
Article:
Tachizawa, EM and Wong, CY (2015) The Performance of Green Supply Chain Management Governance Mechanisms: A Supply Network and Complexity Perspective. Journal of Supply Chain Management, 51 (3). 18 - 32. ISSN 1523-2409

https://doi.org/10.1111/jscm.12072

The Performance of Green Supply Chain Management Governance Mechanisms: A Supply Network and Complexity Perspective

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Abstract

Global supply networks are becoming increasingly fragmented and complex. At the same time, societal pressures surrounding the environmental accountability of firms are growing, with an increasing number of environmental scandals related to supply networks. Traditional governance frameworks of green supply chain management (GSCM) may be insufficient to deal with this new reality, because they do not consider supply network structure/complexity, and how these factors interact with different governance mechanisms. Our study takes into account the complex interplay between GSCM governance mechanisms, supply network structure/complexity, and environmental performance. We introduce a series of theoretical propositions grounded in an extensive review of the GSCM, supply networks, network complexity, and organizational design literatures. In particular we argue that supply network structure and complexity directly affect GSCM effectiveness, but that these effects will be contingent upon the type of governance mechanism applied (formal or informal).

Keywords: environmental issues; sustainability; supplier management; governance mechanisms; complexity; supply network.

Citation: Tachizawa, E.M., Wong, C.Y. (2015) "Performance of green supply chain management governance mechanisms: A supply network and complexity perspective", Journal of Supply Chain Management, 31(5), forthcoming.
DOI: http://dx.doi.org/10.1111/jscm.12072

INTRODUCTION

Attempting to manage increasingly complex supply networks and pressures from various stakeholders, many firms are adopting green supply chain management (GSCM) initiatives to govern their extended supply chains. However, there are many unanswered questions, such as how to influence indirect ties, or how supply network structure affects environmental outcomes (Choi & Linton, 2011). In reality, many recent environmental scandals – toxic waste from the manufacture of Apple products, BP's Gulf of Mexico oil-spill, Tesco and Findus' 'horseburgers' – had their roots in complex supply networks (Kane, 2014). Thus, it is difficult to understand the effectiveness of GSCM governance mechanisms without considering the supply network structure and complexity the firm is embedded in. Furthermore, although most literature posits a positive overall effect of GSCM on environmental performance, recent studies have questioned the effectiveness of practices such as the use of environmental audits (Lee et al., 2012) or the creation of industry standards (Blackman, 2008). A potential reason for such diverse outcomes is related to the utilization of appropriate mechanisms, whether they are formal or informal, to govern network interactions. Depending on the configuration of such mechanisms, a GSCM initiative could either fail or succeed. For example, the excessive reliance on formal environmental auditing is leading to problems of supplier corruption and mistrust (Lee et al., 2012).

The main motivation of this study is to understand how GSCM governance mechanisms and supply network structure/complexity jointly affect the environmental performance of a supply network. In particular, we borrow from the organization design literature the notion of formal and informal governance mechanisms (Dekker, 2004; Gulati & Singh, 1998; Jones et al., 1997; Powell, 1990). Formal mechanisms are, for example, standards, contracts, formalized processes, and control systems such as audits, whereas informal mechanisms consist of information sharing, values, culture, social norms and relationships (Alvarez et al., 2010). In

this study, it is argued that in order to influence direct and indirect ties in supply networks, formal mechanisms are not enough. Likewise, social exchange theory suggests that collaborative initiatives cannot be governed uniquely by formal mechanisms alone (Larson, 1992). Rather than motivating suppliers to improve environmental performance, formal mechanisms such as certifications may make them complacent and merely reactive. Moreover, recent research in supply chain governance suggests that relational aspects should also be considered, especially when there is the possibility of opportunism (Aitken & Harrison, 2013). For example, motivating suppliers by threatening to broadcast negative audit reports, downgrading suppliers' ratings, or using financial incentives may ultimately force them to hide environmental problems (Lee et al., 2012). Thus, informal mechanisms (e.g., incentivizing suppliers to self-disclose problems or to build an environmental culture through supplier forums) are also likely necessary. For example, Lee et al. (2012) describe how some firms use an interactive website with video and chat-groups to monitor environmental performance and share successful experiences among suppliers.

In addition, this study suggests that the effectiveness of both types of governance mechanisms (i.e., formal and informal) will depend on the supply network characteristics (Choi & Kim, 2008; Borgatti & Li, 2009). Surprisingly, there is a lack of studies that discuss how governance mechanisms interact with supply network structure/complexity and their respective impacts on environmental performance. Following the above arguments, we maintain that the effect of GSCM governance mechanisms on environmental performance will depend on the types and interaction of governance mechanisms and supply network characteristics including structure and complexity. We use a network-centric approach because the traditional focal firm and dyadic approach cannot capture the complexity involved in GSCM implementation and the total environmental impact. Furthermore, we view supply networks as emergent, because no single actor can control the structures and

practices of the entire supply network, especially regarding environmental issues. Thus, the contribution of this study is that it will generate novel theoretical propositions that help researchers and managers understand the interactions among GSCM governance mechanisms, supply network structures and complexity from an emergent supply network perspective.

The structure of the paper is as follows: First, we review some theoretical underpinnings related to Green Supply Chain Management (GSCM), supply networks, and GSCM governance mechanisms. Then, grounded in these theoretical premises, we develop theoretical propositions for explaining the roles of supply chain network structural characteristics and complexity in moderating the GSCM governance mechanisms-environmental performance relationship. Lastly, we discuss the limitations and managerial and research implications of the proposed conceptual framework.

THEORETICAL BACKGROUND AND DEVELOPMENT

Green Supply Chain Management

"Green supply chain management" (GSCM) is a set of practices that aims at integrating environmental concerns into the inter-organizational practices of SCM (Zhu et al., 2008), which may include green supply (Green et al., 2012), environmental purchasing (Carter et al. 1998), environmental operations management (Klassen and Angell, 1998) and reverse logistics (Sarkis et al., 2011). One of the objectives of GSCM research is to ascertain the effectiveness of various GSCM practices. Despite a considerable diversity with respect to the conceptualization and classification of GSCM and environmental performance, studies generally argue that GSCM has a positive impact on environmental performance (Florida, 1996; Geffen & Rothenberg, 2000; Florida & Davison, 2001; Golicic & Smith, 2013). Environmental performance has been understood as the positive outcomes for the natural

environment, such as the reduction of solid/liquid waste, emissions, consumption of resources and toxic materials, frequency of environmental accidents, and the increase in compliance with environmental standards (Green & Inman, 2005; Zailani et al., 2012; Zhu & Sarkis, 2004; Zhu et al. 2013;). It has been measured at a focal firm level (Zailani et al., 2012; Zhu & Sarkis, 2004; Zhu et al. 2013;), but it has not been explored at a supply network level, which would be more meaningful. Therefore, in this study, environmental performance is defined at a supply network level.

The validity of a study depends significantly on the validity of its related constructs (Mackenzie, 2003). Even though the field has generally agreed that GSCM is a multi-dimensional construct, its domain and content have not been clearly specified. Some scholars argue supplier management is perhaps a key element of GSCM (Green et al., 2012). In particular, new regulations, for example, RoHS (Restriction of Hazard Substances) in the electronics sector, have represented a fundamental change from controlling outputs to controlling inputs – from 'what comes out of the smokestack to what goes into products' (Esty & Winston, 2006, p. 145). Others argue GSCM should be a comprehensive multi-dimensional construct that includes supplier monitoring and collaboration (Lee & Klassen, 2008; Vachon & Klassen, 2006), environmental standards (Delmas & Montes-Sancho, 2010; Jiang & Bansal, 2003; Lee et al., 2012; Simpson et al., 2012;), green innovation (DeMarchi, 2012; Kesidou & Demirel, 2012; Veugelers, 2012), recycling (Min & Galle, 2001), eco-labels (Houe & Grabot, 2009), or environmental audits (Plambeck, 2012). Subsequently, GSCM has been conceptualized as a multi-dimensional construct which encompasses internal environmental management, external green supply chain management practices, investment recovery and eco-design (Zhu & Sarkis, 2004). The problem of such conceptualizations is that they categorize GSCM practices without anchoring them on specific theoretical perspectives, making it difficult to advance theory.

More meaningful findings might be generated when GSCM is conceptualized based on a specific theoretical lens. For example, GSCM can be either reactive (e.g., monitoring and mitigating suppliers' environmental risk) or proactive (for example, collaborating with other partners to design "cleaner" processes and products, reducing waste, as well as improving resource efficiency (Esty & Winston, 2006; Gimenez & Sierra, 2013; Vachon & Klassen, 2006)). It is argued that screening and monitoring suppliers or doing business with those that meet environmental regulations and standards may be not enough to improve environmental performance; better environmental performance can be achieved by collaborating with suppliers on green product design, holding awareness seminars, and helping suppliers to establish their own environmental program (Vachon & Klassen, 2006).

We argue that governance is another theoretical lens that has great potential to advance knowledge in GSCM. Governance is the "means by which order is accomplished in a relation in which potential conflict threatens to undo or upset opportunities to realize mutual gains", from a transaction cost economics (TCE) perspective (Williamson, 1998, p. 37). Although the notion of governance mechanisms has been largely explored in the inter-organizational networks literature (Gulati & Singh, 1998; Jones et al., 1997) and value chain governance theory (Gereffi & Lee, 2012), its application to GSCM is limited and rather recent (Aitken & Harrison, 2013; Gimenez & Sierra, 2013; Tachizawa & Wong, 2014). Governance of GSCM implementation can be rather tricky. Take supplier auditing and financial incentives, for example. Such governance mechanisms are arguably counterproductive, because they motivate suppliers to act opportunistically (Plambeck, 2012). More specifically, a lack of trust in the buyer-supplier relationship may lead to lower supplier transparency during environmental audits (e.g., hiding potential problems), which increases environmental risk (Lee et al., 2012). In response, the buyer may increase audit efforts, which diminishes mutual

trust. This cycle reinforces a negative feedback loop that will ultimately reduce environmental performance.

Furthermore, it is important to differentiate GSCM governance mechanisms from SCM governance mechanisms generally used for assuring cost, quality and speed in a supply network, for several reasons. First, environmental problems imply more hidden risk than cost/quality/speed issues, because there is more information asymmetry and less visibility (defined as the ability to access information across the supply chain). Second, lower-tier suppliers play a bigger role in GSCM issues, contributing even more to reduced visibility. Third, and paradoxically, firms still consider "green" attributes as secondary compared to cost/quality/speed. For all these reasons, the governance mechanisms used to manage environmental supply chains are not necessarily the same as those used to control cost/quality/speed. Such mechanisms are those referred to in this study as "GSCM governance mechanisms".

Examples of studies on GSCM governance mechanisms include Kogg (2003) and Hoejmose et al. (2013) who discuss how GSCM can be achieved by power leverage and incentives. Similarly, Caniels et al. (2013) and Delmas and Montiel (2010) compare cooperative and arm's length approaches to supplier environmental participation. Moreover, Vachon and Klassen (2006) propose monitoring and collaboration approaches to GSCM, although they do not establish links with complexity or other network structural characteristics. Furthermore, the only study that considered formal and informal governance mechanisms in GSCM implementation (Alvarez et al., 2010) was a longitudinal study that described but did not formulate propositions regarding environmental performance or network characteristics. Thus there is an opportunity to advance GSCM research by better understanding of the role of governance mechanisms in a complex supply network.

Another advantage of adopting the governance theoretic approach is that it can extend the scope of GSCM research beyond the dyadic relationship with first-tier suppliers – the supply network. In this study, governance is defined at the network level. Governance from a network perspective means "the relations through which key actors create, maintain and potentially transform network activities" (Raynolds, 2004, p. 728). In particular, our focus is the set of network governance mechanisms used for monitoring and controlling the behavior of a group of organizations in order to protect the interests of shareholders and community members (Pathak et al., 2014). The roles of network governance mechanisms, for example, contractual safeguards versus trust-building (Powell, 1990), have been highlighted as a potential research area for the following reasons: While most existing GSCM research has a focus on the first-tier supplier, a number of studies have revealed that significant environmental problems are often generated by lower-tier suppliers (Plambeck, 2012). The current approach to conceptualize and theorize GSCM has not considered the lack of visibility (asymmetric information) and direct ties with lower-tiers suppliers (Choi & Kim, 2008) as a factor that impacts its effectiveness. A supply network approach improves visibility by revealing hotspots and hidden risk beyond the first-tier suppliers and to the wider supply network. Thus, private and public governance mechanisms such as legislation, standards (Tallontire et al., 2011) and non-state market-driven governance systems created by NGOs (Cashore, 2002) that have not been taken into account before have emerged as new approaches to multi-tier sustainable supply chain management (Tachizawa & Wong, 2014).

In summary, the effectiveness of GSCM governance mechanisms does not depend on the behavior of individual firms alone but on the interaction of multiple actors in a coordinated network (Esty & Winston, 2006; Plambeck, 2012). Economic behaviors such as opportunism embedded in a network of relationships (Granovetter, 1985) can reduce trust and increase transaction costs (Williamson, 1981). Thus, the network perspective where a system can be

viewed as a set of interrelated nodes and ties (Borgatti & Li, 2009) may offer many new insights to GSCM research. In particular, better visibility would emerge from a network-centric approach because it may depict more clearly the complex interactions that occur simultaneously among multiple parties (Caridi et al., 2010) beyond the first-tier suppliers. The governance perspective can therefore extend GSCM research to consider potential supply network effects.

Figure 1 illustrates a theoretical model for explaining the impacts of GSCM formal and informal governance mechanisms on environmental performance, and how these relationships can be affected by various characteristics of the supply network. Our unit of analysis is the supply network that produces a final product. It is pointless to evaluate the environmental performance of a focal firm because what is being considered is the outcome to the environment as a whole (according to the environmental performance definition mentioned beforehand), and that will depend on the global impact along the supply network. Also, a supply network is subjected to not only governance mechanisms exerted by the focal firm: other players, such as standards agencies, government and NGOs do have influence. Thus, governance mechanisms and environmental performance in the theoretical model are measured at a supply network level. In the sections that follow we develop and introduce the propositions displayed in the model.

INSERT FIGURE 1 AROUND HERE

The Roles of Governance in GSCM

There are different approaches to differentiate GSCM governance mechanisms. The use of standards is more hands-off, while direct management of suppliers is more hands-on (Gimenez & Sierra, 2013). It is argued that hands-off approaches can complement hands-on approaches. Transactional GSCM governance mechanisms, such as the use of assessment or audit, are known to complement the more relational approaches such as using collaboration (Gimenez & Sierra, 2013; Vachon & Klassen, 2006). GSCM governance mechanisms can also be formal or informal. Formalization in the supply network context refers to the degree to which the supply network is controlled by explicit rules, procedures, and norms that prescribe the rights and obligations of the individual companies that populate it (Choi & Hong, 2002). This study focuses on examining the differences and links between formal and informal GSCM governance mechanisms because the ways formal and information mechanisms influence environmental performance differ under varying supply network conditions including complexity.

Formal governance mechanisms can be defined as the structural arrangements designed to influence the behavior of network members in an explicit way (Blome et al., 2013; Huang et al., 2014). They can include command structures, incentive systems, standard operating procedures and documented dispute resolution procedures (Alvarez et al., 2010), and are often based on hierarchical controls (Gulati & Singh, 1998). They explicitly specify expected roles, responsibilities, processes and output standards (Huang et al., 2014). More specifically, formalization of environmental management activities may be realized through environmental standards, audit procedures, codes of conduct, formalized processes or a list of restricted materials (Miemczyk et al., 2012; Pilbeam et al., 2012). Although encompassing mostly monitoring activities, they may include collaborative activities, for example, a supplier visit followed by an action plan.

Formal governance mechanisms are associated with better environmental performance when there is high uncertainty (Alvarez et al., 2010). Uncertainties about the baselines of environmental performance and the critical points among the many lower-tier suppliers can become obstacles for GSCM implementation. To address this issue, Nike established environmental performance baselines and improvement targets for Asian suppliers via a formal environmental management initiative (Plambeck et al., 2012), and Wal-Mart uses a formal assessment methodology globally with a 15-question survey to allocate business and determine with which suppliers to engage at a more strategic level (Plambeck & Denend, 2011).

Formal governance mechanisms are also effective in conditions such as high asset specificity (Williamson, 1981), potential opportunistic behavior (Anderson & Weitz, 1992) and information asymmetries (Li et al., 2010). When buyers and suppliers share common rules and procedures, transaction costs are reduced and information flows are more efficient (Choi et al., 2001). Furthermore, when there are higher technological components, anticipated coordination costs or interdependence (Gulati & Singh, 1998), formal governance helps to reduce coordination needs. Additionally, formal governance can act as a form of normative pressure in the supply network (Di Maggio & Powell, 1983). These pressures may be driven by the desire to professionalize organizational practices and increase environmental performance through mechanisms such as industry standards. For example, formal chain-of-custody certification systems are helping Wal-Mart map its supply network and create visibility of supply network activities, allowing for redesigning the network with the objective of reducing environmental impacts (Plambeck, 2012). Formal governance mechanisms, thus arguably, have a positive effect on the effectiveness of GSCM practices:

Proposition 1: Formal GSCM governance mechanisms positively affect environmental performance.

Nevertheless, formal governance mechanisms have some drawbacks. Designing, implementing and enforcing formal control parameters consume significant organizational resources (Schmoltzi & Wallenburg, 2012). Furthermore, a high level of formal control implies high ex-ante contractual costs and ex-post monitoring and enforcement costs (Huang et al., 2014). Additionally, excessive formal control does not avoid opportunistic behavior and may have a negative impact on buyer-supplier cooperation (Huang et al., 2014). Moreover, the commoditization of auditing systems and widespread corruption have compromised the reliability of environmental standards (Lee et al., 2012). Indeed, suppliers may learn to hide environmental problems by associating with indigenous consulting services (Plambeck et al., 2012). Therefore, informal, trust-based governance mechanisms (e.g., information sharing, values, culture, and norms) may also be necessary.

Informal governance mechanisms can be defined as structural arrangements designed to influence the behavior of organization members based on social control and trust rather than bureaucratic structures (Blome et al., 2013; Huang et al., 2014; Jones et al., 1997; Powell, 1990). They may include information sharing, values, culture, social norms, and relationships (Alvarez et al., 2010). They may substitute or complement formal controls (Kale & Singh, 2007). They facilitate inter-organizational flow of knowledge because they are quicker and less expensive than formal governance (Galaskiewicz, 2011).

Actually, the combination of formal and informal governance mechanisms may have positive effects on performance, because the relational cooperation may compensate the inflexibility of contractual governance and increase trust (Blome et al., 2013; Huang et al., 2014). As argued by transaction cost theory and the concept of bounded rationality, transaction

contracts will often be incomplete (Williamson, 1981) and thus need informal mechanisms to reduce ex-post transaction costs of monitoring and coordination (Kale & Singh, 2007). Informal governance mechanisms may include self-regulation, combined with moral perspectives (Schmoltzi & Wallenburg, 2012). In particular, the combination of both mechanisms is especially effective when the risk of opportunism is high (Huang et al., 2014). For example, Walmart uses a supplier self-reported database for analyzing the ingredients of every chemical-based product (Plambeck & Denend, 2011).

Relationships and social ties are another form of informal governance mechanism. The nature of interdependency means firms in a supply network need to gain access to resources that are distributed across the supply network. Such resources can be acquired through developing relationships with other firms in the network (Sarkis et al., 2011). For example, Wal-Mart gives incentives to non-competitive supplier working groups and collaborates with NGOs to stimulate suppliers' green innovation (Plambeck & Denend, 2011).

Jones et al. (1997) argue that ties between organizations can serve as social mechanisms of control. In these cases, instead of a court-enforced contract, firms may adopt a relational contract, that is, an informal agreement enforced by reputational concerns between parties that interact repeatedly (Baker et al., 2002). Moreover, when there is risk, trust is necessary, and informal network interactions can generate trust (Galaskiewicz, 2011). Further, implicit, broadly defined rules and procedures provide flexibility to network relationships (Choi & Hong, 2002). Examples of GSCM informal governance mechanisms include peer-to-peer learning, non-competitive supplier working groups, NGO partnerships, interactive websites, supplier/industry forums, incentives to self-reporting, and informal monitoring through environmental databases (Plambeck et al., 2012).

Informal governance has acquired recent attention for many reasons. First, growing transparency and scrutiny from NGOs facilitate social control rather than bureaucratic structures (Lee et al., 2012). Moreover, it can be used as the main form of governance when monitoring and formal controls are difficult and costly (McEvily et al., 2003). For example, Nike trains suppliers to monitor their own supply base using NGO websites. Moreover, it promotes the culture of self-reporting, rewarding suppliers that detect a problem and propose a solution - rather than merely punishing any non-compliance (Lee et al., 2012). Industry initiatives such as the Leather Working Group are industry forums that allow suppliers to discuss environmental practices (Lee et al., 2012); it is another form of informal governance.

As a consequence we propose that:

Proposition 2: Informal GSCM governance mechanisms positively affect environmental performance.

Proposition 3: Formal and informal governance mechanisms complement each other to positively affect environmental performance.

The Roles of Supply Network Structure

A supply network can be understood to be the set of firms that participate, directly or indirectly, in supplying industrial inputs to a focal firm, with or without that company's knowledge (Choi et al.., 2001; Choi & Krause, 2006). Ties in this study cover both "hard" material/money flow types and "soft" alliances and sharing-of-information types of ties, because both are critical in the network approach (Borgatti & Li, 2009). That means ties have a multiplexity property - different types of ties can exist simultaneously among a given set of actors (Borgatti & Li, 2009). Furthermore, we consider supply networks from the perspective of an "egocentric" network, i.e. ties centered on egos (Kim et al., 2011)

The supply network perspective is useful for understanding GSCM because supply network characteristics (e.g., complexity) are thought to influence the ways GSCM governance mechanisms affect environmental performance. Broadly speaking, the environmental management from a supply network perspective is about how to simultaneously enable trust among network members and take into consideration supply network complexity (Galaskiewicz, 2011).

Several studies have explored the characterization of different network structures using different methodologies, including case studies (Choi & Hong, 2002; Harland et al., 2001), simulation (Li et al., 2010; Pathak et al., 2009) or social network analysis (Kim et al., 2011). In essence, interdependency and connectedness are two main characteristics of a supply network, which becomes the central idea for studying relationships among two or more parties. For example, resource dependency theory studies the response of an organization to dependency on another (Pfeffer & Salancik, 2003). Social capital also has been used to study social networks (Borgatti & Li, 2009; Autry & Griffis, 2008). Lastly, from the structuration theory perspective (Giddens, 2013), actors in a supply network and context (e.g., network structure) are interdependent and thus they co-evolve to shape GSCM implementation (Sarkis et al., 2011).

The supply network literature has so far identified several main characteristics of supply network structure – centralization, density and complexity (Kim et al., 2011). These concepts are particularly applicable to analyze supply networks through social network analysis (SNA), because they allow an objective, quantitative comparison of different supply networks (Kim et al., 2011). SNA concepts are especially useful to study how the network structure affects individual firms (Borgatti & Li, 2009). The social network perspective

enables the study of not only the actors but also "how interactions among actors constitute a structure that can be analyzed in its own right" (Choi & Kim, 2008, p.7).

Centralization

In this study, centralization is measured at the supply network level and can be defined as the extent to which the overall connectedness is organized around particular nodes in a network (Borgatti & Li, 2009; Choi & Hong, 2002; Kim et al., 2011; Tate & Ellram, 2012). From an organizational context, centralization refers to the degree to which authority or power of decision-making is concentrated (Price & Mueller, 1986).

Centralization affects the relationship between GSCM formal governance mechanisms and environmental performance in several ways. Hearnshaw and Wilson (2013) argue that network coordination is facilitated by the presence of a small number of highly connected nodes (e.g., "hub" firms). Similarly, the literature on strategic networks posits that lead firms may centralize decisions (Gulati et al., 2000), bridging "structural holes" in the network (Burt, 2009). In particular, highly centralized networks will perform well in tasks that demand integrating information, because nodes that are a short path length from other nodes will receive information sooner than distant nodes (Borgatti & Li, 2009). For example, sustainability standards increasingly require that lead firms receive critical information about the chemical composition of their products and processes from direct and indirect suppliers (Esty & Winston, 2006).

The mechanisms by which centralization can strengthen the effect of formal GSCM governance mechanisms on environmental performance have been discussed in the literature. First, centralization involves formal procedures to collect data from the supply network such that it decreases information asymmetry (Sarkis et al., 2011; Simpson, 2010). Second, centralization increases controllability of formal control mechanism in product design which

are crucial for assuring quality and controlling cost and providing orderliness and economies of scale (Choi & Hong, 2002; Kim et al., 2011; Li et al., 2010). Conversely, giving too much freedom for networks to emerge can reduce the predictability of managerial initiatives (Choi et al., 2001). Lastly, centralization decreases coordination costs involved in the formal control processes and improves efficiency at the network level (Kim et al., 2011). In fact, asking suppliers to share information about their environmental strategy formally promotes managerial attention and thus improves performance (Plambeck, 2012). Based on these theoretical arguments we propose that:

Proposition 4: Centralization positively moderates the relationship between formal GSCM governance mechanisms and environmental performance.

Centralization has a different moderating effect on the relationship between GSCM informal governance mechanisms and environmental performance. As commented previously, formal governance is associated with tightly coupled processes, whereas informal governance is related to those that are more loosely coupled. Whereas in tightly coupled supply networks a centralized authority is required to make such systems possible (Skilton & Robinson, 2009), in loosely coupled networks such a level of centralization is not required.

In fact, we argue that centralization has negative effects on GSCM effectiveness. More specifically, it increases the time to take decisions and act in a network (Kim et al., 2011). Sometimes it is more effective for the egos to let the supply network emerge though positive feedback, for example in innovation-related activities (Choi et al., 2001). Conversely, many firms implement decentralized networks in order to improve their environmental performance. Natura, for example, which is a well-known Brazilian cosmetics firm that is often recognized in the press as being a highly sustainable company, has invested in a

decentralized supply network and informal governance mechanisms to innovate and assure superior environmental performance (Jones, 2012).

This argument can also be explained through the concept of power and trust. Mediated forms of power, which are associated with centralization of activities, are those in which deliberate control of reinforcements is expected to change the behavior of the target (Terpend & Ashenbaum, 2012). They have a negative effect on trust within the network (Maloni & Benton, 2000), which is critical for the effectiveness of informal GSCM governance mechanisms. As a consequence, we suggest that:

Proposition 5: Centralization negatively moderates the relationship between informal GSCM governance mechanisms and environmental performance.

Density

Another key characteristic of supply networks is density (Rowley, 1997). Network density is defined as the number of total ties in a network relative to the number of potential ties (Borgatti & Li, 2009; Kim et al., 2011). Network density also affects the relationship between GSCM formal governance mechanisms and environmental performance. However, how this effect occurs will depend on the type of tie considered. More specifically, the density of "soft" (information, values) and "hard" (material, money) ties actuate in different ways. "Hard" ties have a negative moderating effect because they increase the amount of coordination effort from the lead firm. A denser network requires more effort from the egos to manage it (Kim et al., 2011). "Soft" ties also have a negative moderating effect because they allow suppliers to interchange critical information and act opportunistically, for example by sharing information on how to avoid revealing environmental problems during audits (Choi & Krause, 2006; Lee et al., 2012). In an ego network, an actor will better negotiate with several alters if they are unconnected to each other (Borgatti & Li, 2009). This can be

understood using the concept of structural holes (i.e., the absence of ties between two indirectly connected nodes). When the ties among suppliers are information exchanges about their interactions with an ego, more structural holes (and therefore lower network density) will improve performance (Choi & Krause, 2006; Borgatti & Li, 2009). Conversely, if suppliers interact, transaction costs will increase, in order to protect the ego against suppliers' opportunistic behavior (Choi & Krause, 2006).

Based on the above we propose that:

Proposition 6: Density negatively moderates the relationship between formal GSCM governance mechanisms and environmental performance.

The effect of network density on the effectiveness of GSCM informal governance mechanisms can be better understood by relying on the concept of social networks. Informal social networks reduce transaction costs by making opportunism more costly because of the rapid dissemination of information through the network and reputational costs (Gulati et al., 2000). Thus, a denser supply network (i.e., more ties) may reduce transaction costs and improve the effectiveness of informal control mechanisms in the network.

Additionally, informal inter-firm collaboration is often associated with a high network density (Hearnshaw & Wilson, 2013). Thus, a highly dense supply chain may support partner cooperation in environmental initiatives. Finally, resource dependence theory posits that firms may benefit from depending on resources from other network members (Zhu & Sarkis, 2004). In fact, there is empirical evidence showing a positive relationship between resource dependence and supply chain performance (Yang et al., 2008).

In order to better understand the effect of density on the effectiveness of informal GSCM, it is important to distinguish between the different types of network ties. "Soft" ties are more important here than "hard" ties. For example, by connecting with suppliers with few

connections to the network, lead firms can scan disruptive environmental innovations (Von Hippel, 1986). Similarly, Choi and Kim (2008) define "network awareness" capability as a buying company's ability to scan external networks of its key suppliers beyond direct ties. Lower-tier suppliers can provide useful knowledge of the latest technological advances, because they are in contact with non-directly related industries (Choi & Linton, 2011).

Also, by bridging "structural holes", lead firms can increase density and facilitate exchange of information critical to production output. When the ties among suppliers are information exchanges about better integrating their outputs (e.g., scientific or manufacturing knowledge, coordination of product specification, development of new parts), bridging structural holes will positively affect performance (Borgatti & Li, 2009; Choi & Krause, 2006). Likewise, a buyer working with two suppliers in product development might encourage the suppliers to develop a relationship (Skilton & Robinson, 2009). For example, Toyota's supplier association helps broadcast and develop Toyota's best practices (Choi & Krause, 2006). Sharing this information does not reduce the amount of it available to the firm; to the contrary, it may allow synthesis of information that results in a larger overall quantity of knowledge (Borgatti & Li, 2009). We therefore propose that:

Proposition 7: Density positively moderates the relationship between informal GSCM governance mechanisms and environmental performance.

Complexity in Supply Networks

Complexity has been discussed in many academic areas such as physics, engineering, social sciences and management. In a classical definition, Simon (1991) has treated complexity as the product of the number of entities and the number of interactions within a system. Complexity can be analyzed from different levels: task (Handley & Benton, 2013), functional (Perona & Miragliotta, 2004; Smeltzer & Odgen, 2002), organizational (Anderson, 1999),

supply base (Brandon-Jones et al., 2014; Choi and Krause, 2006), and supply chain (Bozarth et al., 2009; De Leew, 2013; Vachon & Klassen, 2002). Nevertheless, shifting the focus from simple supply chains to complex supply networks has become a preferential approach for managing the flow of goods and information more effectively (Skilton & Robinson, 2009). Therefore, in the present study we are mainly interested in complexity defined at the (supply) network level.

Multiple definitions of supply network complexity have been proposed in the literature, and none is predominant. Nevertheless, supply network complexity has several key approaches: The first comes from the definitions of complexity of organizational design literature (Anderson, 1999). In particular, organizational design literature treats complexity as a structural variable that characterizes both the organizations and their environments (Anderson, 1999). The number of activities or sub-systems within an organization has been used to indicate complexity at an organizational level (Daft, 1992). Thus, the number of network participants becomes a key dimension of supply network complexity (Choi & Krause, 2006). Furthermore, organizational design literature applies such conceptualizations of complexity to study vertical complexity (hierarchical), horizontal complexity (across departments) and spatial complexity (geographical locations). Following the same logic, Choi and Hong (2002) and Tate and Ellram (2012) rely on the dimensions of horizontal (number of suppliers), vertical (number of tiers) and spatial (geographical dispersion of suppliers) to study supply network complexity. In particular, geographical dispersion of suppliers may increase information asymmetries and uncertainty because of the different languages, systems, standards, cultures and ways of working applied in different countries and regions.

Another approach, largely applied to study social networks, views complexity in terms of the degree of interrelationships, in addition to the number of nodes in a network (Frenken, 2000).

In particular, Skilton and Robinson (2009) adapted the complexity dimensions of Choi and Krause (2006) to consider the levels and types of interrelationships between suppliers as another key dimension of supply network complexity, in addition to the number of network participants. As the number of nodes or participants as well as the interrelationships among them increases, the load on the supply network that requires coordination increases. Complexity from a supply network perspective is therefore equivalent to the load on the system that requires coordination (Choi & Hong, 2002). Thus, the third dimension that can add coordination load into the supply network is differentiation between suppliers (Choi & Krause, 2006; Skilton & Robinson, 2009). As the suppliers become less unified, more variety of coordination tasks will be needed from an ego perspective. In conclusion, supply network complexity is a multi-dimensional construct that is measured at the supply network level and is defined as a function of the number of network participants, differentiation between suppliers and level and types of interrelationships between suppliers (Choi & Krause, 2006; Skilton & Robinson, 2009).

The Role of Supply Network Complexity

We argue that the effectiveness of formal and informal governance mechanisms can be impacted by supply network complexity. Formal governance mechanisms are usually associated with tightly coupled supply networks, characterized by hierarchical authority and unambiguous performance standards (Perrow, 2011). When coupling is tight, events in one subsystem influence processes in other subsystems in unexpected ways (Skilton & Robinson, 2009). For example, the formal implementation of environmental standards implies changes in manufacturing processes, quality standards, equipment and test parameters in the buyer and its suppliers (Koh et al., 2012). Thus, in this situation, increasing supply network complexity will have a negative effect on GSCM effectiveness.

Moreover, supply network complexity increases the level of effort or operational load required to manage the network (Skilton & Robinson, 2009), and also draws on organizational resources of the focal company (Choi & Krause, 2006). Actually, simply mapping a supply network may be a thorny issue; for example Wal-Mart had to identify the ingredients and suppliers' suppliers of its 6,000 private brands (Plambeck, 2012). Likewise, increasing the number of suppliers will increase the level of coordination required to improve the efficiency of operations (Handfield & Nichols, 1999). Also, contracting and enforcing agreements with suppliers increase transaction costs, especially when there is high differentiation among suppliers' operating procedures (Choi & Krause, 2006). As a consequence, we propose that:

Proposition 8: Supply network complexity negatively moderates the relationship between formal GSCM governance mechanisms and environmental performance.

In general, formal governance mechanisms such as environmental standards are not as effective as informal governance mechanisms when supply network complexity is high (Simpson et al., 2012). Informal governance mechanisms are often related to loosely coupled supply networks, with ambiguous and limited performance standards, and minimal specification of products or methods (Skilton & Robinson, 2009). Thus, each subsystem will be partially isolated from events in another subsystem. Therefore, in this situation, supply network complexity will not have a negative effect on GSCM effectiveness, compared with formal governance mechanisms.

Actually, supply network complexity may strengthen the effects of GSCM informal governance mechanisms on environmental performance. This can be understood by drawing from network effects: the higher the number and diversity of network participants, the more attractive it is to engage in informal GSCM initiatives in the supply network (e.g.,

environmental forums, NGO partnerships, using NGO environmental databases to monitor suppliers, etc.). Additionally, when information is shared among a higher number of network members, suppliers have more incentive to compare their performance with other suppliers and self-identify problems (Lee et al., 2012). Lastly, a greater number of inter-dependent, diversified suppliers with different expertise will increase supplier innovation (Choi & Krause, 2006) because every additional network node will function as an information-processing mechanism that expands the capabilities of the ego (Ahuja, 2000). In addition, under complex processes and in jurisdictions with weak court systems, unforeseen contingencies will make contract enforcement difficult (Tirole, 1999). Under such complexities, informal GSCM governance mechanism based on relationship and social behavior can become more effective. Therefore, we suggest:

Proposition 9: Supply network complexity positively moderates the relationship between informal GSCM governance mechanisms and environmental performance.

DISCUSSION AND CONCLUSIONS

This study advances the GSCM literature by developing theoretical propositions for explaining the moderating effects of supply network structural characteristics and complexity on the effectiveness of GSCM governance mechanisms. The novelty in our theoretical approach is twofold.

First, we propose a supply network perspective to analyze GSCM governance mechanisms' effectiveness, rather than a linear view. We develop theories to explain the relationships between GSCM governance mechanisms, supply network structures and complexity at the network level. We view supply networks as emergent, by taking into account the different parties that could shape the supply network and GSCM implementation. This allows a more sound analysis of complex issues, such as when decisions by a brand lower its own footprint,

but increase the footprint within the supply network. In particular, this study expands existing understanding by pointing out that the effectiveness of GSCM governance mechanisms does not depend only on the lead/focal firm's or supplier's characteristics. Instead, it may be influenced also by supply network structural characteristics and various types of complexity. Although measures of supply network characteristics (e.g., centralization, density, complexity) have been suggested by several authors (Choi & Hong, 2002; Kim et al., 2011; Skilton & Robinson, 2009), they did not relate them to governance mechanisms or performance outcomes. Instead, they claimed that applications of such measures should be developed in further studies.

Second, this study explains how formal and informal governance mechanisms may interact differently with supply network structure and that these interactions have different impacts on environmental performance. Formal and informal approaches to governance have been studied at an organizational level by the organizational theorists, but their roles in GSCM implementation at a supply network level have not been formally examined and understood.

In addition, this study advances the theories of supply networks by focusing on their environmental aspects. Also, it suggests a novel approach to supply networks, according to which supply network structural characteristics and complexity can be operationalized as moderating variables that determine the relationship between network governance mechanisms and performance.

In particular, organizational concepts such as transaction costs and social embeddedness can contribute significantly to explain how these contextual factors interact to improve environmental performance, meaning that the explanation of the effectiveness of GSCM efforts offered by most prior studies focusing on a transactional approach has been incomplete. In this respect, this study contributes to the debate of network control versus

emergence by discussing the conditions under which lead firms can effectively facilitate the improvement of environmental performance in their supply networks. Thus, it assumes an emergent characteristic of GSCM governance mechanisms, in which their final configuration will largely depend on the network behavior rather than on deterministic decisions of the lead firm. Lastly, this study shifts the focus from the monitoring versus collaboration debate prevalent in prior GSCM studies (e.g., Vachon & Klassen, 2006), to a broader discussion of formal versus informal governance mechanisms present in most managerial decisions. The theoretical propositions developed by this study serve as the springboard for advancing research and understanding to the next, more mature stage.

This study also provides several practical implications. Our theorization suggests that it is crucial for supply chain managers to consider the different types of governance mechanisms and how they interact with supply network structure. In particular, formal governance mechanisms are essential, but they become more effective when appropriate informal governance mechanisms are used simultaneously. Next, the effectiveness of formal and informal mechanisms depends on the levels of supply network centralization, density and complexity. Firms could support GSCM efforts by either relying on a combination of highly formalized governance mechanisms, when the supply network is highly centralized and has low density or, alternatively, informal governance mechanisms when the supply network has low centralization and high density. In addition, formal governance mechanisms are suitable for supply networks with low network complexity, whereas informal governance mechanisms are associated with complex networks. The feasibility and performance outcomes of each governance approach under different supply network characteristics should be verified through empirical studies.

The focus on any theoretical perspective often leads to limitations in considering other aspects. As limitations of this study, we can mention the fact that we focus on supply networks and therefore potential moderation effects of other characteristics at the firm, dyad or industry levels. For example firm size, technology or financial resources (Skilton & Robinson, 2009) or environmental dynamism (Wiengarten et al., 2012) have not been analyzed. Moreover, the theoretical propositions of this study should be confirmed through empirical investigation.

By laying down the necessary theoretical foundations, this study may lead to some new streams of research. In particular, the interaction between GSCM governance mechanisms and supply network structure/complexity could be combined with other approaches. For example, one could identify "hot spots" (Liedtke et al., 2010) in the supply network by referring to our theoretical propositions, that is, to identify the nodes in the supply network in terms of their centralization, density, and complexity. Hot Spot Analysis is a qualitative assessment instrument created by the Wuppertal Institute that estimates the resource-intensity of a product along complex value chains. The main objective of a Hot Spot Analysis is to identify central peaks of resource use or sustainability issues along the whole value chain, which are called "hot spots". This notion could complement the proposed framework by providing tools to prioritize GSCM efforts and thus compensate potential negative effects of supply network complexity. Moreover, the use of Hot Spot Analysis could support the decision on which GSCM governance mechanisms are more appropriate for each part of the supply network.

Another promising line of research is to use the proposed framework to explore the antecedents, contextual factors and performance results of environmental collaboration with competitors, for example using joint audits and common supplier databases to accrue power

to pressure common suppliers and increase leverage (Lee et al., 2012). Moreover, one could measure potential interactions between constructs used in the framework. For example, it has been argued that centralization may reduce complexity (Li et al., 2010).

The network perspective is becoming a lingua franca among virtually all sciences (Borgatti & Li, 2009). In the SCM literature in particular the linear perspective fails to capture the complexity needed to understand how firm behavior interacts with the network it is embedded in (Kim et al., 2011). What happens in one part of the network affects the other parts, for example 'when big retailers like Wal-Mart place orders, this reverberates throughout the world' (Galaskiewicz, 2011, p. 6). In this context, this study provides a theoretical underpinning to further understand the complex interactions between supply network structure, GSCM governance mechanisms and environmental performance. We hope it contributes to raise new research streams and advance the field of GSCM studies by developing novel insights about these important issues.

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