Supply Base Complexity and Sustainability Disruption Risk

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Abstract. This working paper presents an overview of our research attempt to examine and integrate risk, sustainability and complexity in supply networks. The propositions developed theoretically in this study contribute a basis for empirical work that would explore the impact of supply base complexity on the level of what we refer to as sustainability disruption risk. The key issue addressed is the relationship between the degree of complexity in the supply base and the level of sustainability supply risk resulting from the association of a focal firm with suppliers. Our focus on sustainability supply risks represents an increasingly important, but relatively unexplored, area of concern for supply chain managers.

Supply base complexity and sustainability disruption risk. The supply chain literature has reflected the emergence of three critical issues that are shaping the way supply chains are managed. These issues are: supply chain sustainability, supply chain disruption risk, and supply chain complexity. The management of each of these individual issues is paramount for supply chain managers. However, in this research, we propose that all three of these key issues maybe interrelated in non-trivial ways and, therefore, should be considered holistically to spur improved development and to facilitate the implementation of effective interventions. The study aims at developing concepts and theoretical propositions that will form the basis for subsequent empirical work to explore the impact of supply base complexity on the level of what we refer to as sustainability disruption risk.

Social and environmental values have become critical competitive requirements for many companies (Hanna and Newman 1994; Berry and Rondinelli 1998; Angell and Klassen 1999; Brio and Junquera 2003). Some proactive firms have implemented sustainable management practices motivated by self-regulation (Hillary and Thorsen 1999), whereas others have responded to pressure from stakeholders including customers, governments, and non-governmental organizations (NGOs). These stakeholders have demanded increasingly higher social and environmental standards (Pagell et al. 2007), wherein sustainable corporate practices and behavior are rewarded, and questionable corporate practices are criticized, particularly by NGOs (Spar and Mure 2003). For instance, surveys report that as many as 75% of customers declare that their purchasing decisions are influenced by a company's reputation with respect to the environment, and 80% of customers declare their willingness to pay more

for products that are environmentally friendly (Drumwright 1994). This marketplace context has brought a new dimension of risk to the forefront of a supply manager's attention.

Supply chain risk and risk management have also become topics of great interest in recent years (Christopher and Lee 2004; Wu et al. 2007). As such, various studies have started to address aspects of supply chain risk; some have focused on the identification of risk sources (Ritchie and Bridley 2007) and risk management techniques (Kleindorfer and Saad 2005; Christopher and Lee 2004; Zsidisin et al. 2004), and others have focused on the negative impact of supply chain disruptions on financial and operational performance measures (Hendricks and Singhal 2005). Several current economic developments have added to the importance of risk management in supply chains: outsourcing, globalization of markets, and increasing reliance on suppliers (Narasimhan and Talluri 2009). These economic developments reflect supply management efforts to improve efficiency and achieve responsiveness. However, the pursuit of efficiency and the growing importance of social and environmental practices add new dimensions to risk management in supply chains and increase the complexity of the supply base.

The same economic developments that are critical for supply chain risk have also led to increasingly complex and dynamic supply networks that consist of more dyads, are more global, and have reduced buffers (reflecting efforts to improve efficiency, such as lean management and JIT inventory). Accordingly, a growing number of studies propose complexity as the main driver of supply chain risk (Choi and Krause 2006; Hoole 2006; Christopher and Lee 2004; Wu et al. 2007; Juettner et al. 2003). This link between complexity and risk highlights the need for a systemic view regarding design decisions on supply chain management, which becomes even more important due to a new type of risk brought by growing social and environmental values – to which we refer as sustainability disruption risk in this study.

Sustainability risk and supply base complexity. The supply base – those suppliers that are actively managed through contracts and the purchase of parts, materials, and services (Choi and Krause 2006) – impacts the focal firm's products, production waste, and disposal (Handfield et al. 2002). The level of this impact has heightened as firms have turned their focus to their core competencies. In doing so, these firms have transferred a significant portion of their value-added activities involved in satisfying the final customer (e.g., manufacturing and design) to the supply base. In turn, operations and supply managers have realized that social and environmental risks can be passed on to their firms through suppliers (Handfield et al. 2005). Along with a concentration on core competencies, the globalization of large companies and their supply networks has led to more firms operating in countries with very different (and many times lower) standards of living than those found in their domestic base (Smith 2003). Therefore, social and environmental pressures in the broader context of the supply network comprise a newly important source of supply risk for a focal firm. As such, safeguarding the firm's reputation and brand image has become crucial (Jennings and Zandbergen 1995; Smith 2003). Thus, globalization and the fragmentation of the supply base have increased its

complexity and the disruption risk in general and disruption risk related to social and environmental aspects surrounding the supply base in particular.

Disruption risk tied to sustainable practices is a critical consideration. The possibility of these disruptions adds to the challenges imposed upon supply managers because, despite all efforts to improve social and environmental performance and to select sustainability-conscious suppliers, a focal firm may still be penalized by customers and other stakeholders for a *supplier's* actions that are not considered socially responsible (Smith 2003). This new dimension of risk is compounded by the increased frequency of interaction with and the nature of the supply base, which presents characteristics of a complex adaptive system.

Complex adaptive systems and dimensions of supply base complexity. Firms are embedded in networks of cooperative and competitive interactions with other organizations (Hakansson 1987). A network consists of nodes (positions occupied by firms) and links (relationships) manifested by the interaction between nodes (Thorelli 1986). A business network is conceptualized as sets of connected interactions among firms (Anderson et al. 1994; Emerson 1981), wherein firms in a single focal dyadic relationship are also involved in other interactions that are connected to the focal relation (Hakansson and Snehota 1995). These connections have further ramifications for indirectly connected dyads (Wilkinson and Young 2002). As such, the relationships maintained by a focal firm originate interconnected webs described as supply networks (Hakansson and Ford 2002) that directly and indirectly impact the activities of a focal firm and that behave as complex adaptive systems (CAS).

The ability of a system to emerge and adapt over time into a coherent form without any singular entity deliberately managing or controlling it is one of the major characteristics of a CAS. For instance, a city is the result of intense and self-organized interactions between various groups of its inhabitants. Thus, one of the major tenets of the CAS perspective is the notion that order is an emergent property of individual interactions between the elements within a system — i.e., complex adaptive systems are self-organized.

In the context of a supply base, each supplier constitutes a system trying to cope with the complexity of its environment in order to either achieve an adequate level of fit with it or to achieve a degree of autonomy with respect to potential constraints that the environment might impose (Varela, Thompson, and Rosh 1991). These dynamics of complexity and its dimensions have consequences for a focal firm. Choi and Krause (2006) define the level of supply base complexity as a function of the following dimensions: the number of suppliers in the supply base, the level of supplier interaction, and the degree of differentiation among suppliers. Each of these dimensions may lead to a different impact on the level of sustainability disruption risk and may interact differently with other characteristics of the supply base of a focal firm.

Conceptual Model. The proposed research is summarized at a high level in the conceptual model seen in Figure 1. Supply base complexity impacts the levels of sustainability risk. In general, complexity makes the management of supply chains more difficult and ambiguous, leading to higher risk levels (Choi and Krause, 2006). In particular, a complex supply base elevates the risk of an event regarding the social or environmental aspects of supply chain sustainability. Sheffi (2006) pointed out that supply chains are only as strong as their weakest link, which is particularly true for supply chain sustainability. Sustainability issues in an individual dyad (even far upstream in the supply chain) have the potential to negatively impact the reputation and performance of a focal firm in the network as whole. However, certain dimensions of complexity may have a counter intuitive effect on the level of sustainability risk. We argue that the aggregate effect of those dimensions impact the supply chain performance. In the empirical framework, we further differentiate between the complexity dimensions, evaluating their individual contributions to sustainability risk and their potential interactions as drivers of sustainability risk.

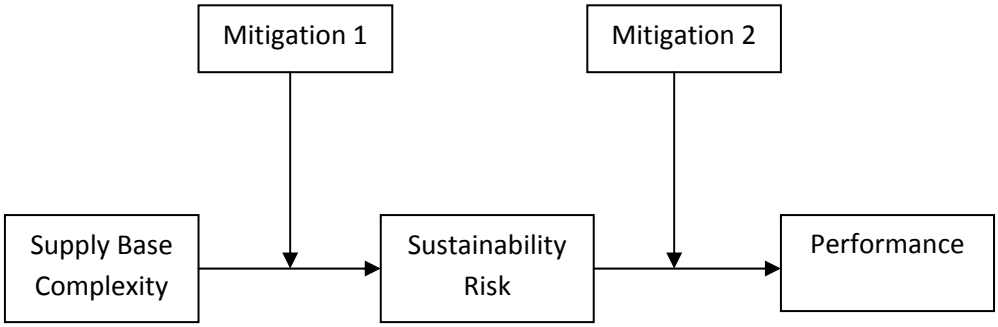

Figure 1: Conceptual Model

The literature points out that sustainability in business has three major aspects: the natural environment, society, and economic performance (Carter and Rogers 1998). These aspects are subsumed on the concept of the triple button line proposed by Elkinton (1998; 2004) and they reflect the challenges faced by supply chain managers. Supply management will be increasingly charged with managing not only short-term financial goals, but also social and environmental risks posed by a focal firm's interactions or associations with the supply network. Thus, the management of sustainability risk should be impacted by the level of complexity of the supply base and this should impact the various measures of supply chain performance. However, different dimensions of complexity and decisions to cope with them may impact the sustainability risk of a supply base differently. The detailed framework and empirical propositions will be presented during the symposium. Our overall propositions derived from our conceptual model are as follows:

Proposition 1: Supply base complexity impacts the level of sustainability risk, but the impact will vary across the different dimensions of complexity.

Proposition 2: Higher levels of sustainability risk are negatively related to supply chain performance.

As part of our framework, we also propose to investigate two separate mitigation areas. First, we focus on the relationship between complexity and sustainability risk. As such, mitigation tools need to focus on the effective management of supply base complexity and are based on systems theory. Second, existing supply chain risk management approaches need to be adjusted to manage the link between sustainability risk and performance. Based on Miller's (1992) work, Juettner et al. (2003) categorize mitigation techniques into four strategies: avoidance, control, co-operation, and flexibility. The avoidance technique involves dropping specific products, suppliers, markets, or geographic areas if the levels of disruptions risk are considered unacceptable by the focal firm. Alternatively, firms may seek to control the contingencies that lead to disruption risk through vertical integration, stockpiling, buffer inventory and capacity, or contractual requirements for suppliers. Co-operation aims to increase supply chain visibility and understanding through the sharing of information. Flexibility, in this context, includes postponement and multi-sourcing strategies. In general, a simplification of the system naturally reduces its complexity (Perrow, 1999). In a supply network context, reducing complexity requires adjustments on its size, heterogeneity, interdependencies or coupling. Importantly, the dimensions of complexity are interrelated and the latent trade-offs between the dimensions need to be considered. The mitigation tools will be examined regarding their ability to overcome the impact of the individual complexity dimensions, resulting in a differentiated assessment of their applicability and effectiveness.

Proposed method. Conceptual theory building is used to develop a framework and propositions representing sustainability management risk. Specifically, we have conducted a content analysis to identify or develop definitions to describe sustainability risk and have reviewed the relevant literature to develop and propose a conceptual framework to examine the interplay between sustainability risk and supply base complexity. To develop the framework, we integrated elements from the literature on risk management, supply base complexity, and sustainable supply chain management by summarizing common elements, contrasting differences and extending existing theory. After refining the conceptual framework, we plan to take testable hypotheses from the framework to perform initial empirical tests. Empirical methodology will be used to test if the proposed relationships hold in the external world. The data is being collected through a large scale survey. Initially we will perform an exploratory data analysis. If the data is deemed appropriate, we will assess the dimensionality, validity, and reliability properties of the measures representing the theoretical concepts used in the portion of the framework on which we are going to focus initially. Once the scales have been purified and the psychometric properties of the scales have been established, we will examine the relationships proposed in the framework through structural equation modeling and other linear statistical models.

Summary. This study aims at contributing to nascent supply base management theory by conceptually integrating it with risk theory and sustainable development studies so we can examine how the different dimensions of complexity affect sustainability disruption risk, what

mitigating strategies are available, and potential outcomes. One important aspect of sustainability disruption risk management is the interplay between the various dimensions of supply network complexity and their potential effects on sustainability disruption. By grasping this topic, managers and researchers can develop effective mitigating strategies. This is timely, as the notion that an organization must manage not only short-term financial results, but also risk factors such as harm resulting from its activities on social and environmental aspects surrounding its supply network is gaining momentum. As corporate critics, social investors, activists, and customers who claim to assess sustainable practices when making purchase decisions pressure firms for enhanced sustainable practices, a framework that frames the interplay between supply base complexity and sustainability disruption risk should assist supply managers and researchers in developing effective interventions.

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