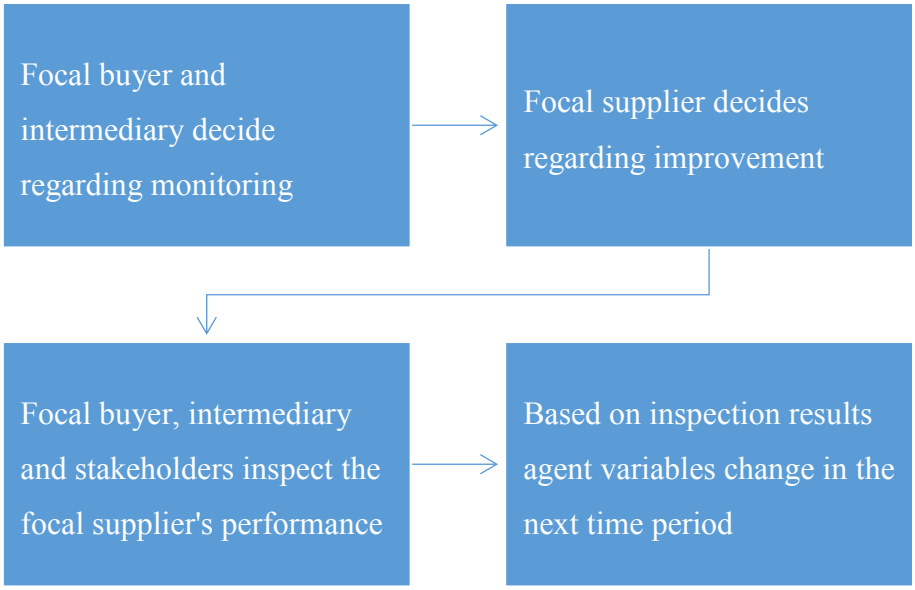

Figure 1: Time Line of the Events

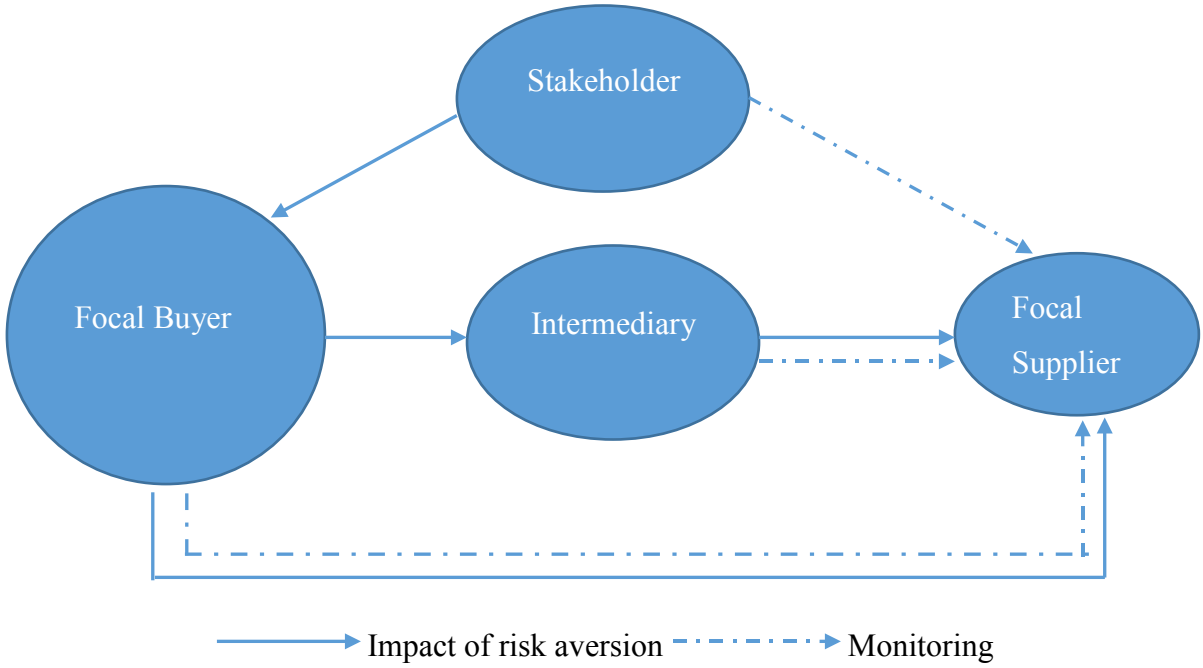

Figure 2: Framework of Experimental Design

3. Model Parameters, Description and Assumptions

This section provides an overview of the research setting and the objectives of the simulation design. To begin with, the simulation tries to understand how evolving behavioral and contextual contingencies lead to an improvement in the level of sustainability performance at the sub-supplier. Supply chain members in the simulation have a decision rule that determines their behavior. The details of the member's variables are reported in Table 1.

Agent	Parameter	Notation and Value Range	Definition
Focal Buyer	Risk Aversion	$R_{bt} \in [0,1]$	Focal buyer's risk preference towards monitoring focal supplier
	Cost of Monitoring	$C_b \in (0, 1]$	Cost incurred by focal buyer to monitor focal supplier
	Monitoring Efficiency	$E_{bt} \in (0, 1]$	Buyers' efficiency of correctly measuring behavior of focal supplier
Intermediary	Risk Aversion	$R_{it} \in [0,1]$	Intermediary's risk preference towards monitoring focal supplier
	Cost of Monitoring	$C \in_i (0, 1]$	Cost incurred by intermediary to monitor focal supplier
	Relationship History	Q_{it}= .5 or 1	If intermediary was caught lax in monitoring focal supplier in the last time period
	Monitoring Efficiency	$E_i \in (0, 1]$	Intermediary's efficiency of correctly measuring behavior of focal supplier
Focal Supplier	Risk Aversion	$R_{st} \in [0,1]$	Risk preference towards not improving sustainability performance as mandated by downstream buyers
	Cost of Sustainability Practice	$C \in_s (0, 1]$	Focal supplier's cost incurred to incorporate sustainability practices
	Relationship History	Q_{st} = .5 or 1	If the focal supplier was caught to be violating by buyer, intermediary or stakeholders in the last time period
Stakeholder	Monitoring Efficiency	$E_s \in [0, 1]$	Stakeholder's efficiency of policing extended supply chain

Table 1: Agent Parameters

In each period, the focal buyer decides whether to monitor the focal supplier. The probability of monitoring is inversely related to the cost of monitoring because higher cost discourages the focal buyer from monitoring. On the other hand, the decision to monitor also depends on the risk aversion of the focal buyer. A high level of risk aversion means that a focal buyer is likelier to monitor the focal supplier, which means that risk aversion is directly

proportional to the probability of monitoring. Equation 1 analytically represents the probability of monitoring by the focal buyer at each period.

$$P_{bt} = 1 - \alpha * (1 - R_{bt}) * C_b \quad (1)$$

where α is a parametric constant.

Similarly, the intermediary also decides whether to monitor the focal supplier in every period. The probability of monitoring is inversely proportional to the cost of monitoring and directly proportional to the risk aversion of the intermediary. It is also assumed that if the focal buyer detected a non-improvement at the focal supplier while monitoring in the last period, it penalizes the intermediary for not doing its duty. Hence, the intermediary is more risk-averse in the following period. This is incorporated by designating the value of Qit to be 0.5 in such cases and 0 otherwise. Equation 2 analytically represents the probability of monitoring by the intermediary at each period.

$$P_{it} = 1 - \beta * (1 - Ri_t) * C_i * (1 - Q_{it}) \quad (2)$$ where

β is a parametric constant

Next, the focal supplier decides between improving and maintaining the same level of sustainability performance. This decision is based on the cost of sustainability practice that is negatively related to the probability of improvement. On the other hand, risk aversion is directly related to the probability of improvement in the level of sustainability performance. This implies, all other factors remaining the same, a risk-seeking supplier is likelier not to improve compared to a risk-averse one. Also, if the focal supplier was caught not improving in the previous period by any of the other members, the focal supplier is more risk-averse in the following period. The

variable Q_{st}captures this by assuming a value of 0.5 in the period after being caught or zero otherwise. Equation 3 below analytically represents the probability of improving the level of sustainability performance at any period by the focal supplier.

$$P_{st} = 1 - \gamma * (1 - R_{st}) * C_s * (1 - Q_{st}) \quad (3)$$ where γ is a parametric constant

To sum it up, based on these equations a focal supplier can be monitored by both the only the focal buyer, only the intermediary, both the focal buyer and intermediary. However, the stakeholders are assumed to be always monitoring with very limited monitoring efficiency. Agency theory states that agents get punished by principals when if they act opportunistically (Delbufalo, 2018). This is captured in the simulation by penalizing the agent every time it misbehaves. First, if the stakeholder detects non-improvement in the focal supplier's performance, it charges the focal buyer to be responsible. Thus, in the next period, the focal buyer becomes more risk-averse by 2% than before. In a similar essence, when the focal buyer detects the lack of improvement at the focal supplier, it punishes both the intermediary and focal supplier (agents). This increases their risk-aversion by 2% in the next period. Finally, when the intermediary detects a lack of improvement in a focal supplier, it punishes the focal supplier to become more risk-averse 2% than before in the next period. Figure 3 below represents the outcomes of non-improvement based on which supply chain member detects it.

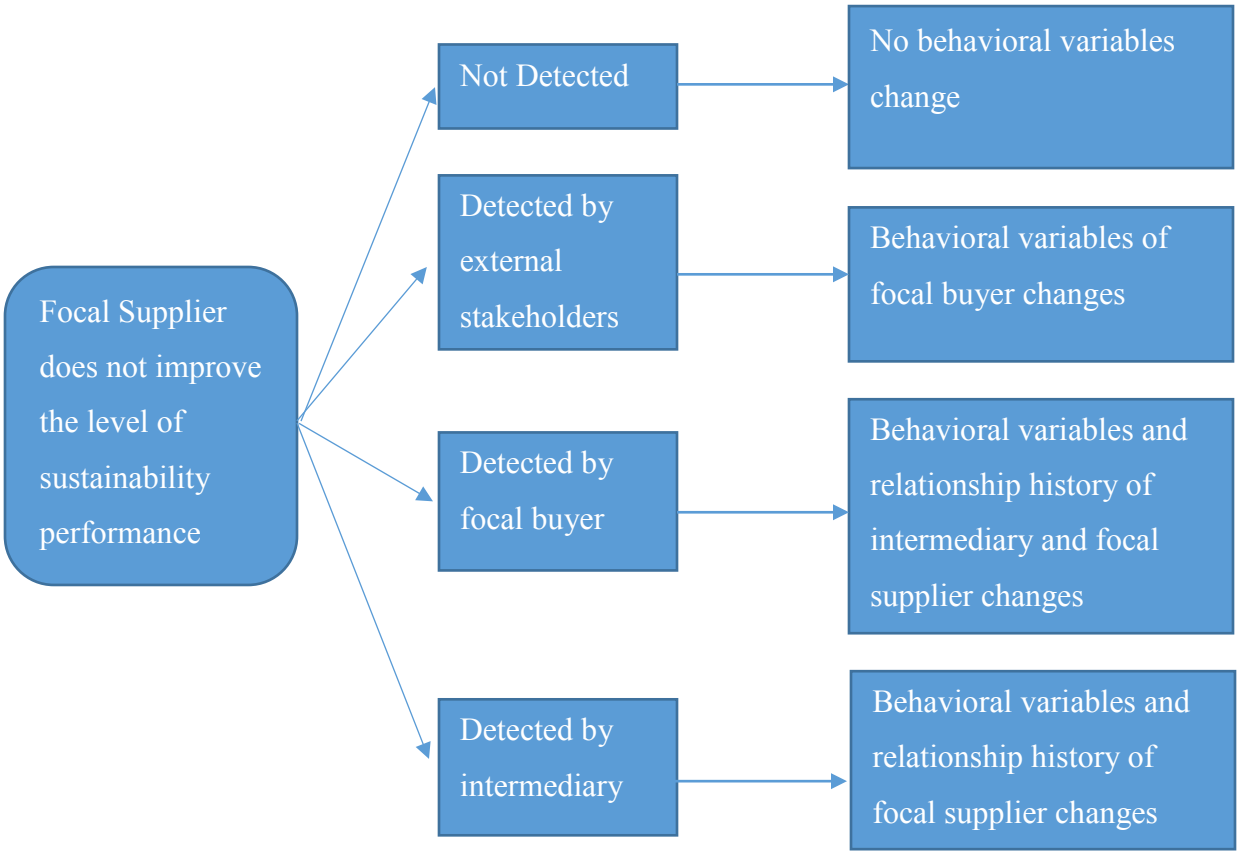

Figure 3: Outcomes of Non-Improvement by the Focal Supplier

3.1. Experimental Design

Based on the previous discussion, I designed an agent-based simulation in NetLogo (v 6.1.0), a popular programmable agent-based modeling environment. Each simulation was run over 200 periods (ticks in NetLogo terminology) and repeated 10 times. The average of the values was reported as the results. The following parameter settings were used for the simulation analyses.

- α, β and γ set to 2.5
- the starting value of risk-aversion of the focal buyer, intermediary and the focal supplier ranges from 0 to 1 with a step-wise increase of 10% [0.0, 0.1, 0.2….1]
- the value of cost of monitoring for the focal buyer and intermediary ranges from 0.1 to 1 with a step-wise increase of 10% [0.1, 0.2, 0.3 ….1]
- the value of cost of sustainability practice for the focal supplier ranges from 0.1 to 1 with a step-wise increase of 10% [0.1, 0.2, 0.3…..1]
- the value of monitoring efficiency of the buyer ranges from 0.5 to 0.2 decreasing[2]by 0.1 which is 20% of the baseline value of 0.5
- the value of stakeholder monitoring efficiency is simulated through 0.2, 0.3 and 0.4 which is four-times, six-times and eight-times the baseline value of 0.05.
- the value of the coefficient of increase in risk aversion is simulated through the values 0.01,

  0.02 and 0.03, the baseline value being 0.02.

[2] Decreasing monitoring efficiency is assumed to represent more information asymmetry between the focal buyer and the supplier

4. Results

This study exploreshow the behavioral characteristics of the supply chain members and varying external contingency factors affect the overall improvement in the level of sustainability performance at the focal supplier at the end of 200 periods. To address this question, this research relied on an agent-based simulation that allowed for manipulating behavioral characteristics and external contingency values. This section discusses the results of the agent-based simulation.

4.1. The Effect of Risk Aversion of Focal Buyer and Intermediary

In the first set of simulation runs, the risk aversion values of the focal buyer and intermediary are varied, keeping all other parameters constant. This analysis assumed that the focal supplier is risk-seeking and hence the starting value of the focal supplier's risk aversion was set to 0. In Figure 4, the improvement in the level of sustainability performance along the x-axis is an effect of intermediary's risk aversion. On the other hand, the improvement along the y-axis is due to the focal buyer risk aversion. As expected, results show that the focal supplier monitored by risk-averse focal buyer and intermediary exhibits the highest improvement in the level of sustainability performance than any other combination. In addition, Figure 4 reports that the improvement rate decreases as the focal buyer become more risk-averse (as seen in the slopes of the improvement curves in Figure 1). The rate of improvement decreases to the point that those risk-averse buyers (top right corner of Figure 4) experience virtually no improvement in the level of sustainability performance while working with risk-averse intermediaries. As shown in the right-hand side of Figure 4, the risk aversion of intermediary has a converging effect on the improvement in the level of the sustainability performance of the focal supplier over time. This implies that as the risk aversion of the intermediary increases, the gap between sustainability performance improvements caused by differing risk-aversion of the focal buyer is diminished.

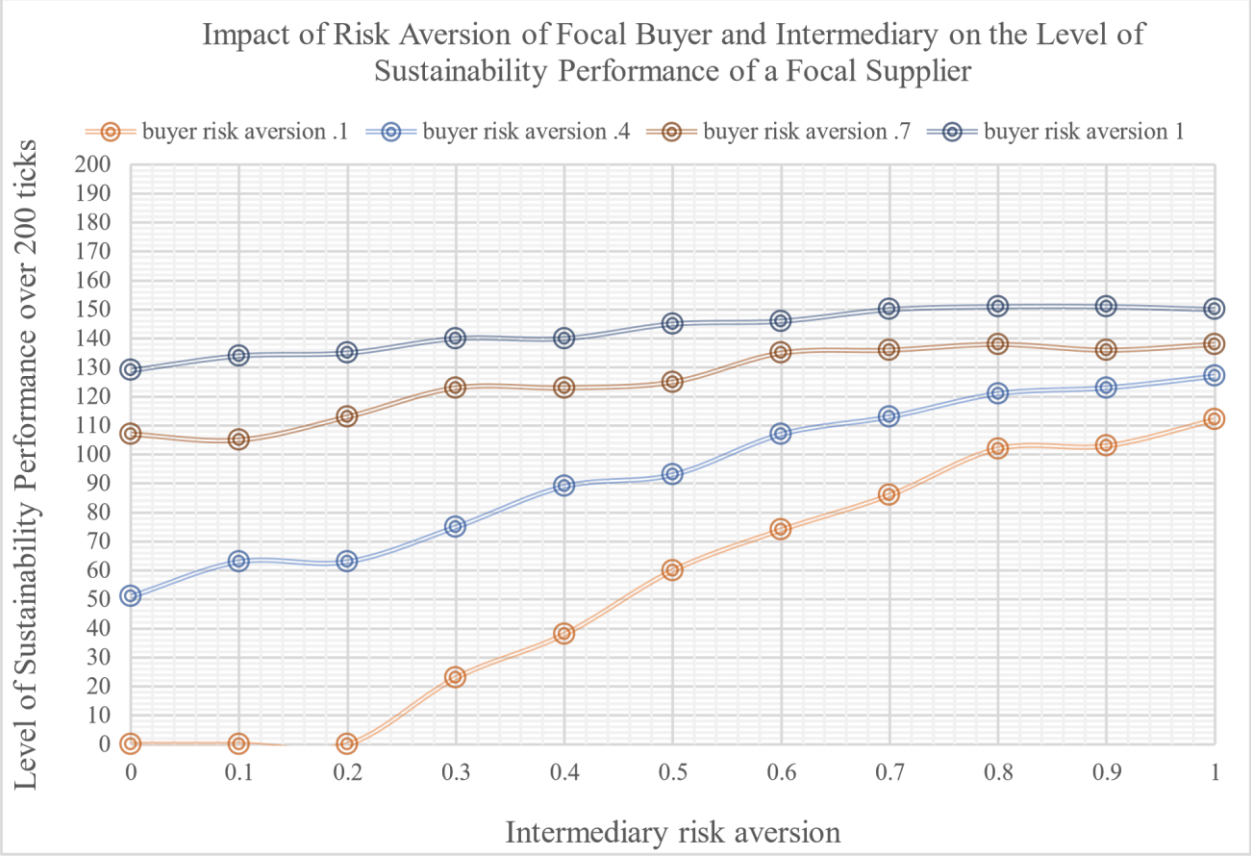

Figure 4: Impact of Buyer and Intermediary Risk Aversion on the Level of Sustainability Performance of a Focal Supplier (Initial Risk Aversion, $R_b = 0$)

The same experiment was repeated changing the risk aversion of the focal buyer from 0 to 0.3 and 0.6. Figure 5 and Figure 6 reports the results of these scenarios, respectively. They reveal that as the risk aversion of the focal supplier increases, the need for strong monitoring mechanisms is reduced. Collectively Figures 4, 5 and 6 show that keeping all factors constant, with increasing risk-aversion of the focal supplier, the level of sustainability performance increases. This is consistent with the simulation design as the decision to improve depends on the risk aversion of the focal supplier.

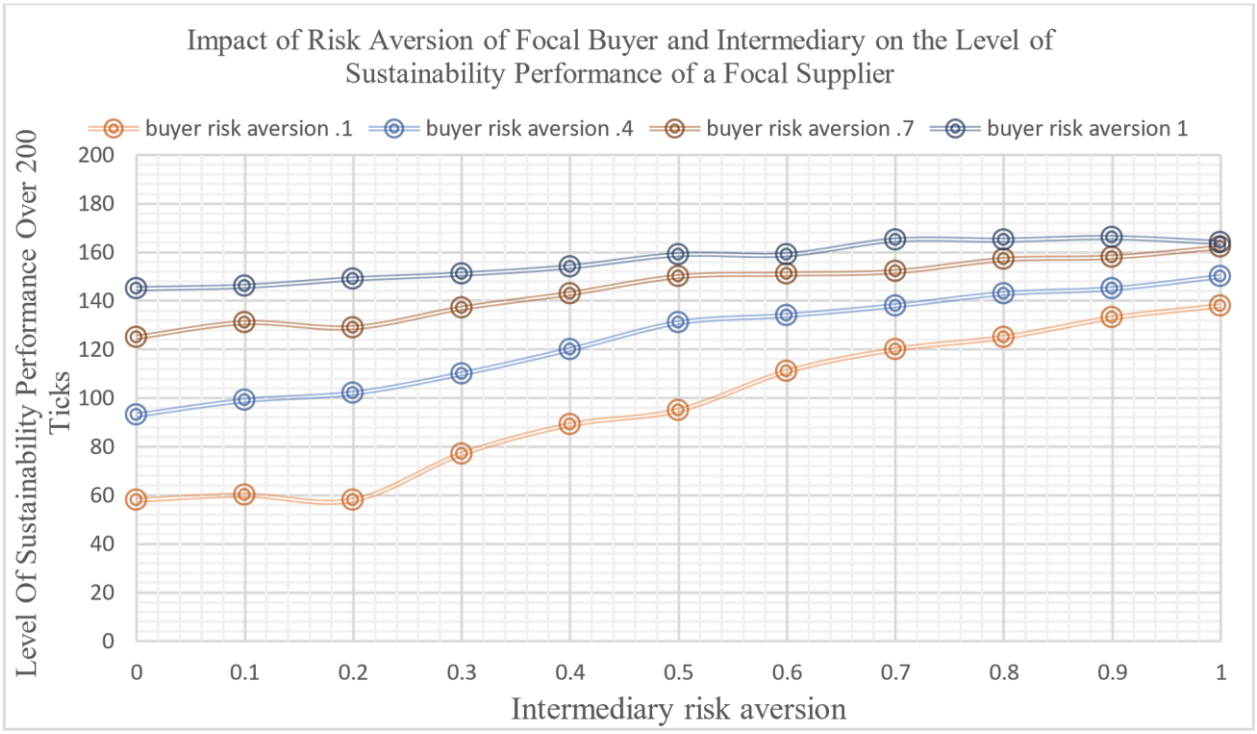

Figure 5: Impact of Buyer and Intermediary Risk Aversion on the Level of Sustainability Performance of a Focal Supplier (Initial Risk Aversion, $R_b = 0.3$)

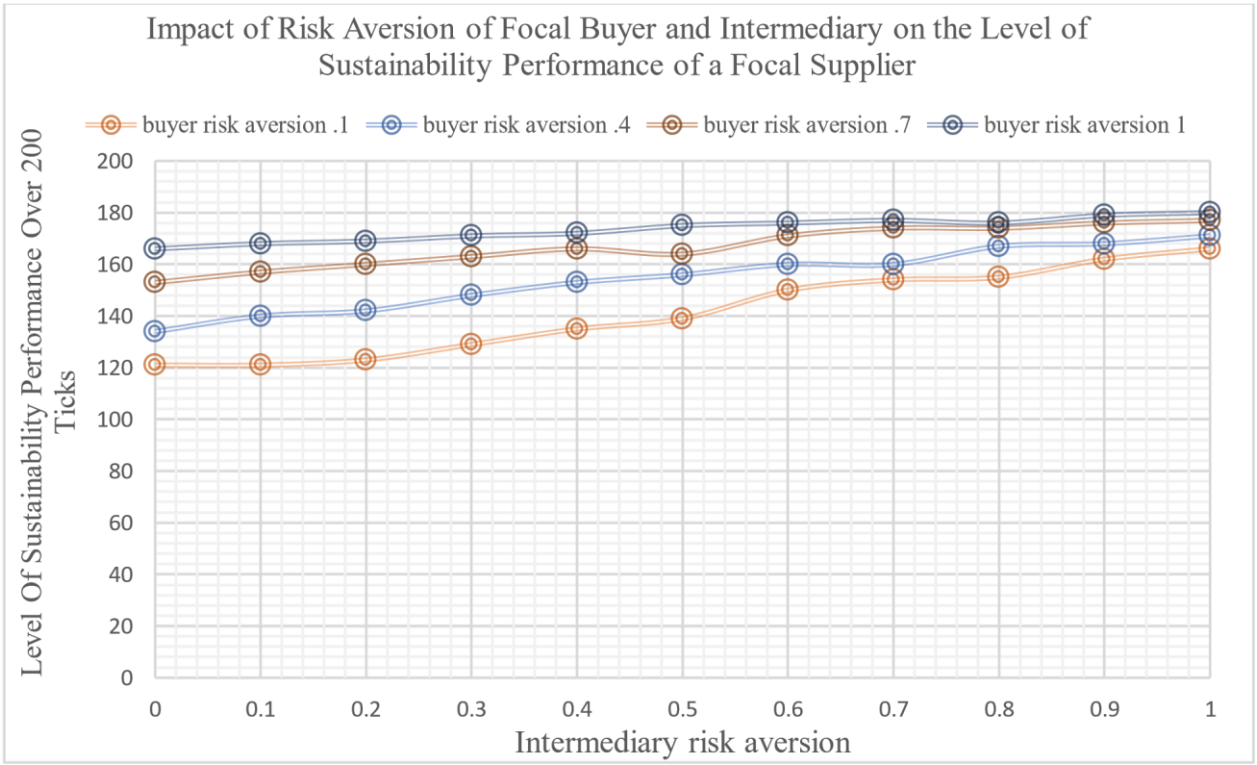

Figure 6: Impact of Buyer and Intermediary Risk Aversion on the Level of Sustainability Performance of a Focal Supplier (Initial Risk Aversion, $R_b = 0.6$)

Figures 5 and 6 show that as the initial value of the risk-aversion of a focal supplier increases, the variation of the improvement of sustainability performance decreases. Further, we find that the combination of a more risk-averse focal buyer and less risk-averse intermediary performs better in improving sustainability performance at a focal supplier, compared to a more risk-averse intermediary and a less risk-averse focal buyer. Besides, as the focal supplier turns more risk-averse the effect of the intermediary to drive improvement in the sustainability performance becomes less important. These three simulation runs show that risk aversion of the focal buyer, intermediary, and focal supplier are interactive and do not have a linearly positive effect on the level of sustainability performance of the focal buyer. These results can be summarized in the following propositions.

Proposition 1a. A risk-averse buyer and a risk-seekingintermediary perform better than a riskseeking buyer and risk-averse intermediary to improve the level of sustainability performance in a focal supplier.

Proposition 1b. Risk-aversion of the intermediary is less significant to improve the level of sustainability performancewhen either the focal buyer or focal supplier is risk-averse.

4.2. The Impact of Stakeholder Pressure

Intuitively, increased stakeholder pressure is likely to positively influence the level of sustainability performance in an extended supply chain of a focal buyer. However, it is less known if stakeholder pressure will be as effective to improve sustainability performance at the focal supplier for varying combinations of risk-aversion of the focal buyer and the intermediary.

To explore this, the stakeholder's monitoring effectiveness, which is a proxy of stakeholder pressure, the value of effectiveness was changed. The analysis reported below explores this effect of stakeholder pressure on the improvement of the sustainability level. (Note that starting risk aversion of both agents is set at 0).

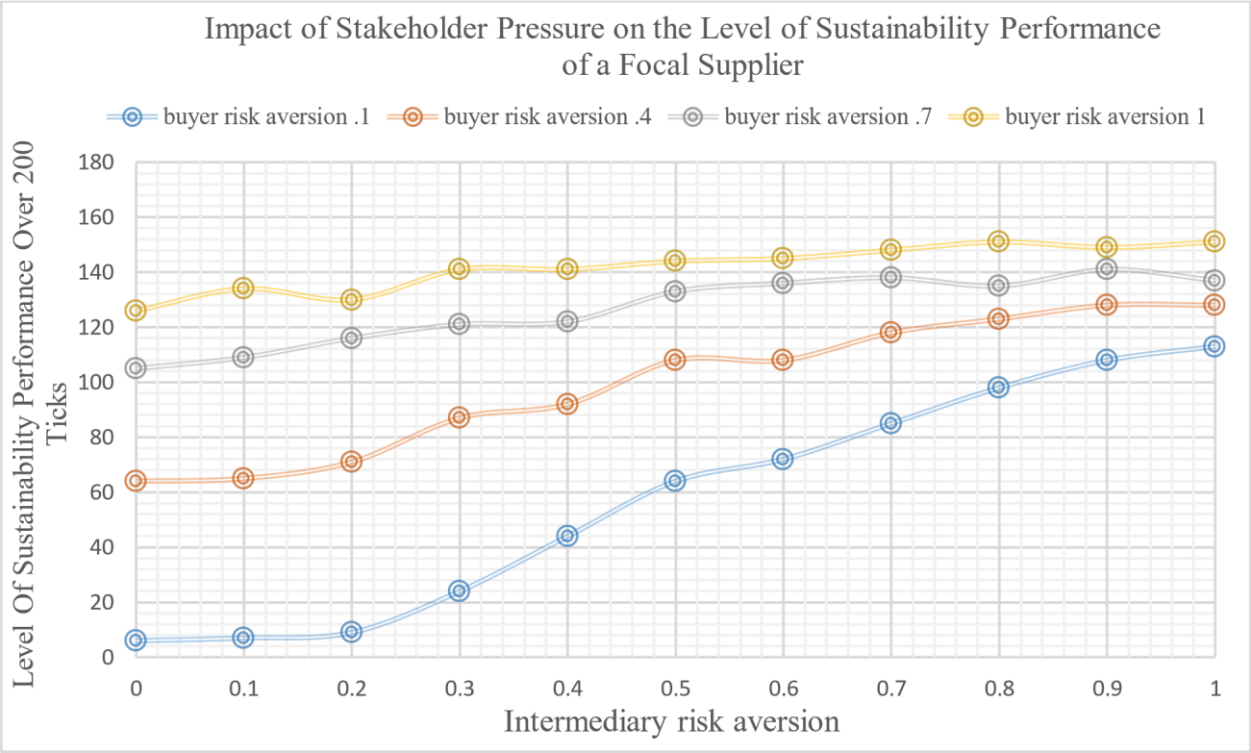

Figure 7: Impact of Stakeholder Pressure on the Level of Sustainability Performance of a Focal Supplier (E_s = 0.2)

Figures 7, 8 and 9 report the improvement pattern in the level of the sustainability performance of a focal supplier (with initial risk aversion R_b = 0.0), while varying the stakeholder pressure at four-times, six-times and eight-times compared to the baseline model. Interestingly, results suggest that stakeholder pressure only makes a difference when a riskseeking buyer and a risk-seeking intermediary are monitoring (bottom left corner of Figures 4, 5 and 6) the focal supplier.

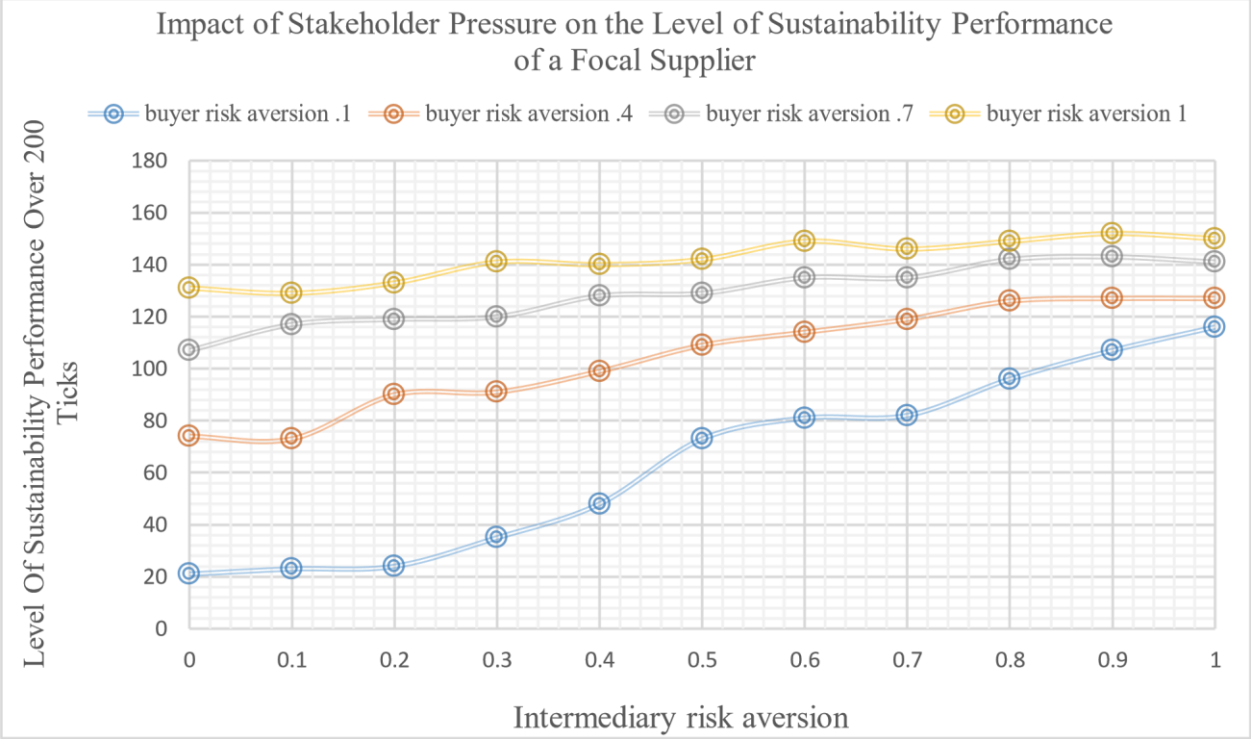

Figure 8: Impact of Stakeholder Pressure on the Level of Sustainability Performance of a Focal Supplier (E_s = 0.4)

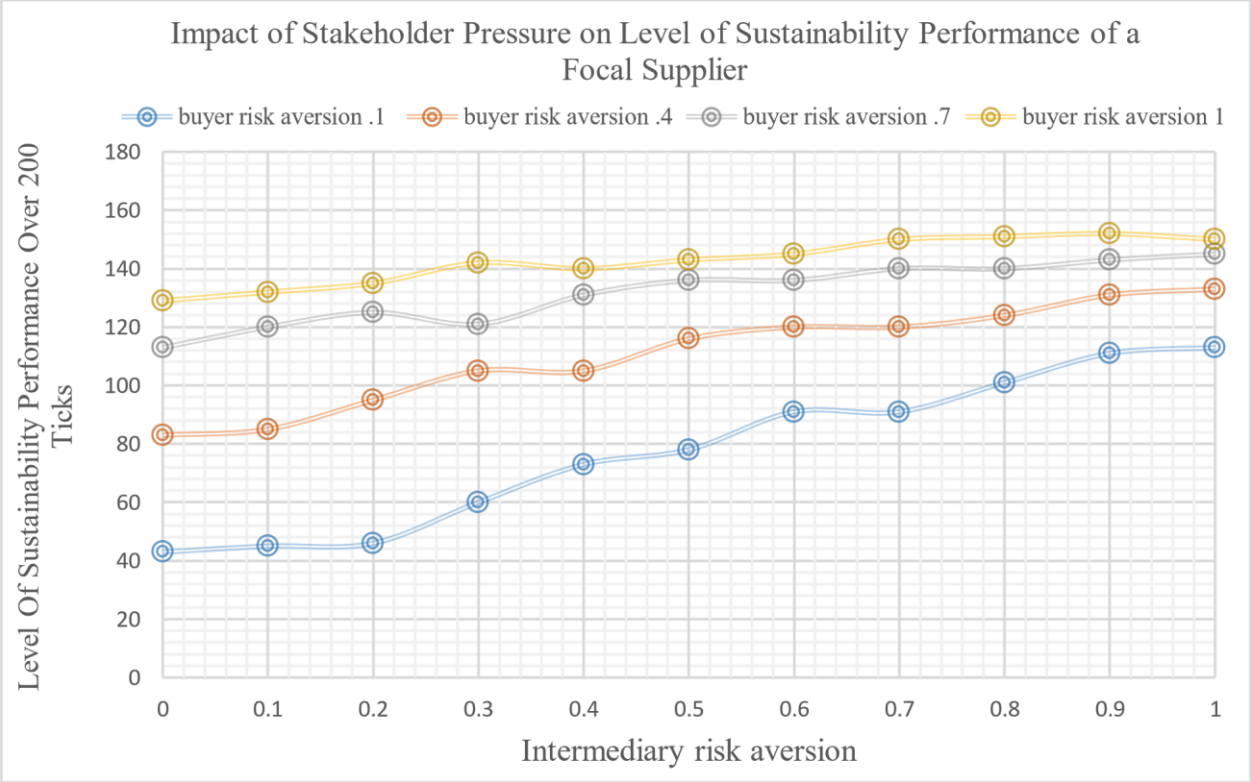

Figure 9: Impact of Stakeholder Pressure on the Level of Sustainability Performance of a Focal Supplier ($E_s = 0.6$)

However, as the risk averseness of the focal buyer and the intermediary increases, the improvement level shows no significant changes (top right corner of Figure 7, Figure 8 and Figure 9). More specifically, increasing the stakeholder pressure improved the sustainability performance of focal suppliers, only when either an extremely risk-seeking buyer or an extremely risk-seeking intermediary monitored them. Thus, only the left-hand side of Figures 7 to 9 responded to the changes in stakeholder pressure values while the right-hand side remained unaffected. The discussion above leads to the following propositions about the impact of the stakeholder pressure on the improvement of the level of sustainability performance at the focal supplier.

Proposition 2a. Stakeholder pressure has a positive effect on improvement in the level of sustainability performance at a focal supplier when a risk-seeking focal buyer and a risk-seeking intermediary are monitoring.

Proposition 2b. Stakeholder pressure has a limited effect on improvement in the level of sustainability performance over time when both one or both the focal buyer and the intermediary are risk-averse.

4.3. Impact of Monitoring Cost

Results reported in Figure 10 show that as the monitoring cost increases for the focal buyer and intermediary, there is a sharp decline in sustainability improvement at the focal supplier level. Assuming the focal supplier is risk-seeking while the focal buyer and intermediary are risk-neutral, as the cost of monitoring the focal supplier increases for both the focal buyer and intermediary there is progressively less improvement in the level of sustainability performance.

As long as the cost of monitoring remains low for the focal buyer, the level of sustainability performance over time remains stable. The reciprocal situation, which is a low monitoring cost at the intermediary and high monitoring cost at the focal buyer, yields worse results. Based on this observation the proposition follows

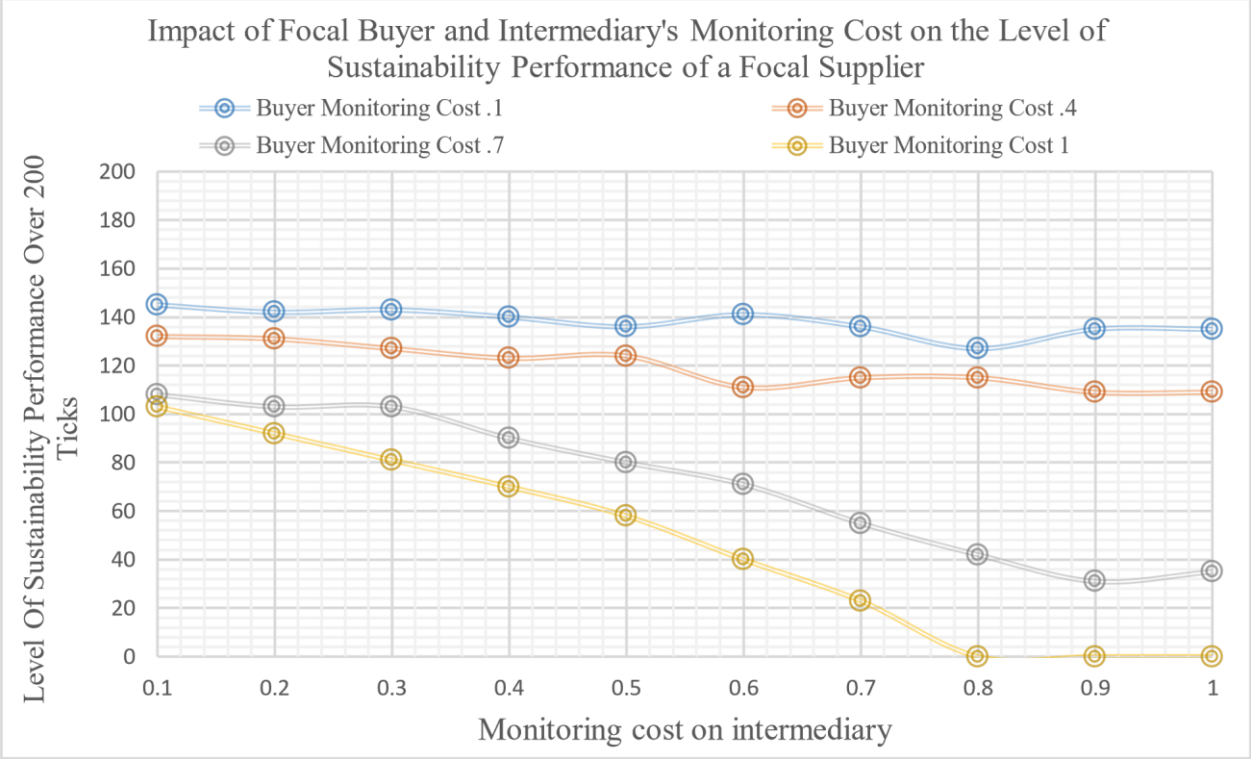

Figure 10: Impact of Monitoring Cost of Focal Buyer and Intermediary on the Level of Sustainability Performance of a Focal Supplier (Initial Risk Aversion $R_b = 0.0$)

Proposition 3a. As the monitoring cost increases for both the intermediary and focal buyer, the level of sustainability performance decreases.

Proposition 3b. Lower monitoring cost at the focal buyer compared to the intermediary yields a better level of sustainability performance at the focal supplier.

4.4. Impact of Supply Chain Power

Simulation analysis explored the role of the supply chain power between the relationships existing between the members. To account for changes in power, the model assumed that when the principal catches an agent, the risk aversion changes by 1% in case of low supply chain power and 3% in case of high supply chain power (2% is the change in the base case). That means when a principal catches its agent cheating, it has limited or greater ability to increase the agent's risk aversion in the following period. As expected, this has a consistent effect on the improvement in improvement of the level of sustainability performance over time at the focal buyer such that, a higher supply chain power yields better sustainability performance compared to low supply chain power.

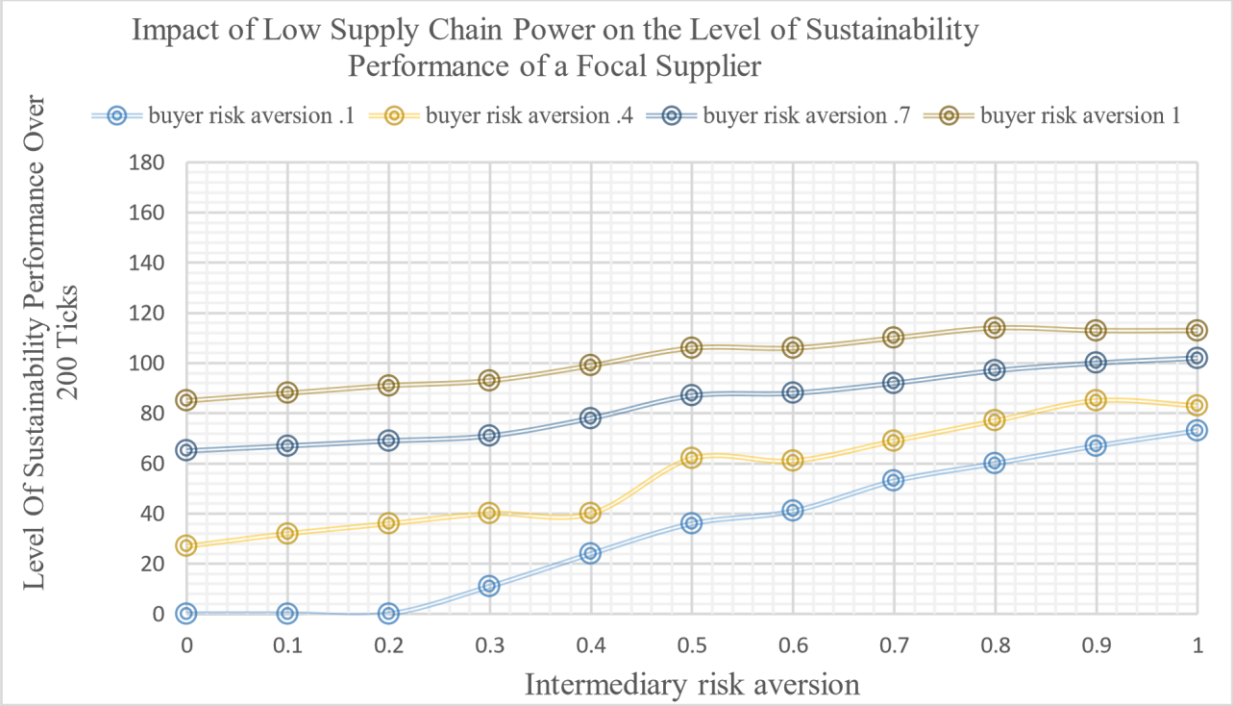

Figure 11: Impact of Low Power of Focal Buyer and Intermediary on the Level of Sustainability Performance of a Focal Supplier (Initial Risk Aversion $R_b = 0.0$)

As Figure 11 and Figure 12 show, there is a considerable difference in the level of sustainability performance improvement at the end. A risk-seeking buyer having higher supply chain power over the intermediary and focal supplier can force better performance, (slope of buyer with the

risk aversion of 0.1) than the risk-averse buyer with the same level of power (slope of buyer with risk aversion 1).

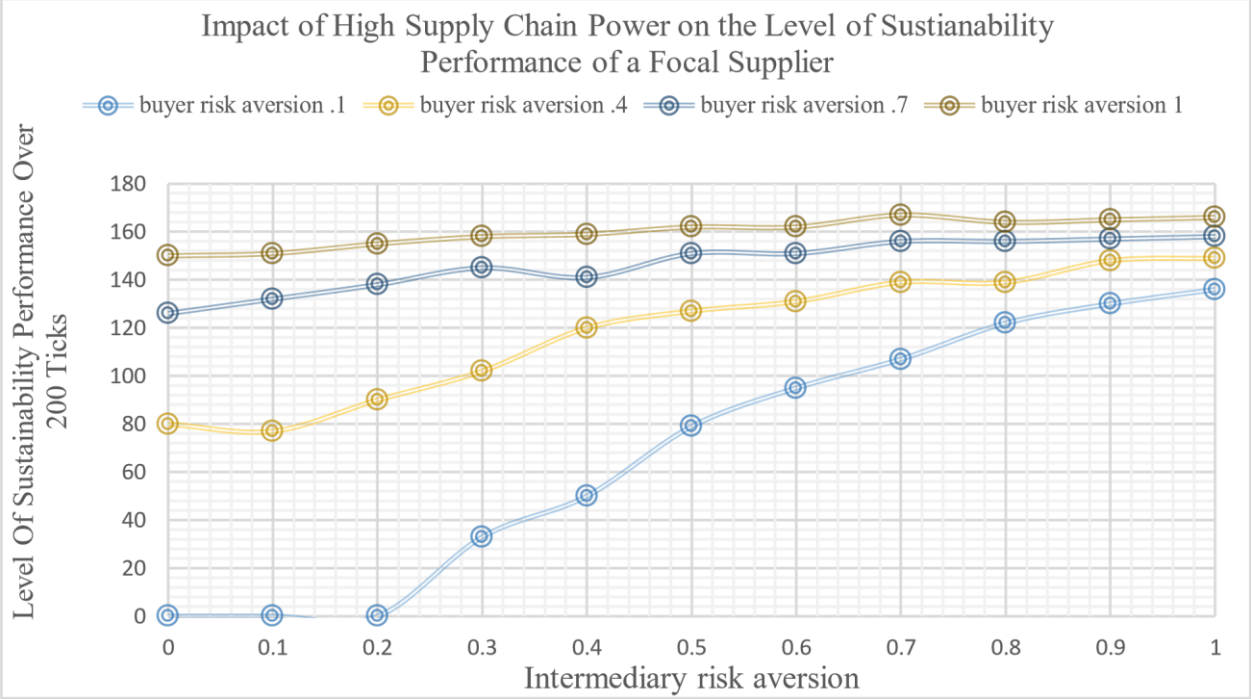

Figure 12: Impact of Low Power of Focal Buyer and Intermediary on the Level of Sustainability Performance of a Focal Supplier (Initial Risk Aversion $R_b = 0.0$)

In short, the risk-averse buyer will not considerably change the sustainability performance of a focal supplier even if they have high supply chain power over the intermediary and focal buyer. The discussion of these results leads to the propositions:

Proposition 4a. Supply chain power over the intermediary and the focal supplier positively influences the level of sustainability performance over time.

Proposition 4b. All factors remaining constant, a risk-seeking focal buyer with higher supply chain power can increase the level of sustainability performance more compared to a risk-averse buyer with the same power.

4.5. Impact of Information Asymmetry

The monitoring efficiency of the focal buyer is varied to explore the effect of information asymmetry in the relation between the focal buyer and focal supplier. Intuitively, when there is high information asymmetry, the monitoring efficiency is reduced, as the focal buyer cannot catch misrepresentation by the focal supplier.The results in Figure 13 and Figure 14 are corresponding to 0.4 $E_{bt}$and 0.3 E_{bt}respectively, which is 20% and 40% less than the base case.

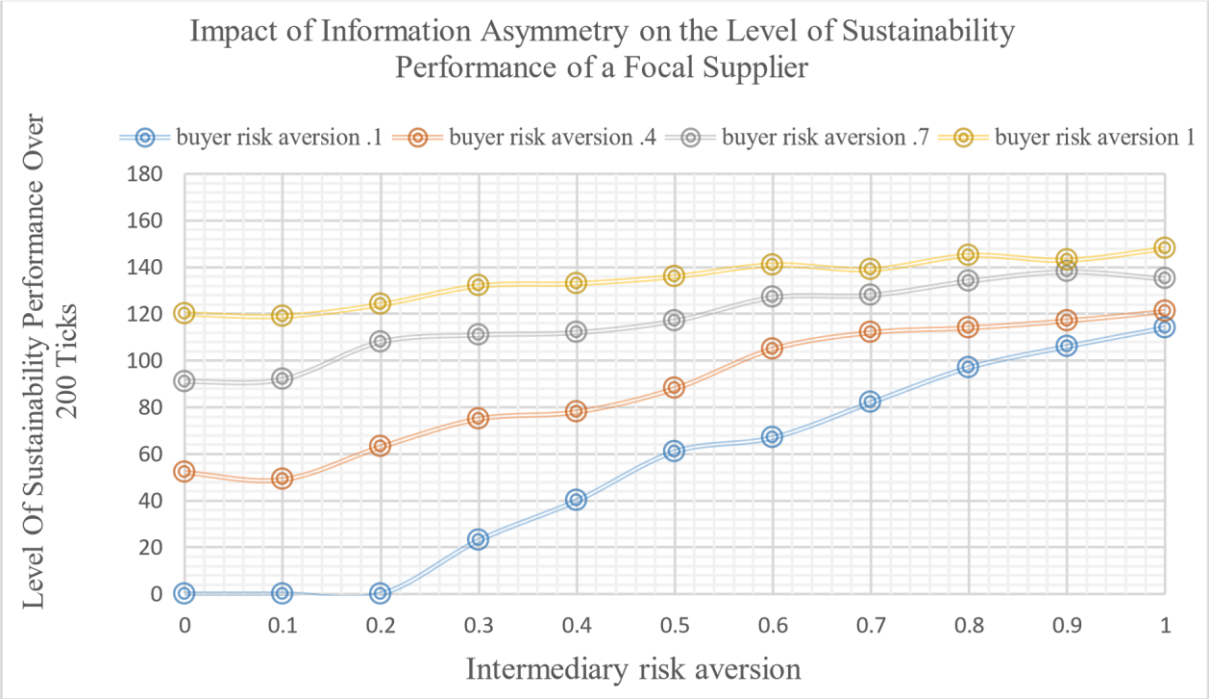

Figure 13: Impact of Information Asymmetry (E_{bt}= 0.4) between Focal Buyer and a RiskSeeking Focal Supplier (Initial Risk Aversion R_b = 0.0) on the Level of Sustainability Performance of a Focal Supplier

In general, the results support the expectation that with increasing information asymmetry, the overall improvement in the level of sustainability performance decreases. Furthermore, a comparison between Figure 13 and Figure 14 shows that as information asymmetry increases, there is a strong convergence of the level of sustainability performance achieved. It can also be noticed that with increasing information asymmetry, the risk-aversion of intermediary strongly

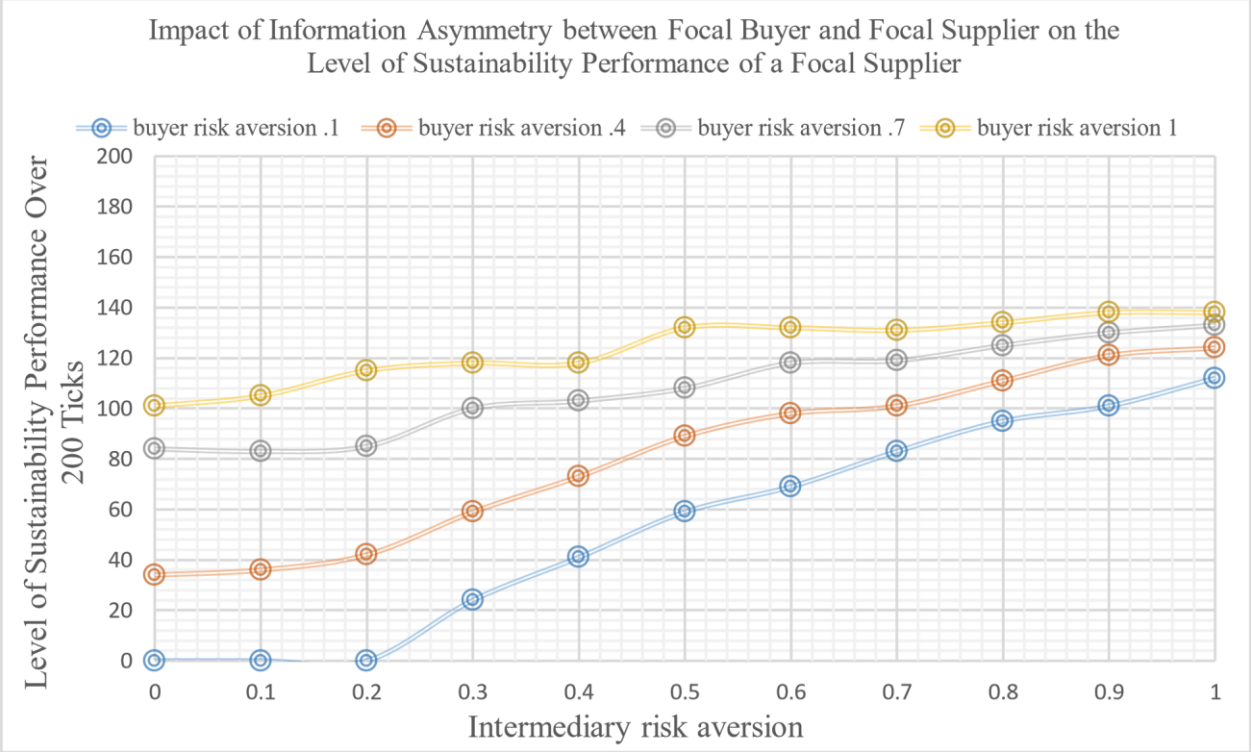

Figure 14: Impact of Information Asymmetry (E_{bt}= 0.3) between Focal Buyer and a RiskSeeking Focal Supplier (Initial Risk Aversion R_b = 0.0) on the Level of Sustainability Performance of a Focal Supplier determines the improvement of sustainability performance, while the effect of the risk-aversion of the focal buyer becomes limited. This implies that at high information asymmetry, focal buyers must be wary of the intermediaries since the increase in the level of sustainability performance at the focal supplier, depends on these intermediaries. Based on these observations the following propositions are forwarded.

Proposition 5a. Increasing information asymmetry between the focal buyer and the focal supplier has an overall negative impact on the level of sustainability performance.

Proposition 5b. With increasing information asymmetry between the focal buyer and the focal supplier, the intermediary's role in improving the level of sustainability performance becomes critical.

4.6. Impact of Cost of Sustainability Practice and Risk Aversion of Focal Buyer

The decision of improving sustainability performance depends on the risk aversion of the focal supplier and the cost of the practice. Therefore, keeping the cost factor constant, a more risk-averse focal supplier is expected to improve its level of sustainability performance more than a riskseeking focal supplier does. The simulation results reported in Figure 15 lend support to this expectation. However, the effect of the cost of practice on the level of sustainability performance is non-linear. As per the results, the level of sustainability performance remains constant as the cost increases. Next, the impact of risk-aversion of the focal supplier has a non-linear relationship to the performance.

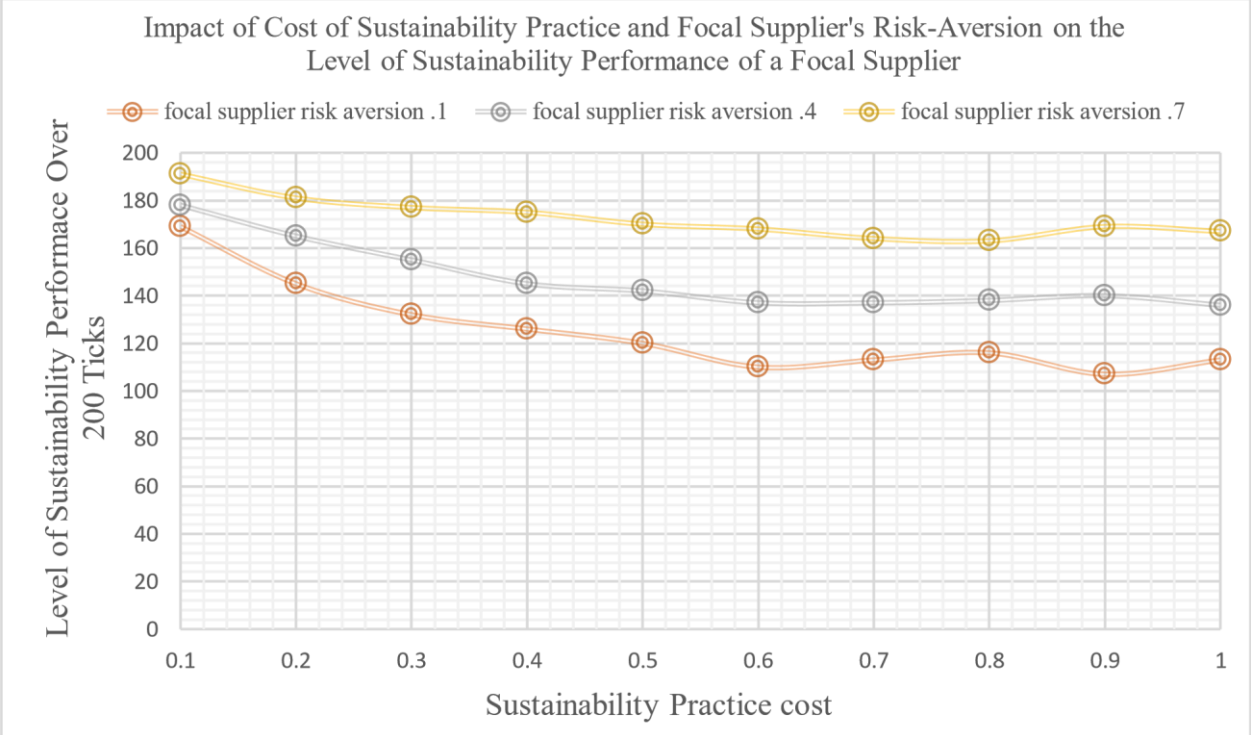

Figure 15: Impact of Cost of Sustainability Practice and Focal Supplier's Risk Aversion on the on the Level of Sustainability Performance of a Focal Supplier while being monitored by Risk-Neutral Focal Buyer and Intermediary (R_{bt}, R_{it} = 0.5)

For example, Figure 15 reports that when the cost of the practice is low, all the focal suppliers achieve a similar level of sustainability performance, no matter how risk-averse they are. This trend changes as the cost of sustainability practice increases. When the cost of the practice is high, there is a significant difference in the level of sustainability performance. Thus, based on the results, the following propositions are proposed.

Proposition 6a. The risk-aversion of the focal supplier and the sustainability practice cost has a positive and negative relationship with the level of sustainability performance, respectively.

Proposition 6b. All other factors being constant, the focal supplier's risk-aversion becomes more critical in achieving a higher level of sustainability performance, as the cost of sustainability practices increases.

5. Discussion

Improving the level of the sustainability performance of lower-tier suppliers is crucial for the focal firm. Prior literature discussed how focal firms use different types of governance mechanisms under specific conditions. Specifically, institutional pressures (Wilhelm et al, 2016a, b), power (Meqdadi, Johnsen & Johnsen, 2019), resources (Wilhelm et al, 2016a, Hofmann et al, 2018), distance (Seles, Jabbour, Jabbour&Dangelico, 2016), and risk perception (Meinlschmidt et al, 2018) influence the approach of sustainability governance and performance.

The results of this study contribute to the existing body of knowledge. Building on the central construct of agency theory, the study explores how risk-aversion can influence the level of sustainability performance. Prior studies suggest that not only risk-aversion of suppliers but all supply chain members are worth investigating. For example, Tong et al (2018a: 64) claimed that risk-aversion of the buyer is crucial to improve supplier performance except, "*when the suppliers in the dyads are sufficiently less risk-taking"*. Extending this approach, this study exploresthe risk-aversion of the three supply chain members – focal buyer, intermediary, and focal supplier. In doing so, the results highlight the interactive nature of risk-aversion of the supply chain members in a multi-tier supply chain. On one hand, the results suggest that if the focal supplier is risk-averse, then the focal buyer and intermediaries could remain relatively less risk-averse (risk-seeking). On the other hand, if the focal supplier is risky, the importance of monitoring by both the focal buyer and intermediary becomes critical to improve the level of sustainability performance. Additionally, we see, that if the focal buyer is risk-seeking, then the intermediary's role can be pivotal to improve the level of sustainability performance.

Next, stakeholder pressure has been a subject of active debate in supply chain sustainability literature (Lee, Klassen, Furlan&Vinelli, 2014; Meixell&Luoma, 2015; Dou et al,

2018; Hofmann et al, 2018). However, it is less understood how it improves the level of sustainability performance in a multi-tier supply chain based on contextual contingencies. The results of this study suggest that increasing stakeholder pressure only improves the performance of lower-tier suppliers when the downstream members are risk-seeking. However, in the case of risk-averse buyer and intermediary, increased stakeholder pressure has a limited effect on the level of sustainability performance. The results serve as a predictive tool to overcome the limitation of field-studies as highlighted by Wilhelm et al (2016b:200) "*stakeholder pressure was less relevant because, due to our sampling approach, all buying firms were exposed to similar degrees of regulatory pressure*".

According to agency theory, the decision to monitor an agent is based on cost. As a result, focal buyers often monitor only selected sub-suppliers (Delbufalo, 2018). Results suggest that if the monitoring cost is high for the focal buyer, the role of the intermediary is critical in improving the level of the sustainability performance. Thus, in an open supply chain structure, the focal buyer needs to ensure that an intermediary can monitor the focal supplier at a low cost. The results lend support to the dual agency roles of the intermediary in achieving sustainability performance (Wilhelm et al, 2016a; Shukla et al, 2018).

A power perspective is an important lens in the sustainable supply chain relationship (see Touboulic, Chicksand& Walker, 2014; Meqdadi et al, 2019). Results suggest that power affects the level of sustainability performance in a multi-tier supply network. High buyer power benefits improvement in the level of sustainable performance. It is particularly significant for a riskseeking focal buyer, which means that a risk-seeking focal buyer reluctant in monitoring will perform substantially better if they are in a powerful position in the supply chain relationship.

Results also indicate that when there is a high power imbalance between the focal buyer and the focal supplier, the role of the intermediary to improve the level of sustainability performance is limited, thus relegating the importance of dual agency role in such situations.

Information asymmetry is a central assumption of agency theory and reality in multi-tier supply chains. This study focuses on the information asymmetry existing between the focal buyer and the focal supplier (Wilhelm et al, 2016b). Results indicate that with increasing information asymmetry, the focal buyer is better off to depend on a risk-averse intermediary to drive the improvement in the level of sustainable performance. Therefore, in the case of high information asymmetry between the focal buyer and focal supplier, the buyer has two choices.
They can either choose to decrease information asymmetry between them by investing resources (Zsidisin&Ellram, 2003) or incentivize intermediaries to strongly couple to their secondary agency role.

According to prior research, focal suppliers often lack financial resources and act on short-term cost consideration. Reported results show that risk-aversion and cost of the sustainability practice can vary the improvement in the level of sustainability performance. Different mechanisms are used to influence the risk-aversion of the focal supplier by terminating relations, third-party interventions, incentives (Pilbeam, Alvarez & Wilson, 2012), and trust (Dou et al, 2018). In addition, a focal buyer must consider the cost of improving sustainability from a focal supplier's perspective. Hence, it is in the best interest of the focal buyer to improve the capability of the focal supplier, reduce the information-seeking, and adoption-related cost of the focal supplier (Tate, Ellram& Dooley, 2014).

6. Conclusion

6.1. Theoretical & Methodological Contributions

This study contributes to the existing literature of multi-tier sustainability by developing a quantitative model of how monitoring by focal buyer and intermediary improves the level of sustainability standard at the lower (focal) supplier. To fill the limitation of a static view of multi-tier sustainability literature, this study focuses on the outcomes of the strategies used to improve the level of sustainability performance in a multi-tier supply network over time. The framework developed allows us to explore sustainability performance not only based on a particular governance strategy but also on the characteristics of all the supply chain members. The results hint that monitoring, as a governance strategy cannot be evaluated in isolation, as it has an interactive relationship with other contextual and behavioral contingencies.

In particular, the analytical model in this study incorporates the contextual and behavioral characteristics of all the supply chain members. By doing so, it highlights that relatively underexplored contingencies, like the cost of sustainability practice from the focal supplier's perspective, can enhance or dampen the need for monitoring by the focal buyer and intermediary. In a similar vein, the results add fresh perspectives to contextual contingencies like stakeholder pressure, by showing that its influence can be limited based on the characteristics of the supply chain members. Besides, it contributes to the growing research on the dual agency roles of firsttier suppliers in a multi-tier supply network. While, previous research (Wilhelm et al, a) focused on conditions where first-tier suppliers embraced this new role, this study outlines the conditions when this role is important to improve the level of sustainability performance and the other times when it is cannot make a difference in the level of sustainability performance.

This study used agent-based modeling to explore how supply chain members adapted their behavior over time. One key advantage of using agent-based modeling is that it allows a more natural unfolding of events, particularly updating risk-aversion of the members based on history incorporating the idea of path-dependency (Busse et al, 2016). This model depicts a more comprehensive view of how supply chain members evolve based on previous experience. It provides a holistic understanding of the influence of the behavioral and contextual contingencies on the improvement in the level of sustainability performance, in a multi-tier setting.

6.2. Managerial Contributions

Policymakers and managers dealing with the multi-tier supply chain can benefit from the proposed framework. As supply chain managers are increasingly responsible for the sustainability performance of their sub-suppliers, the findings help to inform the managerial decision-making process. The findings suggest that managers must focus their efforts based on the characteristics of their supply chain partners. For example, if they have a reliable direct supplier, spending effort to monitor a sub-supplier may be redundant. By contrast, if the relationship with the direct supplier is transactional, managers of buying firms may directly approach sub-suppliers to manage sustainability performance. One more insight for managers is to be aware of the requirements and the associated cost implications for a sub-supplier. Costly practices may likely need extra support from the lead firms if they want sub-suppliers to comply with the requirements.

7. Limitation of the Study

This study has several limitations. First, even though the simulation allows exploring across time, it excludes certain complexities. For example, focal buyers may face unequal pressures on the environmental and social aspects of sustainability (Sancha, Longoni&Giménez, 2015). Further, it may be easy to monitor environmental performance than social performance due to the lack of information related to different practices. Similarly, from a focal supplier's perspective adopting social and environmental practices may require different resources, investments, and capabilities (Tate, Ellram&Gölgeci, 2013). The current study does not include this possibility.

This study ignores an important stream of research that explores sustainability in the multi-tier supply chain. Prior studies show that trust, mutual dependence, and commitment can be developed over time between buyers and suppliers. This implies that monitoring a supplier may not involve the same cost over time since both parties can work to benefit each other (Hausman& Johnston, 2010; Chen, Yeh&Tu, 2008; Hofmann et al, 2018). Further, factors such as top management support, cultural differences, and length of the contract (Grimm et al, 2014; Dou et al, 2018) are not included in the model. Thus, the results can partially account for the improvement in the level of the sustainability performance of a focal supplier. Finally, future research may consider these factors and other governance mechanisms to understand the impact of such contingencies on the improvement of the level of sustainability performance in the multitier supply network.

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