Three Essays on Theorizing Supply Chain-Make Versus Supply Chain-Buy

by

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ABSTRACT

The dissertation aims to provide a new perspective on the management of multi-tier supply chains. When a firm decides to buy a product from a supplier, the buying firm also needs to decide whether to use the supplier to make the lower-tier sourcing decisions or to make those decisions in-house. I call the former "supply chain-buy" and the latter "supply chain-make." If the choice is supply chain-buy, the buying firm releases sourcing control of its bill of materials (BOM) to the top-tier supplier and this supplier, then engages with the supply base to determine the BOM's supply chain. If the choice is supply chain-make, the buying firm maintains sourcing control of the BOM and engages with its own supply base to select the lower-tier suppliers. The dissertation provides a theoretical foundation and empirical observations for understanding the supply chain make-buy decisions. The dissertation consists of three main chapters: Chapter 2 extends the make-or-buy literature into the multi-tier supply management context to provide theoretical reasons for engaging in supply chain-make as opposed to supply chain-buy. Building on transaction cost economics, the knowledge-based view, and structural hole theory, Chapter 2 explains the phenomenon that cannot be fully explained by a single-theoretic perspective. Chapter 3 empirically investigates the economic and behavioral factors that influence individual purchasing managers' supply chain make-buy decision-making. Specifically, the roles of behavioral uncertainty, interpersonal trust, and familiarity are considered. A scenario-based behavioral experiment involving the members of the Institute for Supply Management is employed. Lastly, Chapter 4 studies the performance implications of particular supply network structures influenced by supply chain make-buy decisions. Supply chain make-buy decisions can affect the

prevalence of structural holes in supply networks. Chapter 4 investigates the different

types of structural holes in supply networks. It provides a novel way of understanding

structural holes in the supply network context by distinguishing structural holes between

the focal firm's suppliers (horizontal structural holes) from those between its customers

and suppliers (vertical structural holes). Panel data on supply networks and firm financial

indicators are used for analysis in Chapter 4.

DEDICATION

I dedicate this work to my wife Sukyung
for making me find happiness and love every single day.

I also dedicate this work to my parents for their wholehearted support and trust.

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CHAPTER 1

INTRODUCTION

Why do buying firms engage in their suppliers' sourcing activities? What are the performance implications of this engagement? These are the central questions of this dissertation. To help answer these questions, I reframe the decision regarding the involvement in a supplier's sourcing activities as the "supply chain make-buy" decision. Should the buying firm "make" the supply chain by exerting control over the selection and management of Tier-2 and further upstream suppliers or "buy" the supply chain by delegating the control to the Tier-1 supplier? Identifying the drivers and performance implications of this supply chain make-buy decision is the objective of this dissertation. Chapters 2 and 3 are dedicated to determining the drivers of supply chain make-buy decisions, and Chapter 4 aims to examine the performance implications of the supply network structures associated with supply chain make-buy decisions.

When a firm outsources production of goods or delivery of services to a supplier, the buying firm typically outsources selection and management of Tier-2 and further upstream suppliers to the Tier-1 supplier. However, if the buying firm wants to exert partial control over the selection and management of Tier-2 and further upstream suppliers, it can engage in multi-tier supply management practices such as directed sourcing and the use of approved vendor lists. Under a directed sourcing arrangement, the buying firm contracts directly with a Tier-2 or further upstream supplier and directs the Tier-1 supplier to use the component from that particular supplier (Choi & Linton, 2011; Mena et al., 2013). An approved vendor list is the list of the key suppliers from which the

buying firm recommends a Tier-1 supplier to purchase components whenever possible (Choi & Linton, 2011). Additionally, the buying firm can maintain collaborative relationships with Tier-2 or further upstream suppliers.

Since these multi-tier supply management practices require more managerial resources from the buying firm to identify and manage the relationships with the suppliers beyond Tier-1 supply chains, the buying firm would not engage in these practices unless the benefits outweigh the costs. The conceptual study presented in Chapter 2 explains the theoretical reasons for a buying firm to engage in multi-tier sourcing practices by identifying the conditions in which the benefits of using multi-tier sourcing practices outweigh the costs.

While the study in Chapter 2 focuses on the firm-level decision-making, the study in Chapter 3 focuses on individual supply managers' decisions regarding the use of multi-tier supply management practices. Based on the scenario-based role-playing experiment involving the members of the Institute for Supply Management, Chapter 3 investigates the behavioral tendencies of individual supply managers in making the supply chain make-buy decisions.

Lastly, the study in Chapter 4 examines the performance implications of particular supply network structures that are associated with supply chain make-buy decisions. If a focal firm maintains direct ties with its Tier-2 suppliers, it will have a closed upstream supply network structure. However, if a focal firm's customers have direct ties with its suppliers, the vertical side of its supply network will have a closed structure. Based on archival buyer-supplier relationship network data, Chapter 4 reveals the contrasting performance implications of the two different supply network structures.

CHAPTER 2

THEORIZING SUPPLY CHAIN-MAKE VERSUS SUPPLY CHAIN-BUY

ABSTRACT

While the firm-level make-buy decision has been studied in the literature, consideration of the supply chain-level make-buy decision is largely missing. Current multi-tier supply management practices, which seemingly incur higher governance costs, cannot be properly understood without considering the supply chain-level make-buy decision. In this conceptual paper, we first introduce and clarify the concepts of *supply chain-make* and *supply chain-buy.* Then, building on transaction cost economics, the knowledge-based view, and structural-hole theory, we bring strategic salience to the decisions involved in a buying firm's supply chain make-buy and propose a theoretical framework.

Keywords: *multi-tier supply management, make or buy, supply chain make-buy*

INTRODUCTION

All firms face make-buy decisions. The buy decision entails the utilization of the supplier capability. This supplier directly transacts with the buying firm and is typically called the buying firm's top-tier supplier. Yet, another decision has been observed to occur at the supply chain-level. The buying firm then has to decide whether to use the top-tier supplier to make the lower-tier sourcing decisions or to make those decisions in house (Choi & Linton, 2011). This is a strategic decision that the current literature has overlooked. We call the former "supply chain-buy" and the latter "supply chain-make." If the choice is supply chain-buy, the buying firm releases sourcing control of its bill of materials (BOM) to the top-tier supplier and this supplier, then engages with the supply base to determine the BOM's supply chain. If the choice is supply chain-make, the buying firm maintains sourcing control of the BOM and, engages with its own supply base to select the lower-tier suppliers. Our goal in this paper is to provide a theoretical foundation for understanding the supply chain make-buy decisions.

Figure 1 contrasts firm-level make-buy and supply chain make-buy. From the buying firm's perspective, a firm-level make-buy decision is the decision regarding which firm between the buying firm and top-tier supplier to perform production activities. According to the TCE literature, this choice between internal versus external production is essentially a binary decision (Williamson, 1985). While there can be multiple governance choices (e.g., contractual, relational, hierarchy, alliance, and joint venture), the make-buy decision itself entails a binary outcome − in-house or outsourced. The direct transaction between the buying firm and top-tier supplier becomes the unit-of-analysis. The choice of firm-level buy does not automatically translate into the choice of

supply chain-buy. A buying firm often opts for firm-level buy, yet retain decision making about which "supply chain" performs the production activity. A buying firm can either "buy" the existing supply chain used by its top-tier suppliers, or it can "make" the supply chain by specifying which lower-tier suppliers will produce and deliver the parts in the BOM. In this case, the unit-of-analysis is the *bundle of transactions* including both *direct and indirect transactions* in the supply chain.

Firm-level make-buy

Buying firm

Production within the focal firm

or

Top-tier supplier

Decision to make: Which *firm* to perform the transaction (i.e., make or buy)
Unit of analysis: *Direct transaction* between the buying firm and top-tier supplier

Supply chain make-buy

Buying firm

Top-tier supplier

Tier-2 supplier A

Tier-2 supplier B

Tier-3 supplier A

Tier-3 supplier B

Tier-3 supplier C

Tier-3 supplier D

Decision to make: Which *supply chain* to perform the transactions (i.e., scope of supply chain-make)
Unit of analysis: *Bundle of transactions* including both *direct and indirect transactions* among the buying firm, top-tier supplier, and lower-tier suppliers

→ : Direct transaction
---▶ : Indirect transaction

Figure 1. Comparing Firm-Level Make-Buy and Supply Chain Make-Buy

In contrast to the firm-level make-buy decision being binary, the supply chain make-buy decision occurs across a range of options. A supply chain-make decision involves a choice regarding how much of the BOM will be controlled by the buying firm. That is, the buying firm can try to control the majority or only some of the lower-tier suppliers. If the buying firm chooses not to control, the decision reduces to a supply chain-buy decision. For instance, Chrysler is engaged in supply chain-buy of its center console assembly by delegating the sourcing decisions to its top-tier supplier, whereas Honda dictates many of the key parts and raw material suppliers to the top-tier supplier (Choi & Hong, 2002). The *scope of supply chain-make* is decided depending on how many lower-tier suppliers are specified by the buying firm. This is the essence of the supply chain make-buy decision.

Supply chain-buy is ubiquitous. When a university contracts with Dell or Lenovo to supply laptops, it does not control the lower-tier suppliers. Dell or Lenovo as a supplier makes the sourcing decisions. The university has chosen to "buy" a supply chain. Compared to supply chain-make, supply chain-buy is more straightforward and requires less managerial resources. The buying firm simply delegates the responsibility of lower-tier sourcing to the supplier and pays it for this extra work. In contrast, supply chain-make necessitates a more strategic approach. For example, aircraft and aircraft engine manufacturers including Boeing, General Electric, Northrop Grumman, Rolls-Royce, and Lockheed Martin provide lists of approved processors or vendors to direct their top-tier suppliers to use specific lower-tier suppliers (Boeing, 2015; Lockheed Martin, 2015; Northrop Grumman, 2015). Apple selects lower-tier suppliers and keeps direct contracts with them (Apple Inc., 2015; Satariano & Burrows, 2011). Oracle provides applications

to promote collaboration among top-tier and second-tier suppliers while gaining control over their extended supply chains (Oracle, 2015). These well-known buying companies show a variety of different approaches of supply chain-make.

Without considering both direct and indirect transactions embedded in the BOM structure of an assembly, the buying firm would simply rely on either market or hierarchy (Williamson, 1975). By introducing supply chain-make as another option for managing transactions, we provide a novel way of understanding outsourcing decisions. Our aim is to understand *why buying companies engage in supply chain-make as opposed to supply chain-buy.* More specifically, we investigate the key variables that affect a buying firm's supply chain-make versus supply chain-buy decision and propose an underlying model that captures the supply chain-level make-buy decision. Because supply chain-make requires more resources and effort to initiate and manage ties with lower-tier suppliers, an underlying rationale should exist for the motivation behind the supply chain-make decision. We argue that transaction cost economics (TCE) alone cannot fully explain the phenomenon of supply chain-make, which incurs additional governance costs for the buying firm (Williamson, 1975). The knowledge based view (KBV) of the firm (e.g., Grant, 1996; Kogut & Zander, 1992) is another body of literature applied to make-buy decisions. This too cannot sufficiently explain the buying firm's decision to control lower-tier suppliers. In sum, a further conceptual development is needed to align theory with practice. Recently, scholars have enumerated the usefulness of social network concepts to understand supply chain dynamics (Borgatti & Li, 2009; Choi & Kim, 2008).

To fill the current theoretical void, we build on TCE, KBV, and structural-hole theory. By doing so, we attempt to explain the phenomenon that is not fully explained by

a single-theoretic perspective. In addition, we intend to contribute to the literature on make-buy decisions by suggesting an expanded unit-of-analysis at the supply chain level. Specifically, we adopt as our unit-of-analysis *the bundle of transactions embedded in the BOM structure*, which recognizes the multilevel nature of make-buy decisions.

Our paper is organized as the following. After discussing the existing literature and how our study advances the extant literature, we conceptualize the supply chain make-buy decision. We present the archetypes of control used in the choice of supply chain-make. Then, we identify the key underlying variables that influence supply chain make-buy decisions and present a heuristic model of supply chain make-buy decision making. The final sections discuss theoretical and managerial implications of our study.

LITERATURE REVIEW AND CONCEPTUAL DEVELOPMENT

Multi-Tier Supply Chain Management

The literature on firm-level make-buy decisions has used transaction cost economics (TCE) as a dominant theoretical framework (e.g., Mantel, Tatikonda, & Liao, 2006; McIvor, 2009). More recently, Parmigiani (2007) proposes a "make-and-buy" strategy composed of concurrent making and buying of the same or similar products by the buying firm, and Park and Ro (2011) develop "pseudo-make" to describe the practices which the buying firm engages in the design of the product while the suppliers execute production. These scholars have tried to consider the more complex nature of make-buy decisions. Nonetheless, TCE adopts the individual transaction as the unit-of-analysis (Geyskens, Steenkamp, & Kumar, 2006; Rindfleisch & Heide, 1997; Williamson, 1975). As a result, the researchers studying firm-level make-buy decisions have generally

examined bilateral transactions (Wever, Wognum, Trienekens, & Omta, 2012), and the product being exchanged in a bilateral transaction has been treated as a whole, undivided item.

We begin with an observation that the item in transaction consists of separate parts or materials. In other words, the item being exchanged between the buying firm and supplier generally contains a BOM structure. A BOM lists a product's parts and materials that are associated with the suppliers (Chase, Jacobs, & Aquilano, 2006). Considering this BOM structure, a bilateral transaction of an item includes both the "direct transactions" and "indirect transactions." From the buying firm's perspective, direct transactions occur with its top-tier suppliers (i.e. the buyer is directly engaged in the transaction), whereas indirect transactions take place among the suppliers (i.e. the buyer is indirectly engaged through its top-tier suppliers).

Supply chain management researchers have recognized the importance of understanding and managing "extended" or "multi-tier" supply chains (Choi & Linton, 2011; Lee, 2010; Mena, Humphries, & Choi, 2013; New, 2010). As suppliers are "embedded in larger supply networks rather than in isolation" (Choi & Kim, 2008: 5), an understanding about further upstream supply chains should help buying firms develop effective supply management strategies. Lee (2010) notes that critical players in a firm's supply chain are often several tiers away from the firm. Yan, Choi, Kim, and Yang (2015) offer a typology of critical suppliers in extended supply networks. New (2010) recommends companies to use technologies to track down direct and indirect suppliers and build transparent supply chains. Choi and Linton (2011) suggest that buying firms should establish direct relationships with key lower-tier suppliers.

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In response, Mena et al. (2013) adopt an inductive theory-building approach and investigate how multi-tier supply chains operate. Their analysis offers insights for the power dynamics and interdependence across the buying firm, its supplier (top-tier), and its supplier's supplier (lower-tier). Although they provide costs and benefits for buying firms to connect directly to their key lower-tier suppliers, left unanswered is when and how much the buying firm needs to be connected with their lower-tier suppliers. While a buying firm can influence key product characteristics by directly connecting with the lower-tier suppliers (Mena et al., 2013), it can also specify product characteristics to its top-tier suppliers and monitor them without directly connecting with lower-tier suppliers. Therefore, the question remains as to what are the underlying reasons for the buying firm to keep control over the lower-tier suppliers instead of delegating lower-tier supplier management to the top-tier supplier. Moreover, how far should the buying firm go to control the lower-tier suppliers? Our paper seeks to answer these questions by providing a framework that theorizes the buying firm's make-buy decisions at the supply chain level.

Conceptual Framing of Supply Chain-Make versus Supply Chain-Buy

Given the firm-level "buy" decision, the buying firm considers whether to "make the supply chain" by retaining the component sourcing decisions or to "buy the supply chain" by delegating to the top-tier supplier the component sourcing decisions. In the context of the value chain perspective (Porter, 1985), the supply chain make-buy decision is equivalent to outsourcing a support activity (i.e., sourcing) together with a primary activity (i.e., production). When the buying firm outsources production to the top-tier

supplier, the component-level sourcing activities are often outsourced to the same supplier (i.e., supply chain-buy).

Suppose a buying firm has chosen "supply chain-buy" and purchases a product (e.g., anti-lock break system) from a top-tier supplier. The top-tier supplier is then entrusted to buy parts and components from its own supply base, which would be lower-tier suppliers for the buying firm. They may be second-tier suppliers or may also include some of the third- or even fourth-tier suppliers (Choi & Hong, 2002). These lower-tier suppliers produce and deliver the items indicated in the multi-level BOM that lists the components and subcomponents. For instance, Google is engaged in the supply chain-buy of its Nexus 5 smartphone (Google Inc., 2014; LG Electronics Inc., 2014). A top-tier supplier, LG Electronics, articulates the BOM and makes the sourcing decisions. That means, LGE's suppliers of Nexus 5 components, including display, processor, cameras, battery, and memory suppliers, become lower-tier suppliers to Google.

Table 1 distinguishes the supply chain make-buy decision from the firm-level make-buy decision. Buying firms choosing supply chain-make rely on external production but partially or fully internalize component or materials sourcing (upper right quadrant). Buying firms choosing supply chain-buy rely on its top-tier suppliers for both production and sourcing activities (lower right quadrant). In contrast, buying firms choosing firm-level make perform both production and sourcing internally (upper left quadrant). Lastly, when a buying firm decides to internalize production but to outsource sourcing, it can utilize third- or fourth-party sourcing or logistics providers (lower left quadrant).

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As explained in the introduction, the outcome of a supply chain make-buy decision (i.e., the scope of supply chain-make) is not binary. Rather, it can be described as a proportion of the suppliers of the components in the BOM controlled by the buying firm. Further, the supply chain make-buy choice is not static – the buying firm can continuously increase or decrease the scope of supply chain-make. For example, after the recognition of behavioral uncertainty and supply risks in the garment category in the wake of Tazreen factory fire and Rana Plaza collapse, Walmart increased its direct control over the lower-tier garment suppliers in Bangladesh (Wal-Mart Stores, Inc., 2015). There are three different points on a continuum that the buying firm can select when facing a supply chain make-buy decision – extensive supply chain make, partial supply chain make, and supply chain buy.

Table 1

Comparing Supply Chain Make-Buy with other Practices

		Locus of production activity	
		Internal	External
Sourcing responsibility	Internal	Firm-level "make"	"Supply chain-make"
	External	Sourcing outsourced to a third-party	"Supply chain-buy"

Extensive supply chain-make. Apple outsources its manufacturing operations to Foxconn. However, it retains control over nearly all component sourcing decisions. For example, in 2011, the company directly managed 156 production suppliers that accounted for 97 percent of the company's procurement expenditures (Apple Inc., 2012). The company requires that these suppliers comply with its supplier code of conduct and performs auditing program across its supply chain to ensure supplier compliance. Foxconn, as the top-tier supplier, represents only 1.8 to 2.0 percent of the total sales value of an iPhone or iPad (Kraemer, Linden, & Dedrick, 2011). A much larger portion of the total sales value of Apple products is captured by the suppliers of processors, memory chips, and LCDs (Hesseldahl, 2011; Barboza, 2010). As an electronics manufacturing service (EMS) provider to Apple, Foxconn is directed to work with the component suppliers selected and managed by Apple. Apple collaborates with those lower-tier component suppliers from the new product development stage, working with them to convert prototypes into mass production.

Partial supply chain-make. In their study of automobile supply networks, Choi and Hong (2002: 491) note that Honda combines "delegated authority with a centralized but more subtle control." Honda allows its top-tier supplier to select most of its suppliers, but it also selects a few of the lower-tier suppliers and asks the top-tier suppliers to work with them. Especially for high-priced items and items outside the top-tier suppliers' expertise, Honda centrally controls lower-tier suppliers. Many of these lower-tier suppliers that have a direct relationship with Honda often show more loyalty to Honda than to the top-tier supplier, strengthening Honda's control over multiple tiers of the supply network. Even when Honda does not have direct contract with the lower-tier suppliers, it tries to

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minimize supply risks associated with cost, innovation, and sustainability by providing an "approved vendor list" (AVL) to the top-tier suppliers and making a strong recommendation to choose vendors from the lists (Choi & Linton, 2011).

Supply chain-buy.   About a third of the American retailers, including JC Penney, Kohl's, Macy's, Sears, and Walmart, outsource garment sourcing decisions to the sourcing and logistics company Li & Fung (Urbina & Bradsher, 2013). As one of the largest top-tier suppliers to these retailers, Li & Fung controls a network of 15,000 suppliers in over 60 countries. Drawing from its knowledge of supplier capacity and capability, the company fulfills its customer orders with flexibility and speed by subcontracting garment manufacturing to the factories around the world (Magretta, 1998). Since buying firms delegate all garment sourcing and logistics activities to Li & Fung and since it subsequently makes subcontracting decisions, Li & Fung's customers are mostly uninformed about the factories supplying the products to their products. Governance control of the factories is typically executed only by the top-tier supplier, Li & Fung. For example, when it was revealed that some of the garments for Disney, Sears, and Walmart were produced by the Tazreen factory in Bangladesh, where 112 workers died from the factory fire in 2012, the three companies claimed that they did not have knowledge of this factory because the manufacturing was arranged by Li & Fung and its subcontractors (Ali Manik & Yardley, 2013). Uninformed, unauthorized subcontracting problems in the garment manufacturing industry were highlighted again in the wake of the Rana Plaza garment factory collapse that killed 1131 workers in 2013.

Archetypes of Control Used under Supply Chain-Make

A buying firm can use a variety of control strategies when engaged in supply chain-make.

Depending on its relative power over the top-tier supplier and whether it has formal

contracts with lower-tier suppliers, these practices of control can be broadly categorized

into the following four types (see Table 2).

Directed sourcing.   Directed sourcing can be used when the buying firm has relatively

high power over the top-tier supplier (Choi & Hong, 2002). Under a directed sourcing

arrangement, the buying firm contracts directly with a lower-tier supplier and directs the

top-tier supplier to use the component from that particular supplier (Choi & Linton, 2011;

Mena et al., 2013). For instance, while Honda may control a lower-tier supplier for cost,

it asks the top-tier supplier to manage this lower-tier supplier for quality and delivery.

Directed sourcing arrangements are often found in the automotive industry (Choi &

Hong, 2002; Park and Hartley, 2002; Mena et al., 2013).

Approved vendor list. When the buying firm has relatively high power over the top-tier

supplier but does not want or is unable to establish formal contracts with lower-tier

suppliers, the firm can use an approved vendor list (AVL) or list of approved processors

to control component sourcing. AVL is the list of the key suppliers from which the

buying firm recommends a top-tier supplier to purchase components whenever possible

(Choi & Linton, 2011). Many of the lower-tier suppliers on AVLs do not supply directly

to the buying firms but they supply to the buying firms' top-tier suppliers. Even so, the

buying firms can regard these lower tier suppliers as involved in "making their products."

If parts fail after sales, consumers perceive the products from the buying firms have

failed (Choi & Hong, 2002), and by using AVL, the buying firm reduces the risk of parts

from suppliers unknown to them from entering into their products. Many aircraft and aircraft engine manufacturers use AVL for specifying the key lower-tier suppliers (Boeing, 2015; Lockheed Martin, 2015; Northrop Grumman, 2015).

Strategic alliances with lower-tier suppliers. If the buying firm has relatively little power over the top-tier supplier, it can be difficult to use directed sourcing or impose component suppliers from an AVL. In this case, the buying firm can attempt to control component sourcing by forming formal strategic alliances with some key lower-tier suppliers of the top-tier supplier. Such a strategic alliance seeks to formally align goals and establish joint activities between the buying firm and lower-tier suppliers. Based on coalition theory (Caplow, 1956, 1959), Bastl, Johnson, and Choi (2013) suggest that buying firms that form cooperative relationships with lower-tier suppliers can gain control over top-tier suppliers by exercising collective power through the coalitions.

Collaborative relationships with lower-tier suppliers. Strategic alliance requires the participants to align goals and put significant effort into formation and maintenance of a relationship (Gulati, 1995; Kale & Singh, 2009). Therefore, buying firms may prefer an informal collaborative relationship with lower-tier suppliers as a means to gain some degree of control over a powerful top-tier supplier. The buying firm often forms this type of collaborative relationship with the lower-tier supplier, when the relationship between the top-tier supplier and its lower-tier supplier seems unstable (Mena et al. 2013). Informal communications, meetings at networking events, and even joint participation in various events like conferences can engender this type of collaboration (Cousins, Handfield, Lawson, & Petersen, 2006; Cousins & Menguc, 2006).

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Table 2

Managerial Controls Used for Supply Chain-Make

The relationship

between the buying firm and lower-tier supplier

		Formal	Informal
	High	Directed sourcing	Approved vendor list
The buying-firm's relative power over the top-tier supplier	Low	Strategic alliance	Collaborative relationship

FORMULATION OF PROPOSITIONS

To employ supply chain-make, the buying firm must incur cost for identifying, selecting, negotiating with, monitoring, and maintaining the lower-tier suppliers (Wever et al., 2012). One must consider, then, the conditions for which the cost of supply chain-make could be lower than that of supply chain-buy. Also, there are strategic benefits and future opportunities that supply chain-make could provide over supply chain-buy. Building on TCE (Coase, 1937; Williamson, 1975, 1985) and the knowledge-based view (KBV) of the firm (Grant, 1996; Kogut & Zander, 1992), we identify the variables associated with both cost-driven and strategic reasons for selecting supply chain-make over supply chain-buy. In addition, we apply structural-hole theory (Burt, 1992) to explain how supply chain-make can overcome the potential disadvantages involved in supply chain-buy.

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To develop propositions, we present the theoretical scope and assumptions of our paper. First, we focus on transactions in the *strategic quadrant* (high profit impact, high supply risk) in the classification of purchasing items by Kraljic (1983). Supply chain-make requires significant management resources and effort (Mena et al., 2013). In addition, the buying firm is engaged in a recurrent exchange relationship where it has at least some expertise in the product in transaction. If the buying firm does not have capabilities or the requisite knowledge base (Barney, 1991; Wernerfelt, 1984) to identify key lower-tier suppliers and engage in supply chain-make, it is simply performing "basic procurement" (Gilley & Rasheed, 2000). Lastly, in line with TCE, we assume that the buying firm's decision makers have bounded rationality and that the top-tier and lower-tier suppliers would behave opportunistically.

Transaction Cost Economics and Supply Chain Make-Buy

According to TCE, the firm's decision to transact an operation internally (hierarchy) or externally (market) depends on its *ex-ante* and *ex-post* costs of exchange (Coase, 1937; Williamson, 1975). Transactions occur when goods are transferred across different firms (Williamson, 1981) and transaction costs are described as "frictions" of doing business with external firms (Williamson, 1985). Williamson (1975, 1985) maintains that due to bounded rationality and opportunism of economic actors, certain transaction dimensions − behavioral uncertainty, frequency, and asset specificity − increase the costs of market governance (i.e., transaction costs). If the costs of market governance exceeds the costs of hierarchical governance, the firm chooses to internalize the transaction (Williamson, 1975, 1985).

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Unlike the firm-level make-buy decision, the supply chain make-buy decision involves the analysis of transactions at two different levels − one at the *direct* transaction-level between the buying firm and top-tier supplier and the other at the *indirect* transaction-level between the buying firm and lower-tier suppliers. Although our study occurs at the supply chain-level, two of the three dimensions from TCE remain relevant: behavioral uncertainty and asset specificity – frequency is less relevant because we focus on recurrent exchange relationships between the buying firm and supplier. Behavioral uncertainty and asset specificity are relevant because when the buying firm decides for a direct transaction, it can still choose to keep some control over the indirect transactions involving the component sourcing activities. In other words, whether to perform component sourcing activities internally or externally and how much of the component sourcing to control or delegate are influenced by behavioral uncertainty and asset specificity.

Behavioral uncertainty. Behavioral uncertainty creates governance problems in exchange relationships (Williamson, 1975, 1985) stemming primarily from the difficulty the buying firm faces in managing suppliers to meet performance requirements (John & Weitz, 1988; Rindfleisch & Heide, 1997; Williamson, 1985). This difficulty is conceptualized as the difficulty in screening, supervising, and monitoring an exchange partner (John & Weitz, 1988; Koch & McGrath, 1996) and the difficulty in measuring performance (Chandler, McKelvie, & Davidsson, 2009; Stump and Heide, 1996). In the context of supply chain-buy, behavioral uncertainty makes it difficult for the buying firm to ensure the performance of the delegated sourcing activities. We argue that the buying firm faces the supply chain make-buy decision when it continues to perceive

unacceptable behavioral uncertainty in the direct transaction. After Tazreen factory fire and Rana Plaza collapse in Bangladesh, Walmart initiated direct relationships with the factories in Bangladesh to provide supports for quality and safety improvements, even though these factories are the second-tier suppliers to the retailer (Wal-Mart Stores, Inc., 2015). The retailer also added the "one-strike you're out" policy on unauthorized subcontracting.

Relying on supply chain-buy under high behavioral uncertainty may leave the buying firm vulnerable to the top-tier supplier's potential opportunism. When the buying firm delegates the selection and control of the second-tier suppliers to the top-tier supplier, the top-tier supplier becomes the bridge between the buying firm and the second-tier vendors (Burt, 2000a, 2002; Li & Choi, 2009). The top-tier supplier becomes *tertius gaudens* or "the third that benefits" (Simmel, 1922; Merton, 1957). Under this condition, the buying firm and the lower-tier suppliers are not directly linked together but indirectly linked through the top-tier supplier. There is a "structural hole" between the buying firm and its lower-tier suppliers (Burt, 1992). The top-tier supplier in the bridge position can broker information flow between people and control the activities that involve lower-tier suppliers. As the top-tier supplier takes advantage of its position and selectively transfers upstream supply chain information to the buying firm, the task becomes even more difficult for the buying firm to verify the top-tier supplier's compliance. For example, the top-tier supplier with delegated sourcing authority can more easily disguise component cost or quality from the buying firm (Choi & Linton, 2011).

Supply chain-make helps the buying firm to curb behavioral uncertainty by allowing the firm to acquire upstream supply chain information directly from key lower-tier suppliers. Burt (2002) terms this loss of the bridge position as "bridge decay." By having direct linkages to the lower-tier suppliers that could critically impact the buying firm's performance requirements, the buying firm is able to prevent the top-tier supplier from exploiting its bridge position. For instance, knowledge of cost reductions in the lower-tier supply market can aid in price negotiations. Awareness of potential quality problems at sub-components that are interdependent with other components can aid in better product design specifications. Therefore, the buying firm facing difficulties in verifying the top-tier supplier's performance will expand the scope of supply chain-make to reduce behavioral uncertainty.

In contrast to behavioral uncertainty in direct transactions, behavioral uncertainty in indirect transactions is likely to reduce the buying firm's scope of supply chain-make. In order for the buying firm to initiate collaborative relationships with the lower-tier suppliers, the buying firm needs to be able to reliably assess their performance (Gulati & Singh, 1998; Parkhe, 1993). Moreover, directing the top-tier supplier to work with specific lower-tier suppliers creates additional complexity in the supply network as the relationships between the top-tier supplier and selected lower-tier suppliers are influenced by the relationships between the buying firm and lower-tier suppliers (Bastl et al., 2013; Choi, Dooley, & Rungtusanatham, 2001; Choi & Hong, 2002; Mena et al., 2013). Therefore, the buying firm engages in supply chain-make when it has some certainty about the lower-tier suppliers' behaviors. In contrast, if the buying firm faces difficulties in measuring performances of the lower-tier suppliers, it would prefer to delegate

component sourcing activities to the top-tier supplier and require it to manage the lower-tier suppliers and strengthen monitoring activities.

Proposition 1:   Behavioral uncertainty in the (a) direct transaction of the purchased product increases the scope of supply chain-make, while that in the (b) indirect transactions of the components decreases the scope of supply chain-make.

Asset specificity.   Williamson (1985) presents asset specificity as the most important factor that differentiates ways of organizing transactions. Asset specificity refers to the "durable investments that are undertaken in support of particular transactions" (Williamson, 1985). As specific assets are not reusable outside the relationship between the original exchange partners, a long-term relationship is valued (Dyer & Singh, 1998). At the same time, asset specificity gives rise to contractual or relational safeguard problems because of potential exploitation of specific assets by exchange partners (Geyskens et al., 2006). TCE predicts that transactions characterized by asset specificity will be internalized (i.e., organized by unified ownership and vertically integrated) (Williamson, 1975, 1985).

In the context of our study, asset specificity refers to both specific investments required for the direct transaction between the buying firm and top-tier supplier as well as the indirect transactions between the buying firm and lower-tier suppliers. First, asset specificity in the direct transaction is required for the buying firm to consider the choice of supply chain-make. Without the presence of asset specificity, the relationship between the buying firm and top-tier supplier is too fragile (Dyer & Singh, 1998; Ganesan, 1994) for engaging in supply chain-make as one firm can easily end the exchange relationship.

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Therefore, the buying firm's tendency when direct transaction asset specificity is low would be to avoid the costly control over the lower-tier suppliers. However, as asset specificity in the direct transaction increases, the incremental cost for increasing control beyond the top-tier supplier is reduced. Therefore, the buying firm would move toward more direct control over the top-tier supplier's component sourcing activities to safeguard from potential opportunistic behaviors.

In transactions between the buying firm and lower-tier suppliers, asset specificity also influences to the scope of supply chain-make. If the indirect transaction of a component requires specific investments from the buying firm, the buying firm would prefer not to delegate the sourcing of that specific component to the top-tier supplier. Such delegation could expose the buying firm to the risk of the top-tier supplier switching the lower-tier supplier. For example, Apple has worked with a second-tier supplier Catcher Technology for a specific new tooling equipment to develop the aluminum body of the MacBook (Satariano & Burrows, 2011). With significant joint investment from both companies in aluminum body technology, Apple has expanded the use of Catcher's aluminum body to other product lines including the iPad and iPhone (Dou, Liu, & Negishi, 2014). Even though the top-tier supplier Foxconn itself has aluminum body production capability, Apple has been using Catcher's aluminum body because of the specific investments made together with this second-tier supplier (Blankfeld, 2015). Thus, if the BOM of the purchased product includes more components requiring specific investments, the buying firm would try to control the sourcing of those components.

Proposition 2:   Asset specific investments for the (a) direct transaction of the purchased

product and/or (b) indirect transactions of the components increase the

scope of supply chain-make.

Exposure to supply risk.   Uncertainty and risk are different but related. Uncertainty

represents exogenous disturbances (Williamson, 1985) while risk is defined as the

possibility of loss (Yates & Stone, 1992; Chiles & McMackin, 1996). Unlike uncertainty,

risk involves the probabilities and impacts of the events associated with loss (Yates &

Stone, 1992). In the supply management context, the "impact" of loss incorporates the

"strategic importance" dimension of the Kraljic matrix (Kraljic, 1983; Olsen & Ellram,

1997). When the buying firm evaluates transactions of the product and components for a

supply chain make-buy decision, it would have to consider probabilities and impacts of

potential risk events.

Supply risk refers to the potential loss associated with an event in inbound supply

that prevents the buying firm from meeting customer demand (Ellis, Henry, & Shockley,

2010; Zsidisin, 2003). The potential loss that embodies supply risk includes not only a

financial or performance loss but also a physical or social loss to the natural environment

and society (Cousins, Lamming, & Bowen, 2004; Mitchell, 1995). Choi and Krause

(2006) regard supply risk as one of the key areas of supply base management since it

covers the risk beyond the risk of supplier opportunism.

Relying on only the top-tier supplier for sourcing can expose the buying firm to

supply risks associated with financially, environmentally, and socially undesirable events.

This is in part because the top-tier supplier places its own best interests first, creating

possible lapses in risk management measures to protect the buying firm. For example, a

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plant explosion at Evonik, the world's largest specialty resin producer and a lower-tier

supplier for many automakers, caused automotive fuel and brake line part shortage

problems for GM, Ford, Toyota, and Chrysler (Bennett & Hromadko, 2012). When the

Gulf of Mexico oil spill happened in 2010, BP was blamed for delegating decision-

making to its chief subcontractors − Halliburton and Transocean − who oversaw offshore

drilling operation of the second-tier supplier, Deepwater Horizon (Broder, 2010).

Sheffi and Rice (2005) argue that buying firms should build control systems that

detect supply disruption quickly and support timely corrective actions. Under a supply

chain-buy decision that allows the top-tier supplier to occupy the structural hole, the

buying firm faces difficulties in securing proper upstream information necessary for

detecting supply disruptions and preparing timely corrective actions. In contrast, a supply

chain-make arrangement helps the buying firm to be resilient to supply risks by providing

direct access to upstream supply information and, thus, stability in the supply network

(Choi & Hong, 2002). Lee (2010) argues that companies should examine the members in

the extended supply chains and collaborate with the lower-tier suppliers to reduce

environmental risks in the supply chains. Undesirable events in inbound supply can occur

at any tiers of the supply chain. Therefore, as the level of exposure to supply risk in direct

transactions and in indirect transactions of the product increases, the buying firm will

build a more resilient supply chain by increasing the scope of supply chain-make.

Proposition 3: The level of supply risk exposure in the (a) direct transaction of the

purchased product and/or (b) indirect transactions of the components

increase the scope of supply chain-make.

The Knowledge-Based View of the Firm and Supply Chain Make-Buy

While the supply chain make-buy model based on TCE considers the buying firm's need for controlling risks and economizing governance cost, it does not take into account the potential future opportunities that supply chain-make could provide over supply chain-buy. Based on the knowledge-based view (KBV) of the firm, we identify the key underlying variables that give rise to the opportunities (e.g., technological development) provided by supply chain-make.

According to KBV, firms are better at integrating and applying individual knowledge than markets when the knowledge is tacit and the activities between the exchanging units are interdependent (Grant, 1996; Kogut & Zander, 1992; Weigelt, 2009). Since the market cannot achieve the stability of the knowledge exchange relationships within the firm and gives rise to opportunism under highly interdependent exchange activities (Grant, 1996), the buying firm would likely choose to internalize operations characterized by high tacitness and interdependence. By extension, the supply chain make-buy decision is also influenced by the tacitness of the knowledge associated with the purchased product and interdependence in the product architecture. If the buying firm relies on supply chain-buy (i.e. turning to the market), even though the sourcing of the product is characterized by high tacitness and interdependence, the firm may be exposed to higher risk of knowledge erosion (Lorenzoni & Lipparini, 1999; Teece, 1986) and lose potential future opportunities created from successfully integrating and applying knowledge (Reitzig & Wagner, 2010; Weigelt, 2009).

Tacitness of intellectual property. Product-related intellectual property (i.e., product design and component technologies) can be protected by patent, copyright, trademark,

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allied rights, and trade secrets (Choi, Budny, & Wank, 2004; Cornish, Llewelyn, & Aplin, 1989). If a firm owns the intellectual property associated with the product or component in exchange and licenses it to the exchange partner, the licensor-licensee relationship is added to the buyer-supplier relationship, which is called the knowledge supply chain (Choi et al., 2004). In this setting, the tacitness of the knowledge being transferred between the two firms can critically influence the firm's supply chain make-buy decision. Tacit knowledge is difficult to codify and therefore difficult to be transferred (Nonaka, 1994; Nonaka & Von Krogh, 2009). When the product-related intellectual property specifications can be easily codified, the buying firm and top-tier supplier can efficiently exchange information regarding the product (Gereffi, Humphrey, & Sturgeon, 2005). They can also exchange specifications regarding component sourcing with little coordination efforts.

In contrast, when the knowledge associated with the intellectual property is tacit, then at least one of the two exchange partners may not fully understand the needs and specifications involved in component sourcing, and the buying firm may not be able to relinquish component sourcing decisions entirely to the top-tier supplier. As the tacitness of the product or component-related intellectual property increases, the difficulty in coordinating component sourcing activities through supply chain-buy would also increase. This could limit the buying firm's integration and application of the product-related knowledge and hamper technological developments (Brusoni, Prencipe, & Pavitt, 2001; Parmigiani, 2007). Thus, the buying firm would engage more extensively in supply chain-make when the product and component-related intellectual properties are characterized by higher tacitness.

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Proposition 4: Tacitness of the intellectual properties of the (a) product in direct transaction and/or (b) components in indirect transactions increases the scope of supply chain-make.

Interdependence in the product architecture. Interdependence in the product architecture causes technological uncertainty associated with the purchased product (Brusoni et al., 2001; Furlan, Cabigiosu, & Camuffo, 2014; Henderson & Clark, 1990). Technological uncertainty refers to the difficulty in forecasting the technical requirements associated with the purchased product and its components (Geyskens et al., 2006; Stump & Heide, 1996; Walker & Weber, 1984). Interdependence in the product architecture is the degree of the coupling among components in a product (Brusoni et al., 2001; Terwiesch & Loch, 1999). When the product architecture is interdependent, it becomes more challenging for the buying firm to monitor the suppliers' technological capabilities and cost reduction efforts (Camuffo, Furlan, & Rettore, 2007). If a component is tightly coupled with other components, a change in the components requires changes in other parts of the product and creates a "snowball effect" in engineering changes (Terwiesch & Loch, 1999). Engineering changes such as "changes to parts, drawings, or software that have already been released" (Terwiesch & Loch, 1999) have various negative impacts on product development and production costs.

If the buying firm chooses supply chain-buy, interdependent product architecture creates information asymmetry. In this case, the top-tier supplier would have more information about component technological changes than the buying firm. Given its position as the bridge, the top-tier supplier is set up to take advantage of the information asymmetry. This information asymmetry can gradually erode the buying firm's

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technological capability. KBV researchers have argued that excessive outsourcing of upstream activities means firms miss opportunities to learn technological advancements in times of technological changes (Brusoni et al., 2001; Reitzig & Wagner, 2010; Weigelt, 2009). If the buying firm completely outsources its sourcing activities to the top-tier supplier (i.e., supply chain-buy), the buying firm would face information disadvantage over the top-tier supplier regarding component technologies and lose opportunities to learn, impeding the development of its technological capabilities.

A natural way to tackle this technological information asymmetry is to obtain information directly from the lower-tier suppliers. Maintaining direct ties with lower-tier suppliers should provide more opportunities for the buying firm to learn new developments in component technologies, detect engineering change requirements early, and strengthen its technological capabilities. Over time, supply chain-make will allow the buying firm to accumulate information critical to engineering changes and enhance know-how on interdependencies in the product architecture and managing the impacts of engineering changes. Therefore, if the product in transaction is characterized by more interdependent product architecture, the buying firm would increase the extensiveness of supply chain-make.

Proposition 5: Interdependence in the product architecture in transaction increases the scope of supply chain-make.

A Heuristic Model for Supply Chain Make-Buy

We consolidate key variables into a heuristic model that integrates the TCE and KBV arguments. TCE provides the governance cost side rationale for selecting supply chain-

make over supply chain-buy. Governance cost of supply chain-buy represents the governance cost of the exchange relationship with the top-tier supplier, while governance cost of supply chain-make includes the governance cost of the exchange relationships with the top-tier supplier and with lower-tier suppliers. At the low levels of asset specificity, behavioral uncertainty, and supply risk, the governance cost of supply chain-make is higher than governance cost of supply chain-buy, given the additional efforts required to manage the relationships with the lower-tier suppliers. However, as asset specificity, behavioral uncertainty, and supply risk increase, the governance cost of supply chain-buy exceeds the governance cost of supply chain-make. Under higher asset specificity, behavioral uncertainty, and supply risk, letting the top-tier supplier to control all sourcing activities will incur higher governance cost by restricting the buying firm's access to information that can be critical to mitigate the risk of opportunism and supply risk. Based on the TCE framework, we can predict that the buying firm would choose supply chain-make when the governance cost of supply chain-buy exceeds that of supply chain-make.

The supply chain make-buy decision based on simply governance cost, however, ignores the opportunity cost of choosing supply chain-buy over supply chain-make. Supply chain-buy exposes the buying firm to the risk of knowledge erosion (Lorenzoni & Lipparini, 1999; Teece, 1986), hence the potential loss of opportunities in integrating and applying product-related knowledge for technological developments (Reitzig & Wagner, 2010; Weigelt, 2009). This opportunity cost is positively associated with tacitness of intellectual property and interdependence in the product architecture. Considering both governance and opportunity costs, the firm would choose supply chain-make when the

overall cost (sum of governance and opportunity costs) of supply chain-buy exceeds the overall cost of supply chain-make.

Figure 2 depicts the heuristic model of the relationship among cost (i.e., governance and opportunity costs) and the risk associated with the key theoretical variables in our framework. The horizontal axis in the graph represents the overall risk (R), which includes the risk of opportunism, supply risk, and risk of knowledge erosion. R is influenced by asset specificity (K), behavioral uncertainty (U_B), supply risk (R_S), tacitness of intellectual property (T), and interdependence in the product architecture (I). The vertical axis of the graph represents the overall cost, which includes both the governance and opportunity costs. Figure 2 shows that both costs of supply chain-make (C_M) and supply chain-buy (C_B) increase as risk (R) increases. At a low level of R, C_M is higher than C_B. However, as the rate of increase of C_B is steeper than that of C_M, C_B exceeds C_M from the point A of overall risk. Therefore, the buying firm will choose supply chain-make when R is higher than A and choose supply chain-buy when R is lower than A.

Cost

C_B

C_M

R*

A

SC Buy ← → SC Make
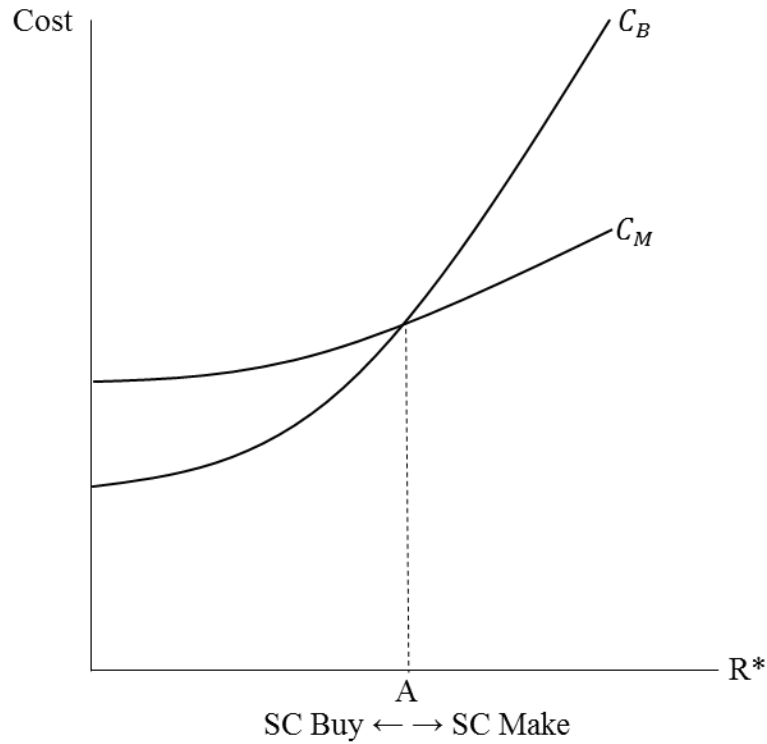
* R is a function of K, U_B, R_S, T, and I

C_B: Cost of supply chain buy
C_M: Cost of supply chain make
K: Asset specificity
U_B: Behavioral uncertainty
R_S: Supply risk
T: Tacitness of intellectual property
I: Interdependence in the product architecture

Figure 2. The Heuristic Model of the Supply Chain Make-Buy Decision. Adapted from

Chiles & McMackin (1996) and Williamson (1985)

Cost

C_B

C_M

C_H

A   O   B   R*

SC Buy | SC Make | Make
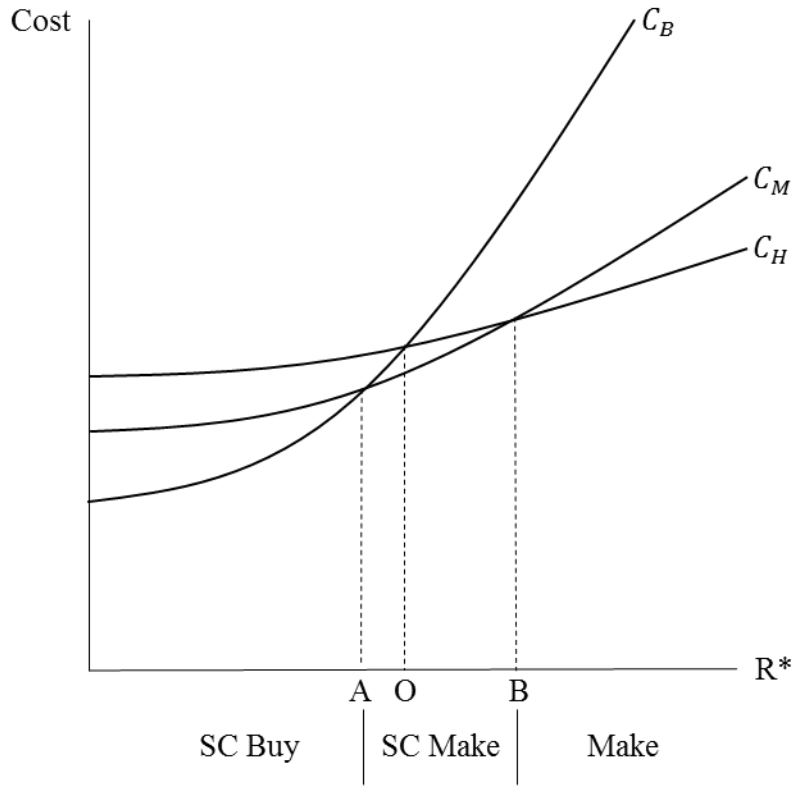
* R is a function of K, U_B, R_S, T, and I

C_B: Cost of supply chain buy
C_M: Cost of supply chain make
C_H: Cost of hierarchy (make)
K: Asset specificity
U_B: Behavioral uncertainty
R_S: Supply risk
T: Tacitness of intellectual property
I: Interdependence in the product architecture

Figure 3. The Heuristic Model of the Supply Chain-Make, Supply Chain-Buy, and Make.

Adapted from Chiles & McMackin (1996) and Williamson (1985)

Our study deliberately focuses on the supply chain-level make-buy decision

assuming that the buying firm has already made a buy decision. However, it is also

possible that the supply chain-level make-buy decision influences the firm-level make-

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buy decision itself. If the buying firm makes firm-level and supply chain-level make-buy decisions concurrently rather than sequentially, it would compare the costs of three options − supply chain-buy, supply chain-make, and make − and select the option with the lowest cost. Figure 3 presents an idealized heuristic model with the three options. Without considering the supply chain-make option, the buying firm will make the decision at point O, where the costs of traditional buy (C_B) and traditional make intersect. However, if the buying firm considers the supply chain-make option, it would choose supply chain-make between the two points A and B, where the cost of supply chain-make (C_M) is lower than both the costs of supply chain-buy (C_B) and hierarchy (C_H) (i.e., firm-level make). Having the third option − supply chain-make − can shift the risk levels at which the managers make critical decisions and directly influence the choice between markets and hierarchies (Williamson, 1975).

DISCUSSION

We introduce the concept of supply chain make-buy and provide several key theoretical variables that can influence the buying firm's supply chain make-buy decisions. The recent supply chain management literature calls for extending the firms' attention into further upstream supply chains (Choi & Linton, 2011; Lee, 2010; Mena et al., 2013; Pagell, Wu, & Wasserman, 2010). By considering the supply chain-level make-buy decision beyond the firm-level make-buy decision, our study provides a basis for better understanding the firm's decision to reach and control "multi-tier" (Mena et al., 2013) or "extended" (Lee, 2010) supply chains. Researchers have suggested several practical reasons for extending the buying firm's control over multiple tiers of the supply chain

(i.e., supply chain-make), including cost, innovation, and sustainability reasons (Choi & Linton, 2011; Lee, 2010). Building on TCE, the KBV, and structural-hole theory, we offer a theoretical framework that integrates different reasons for selecting supply chain-make over supply chain-buy.

Our study contributes to the literature on make-buy decisions by considering the "bundle of transactions" as the unit-of-analysis and expanding the level of analysis from the dyadic context (i.e., direct transaction between the buying firm and top-tier supplier) to the multi-tier level (i.e., direct and indirect transactions among the buying firm, top-tier supplier, and lower-tier suppliers). The buy decision in the traditional make-buy entails the decision on which "supplier" performs the production activities. In contrast, the supply chain make-buy is about which "supply chain" to perform those activities. To "make" the supply chain, the buying firm has to exercise control over some lower-tier suppliers that lie beyond the top-tier suppliers. The existing literature on make-buy decision mainly focuses on transactions of the product between two exchange partners (e.g., John & Weitz, 1988; Parmigiani, 2007; Walker & Weber, 1984). The present study adds to this body of literature by providing a new perspective which considers the transactions throughout the supply chain involving the lower-tier suppliers.

The propositions and heuristic models in our paper offer a new perspective for organizing transactions to mitigate risks. Traditional ways of organizing transactions − vertical integration, contractual/relational governance, alliance, and joint venture − are the potential outcome of the transactional risk/opportunity assessments and the existing literature have examined these mechanisms with the focus on bilateral transactions (Geyskens et al., 2006; Rindfleisch & Heide, 1997; Wever et al., 2012). By considering

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both direct, bilateral transactions and indirect transactions, our Propositions 1 and 2 divert from the traditional TCE literature's predictions on organizing transactions. For example, without recognizing the supply chain-make option, the traditional TCE literature would suggest the buying firm adopting hierarchical governance when the transaction with the top-tier supplier is characterized by high asset specificity and behavioral uncertainty (Williamson, 1975, 1985). However, our supply chain make-buy model implies that the buying firm does not necessarily have to rely on hierarchical governance if it can reduce the risk of opportunism by engaging in supply chain-make. We also suggest that buying firms should assess asset specificity and behavioral uncertainty in both direct and indirect transactions.

The traditional supply risk management literature suggests firms using additional supply sources, increase safety stock, or reduce capacity utilization under high supply uncertainty (Lee, 2002; Manuj & Mentzer, 2008). However, Proposition 3 and our heuristic model suggest that the buying firm should first consider the supply chain-make option, before selecting costly redundancy or hedging strategies to manage supply risks (Sheffi & Rice, 2005). Propositions 4 and 5 also imply that the buying firm can utilize supply chain-make to partially take advantage of "learning by doing" (Adler & Clark, 1991; Pisano, 1994; Von Hippel & Tyre, 1995) regarding technological developments and mitigate the risk of knowledge erosion instead of fully engaging in firm-level make or "make-and-buy" (Parmigiani, 2007).

Implications for Research and Managerial Practice

A buying firm has the option of being involved in its top-tier supplier's sourcing activities. Future research could investigate further the different archetypes of managerial control used for supply chain-make and how they could change the relationships among the buying firm, top-tier supplier, and lower-tier suppliers. The recent literature on the triadic relationships among the buying firm and suppliers has noted that changes in a dyadic relationship embedded in a triad would alter other relationships within the triad (e.g., Bastl et al., 2013; Choi & Wu, 2009; Mena et al., 2013). Since the use of control for supply chain-make would change the nature of multiple triadic relationships in the supply network, examining the effects of using the different archetypes introduced in our study would be a worthwhile endeavor.

Future studies should develop testable hypotheses from the propositions presented in our study. Researchers could utilize the measures developed by the literature built on TCE (Anderson, 1985; Heide & Stump, 1995; Walker & Weber, 1984) and the KBV (McEvily & Chakravarthy, 2002; Poppo & Zenger, 1998; Wiklund & Shepherd, 2003) to conduct survey-based empirical studies. Researchers could also employ panel data on contractual buyer-supplier relationships (e.g., Autry & Golicic, 2010; Banerjee, Dasgupta, & Kim, 2008), which would be essential for understanding how the key underlying variables suggested by our study shape the pattern of the relationships among the buying firms and lower-tier suppliers. Behavioral investigations are another path to empirically evaluating our propositions. Since our propositions are about managers' decision making, scenario-based role-playing experiments (Rungtusanatham, Wallin, & Eckerd, 2011) could be applied to understand how the managers make supply chain-level

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make-buy decisions. In addition to the variables presented in our study, identifying the potential biases that influence supply chain make-buy decision making could further facilitate theoretical development.

For managers, our study provides a guideline for making the choice between supply chain-make and supply chain-buy. It also offers some suggestions for managing multiple tiers of the supply network, if their decision is supply chain-make. Events such as the Tazreen factory fire in Bangladesh and the BP oil spill in the Gulf of Mexico remind the importance of careful selection and management of the lower-tier suppliers. However, since supply chain-make incurs additional governance costs of managing the relationships with the selected lower-tier suppliers, managers should compare the costs and strategic benefits of supply chain-make and supply chain-buy under different circumstances.

Asset specificity, behavioral uncertainty, and supply risk can increase the cost of managing exchange relationships with the top-tier suppliers. In addition, under high tacitness of intellectual property and interdependence in the product architecture, supply chain-buy can quickly erode the firm's opportunities for technological developments. Considering these variables will help the managers make the right supply chain make-buy decision. In the wake of Tazreen factory fire and Rana Plaza collapse in Bangladesh, Walmart recognized threatening behavioral uncertainty and supply risk from both top-tier and lower-tier garment suppliers and significantly increased the scope of supply chain-make in garment category (Wal-Mart Stores, Inc., 2015). However, rather than being reactive to these disruptive events, we urge managers to proactively assess the key variables in our paper and engage in supply chain-make accordingly. We provide a few

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useful ways of controlling the component sourcing that the managers can choose from and make some suggestions for how managers may be able to adopt the directed sourcing, AVL, strategic alliance, and collaborative relationship. We also point out how the implementation of these strategies will depend on the relative power of the top-tier suppliers and formalization of the relationships with the lower-tier suppliers. Our framework for supply chain make-buy will help managers make decisions regarding when and how extensively to engage in supply chain-make.

CHAPTER 3

TO DELEGATE OR CONTROL? A BEHAVIORAL INVESTIGATION OF THE

MULTI-TIER SOURCING DECISION

ABSTRACT

Whether to delegate full responsibility to a Tier-1 supplier or retain partial control over

subcomponent sourcing in lower-tier suppliers is a critical decision for supply mangers.

Full delegation is efficient, while partial control helps mitigate supply chain risks. We

examine the economic and behavioral factors that influence individual supply managers'

decision-making when faced with such multi-tier sourcing decisions. A behavioral

experiment of 259 supply managers tests the effects of these variables on the extent and

mode of multi-tier sourcing interventions. Results suggest that supply managers exert less

multi-tier control when they have high levels of interpersonal trust in the sales

representatives, an effect accentuated by familiarity with suppliers in the lower-tiers.

Behavioral uncertainty of the Tier-1 supplier leads to higher extent of multi-tier control

only when the supply manager has high levels of familiarity with potential suppliers at

Tier-2 and below.

Keywords: multi-tier sourcing, sourcing strategy, behavioral experiment

INTRODUCTION

Strategic sourcing and supply base reduction methodologies have seen Tier-1 suppliers assume significant sourcing responsibilities on behalf of their customers, extending into the selection and management of lower-tier (Tier-2 and below) suppliers. High profile incidents like Boeing 787 delays, Rana Plaza collapse, and BP oil spill have led firms to reevaluate the role of Tier-1 suppliers in their supply chains. In response, buyers are increasingly using multi-tier sourcing practices such as approved vendor list and directed sourcing in an effort to re-exert control over lower-tier suppliers (Choi & Linton, 2011; Lee, 2010; Mena, Humphries, & Choi, 2013). However, the experience these firms suggests limited insights about how and when to apply these practices.

Multi-tier sourcing is a strategic decision that influences the firm's supply network structure. Benefits may include aiding in controlling supplier performance (Choi & Hong, 2002; Mena et al., 2013), access to technological and market information (Choi & Linton, 2011), and helping develop sustainable supply chains (Lee, 2010). However, multi-tier sourcing also requires more time and effort from individual supply managers and may increase relational tensions in buyer-supplier relationships (Choi & Hong, 2002; Mena et al., 2013). While previous literature has examined other types of strategic sourcing decisions made by individual supply managers like make-buy (e.g., Mantel, Tatikonda, & Liao, 2006) and supplier selection (e.g., de Boer & van der Wegen, 2003; Kull, Oke, & Dooley, 2014), the role of supply managers as the key instigators of multi-tier sourcing decision has remained underexplored. As the behavioral agents that make decisions on behalf of their firms (Wiseman & Gomez-Mejia, 1998), supply managers are incentivized to increase firm performance, but they are also subject to heuristics and

cognitive biases (Tversky & Kahneman, 1974). This study examines the economic and behavioral factors that influence a supply manager's multi-tier sourcing decision-making.

When making multi-tier sourcing decisions, supply managers need to consider when to apply the practices and how much control to exert. On the former, we build on information economics and behavioral decision theories to examine the key factors that affect a supply manager's decision: behavioral uncertainty regarding the Tier-1 supplier's performance, the supply manager's familiarity with the suppliers in the lower-tier of the supply base, and the level of interpersonal trust between the supply manager and the Tier-1 supplier's sales representative. On the latter question, we consider two complementary elements of multi-tier control over subcomponent sourcing: one regarding the extent of bill-of-materials cost controlled by the buyer; and the other regarding the choice of governance mode, ranging from the use of approved vendor lists (suggested or mandated) to directed sourcing. When using an approved vendor list, a buyer requires Tier-1 suppliers to select their suppliers only from the list of vendors approved by the buyer (Choi & Hong, 2002; Choi & Linton, 2011). Such an approach is used extensively by leading aircraft and aircraft engine manufacturers with their Tier-1 suppliers (Boeing, 2015; Lockheed Martin, 2015; Northrop Grumman, 2015). In a directed sourcing arrangement, a buyer negotiates directly with lower-tier suppliers regarding pricing and other specifications and directs Tier-1 suppliers to work with them (Choi & Hong, 2002; Mena et al., 2013; Park & Hartley, 2002). For instance, Apple devotes considerable resources to work intensively in this manner with a selected number of lower-tier suppliers (Apple Inc., 2015; Satariano & Burrows, 2011).

Our study makes a number of contributions. First, we are the first study, as far as we are aware, that examines the dynamics of how supply managers make decisions in this emerging, but increasingly important, context of multi-tier sourcing. In doing so, we provide guidance to supply managers on the efficient use of multi-tier sourcing. Second, previous studies on multi-tier sourcing decisions have focused on the drivers at the organizational level. Our experimental design focuses on the individual level of unit of analysis and help shed light on the behavioral tendencies of the instigators of these decisions, the individual supply manager. Third, we contribute to the supply chain literature by extending the focus to consider not only direct bilateral transactions with a Tier-1 supplier, but also the indirect transactions with lower-tier suppliers. This extended view of transaction analysis allows us to consider various conditions and ways of governing transactions.

We develop a behavioral experiment with 259 supply managers to test our hypotheses of interest. The remainder of the paper proceeds as follows: we review the literature in the second section, discuss methods in the third section, while the fourth section overviews the results. We discuss the findings with respect to multi-tier sourcing control via extent of responsibility and mode of control in the fifth section. We conclude with implications for managers and the literature.

THEORY DEVELOPMENT

Multi-Tier Sourcing as a Response to Information Asymmetry

The trends of outsourcing, supply-base reduction, and reliance on strategic suppliers have seen Tier-1 suppliers play an increasingly central role in the management of their customers' supply chains (Choi & Linton, 2011; Rossetti & Choi, 2005). Their direct exchange relationships with Tier-2 suppliers means they possess more information about the nature of lower-tier supply chains than supply managers of buying companies (Mishra, Heide, & Cort, 1998). For example, Tier-1 suppliers have greater insights on subcomponent cost, quality, capacity, supply risks, and technological development. Without direct ties between supply managers and Tier-2 suppliers, Tier-1 suppliers can take information broker positions and benefit from information asymmetry by selectively transferring upstream supply chain information to the supply managers of the buyers (Burt, 1992; Li & Choi, 2009). Critical sub-suppliers may also be several tiers removed from focal firms (Lee, 2010; Yan, Choi, Kim, & Yang, 2015). Because information search is costly (Stigler, 1961) and individuals have different search costs (Salop, 1977; Salop & Stiglitz, 1977), information asymmetry and associated problems such as moral hazard, opportunism, and adverse selection are prevalent among economic actors (Akerlof, 1970; Hölmstrom, 1979; Williamson, 1985).

Multi-tier sourcing or "extended" supply management practices have been suggested as one way of managing the uncertainty arising from information asymmetry in this context (e.g., Choi & Linton, 2011; Lee, 2010; Mena et al., 2013; New, 2010). In highlighting the dangers of delegating management of lower-tier suppliers to Tier-1 suppliers, Choi and Linton (2011) suggest that buyers should directly manage key lower-

tier suppliers by retaining control over the bill-of-materials and maintaining close relationships with key lower-tier suppliers. New (2010) discusses the use of information technologies to monitor and disclose information regarding direct and indirect suppliers in response to consumer pressures for product provenance. In case studies in the food industry, Mena et al. (2013) suggest that a closed supply chain structure comprised of direct relationships between buyers and Tier-2 suppliers provides the sense of interdependence and stability to supply chain members. However, engaging in multi-tier sourcing is not costless and requires additional managerial resources and efforts from individual supply managers (Mena et al., 2013). The firm incurs higher information search costs to identify and monitor potential lower-tier suppliers to be included in approved vendor lists or directed sourcing arrangements. For example, Apple regularly audit selected lower-tier suppliers to gain insights on potential sustainability risks embedded in their supply chain (Apple Inc., 2015). While directed sourcing can provide more centralized subcomponent sourcing control, it typically requires more managerial resources than using approved vendor lists.

The next subsection develops our theoretical framework exploring how the reliance on multi-tier sourcing practices is influenced by the supply manager's expectations of behavioral uncertainty of the Tier-1 supplier, their inter-personal trust with supplier's salesperson, and their familiarity with potential suppliers at Tier-2 and below. Figure 4 outlines these relationships.
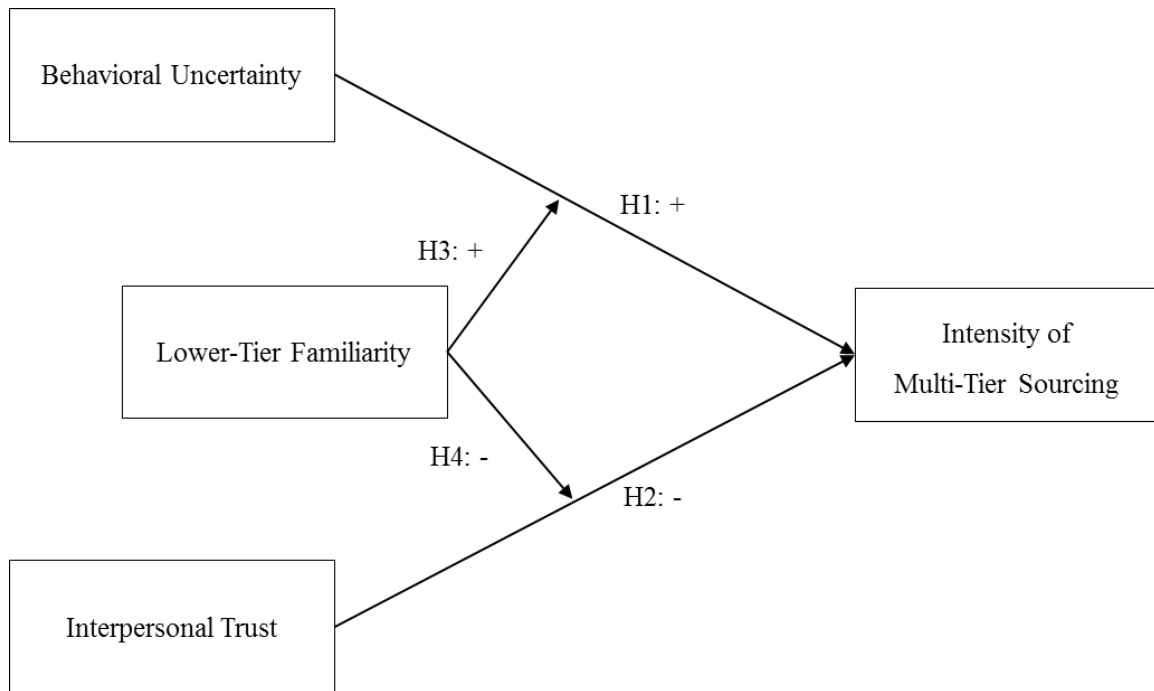
Figure 4. Theoretical Model

Behavioral Uncertainty and the Intensity of Multi-Tier Sourcing

Behavioral uncertainty refers to the difficulty of assuring an exchange partner's
performance or adherence to established agreements (Geyskens, Steenkamp, & Kumar,
2006; John & Weitz, 1988; Williamson, 1985). Higher levels of behavioral uncertainty
increase the risk of opportunistic behaviors by the exchange partner (Williamson, 1985).
Supply managers are the behavioral agents who manage exchange relationships with
suppliers (Wiseman & Gomez-Mejia, 1998), and as such the behavioral uncertainty
exhibited by a supplier will influence their perceptions of risk in that relationship.
Behavioral uncertainty of a Tier-1 supplier may be associated with multiple performance
criteria including cost, quality, flexibility, and sustainability. In this paper, we focus on
behavioral uncertainty regarding the Tier-1 supplier's *cost* performance. Cost

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performance is typically the most salient performance criterion for individual supply managers, so behavioral uncertainty of the supplier on this dimension represents a direct employment risk or may adversely affect other performance-related rewards (Wiseman & Gomez-Mejia, 1998). Choi and Hong (2002) observe that cost considerations are the dominant reason for adopting multi-tier sourcing practices in the automotive industry.

When faced with uncertainty, the behavioral decision theory literature suggests that individuals first seek to reduce uncertainty through information search (Berger & Calabrese, 1975; Lipshitz & Strauss, 1997). While the supply manager may seek cost-related information from the Tier-1 supplier, the supplier's role as an information broker between the firm and the lower-tier suppliers gives rise to information asymmetry and the threat of opportunism (Burt, 1992). In response, firms may seek to validate that information, or generate additional information, by engaging third parties (Janis & Mann, 1977). In our setting, engaging with suppliers at Tier-2, or below, through multi-tier sourcing practices allows supply managers to exert greater control over the selection of suppliers, and to reduce information asymmetry and behavioral uncertainty by acquiring cost-related information directly. Hence, we propose that the supply manager will increase the intensity of multi-tier sourcing under conditions of high behavioral uncertainty on Tier-1 supplier's cost performance.

H1: Behavioral uncertainty regarding the Tier-1 supplier's cost performance increases the intensity of multi-tier sourcing.

Interpersonal Trust and the Intensity of Multi-Tier Sourcing

The role of trust in reducing perceived information asymmetry and behavioral uncertainty in interpersonal relationships has received a great deal of attention (e.g., Kollock, 1994; Wicks, Berman, & Jones, 1999; Zaheer, McEvily, & Perrone, 1998). Trust has been conceptualized as confidence or predictability in the counterpart's behavior or goodwill (Ring & Van de Ven, 1992; Zucker, 1986; Zaheer et al., 1998). Trust in someone enables individuals to act as if behavioral uncertainty or information asymmetry in the relationship is reduced (Tomkins, 2001). From a supply manager's perspective, trust in the exchange relationship with a Tier-1 supplier can exist at two different levels— interorganizational and interpersonal levels (Zaheer et al., 1998). Interorganizational trust and interpersonal trust are related, but they are two distinct concepts that can influence exchange relationships differently (Zaheer et al., 1998).

Interpersonal trust can reduce the supply manager's perceived behavioral uncertainty in the exchange relationship by facilitating mutual obligations and making it easier to monitor the partner's behaviors (Moran, 2005). For a supply manager, the level of interpersonal trust in the relationship with the sales representative of the Tier-1 supplier can be perceived as an essential representation of reduced behavioral uncertainty. As interpersonal trust reduces efforts for controls such as rules and monitoring (De Jong & Elfring, 2010; Dirks, 1999), a supply manager who trusts the sales representative of the Tier-1 supplier may decrease reliance on controlling mechanisms including multi-tier sourcing.

Moreover, using local representativeness heuristic, supply managers may extrapolate the level of interpersonal trust to the level of the inter-organizational

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relationship (Kahneman & Tversky, 1972; Tversky & Kahneman, 1974). Local representativeness arises as people have a tendency to believe that "small samples are highly representative of the populations from which they are drawn" (Tversky & Kahneman, 1974: 1125-1126). For example, people tend to extrapolate their evaluation of student teachers' performances in practice lessons to the predictions of the teachers' future teaching performances (Kahneman & Tversky, 1973). Investors may also misattribute a small sample of favorable descriptions of companies as good representations of their future returns (Chen, Kim, Nofsinger, & Rui, 2007). As the salesperson is the most salient indicator of their organization's trustworthiness, the greater the interpersonal trust, the greater confidence the supply manager has in the Tier-1 supplier. Consequently, they may engage in reduced efforts in monitoring and safeguarding (Villena, Revilla, & Choi, 2011), and consequently, a decreased intensity of multi-tier sourcing.

H2: Interpersonal trust in the Tier-1 supplier's sales representative decreases the intensity of multi-tier sourcing.

Familiarity and the Intensity of Multi-Tier Sourcing

Applying information economics, scholars have associated familiarity to potential exchange partners or investment options with lower information search cost and facilitated investments in exchange relationships (Huberman, 2001; Ke, Ng, & Wang, 2010; Massa & Simonov, 2006; Reuer, Tong, Tyler, & Ariño, 2013). Reuer et al. (2013) suggest that executives' familiarity with foreign firms' resources reduces perceived risk of adverse selection and promotes international joint ventures or acquisitions. Huberman

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(2001) observes that shareholders tend to invest in the stocks of the familiar companies. Ke et al. (2010) also find that fund managers prefer to invest in the familiar companies with a local presence. Massa and Simonov (2006) argue that investors mostly invest in familiar stocks because familiarity is regarded as the proxy for information and lowers cost of information access. In the same vein, collecting information directly from potential lower-tier suppliers can be easier for a supply manager who is already familiar with those lower-tier suppliers. In this study, we also investigate whether the supply manager's familiarity with potential lower-tier suppliers influences the manager's multi-tier sourcing decision.

As multi-tier sourcing practices typically require more resources and managerial efforts from the buyer (Mena et al., 2013), supply managers would prefer to engage in multi-tier sourcing when it is perceived to be less costly to do so. In interorganizational exchange relationships, familiarity with exchange partners can reduce information search cost and promote investments in the relationships (Huberman, 2001; Ke, Ng, & Wang, 2010; Massa & Simonov, 2006; Reuer, Tong, Tyler, & Ariño, 2013). To initiate collaborative relationships, a company needs to reliably assess its exchange partners' performance (Gulati & Singh, 1998; Parkhe, 1993). In the context of the multi-tier sourcing decision-making, a supply manager's familiarity with the potential suppliers at Tier-2 and below (lower-tier familiarity) can reduce the cost of acquiring information about the subcomponents and lower-tier suppliers to be included in the approved vendor list or directed sourcing arrangement. If the supply manager is not familiar with the potential lower-tier suppliers, it will require even more managerial efforts to acquire information about them and reliably assess their performance. Therefore, when faced

with high behavioral uncertainty from the Tier-1 supplier, it will be easier for the supply manager who is more familiar with the potential lower-tier suppliers to increase the extent of multi-tier sourcing. In contrast, the supply manager with little familiarity with the potential lower-tier suppliers would find it more difficult and therefore less likely to increase the intensity of multi-tier sourcing even when perceived behavioral uncertainty from the Tier-1 supplier is high. Thus, we hypothesize that:

H3: Lower-tier familiarity moderates the relationship between behavioral uncertainty and the intensity of multi-tier sourcing, such that the relationship is more positive when lower-tier familiarity is high.

We also expect that lower-tier familiarity would moderate the effect of interpersonal trust on the intensity of multi-tier sourcing. If supply managers do not clearly distinguish interorganizational trust from interpersonal trust due to representativeness heuristic (Kahneman & Tversky, 1972), interpersonal trust would have a significant negative effect on the intensity of multi-tier sourcing, as hypothesized in H2. Then, supply managers who are already familiar with potential lower-tier suppliers can increase the extent of multi-tier sourcing when they personally distrust sales representatives of Tier-1 suppliers. In contrast, the search cost for engaging in multi-tier sourcing would be higher for the supply managers with low lower-tier familiarity, and therefore, it would be more difficult for them to increase the intensity of multi-tier sourcing even when they personally distrust their counterparts from Tier-1 suppliers. Thus, it is hypothesized that:

H4:   Lower-tier familiarity moderates the relationship between interpersonal trust and the
intensity of multi-tier sourcing, such that the relationship is more negative when
lower-tier familiarity is high.

METHODOLOGY

We utilized an experimental vignette methodology (EVM), also known as a scenario-
based role-playing experiment (Aguinis & Bradley, 2014; Rungtusanatham, Wallin, &
Eckerd, 2011; Weber, 1992). EVM is used to enhance experimental realism while also
manipulating and controlling independent variables, hence preserving both internal and
external validity of the experiment (Aguinis & Bradley, 2014). EVM is particularly
useful when "it is difficult to experimentally manipulate sensitive topics in an ethical
manner" (Aguinis & Bradley, 2014: 357). Since EVM utilizes hypothetical scenarios, it
can address sensitive topics. Decisions regarding multi-tier sourcing inevitably involve
confidential information of the buying companies and suppliers. Moreover, the
complexity of real life supply networks means that field or laboratory experiments are not
feasible. Therefore, EVM is well suited to the context of our study.

We used a 2^3 full-factorial model as the design of our experiment, resulting in
eight scenarios in which the manipulated variables are behavioral uncertainty,
interpersonal trust, and lower-tier familiarity. The experiment was executed using self-
administered on-line questionnaires with actual supply managers as participants. Each
participant of the experiment was given one of the eight scenarios with either high or low
levels of each manipulated variable. At the end of the scenario, each participant was

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asked to choose the intensity of multi-tier sourcing in terms of the extent and mode described in the Variables subsection.

Sample and Data Collection

To establish face validity of the scenarios and questionnaire of our experiment, we first interviewed four supply managers working in the United States, South Korea, and China on their use of multi-tier sourcing practices. Based on the interviews and our theoretical argumentation, we developed the research instrument and shared it with the same four supply managers to receive feedback. We then administered three phases of pilot tests to improve the validity of our instrument. First, we conducted a small-scale pretest involving 16 master's students enrolled in a supply chain management course in the United Kingdom. After incorporating this feedback, we tested and analyzed the revised instrument with 69 senior undergraduate students and 123 MBA students taking supply chain management courses at three large universities across the United States and the United Kingdom. Finally, we collected data and feedback from 30 practicing supply chain managers from ten different companies.

To ensure that the participants detected the differences between high and low experimental treatments of the variables in the scenarios, we performed manipulation checks during the process of pilot testing (Bachrach & Bendoly, 2011; Rungtusanatham et al., 2011). The results of the t-tests comparing high and low levels of behavioral uncertainty ($t = -8.030$, $p < 0.001$), interpersonal trust ($t = -9.540$, $p < 0.001$), and lower-tier familiarity ($t = -5.768$, $p < 0.001$) strongly support that the participants could detect the manipulations of the experimental factors in the scenarios.

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Our study focuses on individual supply managers' decision-making regarding multi-tier sourcing. Therefore, we targeted actual supply managers as the participants of the experiment. The sample was drawn from the members of the Institute for Supply Management (ISM). Members were contacted by e-mail with a link to the online experiment and survey instrument. To motivate participation, $25 Amazon online gift cards were distributed to sixty randomly selected participants who completed the online experiment. 465 members of ISM agreed to participate, and 321 completed the survey. Excluding responses with missing values (56) or participants who indicated no supply management experience (6), 259 usable responses were received. Participants, on average, had 23 years of work experience and 14 years of experience in supply management. The final sample was 30% female, and the average age was 46. 58% of the participants were professionals in manufacturing industries, and 42% were in service industries. The average firm size of the participants was 10,632.

We also checked whether the randomly distributed eight scenarios are confounded with the demographics of our sample. The results of the ANOVA tests indicate that the eight scenarios are not confounded with firm size ($F = 0.988$, $p > 0.05$), work experience ($F = 1.325$, $p > 0.05$), personal risk propensity ($F = 1.528$, $p > 0.05$), or age ($F = 1.381$, $p > 0.05$).

Variables

Intensity of multi-tier sourcing. We use two proxies to assess our dependent variable, the intensity of multi-tier sourcing. The first proxy—extent of multi-tier sourcing management—is a seven-point Likert scale where participants indicated the degree of

direct subcomponent sourcing control that they wish to exercise over the Tier-1 supplier. The seven options range from full control by the Tier-1 supplier to full control by the buyer. Our second proxy—mode of multi-tier sourcing—was an ordered categorical variable based on the degree of the buyer's centralized control over lower-tier suppliers. Participants were asked to select one of three options: a suggested approved vendor list (1 = low control), a mandated approved vendor list (2 = intermediate control), and directed sourcing (3 = high control).

Behavioral uncertainty. We operationalize behavioral uncertainty as the perceived degree of difficulty in securing the Tier-1 supplier's cost performance. We manipulate the scenarios with two conditions. The first treatment condition is where the supply manager faces difficulty in securing the Tier-1 supplier's cost performance (high behavioral uncertainty), while the second treatment condition is where the supply manager is confident in the Tier-1 supplier's cost performance (low behavioral uncertainty).

Interpersonal trust. Interpersonal trust between the supply manager and sales representative of the Tier-1 supplier is manipulated by adapting the behavioral experiment by Dirks (1999) and the interpersonal trust measure used by Zaheer et al. (1998). The two treatment conditions for interpersonal trust describe the situations where the supply manager personally trusts (high interpersonal trust) or distrusts (low interpersonal trust) the sales representative of the Tier-1 supplier.

Lower-tier familiarity. Our moderator variable is the supply manager's familiarity with potential suppliers at Tier-2 and below. Our manipulations are in line with previous work incorporating this construct in behavioral experiment studies by Hada, Grewal, and

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Lilien, (2013) and Reuer et al. (2013). The two treatment conditions represent the circumstances where the supply manager has high (or low) levels of familiarity and experience of working with potential suppliers at Tier-2 and below.

Control variables. To address potential confounds we include a number of control variables, including the participant's personal risk propensity, years of work experience, current industry, firm size (natural log of the number of employees), and age. Personal risk propensity assesses individuals' risk-taking behavior, and is included in the study as it may alter their choice regarding the intensity with which multi-tier sourcing management is applied. The multi-item scale is adapted from Meertens and Lion (2008), and has a Cronbach's Alpha of 0.69. Years of work experience and age are also included because individuals' risk-taking behavior changes over time (Sitkin & Weingart, 1995) and decision-makers rely on past experiences of successful decisions (Riedl, Kaufmann, Zimmermann, & Perols, 2013). Although our experiment is based on hypothetical scenarios, we control for industry as multi-tier practices can differ across sectors and firm size to reflect the managerial resources available for exercising such practices.

Analysis

Tables 4 provides the ordinary least squares (OLS) regression results for the extent of multi-tier sourcing management, while Table 5 illustrates the result of the ordered logistics regression for mode of multi-tier sourcing. H1 predicted that greater behavioral uncertainty would lead to more intensity of multi-tier sourcing management. We find mixed support, with no significant main effect on the extent of multi-tier sourcing ($B = 0.11$, $p > 0.05$), but significant increase in the likelihood of sourcing control mode by the

buyer (B = 0.27, p < 0.05). For H2 we find that interpersonal trust in the Tier-1 supplier's

sales representative significantly decreases both the extent of multi-tier sourcing

management (B = -0.27, p < 0.01) and the degree of centralized control mode adopted (B

= -0.41, p < 0.01). Regarding H3 and H4, there is a positive interaction between lower-

tier familiarity and behavioral uncertainty (B = 0.286, P < 0.01) and a negative

interaction between lower-tier familiarity and interpersonal trust (B = -0.280, p < 0.01)

for extent of multi-tier sourcing. No significant interaction effects were found for the

mode of multi-tier sourcing. Figure 5 shows that the positive effect of behavioral

uncertainty on the extent of multi-tier sourcing is stronger when the supply manager is

familiar with potential suppliers at Tier-2 or below. While behavioral uncertainty does

not have a significant effect on the extent of multi-tier sourcing when lower-tier

familiarity is low (B = -0.18, p > 0.1), it has a significant positive effect under high

lower-tier familiarity (B = 0.39, p < 0.01). Similarly, Figure 6 illustrates that the negative

impact of interpersonal trust on the extent of multi-tier sourcing is strengthened under

high familiarity with indirect suppliers. Under the low level of lower-tier familiarity, the

effect of interpersonal trust on the extent of multi-tier sourcing is not significant (B = -

0.01, p > 0.1). In contrast, interpersonal trust significantly decreases the extent of multi-

tier sourcing at the high level of lower-tier familiarity (B = -0.55, p < 0.001).

Table 3

Correlation and Descriptive Statistics

	1	2	3	4	5
1. Behavioral Uncertainty	1				
2. Tier-2 Familiarity	0.004	1			
3. Interpersonal Trust	-0.003	-0.012	1		
4. Extent of Multi-Tier Sourcing	0.067	-0.050	-0.157*	1	
5. Mode of Multi-Tier Sourcing	0.124*	0.091	-0.185*	0.194*	1
6. Personal Risk Propensity	0.103	0.099	-0.015	-0.054	-0.079
7. Work Experience	-0.001	-0.156*	-0.105	-0.062	-0.111
8. Industry	-0.057	0.081	0.046	-0.053	0.120
9. Firm Size	-0.048	-0.109	-0.007	-0.175*	-0.172*
10. Age	0.038	-0.128*	-0.123*	0.030	-0.098
Mean	0.042	0.004	-0.019	3.969	2.112
Standard Deviation	1.001	1.002	1.002	1.532	0.806

	6	7	8	9	10
6. Personal Risk Propensity	1				
7. Work Experience	0.025	1			
8. Industry	0.041	-0.209*	1		
9. Firm Size	-0.202*	-0.022	0.081	1	
10. Age	0.019	0.838*	-0.198*	-0.059	1
Mean	4.143	23.768	0.575	7.325	46.216
Standard Deviation	1.262	12.066	0.495	2.161	11.330

* $p < 0.05$

Table 4

Regression Results Predicting the Extent of Multi-Tier Sourcing

Dependent Variable	Model 1		Model 2		Model 3	
Extent of Multi-Tier Sourcing	**Estimate**	**S.E.**	**Estimate**	**S.E.**	**Estimate**	**S.E.**
(Constant)	5.627***	0.622	5.790***	0.617	5.862***	0.596
Control variables						
Industry (mfg. = 1, service = 0)	-0.124	0.193	-0.087	0.191	-0.069	0.185
Firm size (ln number of employees)	-0.134**	0.044	-0.141**	0.044	-0.154***	0.043
Age	0.033*	0.015	0.030*	0.015	0.029*	0.014
Work experience (years)	-0.036*	0.014	-0.036*	0.014	-0.033*	0.014
Risk propensity	-0.166†	0.086	-0.170*	0.085	-0.178*	0.082
Experimental variables						
Behavioral uncertainty (H1)			0.084	0.092	0.111	0.089
Interpersonal trust (H2)			-0.248**	0.092	-0.273**	0.090
Tier-2 familiarity			-0.122	0.094	-0.139	0.090
Interactions						
Familiarity*Uncertainty (H3)					0.286**	0.090
Familiarity*Trust (H4)					-0.280**	0.089
R^2	0.070		0.104		0.172	
Adjusted R^2	0.052		0.075		0.138	
R^2 change			0.024*		0.068***	
F-statistic	3.80		3.63		5.14	
N	259		259		259	

† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Unstandardized coefficients are reported.
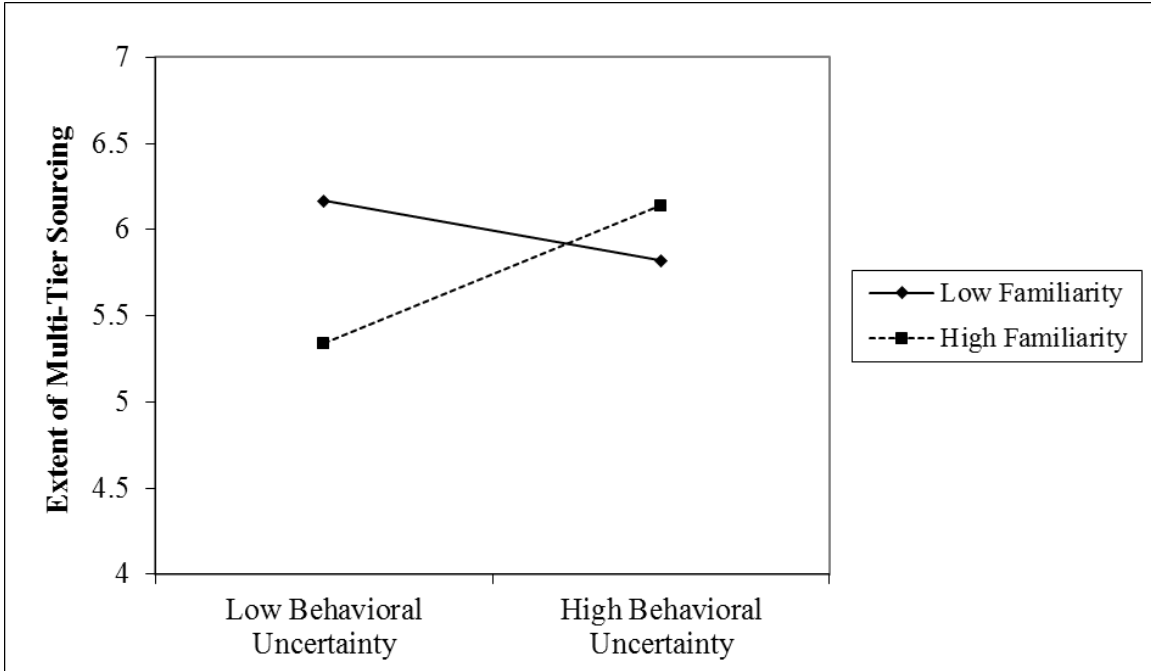
Figure 5. Interaction between Lower-Tier Familiarity and Behavioral Uncertainty
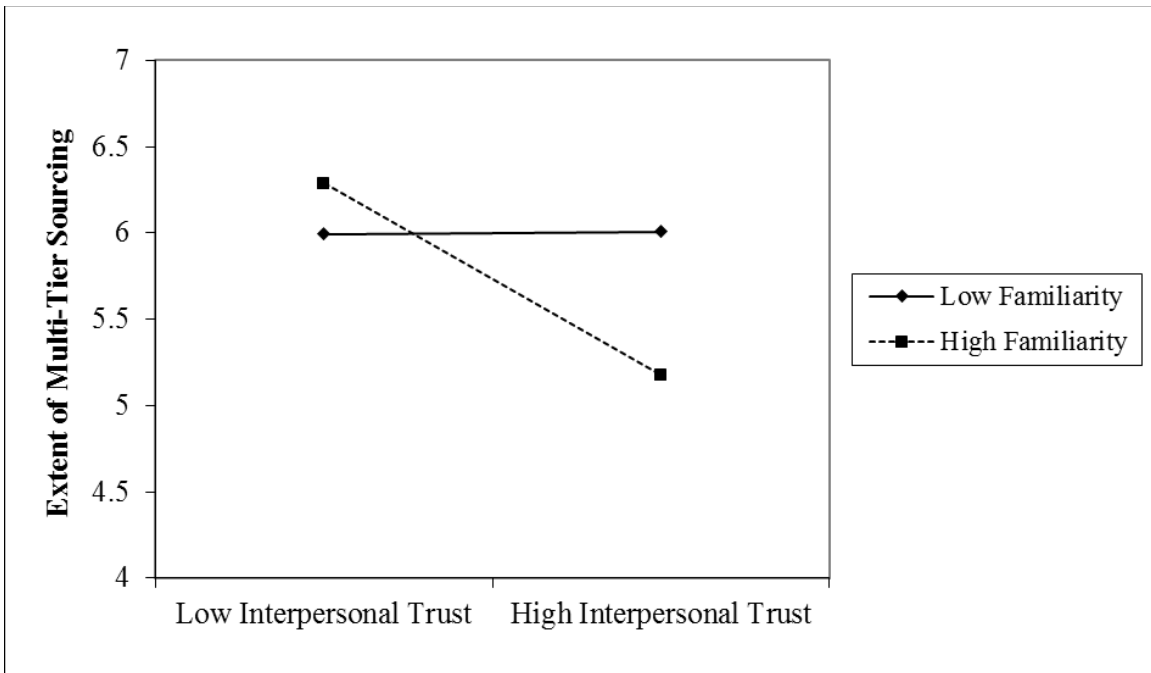
Figure 6: Interaction between Lower-Tier Familiarity and Interpersonal Trust

Table 5

Ordered Logistic Regression Results Predicting the Mode of Multi-Tier Sourcing

Dependent Variable	Model 1		Model 2		Model 3	
Mode of Multi-Tier Sourcing	Estimate	S.E.	Estimate	S.E.	Estimate	S.E.
Control variables						
Industry (mfg. = 1, service = 0)	0.507*	0.243	0.598*	0.249	0.589*	0.249
Firm size (ln number of employees)	-0.188**	0.057	-0.196**	0.059	-0.196*	0.059
Age	-0.005	0.019	-0.011	0.019	-0.011	0.019
Work experience (years)	-0.009	0.017	-0.007	0.018	-0.007	0.018
Risk propensity	-0.177	0.109	-0.201†	0.111	-.0201†	0.110
Experimental variables						
Behavioral uncertainty (H1)			0.262*	0.119	0.274*	0.120
Interpersonal trust (H2)			-0.408**	0.121	-0.413**	0.122
Tier-2 familiarity			0.093	0.120	0.093	0.121
Interactions						
Familiarity*Uncertainty (H3)					0.034	0.120
Familiarity*Trust (H4)					-0.083	0.119
Log-likelihood	-273.171		-264.490		-264.209	
χ^2	17.75		35.11		35.67	
χ^2 difference			17.36***		0.56	
Pseudo R^2	0.032		0.062		0.063	
N	259		259		259	

† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Unstandardized coefficients are reported.

DISCUSSION

Our study contributes to the emerging supply chain practice of multi-tier sourcing (Choi & Linton, 2011; Lee, 2010; Mena et al., 2013; New, 2010; Yan et al., 2015). Previous literature has pointed to the role of different performance objectives (e.g., sustainability, technology, and cost) (Choi & Linton, 2011) or relative procurement competence between the buyer and supplier (Brewer, Ashenbaum, & Carter, 2013) in the adoption of

multi-tier sourcing practices. Our paper focuses on the decision-making of individual supply managers, who typically have significant discretion over selection and management of lower-tier suppliers. By investigating the intensity of multi-tier sourcing by individual supply managers in response to behavioral uncertainty, interpersonal trust, and familiarity with lower-tier suppliers, our study contributes to the growing stream of work in this area.

Regarding the role of behavioral uncertainty, the results suggest that supply managers select the mode of multi-tier sourcing with more centralized control when they perceive higher behavioral uncertainty. In contrast, behavioral uncertainty does not have a significant main effect on the extent of multi-tier sourcing control. This result implies that supply managers try to cope with the uncertainty in their Tier-1 suppliers' cost performance by focusing on exerting direct control over specific lower-tier suppliers through directed sourcing or mandating approved vendor lists rather than trying to control a broader set of lower-tier suppliers. Since controlling a large proportion of subcomponents and pertinent lower-tier suppliers can be burdensome for supply managers, those who are faced with high behavioral uncertainty seem to select the mode of multi-tier sourcing with more strict control without necessarily increasing the extent of multi-tier sourcing control.

The level of a supply manager's interpersonal trust in the sales representative of the Tier-1 supplier has a significant and negative effect on both the extent and mode of multi-tier sourcing management. This finding is intriguing since it suggests that a relational factor (i.e., interpersonal trust) plays a more important role than an economic driver (i.e., behavioral uncertainty) in making multi-tier sourcing decisions. It may be

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reflective of the representativeness heuristic (Kahneman & Tversky, 1972; Tversky & Kahneman, 1974), where supply managers seem to extrapolate interpersonal trust in the sales representative of the Tier-1 supplier to the trust in the overall organization. This finding is consistent with prior literature suggesting the relationships between individuals are an important factor in supply chain governance (Gligor & Autry, 2012; Handfield & Bechtel, 2002).

With regard to our moderation hypotheses, we show that under conditions where the supply manager is highly familiar with potential lower-tier suppliers, they will significantly increase the extent of multi-tier sourcing control as behavioral uncertainty moves from low to high. By contrast, we see no difference in the extent of multi-tier sourcing control when the supply manager has low familiarity, regardless of the degree of behavioral uncertainty. This finding highlights the importance of familiarity with lower-tier suppliers in multi-tier sourcing decision-making: it *enables* the supply manager to increase the buyer's control over the selection and management of Tier-2 suppliers to deal with behavioral uncertainty of the Tier-1 supplier. Similarly, when behavioral uncertainty of the Tier-1 supplier is low, lower-tier familiarity allows supply managers to reduce the scope of their intervention, conserving valuable managerial time and attention. This finding supports the research pointing to the importance of building supply market intelligence in making effective decisions (Handfield, 2006).

Lower-tier familiarity also strengthens the impact of interpersonal trust. Relative to low lower-tier familiarity condition, supply managers with high lower-tier familiarity are more willing to delegate sourcing responsibility to the Tier-1 supplier as the level of interpersonal trust in the sales representative increases.

Theoretical Implications

Our findings suggest that individual supply managers' decisions regarding the use of multi-tier sourcing practices are subject to several key heuristics. First, when faced with uncertainty in the Tier-1 supplier's cost performance, supply managers try to reduce uncertainty by exercising greater control over subcomponent sourcing and minimizing information asymmetry between the buyer and the Tier-1 supplier. This finding is in line with the *reduce* part of the R.Q.P. (reduce, quantify, and plug) heuristic suggested by behavioral decision theories (Janis & Mann, 1977; Lipshitz & Strauss, 1997). Second, supply managers tend to be influenced more saliently by interpersonal-level trust than interorganizational-level behavioral uncertainty when they make multi-tier sourcing decisions. This finding indicates the presence of a representative heuristic (Kahneman & Tversky, 1972; Tversky & Kahneman, 1974) in such decision-making. Lastly, while supply managers use multi-tier sourcing practices to cope with perceived uncertainty in the relationship with the Tier-1 supplier, the extent of use is subject to their familiarity with potential Tier-2 suppliers. As familiarity can reduce perceived search cost (Reuer, Tong, Tyler, & Ariño, 2013), supply managers who are familiar with potential Tier-2 suppliers adjust the extent of multi-tier sourcing more sensitively according to the perceived level of behavioral uncertainty and interpersonal trust in the relationship with the Tier-1 supplier.

Our study also provides theoretical implications to the literature on make-buy decisions. For supply managers, the decision regarding direct control over lower-tier suppliers using multi-tier sourcing practices can be understood as the 'supply chain make-buy' decision—should they 'make' the supply chains of a purchased item by

controlling the selection and management of lower-tier suppliers or 'buy' the supply

chains by delegating control to a Tier-1 supplier? The traditional transaction cost

economics (TCE) literature mostly considers bilateral transactions between two economic

entities as the unit of analysis (Geyskens et al., 2006; Wever et al., 2012; Williamson,

1975). As a result, the literature on make-buy decisions adopting TCE also has focused

on the factors embedded in bilateral transactions (e.g., asset specificity and behavioral

uncertainty in the exchange relationship with a supply chain partner). Our study, from a

buyer's perspective, considers not only direct bilateral transaction decisions with a Tier-1

supplier but also indirect transaction decisions with Tier-2 suppliers. We argue that

supply managers make multi-tier sourcing decisions by considering the factors embedded

in not only direct transactions with a Tier-1 supplier (e.g., behavioral uncertainty and

interpersonal trust) but also indirect transactions with potential lower-tier suppliers

(lower-tier familiarity). This extended view of transaction analysis allows us to consider

various conditions and ways of governing transactions. For instance, when behavioral

uncertainty of a Tier-1 supplier is high but that of certain Tier-2 suppliers is low, the

buyer can make subcomponent sourcing decisions on behalf of the Tier-1 supplier. In

contrast, when a Tier-1 supplier's performance is reliable and the nature of Tier-2

suppliers is unknown, the buyer can delegate subcomponent sourcing to the Tier-1

supplier. These various potential arrangements of multi-tier transactions call for further

developments in the literature on make-buy decisions to consider both direct and indirect

transactions when analyzing transaction costs.

Managerial Implications

Our study provides practical implications to buying companies that implement multi-tier sourcing practices. We shed light on the conditions under which these practices, such as directed sourcing and approved vendor lists are more likely to be used by supply managers to control the actions of their Tier-1 suppliers and lower-tier supply chains. Yet, the use of multi-tier sourcing practices also requires more managerial resources and may aggravate relational tensions between buying companies and their Tier-1 suppliers (Choi & Hong, 2002; Mena et al., 2013). Balancing these trade-offs between control and sourcing efficiency is a difficult challenge for supply managers.

The result of our experiment suggests that supply managers' familiarity with Tier-2 suppliers helps them navigate these trade-offs in determining the extent of multi-tier sourcing. For example, when faced with higher uncertainty in a Tier-1 supplier's behavior, high familiarity enables supply managers to commit more resources in controlling the sourcing decision. Conversely, when faced with lower uncertainty, their familiarity with potential lower-tier suppliers increases their willingness to delegate authority to the Tier-1 supplier. Moreover, supply managers who lack familiarity with potential lower-tier suppliers do not adjust their extent of multi-tier sourcing practices regardless of the level of the Tier-1 supplier's behavioral uncertainty. For a firm that intends to use multi-tier sourcing practices, it is of vital importance to encourage and train supply managers to be more familiar with potential Tier-2 and further upstream suppliers. Developing supply market intelligence through practices like strong category management, supply chain mapping, use of Request for Information (RFI), and membership of relevant supplier trade associations may all be useful.

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We also find evidence that interpersonal trust may give supply managers confidence to delegate greater responsibility to Tier-1 suppliers. Consistent with the governance literature (Poppo & Zenger, 2002), our findings indicate that trust may substitute for the use of economic governance mechanisms in buyer-supplier relationships. We caution however that this finding is at the interpersonal level; the representativeness heuristic means that individual supply managers may overestimate the trustworthiness of the supplier overall, leading them to under-invest in governance. Ensuring supply managers can separate the levels of interpersonal trust from the broader, but potentially weaker, signals of supplier trustworthiness is important. Nonetheless, the role of familiarity in lower-tier suppliers comes to fore, as with behavioral uncertainty. Where the supply manager also holds high levels of indirect supplier familiarity, they delegate greater authority to Tier-1 supplier, than when familiarity is low. In a sense, this resonates with the saying 'trust but verify' – the supply manager not only has confidence that the supplier will perform as promised, but also holds the domain knowledge to verify that the performance is appropriate.

LIMITATIONS AND FUTURE RESEARCH

Our study focuses on behavioral uncertainty in terms of the difficulty of predicting a Tier-1 supplier's cost performance. While supply managers' sourcing decisions are primarily driven by such cost concerns (Choi & Hong, 2002; Ellram, 1992), other dimensions of performance like quality, flexibility, innovation, and sustainability are also important determinants of multi-tier sourcing. As such, future work could vary the driver of behavioral uncertainty or examine how managers from other functional areas such as

R&D, manufacturing, or corporate social responsibility may approach this challenge. Future studies could adopt field research approaches to investigate how the managers from different functional areas interact with each other to transform individual decisions regarding multi-tier sourcing to an organizational-level decision.

Given our focus on the multi-tier sourcing decisions of individual supply managers, we emphasized their connection to the Tier-1 supplier and broader familiarity with potential Tier-2 suppliers. We were unable to unpack how the characteristics of individual lower-tier suppliers influence the sourcing decision. Since subcomponents supplied by Tier-2 suppliers are embedded within the component supplied by a Tier-1 supplier, the decision regarding whether to control a particular subcomponent sourcing can be influenced by the factors at both Tier-1 and Tier-2 levels. Incorporating this hierarchical nature of multi-tier sourcing decisions into a multi-level experimental design (Quinn & Keough, 2002; Raudenbush, 1993) will further enhance our understanding of how buying companies use multi-tier sourcing practices.

Finally, although we used EVM with practicing supply managers to preserve internal and external validity of the experiment, the scenarios in our experiment describe hypothetical situations in an artificial environment. Case studies or field experiments that investigate actual multi-tier sourcing decisions would reveal more complex decision-making process and relevant biases associated with supply managers' control over the selection and management of lower-tier suppliers.

CONCLUSIONS

We investigate an emerging practice of multi-tier sourcing. While the artefacts of multi-tier sourcing lie at the organizational level, the decision to engage in this practice rests primarily with individual supply managers. Shedding light on the behavioral aspects of their efforts to achieve efficient sourcing through delegation to a key supplier versus the managing risks through exerting sourcing control over lower-tier suppliers is valuable. In particular, we highlight the moderating role of familiarity with indirect suppliers in enabling supply managers to adjust the extent of multi-tier sourcing in response to behavioral uncertainty and interpersonal trust. Further work exploring the dynamics of multi-tier sourcing is encouraged.

CHAPTER 4

HORIZONTAL VERSUS VERTICAL STRUCTURAL HOLES IN

SUPPLY NETWORKS: CONTRASTING PERFORMANCE IMPLICATIONS FOR

FOCAL FIRMS

ABSTRACT

Our study investigates the relationship between structural characteristics of the networks of buyer-supplier relationships (i.e., supply networks) and firm financial performance. In particular, we introduce a novel approach to understanding structural holes in supply networks and examine the performance implications of the disconnections between the focal firm's suppliers (i.e., horizontal structural holes) and the disconnections between the focal firm's customers and suppliers (i.e., vertical structural holes). Our analysis based on the longitudinal supply network involving semiconductor manufacturers and their direct/indirect customers and suppliers reveals contrasting effects of horizontal versus vertical structural holes on focal firms' financial performances. We also find that these contrasting influences of the two types of structural holes are more salient for the firms with high innovation capability.

Keywords: structural hole theory, supply network, social network analysis

INTRODUCTION

The growing body of literature that applies social network theories to supply networks

focuses on the connection between network structures and firm performances (e.g.,

Bellamy, Ghosh, & Hora, 2014; Borgatti & Li, 2009; Carnovale & Yeniyurt, 2015; Choi

& Kim, 2008; Dong, Liu, Yu, & Zheng, 2015). The studies in this body of literature

suggest that structural characteristics of supply networks are critically influential for firm

performances as supply network structures are associated with firm innovation

performance (Bellamy et al., 2014; Carnovale & Yeniyurt, 2015), supplier selection and

management (Choi & Kim, 2008; Yan, Choi, Kim, & Yang, 2015), supply risk (Simchi-

Levi et al., 2015) and opportunism between supply chain partners (Dong et al., 2015).

The linkages between interfirm network structures and firm performances have

been investigated frequently in the contexts of strategic alliance network, joint venture

network , and joint research and development (R&D) network (e.g., Baum, Calabrese, &

Silverman, 2000; Capaldo, 2007; Dyer & Nobeoka, 2000; Gulati, 1998; Lavie, 2007;

Zaheer & Bell, 2005). However, despite the increasing attention to the linkages between

supply network structures and firm performances, there has been a lack of studies that

empirically test the direct relationship between the structural characteristics of supply

networks and firm financial performance. The performance implications of supply

networks require special attention due to the unique characteristics of supply networks.

Unlike strategic alliance or joint venture networks, supply networks are characterized

with certain directions of materials, service, information, and monetary flows. Firms in a

supply network have their unique production or service roles (e.g., memory chip

manufacturer, mobile phone assembler, original equipment manufacturer, consumer

electronics retailer, etc.), but their roles as buyer or supplier are relative to the perspective of the focal firm (Carter, Rogers, & Choi, 2015).

Considering these unique characteristics of supply networks, our study provides an empirical investigation that aims to provide the implications of particular supply network structures for firm financial performance. We suggest a novel way of understanding structural holes (Burt, 1992) in supply networks and introduce two different types of structural holes: horizontal structural holes—the disconnections between a focal firm's suppliers—and vertical structural holes—the disconnections between the focal firm's customers and suppliers (see Figure 7). As a focal firm has multiple roles (e.g., customer, supplier, or middleman) in a supply network (Carter et al., 2015), structural holes can have very different influences on the focal firm depending on how we define the structural holes. Accordingly, we try to answer the following research question: What are the effects of horizontal and vertical structural holes on the focal firm's financial performance? Based on the panel data of the network of buyer-supplier relationships spanning an eleven-year period, we provide evidence for the contrasting impacts of horizontal versus vertical structural holes on focal firms' financial performances. We also show that these contrasting influences of the two types of structural holes are more salient for innovative firms.
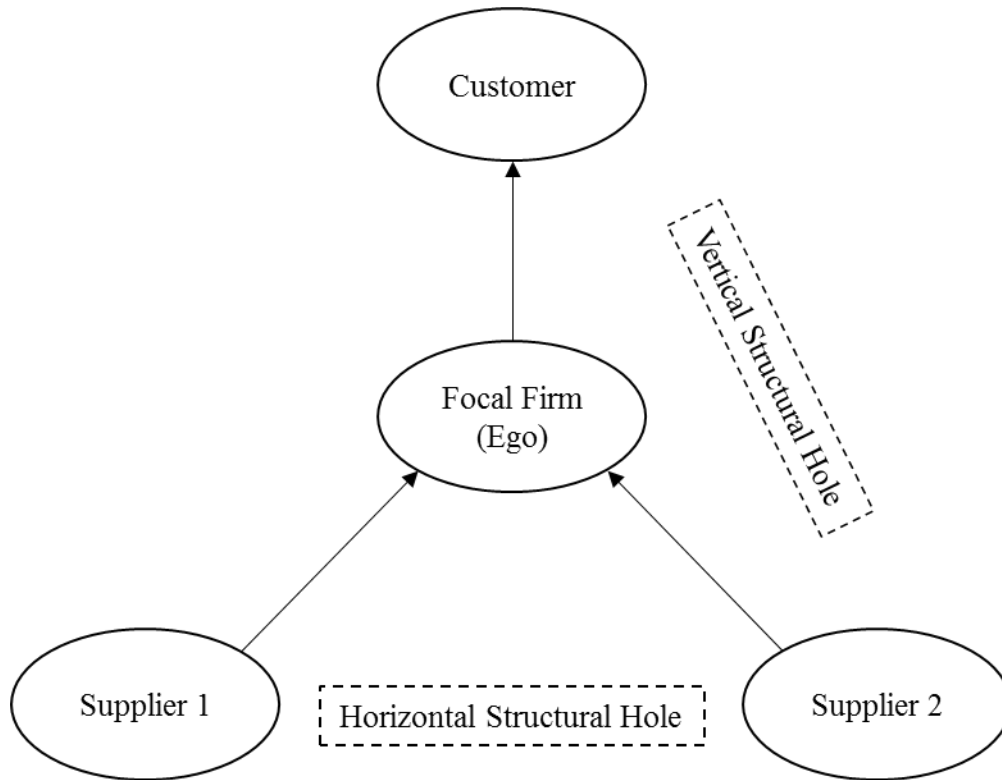
Figure 7. Horizontal Structural Hole and Vertical Structural Hole

We intend to contribute to the supply network literature by introducing the concepts of horizontal and vertical structural holes and providing empirical evidence based on archival data for the linkage between structural characteristics of supply networks and firm financial performance. Especially, the relationship between structural holes in supply networks and firm financial performance has remained unclear possibly because the conflicting roles of horizontal and vertical structural holes were not distinguished. Our study also contributes to the social network literature by suggesting an avenue for resolving the ongoing debate regarding the benefits of dense networks with less structural holes versus sparse networks rich in structural holes (e.g., Burt, 1992; Coleman, 1988, 1990; Reagans & Zuckerman, 2008). The conceptual distinction between

horizontal and vertical structural holes in a directional network such as supply network

allows us to clarify the conditions where a focal firm can benefit from both dense and

sparse networks. In addition, our study provides practical implications for managers

regarding how innovative firms can utilize and develop supply network structures

strategically.

THEORETICAL DEVELOPMENT AND HYPOTHESES

Structural Hole Theory

Structural hole theory (Burt, 1982, 1992) emphasizes the benefits of having non-

redundant ties with other network members who are not connected with one another.

Structural hole refers to the disconnection between the focal player's contacts (Burt,

1992). If two actors in a network are not directly connected to each other but indirectly

connected through a focal player, it is located on a structural hole. Burt (1997) argues that

the players who are bridging structural holes have diverse contacts and therefore have

wider access to information and can capture opportunities earlier than their peers (i.e.,

information benefits). He adds that the players sitting on structural holes are also in a

better position to know when it would be valuable to bring two disconnected people

together and control the relationship between them (i.e., control benefits). Simmel (1922)

and Merton (1957) term these players who benefit from bridging structural holes the

tertius gaudens (the third who benefits). Burt (1992) argues that having redundant ties

with the contacts with no structural holes is inefficient because it requires additional

efforts to maintain those ties while the information acquired through them is repetitive.

In the supply chain literature, structural hole theory or the arguments around ego network density (e.g., Burt, 1992; Coleman, 1988; Obstfeld, 2005; Reagans & Zuckerman, 2008) has been applied to examine the influence of structural characteristics of supply networks on focal firms' innovation output (Autry & Griffis, 2008; Bellamy et al., 2014; Carnovale & Yeniyurt, 2015), joint venture formations (Carnovale, Rogers, & Yeniyurt, 2016), operational performance (Kim, 2014), retailers' role in distribution channels (Davis-Sramek, Germain, & Stank, 2010), opportunism (Dong et al., 2015), services outsourcing (Li & Choi, 2009), and supplier-supplier relationships (Choi & Wu, 2009; Hong & Hartley, 2011). Yet, the evidence for the direct connection between structural holes and firm financial performance has remained elusive.

We argue that in the supply network context, structural holes can involve very different types of non-redundant contacts which result in different types of structural holes. Not considering the differences in the types of structural holes can provide mixed implications to the competitive position of the focal firm. Due to the unique conditions in supply networks involving directionality of materials, service, information, and monetary flows (Carter et al., 2015), structural holes in supply networks can have very different performance implications to the focal firm depending on how the structural holes are defined. In other words, the effects of structural holes on firm performance are relative to different types of structural holes. In our study, we distinguish two different types of structural holes—horizontal structural hole and vertical structural hole (see Figure 7). We expand the terms "horizontal" and "vertical" ties among buyers and suppliers (Lazzarini, Claro, & Mesquita, 2008) and apply them to describe the "lack" of ties or disconnection. A horizontal structural hole in our study refers to the structural hole between two

suppliers of a focal firm. In contrast, a vertical structural hole is defined as the structural

hole between a customer and a supplier of a focal firm. If multiple customers and

suppliers are not connected through buyer-supplier relationships among themselves, the

focal firm can have multiple horizontal and vertical structural holes in its ego network.

We investigate the influence of these horizontal and vertical structural holes on firm

financial performance.

Horizontal Structural Holes

Horizontal structural holes exist when a focal buying firm's suppliers do not have buyer-

supplier relationships among themselves. If we simply apply structural hole theory

without considering the unique characteristics of supply networks, having ties with the

suppliers that have buyer-supplier ties between them can be regarded as being redundant

and inefficient (Burt, 1992, 2000b). However, we argue that in the supply network

context, more ties between a focal buying firm's suppliers (less horizontal structural

holes) do not necessarily limit its information and control benefits as *tertius gaudens*.

Since the focal buying firm procures materials or services from suppliers, it plays the role

as an integrator rather than a broker or middleman between the suppliers. In this context,

existing buyer-supplier ties between suppliers can allow the focal firm to facilitate

cooperation in its upstream supply network (Wu & Choi, 2005). We assume that the

suppliers do not collude against the common buyer since such collusions are illegal.

Contrasting with structural hole theory, Obstfeld (2005) introduces the concept of

tertius iungens (the third who connects) and proposes the advantages of dense social

networks with less structural holes. Based on Schumpeter's (1934) view that innovation

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emerges from combining people, knowledge, and resources, Obstfeld (2005) argues that individuals in dense social networks are in advantageous positions to facilitate collaborative interactions and promote innovations. Schumpeter (1934) also recognizes that innovation is the key source of firm competitiveness and economic development. Dense social networks provide conditions for clarifying expectations about effective roles of the network members (Podolny & Baron, 1997) and therefore, reduce risks in exchange relationships (Moran, 2005). Coleman (1988) also argues that a dense network creates social norms and trustworthiness by allowing the network members to use reputation effectively as a collective sanctioning mechanism. Bizzi (2013) observes that structural holes in group relationships create frictions and problems among the members.

Since suppliers play critical roles in the process of creating and delivering products, connections among suppliers (i.e., lack of horizontal structural holes) can make it easier for a focal buying firm to combine resources across the supply network and create innovation. Buying firms can proactively create relationships among their suppliers to achieve collaborative synergy and market efficiency (Dyer & Nobeoka, 2000; Wu & Choi, 2005). Mena, Humphries, and Choi (2013) suggest that closed supply network structure provides the sense of stability and interdependence to the supply network members. In this context, a buying firm can better encourage suppliers to engage in collaborate activities such as quality improvement, cost reduction, new product development, and capacity sharing.

Moreover, in a supply network structure without ties between suppliers (i.e., more horizontal structural holes), a buying firm must rely on each supplier for relevant upstream supply information. In this setting, the suppliers may develop less sense of

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interdependence and tend to behave more opportunistically, as it becomes more difficult

for the focal buying firm to verify supply information from multiple routes and use

reputation as collective sanctions against opportunism. Burt (1992) assumes that

information is not manipulated by the actors in the network, but this may not be readily

assumed due to potential opportunism (Williamson, 1975, 1985). By the same

mechanism that benefits *tertius gaudens*, a focal buying firm's upstream supply network

rich in horizontal structural holes concedes information and control benefits to its

suppliers, as the other members of the network are more likely to be located on structural

holes in an open network structure (Reagans & Zuckerman, 2008). In contrast, if more

suppliers have buyer-supplier ties with one another, the buying firm can improve its

financial performance through the closed supply network structure by limiting

opportunistic behaviors from suppliers and facilitate cooperation between them (Wu &

Choi, 2005). Thus, we hypothesized that:

H1:   The extent of horizontal structural holes in the focal firm's supply network is

         negatively associated with its financial performance.

Vertical Structural Holes

        In contrast to horizontal structural holes, vertical structural holes can enhance the

competitive position of a focal firm. When the focal firm is located on many structural

holes between its customers and suppliers, it can actively play the role of the broker or

middleman that controls the flows of materials and information. As materials or services

flow from the supplier to the customer *through* the focal firm, it can take advantage of the

tertius gaudens (Merton, 1957; Simmel, 1922) position by selectively transferring critical

supply-side and demand-side information between its customers and suppliers (Li & Choi, 2009). As the information coming from the focal firm's upstream supply chains is likely to be very different from the information from its downstream supply chains, the focal firm can enjoy information benefits by having many customers that are disconnected with many of its and suppliers (i.e., many vertical structural holes). This unique position in the network creates opportunities for the focal firm to combine and create new ideas (Burt, 2004). On the contrary, if the focal firm's customers and suppliers are connected through buyer-supplier relationships, they can exchange critical supply and demand-side information without the brokerage of the firm in the middle, and it will no longer be in a position to access unique information from both sides.

In addition to information benefits, if the focal firm sits on multiple structural holes between several suppliers and customers, it can leverage its position as a broker and control material/service flows from certain suppliers to certain customers. Choi and Linton (2011) describe the situation where Qualcomm had enjoyed superior financial gains by controlling information and financial flows between the previously disconnected customer (LG Electronics) and supplier (TSMC). These information and control benefits will allow the focal firm to improve its financial performance (Burt, 1992). Overall, a focal firm located in a network rich in vertical structural holes is in a unique position to collect and integrate information from both supply and demand sides and control the information and material flows for its own benefit. Therefore, we expect vertical structural holes in the focal firm's network to have a positive association with its firm financial performance.

H2:   The extent of vertical structural holes in the focal firm's supply network is

positively associated with its financial performance.

Innovation Capability and Structural Holes

Horizontal structural holes can be more damaging for innovative buying firms under fast-

changing technological environment. The risk related to having horizontal structural

holes becomes more salient for innovative buying firms because they rely more heavily

on technological developments of their products (Hargadon & Sutton, 1997; Henderson

& Clark, 1990). For a focal buying firm, allowing the direct suppliers to occupy structural

hole positions between the focal firm and other suppliers can limit its access to critical

technological developments at the component level, gradually eroding the firm's core

capability and in turn, financial performance (Brusoni, Prencipe, & Pavitt, 2001; Reitzig

& Wagner, 2010; Weigelt, 2009). An upstream supply network with many horizontal

structural holes makes it more difficult for a buying firm with high innovation capability

to transfer tacit technological knowledge (Reagans & Zuckerman, 2008) and induce

collaborations among suppliers to facilitate developments of innovative products (Dyer &

Hatch, 2006). Furthermore, the innovative buying firm with many horizontal structural

holes can face more difficulties in monitoring technological advancements and cost

reduction efforts of the suppliers (Camuffo, Furlan, & Rettore, 2007) due to the lack of

redundant information sources in the upstream supply network that provide and

corroborate information regarding component-level technological developments.

In contrast, a denser supply network with less horizontal structural holes can be

particularly beneficial for innovative firms due to the high potential for advancing

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technological knowledge through intensive interactions and exchange of ideas among the network members (Ahuja, 2000; Obstfeld, 2005). Dense networks can serve as the locus of shared knowledge (Kogut & Zander, 1992; Nahapiet & Ghoshal, 1998) and facilitate the transfer of tacit knowledge (Hansen, 1999; Uzzi, 1997), which is crucial for innovation (Leonard & Sensiper, 1998; Nonaka & Takeuchi, 1995). Moreover, a dense upstream supply network can reduce information disadvantage of the innovative buying firm by providing multiple sources of reaffirming information regarding component technological developments. Overall, for an innovative focal firm, more connections among its suppliers (less horizontal structural holes) can be particularly advantageous for developing and mobilizing technological knowledge and sustain its competitiveness through further innovation (Obstfeld, 2005). Therefore, the negative relationship between horizontal structural holes and firm financial performance is expected to be stronger when innovation capability of the focal firm is high.

H3:   The focal firm's innovation capability moderates the relationship between the extent of horizontal structural holes and its financial performance such that the negative relationship is strengthened when innovation capability is high.

On the contrary, the positive relationship between vertical structural holes and firm performance can be stronger when a focal firm already has high innovation capability. Existing stocks of knowledge are critical to the process of combining and creating new knowledge (Obstfeld, 2005). Additionally, Burt (2004) argues that structural holes provide more opportunities for generating good ideas though access to diverse information. With readily advanced innovation capability, the focal firm can better detect, interpret, assimilate, and apply new information regarding technological

developments and market changes from both supply-side and demand-side and apply it for its own product or process innovation (Cohen & Levinthal, 1990; Lane & Lubatkin, 1998). Rowley, Behrens, and Krackhardt (2000) observe that in environments such as the semiconductor industry with fast technological developments, structural holes are positively associated with firm performance. Zaheer and Bell (2005) also find that innovative mutual fund firms that also bridge structural holes are better at improving their performance. The disconnections between the focal firm's customers and suppliers allow it to play the role as a broker of technological and market information and provide a unique position to match market opportunities with technological developments from upstream supply chains.

These opportunities originating from vertical structural holes would be less valuable for a focal firm with poor innovation capability, since it may not have dynamic capabilities of identifying, combining, and exploiting the opportunities (Eisenhardt & Martin, 2000; Lawson & Samson, 2001; Teece, Pisano, & Shuen, 1997; Zollo & Winter, 2002). An innovative focal firm would be better at recognizing the value of technological developments and selectively transferring or withholding technological information and utilizing it to the firm's own benefit. Hence, for a focal firm with high innovation capability, more vertical structural holes can provide more opportunities for integrating and recreating unique information that can be accessed from both upstream and downstream supply chains and further improve its financial performance.

H4: The focal firm's innovation capability moderates the relationship between the extent of vertical structural holes and its financial performance such that the positive relationship is strengthened when innovation capability is high.

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METHODOLOGY

Sample and Data Sources

The data is collected from three data sources—Compustat Fundamentals Annual, FactSet Supply Chain Relationships, and the United States Patent and Trademark Office (USPTO) patent database. Initial sample companies will be all publicly traded manufacturing companies listed in the semiconductor and other electronic component manufacturing (33441) industry. We selected this industry since the majority or the firms in this industry is publicly traded and they are both customers and suppliers to many other firms. This middle-tier supply network positions of the firms in the semiconductor and other electronic component manufacturing industry allow us to observe multiple horizontal and vertical structural holes. The initial sample companies (363 firms with 2,490 observations) are identified using Compustat, and then their supply chain relationships are collected from FactSet Supply Chain Relationships database. FactSet Supply Chain Relationship database provides the archival data on more than 300,000 contractual buyer-supplier relationships among more than 21,000 firms from 2003 (FactSet, 2017). FactSet identifies contractual buyer-supplier relationships based on the companies' annual reports, regulatory disclosures, and other announcements. The companies that are not identified in FactSet Supply Chain Relationships or have less than three suppliers or two customers are excluded from the final sample. We used the USPTO patent database to collect the number of granted patent applications of the companies in the final sample. The final sample includes 164 firms with 1,115 observations across the eleven-year period.

Since not all the firms in the initial sample from Compustat are selected as the final sample, sample selection bias can exist (Berk, 1983; Greene, 1981; Heckman, 1979). To prevent endogeneity problems originating from sample selection, we used the Heckman selection model (Heckman, 1979) for analysis. Heckman models consist of two estimation stages. In the first stage, we used a probit model to predict the probability of being in the sample in a specific year with the sample focal firm's yearly news article search count and the firm size in terms of the natural log of the number of employees. News article search count was obtained by searching the focal firm using ProQuest. Since the contractual buyer-supplier relationships captured in the FactSet Supply Chain Relationships database are identified based on company announcements, news article search count and firm size are highly correlated with the likelihood of being included in the final sample of our data. Table 6 shows the result of the probit estimation in which news article search count and the natural log of the number of employees are strong predictors of the probability of being in the sample. Then, based on the predicted values from the first stage estimation, we calculated inverse Mills ratios (Heckman, 1979) and included them as a control variable in the second stage estimations, which test our hypotheses.

Table 6

First Stage Probit Estimation of the Heckman Selection Model

Dependent variable: Sample (1, 0)	Coefficient
Constant	−2.152***
	(0.107)
Article search count	0.014***
	(0.001)
Firm size (ln number of employees)	0.237***
	(0.015)
Wald χ^2	740.66
Pseudo R^2	0.216
N	2490

*** $p < 0.001$
Unstandardized coefficients are reported.
Standard errors in parenthesis.

Variables

Dependent Variables. Two dependent variables are used to measure the focal firm's

financial performance. First, return on assets (ROA) measures the short-term financial

performance. Second, Tobin's q (Tobin, 1969) is used to measure the focal firm's stock

market performance that reflects investors' expectations of the firm's long-term financial

performance. Within the economics and finance literature, long-term, future value of the

firm is often measured using Tobin's q whereas ROA (net income/total assets) is

typically used to measure backward-looking, short-term financial performance of the firm

(Anderson, Fornell, & Mazvancheryl, 2004; Mittal, Anderson, Sayrak, & Tadikamalla,

2005). Tobin's q is calculated as the following:

$$\text{Tobin's q} = \frac{\text{Market value of equity} + \text{Book value of liabilities}}{\text{Book value of equity} + \text{Book value of liabilities}}$$

Market value of equity is calculated by multiplying the outstanding year-end number of shares by share price.

Independent Variables. The two independent variables of this study are horizontal and vertical structural holes. Both measures are adapted from Burt's (1992) aggregate constraint measure. Aggregate constraint measures the degree of concentration of a firm's time and energy in a single group of interconnected member firms in the firm's ego network. In other words, it measures the degree of having no access to structural holes (Burt, 1992: Chapter 2). The formulas for Burt's aggregate constraint are the following:

$$C_i = \Sigma_j c_{ij}, i \neq j$$

Where C_i is network constraint on firm i and c_{ij} measures i's dependence on contact j.

$$c_{ij} = (p_{ij} + \Sigma_q p_{iq} p_{qi})^2, i \neq q \neq j$$

Where p_{ij} is the proportion of i's network time and energy directly spent on j and $\Sigma_q p_{iq} p_{qi}$ is the proportion of i's network time and energy indirectly spent on j.

Since Burt's (1992) aggregate constraint measures no access to structural holes and it ranges from 0 to 1, we will use $1 - C_i$ as the measure of the extent of structural holes. To measure the extent of horizontal structural holes, we extracted the focal firm's ego network involving the buyer-supplier relationships between the focal firm and its direct suppliers, and the buyer-supplier relationships among the focal firm's direct suppliers. Then we calculated C_i for each focal firm. To measure access to vertical structural holes, the focal firm's ego network involving the focal firm, its direct customers and suppliers, and the buyer-supplier relationships between customers and suppliers are extracted. The same calculation of C_i is applied to these second type of networks to measure vertical structural holes.

Moderator Variable. The focal firm's innovation capability is measured using the natural log of the number of the firm's patents obtained in the past five-year period. Patents are commonly used to measure innovation capability of a firm (Bellamy et al., 2014; Hall, Jaffe, & Trajtenberg, 2005; Hoetker, 2005; Romijn & Albaladejo, 2002).

Control Variables. Control variables include global network centrality measures and other firm-level variables that can be correlated with both independent and dependent variables. Global network centrality measures include indegree and outdegree centralities and input and output closeness centralities (Freeman, Roeder, & Mulholland, 1979; Prell, 2012). Since Burt's constraint measure is dependent on the number of ties that the focal player has (Burt, 1992), it is necessary to control for indegree and outdegree centralities to capture the difference between horizontal and vertical structural holes. Closeness centralities are included in the model to control for the effect of being adjacent to the overall members of the industry-wide network. Since larger firms can have more resources to influence supply chain members power (Casciaro & Piskorski, 2005; Pfeffer & Salancik, 2003), we use natural logarithm of total assets as a control for firm size. Other firm-level variables that can be correlated with market valuation and short-term financial performance are also included as control variables. They include debt to equity ratio (liabilities/equity), R&D intensity (R&D expense/sales), capital intensity (capital expense/sales), and cost of goods sold to sales ratio (COGS/sales). Year dummy variables are also included to control for unobserved heterogeneity across time. Tables 2 and 3 show descriptive statistics and pairwise correlations of the variables in our study.

Table 7

Descriptive Statistics (N = 1,115)

Variable	Mean	Std. dev.	Min	Max
1. Firm size (ln total assets)	6.899	1.859	1.648	11.433
2. Debt to equity ratio	0.302	2.253	−33.223	32.675
3. R&D intensity	0.199	0.325	0	5.304
4. Capital intensity	0.096	0.159	0.001	2.922
5. COGS/Sales	0.577	0.349	0.117	6.431
6. Innovation capability	4.132	2.479	0	9.206
7. Indegree centrality	13.283	15.449	3	214
8. Outdegree centrality	20.240	16.709	2	149
9. Input closeness centrality	0.113	0.021	0.001	0.175
10. Output closeness centrality	0.156	0.035	0.001	0.234
11. Horizontal structural holes	0.093	0.073	0.014	1
12. Vertical structural holes	0.060	0.046	0.009	0.556
13. Return on assets	−0.019	0.167	−0.983	0.312
14. Tobins' Q	1.732	2.287	−35.846	21.078

Table 8

Correlation Matrix (N = 1,115)

	1	2	3	4	5	6	7
1. Firm size (ln total assets)	1.000						
2. Debt to equity ratio	0.020	1.000					
3. R&D intensity	-0.292*	-0.032	1.000				
4. Capital intensity	0.229*	0.034	-0.002	1.000			
5. COGS/Sales	-0.074*	0.027	0.531*	0.059	1.000		
6. Innovation capability	0.556*	-0.031	0.013	0.104*	-0.208*	1.000	
7. Indegree centrality	0.487*	-0.011	-0.079*	0.079*	-0.128*	0.452*	1.000
8. Outdegree centrality	0.327*	-0.021	-0.050	0.019	-0.143*	0.326*	0.481*
9. Input closeness centrality	0.083*	-0.013	0.026	-0.002	-0.064*	0.182*	0.326*
10. Output closeness centrality	0.133*	-0.048	0.025	0.021	-0.108*	0.307*	0.196*
11. Horizontal structural holes	-0.285*	0.008	0.008	-0.083*	0.125*	-0.393*	-0.368*
12. Vertical structural holes	-0.280*	0.019	0.037	-0.049	0.148*	-0.357*	-0.335*
13. Return on assets	0.356*	-0.126*	-0.322*	0.022	-0.177*	0.183*	0.206*
14. Tobins' Q	-0.092*	0.603*	0.125*	-0.045	-0.045	0.079*	0.034

	8	9	10	11	12	13	14
8. Outdegree centrality	1.000						
9. Input closeness centrality	0.125*	1.000					
10. Output closeness centrality	0.467*	0.398*	1.000				
11. Horizontal structural holes	-0.451*	-0.366*	-0.570*	1.000			
12. Vertical structural holes	-0.551*	-0.235*	-0.499*	0.823*	1.000		
13. Return on assets	0.126*	0.026	0.032	-0.063*	-0.033	1.000	
14. Tobins' Q	0.010	0.084*	0.067*	-0.022	0.003	0.101*	1.000

* > 0.05

Analysis

We conducted the analysis with the sample firms in the semiconductor and other electronic component manufacturing industry (5-digit NAICS 33441) listed in Compustat for the eleven-year period from 2004 to 2014. After identifying initial sample firms from Compustat, we used the FactSet Supply Chain Relationships database to build an industry-wide network at the end of each year from 2003 to 2013. The network involves the sample focal firms and their direct customers and suppliers and the customers and suppliers of the direct customers and suppliers (i.e., indirect customers and suppliers). As an example, Figure 8 shows a diagram of the network at the end of 2012. It includes 30,099 buyer-supplier relationships among 7,373 firms. Using the industry-wide networks across the eleven-year period, we calculated network measures such as various centrality measures and the structural hole measures.
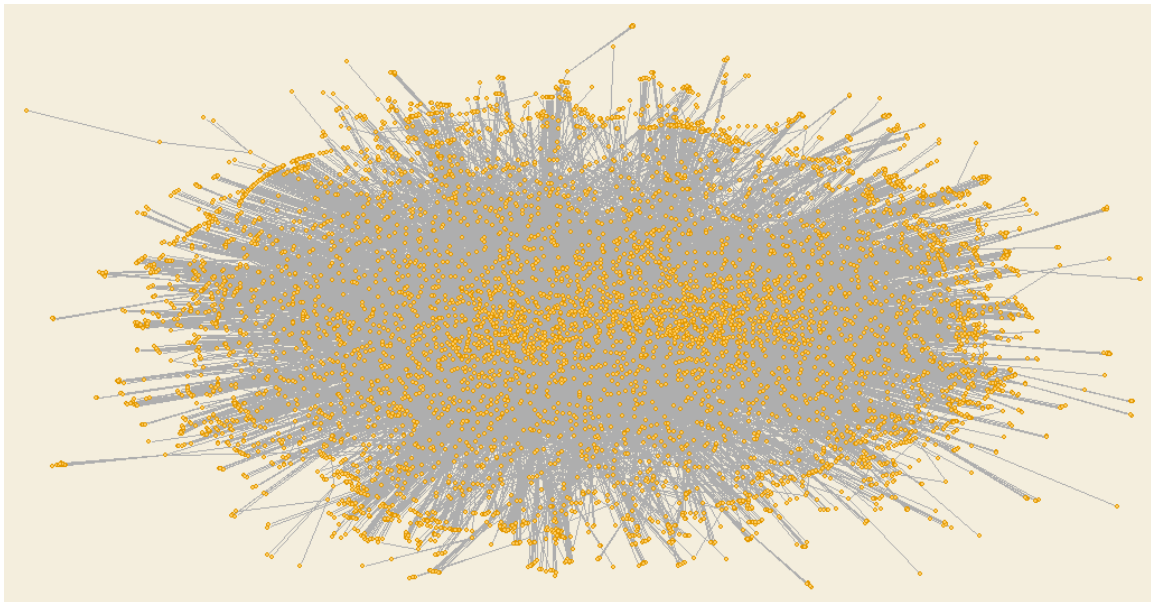

Figure 8. Sample Network Diagram in 2012

Our data has a panel structure in which the variables are measured multiple times over several years. Each variable is measured once a year. To analyze the panel data and control for unobserved heterogeneity across the firms in the sample, we used fixed effect models. To minimize multicollinearity problems when testing interaction effects, we grand-mean centered (Enders & Tofighi, 2007; Hofmann & Gavin, 1998) horizontal and vertical structural holes and innovation capability variables.

The regression equation below represents the fixed effect model we used to test our hypotheses:

$$Y_{it} = \beta_0 + \beta_1 Horizontal\_Structural\_Holes_{it} + \beta_2 Vertical\_Structural\_Holes_{it}$$
$$+ \beta_3 Innovation\_Capability * Horizontal\_Structural\_Holes_{it}$$
$$+ \beta_4 Innovation\_Capability * Vertical\_Structural\_Holes_{it} + \beta_n X_{it} + \alpha_i$$
$$+ u_{it}$$

Where:

Y_{it} indicates the two dependent variables (ROA and Tobin's q) where i is firm and t is year.

X_{it} includes control variables, innovation capability, and year fixed effects.

α_i indicates firm fixed effects and u_{it} is the error term.

RESULTS

We conducted two separate fixed-effects regression analyses with ROA and Tobin's q as dependent variables. Clustered robust standard errors were used to estimate the significances of the coefficients. Table 9 shows the result of the fixed-effects regression with ROA as the dependent variable. Model 3 shows the result after controlling for

sample selection bias. The coefficient for horizontal structural holes ($B = -0.41$, $p > 0.1$) is not significant at the $p < 0.05$ level. Therefore, H1 is not supported when the dependent variable is ROA. However, the coefficient for vertical structural holes ($B = 0.68$, $p < 0.05$) is significant, supporting H2. The interaction between innovation capability and horizontal structural holes ($B = -0.18$, $p < 0.01$) has a significant negative association with ROA, supporting H3. Figure 9 shows that the negative effect of horizontal structural holes is stronger when the focal firm has higher innovation capability. In addition, the interaction between innovation capability and vertical structural holes ($B = 0.21$, $p < 0.05$) has a significant positive association with ROA, supporting H4. Figure 10 shows the positive effect of vertical structural holes on ROA is stronger for the focal firm with higher innovation capability.

Table 9

Result of the Fixed-Effects Regression with ROA as Dependent Variable

Dependent variable: ROA	Model 1	Model 2	Model 3
Constant	−0.216†	−0.241*	−0.293*
	(0.118)	(0.115)	(0.122)
Firm fixed-effects	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes
Inverse Mills ratio			0.029
			(0.034)
Firm size (ln total assets)	0.021	0.021	0.026†
	(0.015)	(0.015)	(0.015)
Debt to equity ratio	−0.005	−0.005	−0.005
	(0.004)	(0.004)	(0.004)
R&D intensity	−0.342***	−0.344***	−0.340***
	(0.051)	(0.051)	(0.050)
Capital intensity	0.049	0.048	0.047
	(0.034)	(0.034)	(0.034)
COGS/Sales	0.156**	0.157**	0.155**
	(0.046)	(0.046)	(0.045)
Innovation capability	−0.013	−0.009	−0.008
	(0.010)	(0.010)	(0.010)
Indegree centrality	−0.0001	−0.0001	−0.0001
	(0.0004)	(0.0004)	(0.0004)
Outdegree centrality	−0.0001	0.0003	0.0003
	(0.001)	(0.001)	(0.001)
Input closeness centrality	−0.379	−0.381	−0.373
	(0.347)	(0.344)	(0.342)
Output closeness centrality	0.435	0.525	0.538
	(0.404)	(0.361)	(0.359)
Horizontal structural holes (H1)		−0.402	−0.411
		(0.258)	(0.258)
Vertical structural holes (H2)		0.683*	0.683*
		(0.327)	(0.331)
Horizontal SH × Innov. capa. (H3)		−0.181**	−0.184**
		(0.069)	(0.069)
Vertical SH × Innov. capa. (H4)		0.205*	0.206*
		(0.093)	(0.094)
R^2 within	0.158	0.168	0.169
F-test		3.44**	0.74
N observations	1115	1115	1115
N groups	164	164	164

† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Unstandardized coefficients are reported.
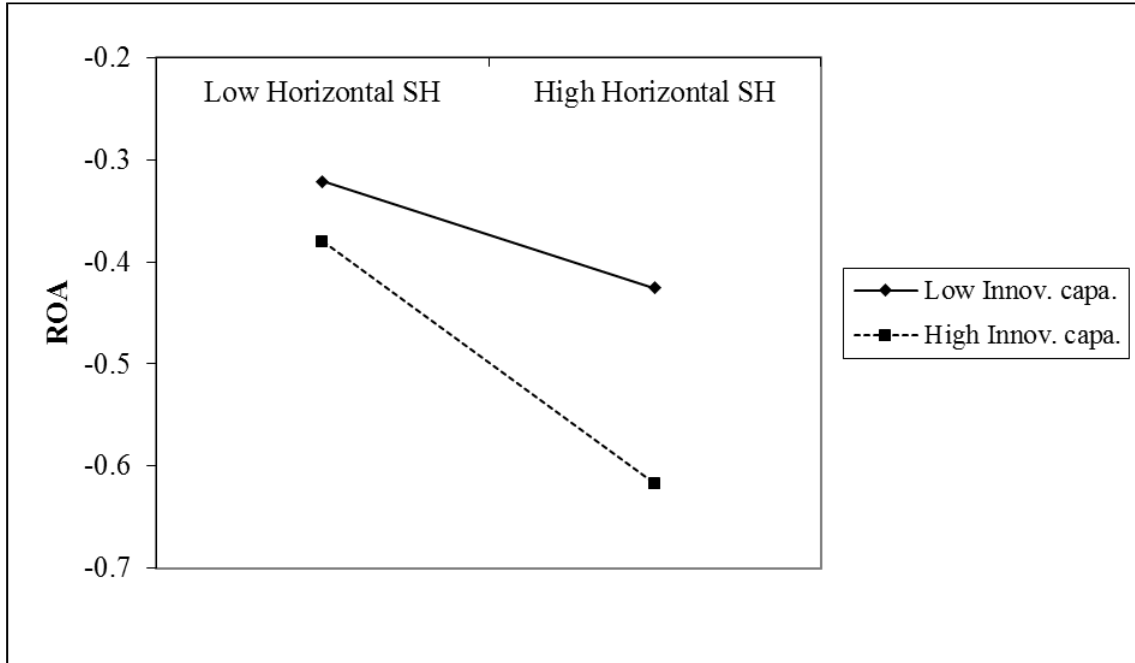Clustered robust standard errors in parenthesis.

Figure 9. Interaction between Horizontal Structural Holes and Innovation Capability on ROA
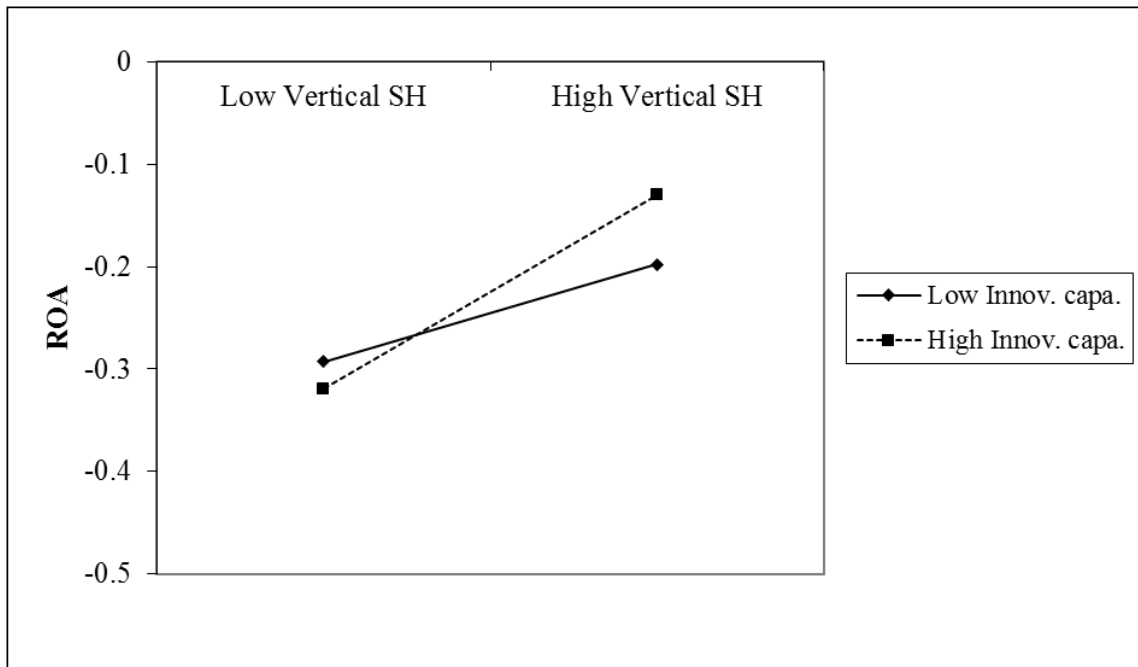

Figure 10. Interaction between Vertical Structural Holes and Innovation Capability on ROA

Table 10 shows the result of the fixed-effects regression with Tobin's q as the dependent variable. After controlling for sample selection bias in Model 3, horizontal structural holes (B = −4.64, p < 0.05) show a significant negative association with Tobin's q, providing support for H1. In contrast, vertical structural holes (B = 5.95, p < 0.5) show a significant positive association with Tobin's q, supporting H2. The interaction between innovation capability and horizontal structural holes (B = −1.76, p < 0.01) has a significant negative association with Tobin's q, supporting H3. Figure 11 is the interaction plot which shows that the negative impact of horizontal structural holes is stronger when the focal firm has higher innovation capability. However, the interaction between vertical structural holes (B = 1.48, p > 0.1) does not have a significant association with Tobin's q, not supporting H4.

Overall, H2 and H3 are fully supported, and H1 and H4 are partially supported. H1 is supported only when the dependent variable is ROA while H4 is supported only when the dependent variable is Tobin's q. We interpret and discuss these results further in the following section.

Table 10

Result of the Fixed-Effects Regression with Tobin's Q as Dependent Variable

Dependent variable: Tobin's q	Model 1	Model 2	Model 3
Constant	6.854***	6.709***	7.509***
	(1.506)	(1.497)	(1.586)
Firm fixed-effects	Yes	Yes	Yes
Year fixed-effects	Yes	Yes	Yes
Inverse Mills ratio			−0.444
			(0.344)
Firm size (ln total assets)	−0.756***	−0.748***	−0.814***
	(0.201)	(0.198)	(0.204)
Debt to equity ratio	0.708**	0.707**	0.709**
	(0.209)	(0.209)	(0.209)
R&D intensity	−0.535	−0.547	−0.607
	(.668)	(0.680)	(0.656)
Capital intensity	0.436	0.418	0.437
	(0.727)	(0.719)	(0.718)
COGS/Sales	0.154	0.171	0.211
	(0.492)	(0.491)	(0.481)
Innovation capability	0.102	0.167	0.157
	(0.113)	(0.115)	(0.113)
Indegree centrality	−0.005	−0.006	−0.007
	(0.004)	(0.004)	(0.004)
Outdegree centrality	0.011†	0.014*	0.014*
	(0.006)	(0.007)	(0.007)
Input closeness centrality	−2.094	−2.223	−2.347
	(4.008)	(4.071)	(4.065)
Output closeness centrality	−2.143	−2.039	−2.237
	(2.975)	(2.535)	(2.567)
Horizontal structural holes (H1)		−4.789*	−4.644*
		(2.158)	(2.152)
Vertical structural holes (H2)		5.950†	5.954*
		(3.046)	(3.016)
Horizontal SH × Innov. capa. (H3)		−1.800**	−1.762**
		(0.669)	(0.678)
Vertical SH × Innov. capa. (H4)		1.481	1.478
		(0.953)	(0.952)
R^2 within	0.587	0.591	0.592
F-test		2.65*	0.20
N observations	1115	1115	1115
N groups	164	164	164

† $p < 0.1$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$
Unstandardized coefficients are reported.
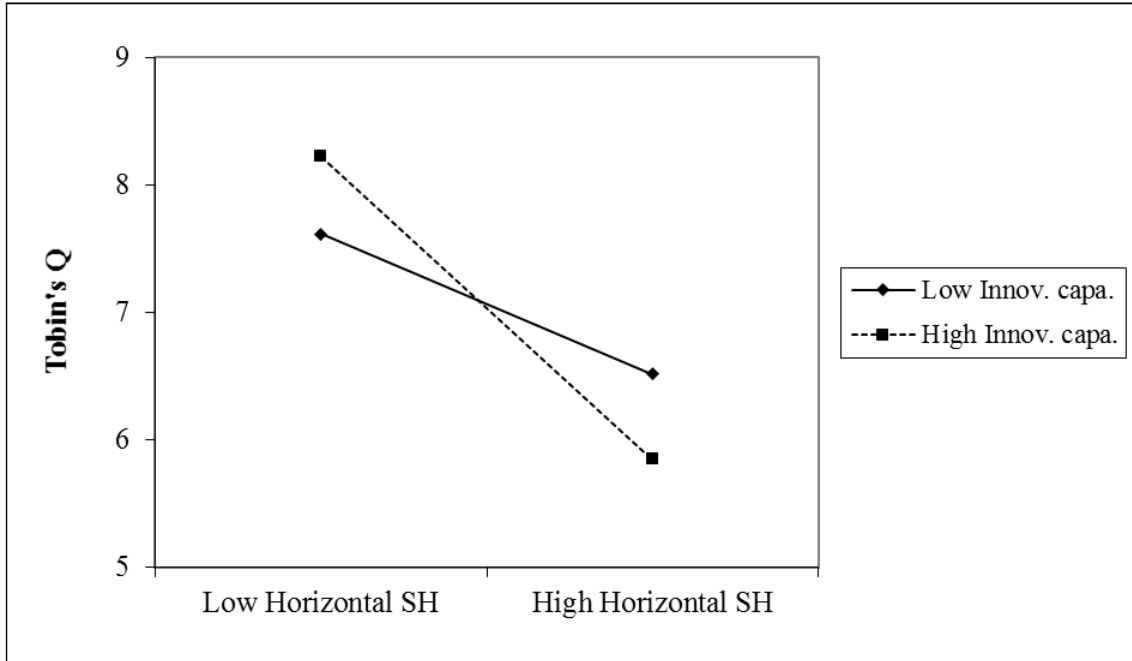Clustered robust standard errors in parenthesis.

Figure 11. Interaction between Horizontal Structural Holes and Innovation Capability on Tobin's Q

DISCUSSION

The results of the analysis provide contrasting financial performance implications of horizontal versus vertical structural holes in supply networks for focal firms in the semiconductor and other electronic component manufacturing industry. We found that horizontal structural holes have a negative impact on ROA whereas vertical structural holes positively influence both ROA and Tobin's q of the focal firm. In other words, having suppliers that are disconnected (i.e., no buyer-supplier relationship) with each other is detrimental to a firm's financial performance while disconnections between the focal firm's customers and suppliers can improve its financial performance. These contrasting aspects of horizontal versus vertical structural holes seem to influence the

focal firm's short-term and long-term financial performances differently. On the one hand, having more suppliers that are connected to each other through buyer-supplier relationships (i.e., less horizontal structural holes) is associated with the focal firm's long-term (Tobin's q) rather than a short-term (ROA) financial performance. This finding may imply that although the focal firm with less horizontal structural holes cannot pursue short-term financial gains by taking an information broker position and preventing information sharing among its suppliers, it can benefit in the long-term from collaborations among the suppliers that are facilitated by existing buyer-supplier relationships with each other. On the other hand, more vertical structural holes between the focal firm's customers and suppliers are associated with better short-term (ROA) and long-term (Tobin's q) financial performances. This finding supports the classic arguments of structural hole theory (Burt, 1982, 1992). A focal firm with more vertical structural holes can have better access to unique information from both upstream and downstream supply chains and use the unique information to improve its financial performance.

We also found that for an innovative focal firm, more disconnections among its suppliers (i.e., more horizontal structural holes) can be harmful to both short-term and long-term financial performances. Reagans and Zuckerman (2008) argue that there are risks associated with relying on non-redundant ties with more structural holes, because ambiguous information or tacit knowledge may be better transferred through redundant ties in a dense network. Therefore, an innovative focal firm with rich tacit knowledge in new product or process development would find it more difficult to facilitate knowledge transfer among suppliers if they do not interact with each other through buyer-supplier

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relationships. On the contrary, the positive interaction between vertical structural holes and innovation capability on ROA suggest that innovative focal firms are better at improving short-term financial performance by utilizing their middleman positions between customers and suppliers. With superior absorptive capacity and existing stocks of knowledge accumulated through innovation activities (Cohen & Levinthal, 1990; Tsai, 2001), focal firms with higher innovation capability seem to better utilize unique information from upstream and downstream supply chains and improve short-term financial performance. However, potentially due to the lack of innovation collaborations and cohesion between customers and suppliers, innovative focal firms with more vertical structural holes do not enjoy additional long-term financial gains compared to their less innovative counterparts.

Theoretical Contribution

The findings of our study highlight the importance of considering directionality in supply networks and suggest the relativity of structural holes in such networks. Depending on how structural holes are defined based on the directions of the ties in a supply network, structural holes can have contrasting effects on a focal firm's performance. Structural holes can exist between not only the focal firm's suppliers but also its customers and suppliers. Unlike other interfirm alliance or joint venture network research in strategic management where ego firms and alter firms are all "partners," the context of our study is the supply network where the nodes can be either buyers or suppliers relative to the perspective of the focal firm (Carter et al., 2015). Not considering these unique characteristics of supply network can provide inaccurate implications on the

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roles of structural holes in supply networks. As Borgatti and Li (2009) suggest, we avoid simplistic application of social network concepts into the supply network context. We intend to contribute to both structural hole theory and the literature on supply network structures by providing theoretical and empirical evidence for how the mechanisms behind structural holes can function differently relative to the specific contexts in supply networks.

Our study also contributes to the ongoing debates regarding the performance implications of redundant ties or dense networks in the social network literature (e.g., Burt, 1992; Coleman, 1988, 1990; Reagans & Zuckerman, 2008; Rowley et al., 2000). By considering the directions of the flows in supply networks and distinguishing horizontal and vertical structural holes, we provide the potential for resolving seemingly competing arguments about the benefits of dense networks (Coleman, 1988, 1990) versus structural holes (Burt, 1992). Based on the empirical evidence of our study, we call for further theoretical and methodological developments that incorporate directionality in conceptualizing structural holes or interconnectedness in a network.

In addition, our study also contributes to the field of supply chain management by applying social network theories and analysis for empirical testing. While there have been continued applications of social network analysis for analyzing supply networks (Carnovale & Yeniyurt, 2014; Kim et al., 2011), the use of the methodology is still in its nascent stage partly due to the difficulties in acquiring large-scale supply network data. By utilizing the longitudinal buyer-supplier relationship data in the FactSet Supply Chain Relationships database, we apply social network analysis and provide new ways of understanding structural holes in supply networks.

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Managerial Implications

Our study provides several managerial implications. First, especially for a firm with high innovation capability, developing dense upstream supply networks with more buyer-supplier relationships among its suppliers can be beneficial for its overall financial performance. Even for a firm with lower innovation capability, dense upstream supply networks can be useful for preventing opportunistic behaviors and improve its long-term financial performance. There are multiple ways of developing denser upstream supply networks. Buying firms can induce contractual relationships between suppliers (Wu & Choi, 2005), initiate direct contractual relationships with Tier-2 suppliers (Choi & Hong, 2002; Choi & Linton, 2011), or select suppliers with existing buyer-supplier relationships among themselves. Buying firms should consider these options to reduce horizontal structural holes in their upstream supply networks.

In addition, a firm in middleman positions between its multiple customers and suppliers can enjoy superior financial performances by actively sustaining vertical disconnections between the customers and suppliers. Supply chain scholars have emphasized the dangers of supply chain disintermediation in which a focal firm's customers make direct transactions with the focal firm's suppliers (Li & Choi, 2009; Rossetti & Choi, 2008). Conceptually, the more supply chain disintermediation, the less vertical structural holes for a focal firm. By developing the concept of vertical structural holes and empirically testing their effects on firm financial performance, our study substantiates the arguments for the dangers of supply chain disintermediation. Managers should be aware of the financial disadvantages of supply chain disintermediation and

engage actively in sustaining middleman positions of their firms between customers and suppliers.

Limitations and Future Research

The potential threat to external validity of this study comes from the fact that the sample firms are from only the semiconductor and other electronic component manufacturing industry. Future studies should investigate the effects of vertical and horizontal structures in other industry contexts. Although this study tries to limit endogeneity issues by using multiple control variables, year and firm fixed effects, and the Heckman selection model, there is a possibility of omitted variable bias. For example, the focal firm's or its customers' collaborative tendency to supply chain members may influence both the structural holes and the financial performance of the firm. Identification of these potential omitted variables will enhance the validity of this study's findings. Another limitation of this study comes from the limitations in the FactSet Supply Chain Relationship data. The buyer-supplier relationships identified in this data do not show the relative importance of the relationships. The data shows only the existences of the buyer-supplier relationships in binary formats. Future studies can develop more advanced measures for vertical and horizontal structural holes by incorporating the relative importance of the focal firm's customers and suppliers.

CHAPTER 5

CONCLUSIONS

This dissertation investigates the theoretical and behavioral factors that influence supply

chain make-buy decisions and provides performance implications of supply network

structures that are associated with supply chain make-buy. The findings of the

dissertation provide important implications to both theory and managerial practice.

The first study in Chapter 2 contributes to the literature on make-buy decisions by

considering the "bundle of transactions" as the unit-of-analysis and expanding the level

of analysis from the dyadic context (i.e., direct transaction between the buying firm and

top-tier supplier) to the multi-tier level (i.e., direct and indirect transactions among the

buying firm, top-tier supplier, and lower-tier suppliers). The present study adds to this

body of literature by providing a new perspective which considers the transactions

throughout the supply chain involving the lower-tier suppliers. The propositions and

heuristic models in Chapter 2 also offer a new perspective for organizing transactions to

mitigate risks. By considering both direct, bilateral transactions and indirect transactions,

Chapter 2 diverts from the traditional TCE literature's predictions on organizing

transactions. For example, without recognizing the supply chain-make option, the

traditional TCE literature would suggest the buying firm adopting hierarchical

governance when the transaction with the top-tier supplier is characterized by high asset

specificity and behavioral uncertainty (Williamson, 1975, 1985). However, the supply

chain make-buy model implies that the buying firm does not necessarily have to rely on

hierarchical governance if it can reduce the risk of opportunism by engaging in supply chain-make.

For managers, Chapter 2 provides a guideline for making the choice between supply chain-make and supply chain-buy. It also offers some suggestions for managing multiple tiers of the supply network, if their decision is supply chain-make. Asset specificity, behavioral uncertainty, and supply risk can increase the cost of managing exchange relationships with the top-tier suppliers. In addition, under high tacitness of intellectual property and interdependence in the product architecture, supply chain-buy can quickly erode the firm's opportunities for technological developments. Considering these variables will help the managers make the right supply chain make-buy decision.

The second study of this dissertation (Chapter 3) suggest that individual supply managers' decisions regarding the use of multi-tier sourcing practices are subject to several key heuristics. First, when faced with uncertainty in the Tier-1 supplier's cost performance, supply managers try to reduce uncertainty by exercising greater control over subcomponent sourcing and minimizing information asymmetry between the buyer and the Tier-1 supplier. Second, supply managers tend to be influenced more saliently by interpersonal-level trust than interorganizational-level behavioral uncertainty when they make multi-tier sourcing decisions. Lastly, while supply managers use multi-tier sourcing practices to cope with perceived uncertainty in the relationship with the Tier-1 supplier, the extent of use is subject to their familiarity with potential Tier-2 suppliers.

The result of the experiment suggests that supply managers' familiarity with Tier-2 suppliers helps them navigate these trade-offs in determining the extent of multi-tier sourcing. For a firm that intends to use multi-tier sourcing practices, it is of vital

importance to encourage and train supply managers to be more familiar with potential

Tier-2 and further upstream suppliers. Chapter 3 also finds evidence that interpersonal

trust may give supply managers confidence to delegate greater responsibility to Tier-1

suppliers. Ensuring supply managers can separate the levels of interpersonal trust from

the broader, but potentially weaker, signals of supplier trustworthiness is important.

Nonetheless, the role of familiarity in lower-tier suppliers comes to fore, as with

behavioral uncertainty. Where the supply manager also holds high levels of indirect

supplier familiarity, they delegate greater authority to Tier-1 supplier, than when

familiarity is low. This encourages supply managers to have not only confidence that the

supplier will perform as promised, but also the domain knowledge to verify that the

performance is appropriate.

Lastly, the study in Chapter 4 highlights the importance of considering

directionality in supply networks and suggests the relativity of structural holes in such

networks. Depending on how structural holes are defined based on the directions of the

ties in a supply network, structural holes can have contrasting effects on a focal firm's

performance. Not considering these unique characteristics of supply network can provide

inaccurate implications on the roles of structural holes in supply networks. Chapter 4

contributes to both structural hole theory and the literature on supply network structures

by providing theoretical and empirical evidence for how the mechanisms behind

structural holes can function differently relative to the specific contexts in supply

networks. Chapter 4 also contributes to the ongoing debates regarding the performance

implications of redundant ties or dense networks in the social network literature (e.g.,

Burt, 1992; Coleman, 1988, 1990; Reagans & Zuckerman, 2008; Rowley et al., 2000). By

considering the directions of the flows in supply networks and distinguishing horizontal and vertical structural holes, the study provides the potential for resolving seemingly competing arguments about the benefits of dense networks (Coleman, 1988, 1990) versus structural holes (Burt, 1992).

Chapter 4 also provides several managerial implications. First, especially for a firm with high innovation capability, developing dense upstream supply networks with more buyer-supplier relationships among its suppliers can be beneficial for its overall financial performance. Even for a firm with lower innovation capability, dense upstream supply networks can be useful for preventing opportunistic behaviors and improve its long-term financial performance. In addition, a firm in middleman positions between its multiple customers and suppliers can enjoy superior financial performances by actively sustaining vertical disconnections between the customers and suppliers. By developing the concept of vertical structural holes and empirically testing their effects on firm financial performance, the study substantiates the arguments for the dangers of supply chain disintermediation.

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APPENDIX A

SURVEY DESIGN

1. Invitation Letter

Dear Participant,

Thank you very much for helping with this research project. I am a Ph.D. student in the Department of Supply Chain Management at Arizona State University. My research team (Professors Benn Lawson, Thomas Kull, and Thomas Choi) and I are studying managers' decision making about the allocation of sourcing responsibility between lead OEM firms and their Tier 1 suppliers. We are particularly interested in understanding how managers make these decisions under different situations. We are willing to share the results of the study that may help your future supply decisions.

You can expect this survey to take 5-10 minutes to complete. There are two parts in this survey. The first part describes a supply chain decision making scenario and asks your choices. The second part asks your background information and preferences.

Your participation in this research is voluntary and you can skip the questions if you wish. Your participation will enhance understanding of supply decision making and help future supply chain students and managers. Your answers are confidential and there are no expected risks or discomfort to your participation. Aggregate responses will be analyzed, summarized, presented at research conferences, and may be published in academic journals. Results will be shared only in aggregate forms and your personal details will not be disclosed. You must be 18 years or older to participate.

For any questions regarding this research, please contact me: Sangho Chae (schae9@asu.edu, 480-965-6044). You can also contact Professor Thomas Kull (thomas.kull@asu.edu, 480-965-6125). For any questions about your rights as a participant in this research, or if you feel you have been placed at risk, please contact the Chair of the Human Subjects Institutional Review Board, through the Arizona State University Office of Research Integrity and Assurance, at 480-965-6788.

Thank you again for your help.

Sincerely,

Sangho Chae

Department of Supply Chain Management

Arizona State University

2. Scenario Introduction

You are a purchasing manager at a global automotive producer and responsible for the procurement of in-car entertainment systems. Profit margins at your company have recently come under intense pressure, and while your job performance is evaluated against multiple criteria, the most important is achieving target cost goals.

Recently, your company and a local electronics supplier have been working together to design an innovative entertainment system for the latest range of models. The entertainment system is considered a strategic module with high profit impact, and your company has retained all intellectual property, including drawings, schematics, and bill of materials (BOM). The electronics supplier has already been selected as the Tier-1 supplier. However, the design of the in-car entertainment system requires the procurement of technologically advanced, highly complex sub-components from suppliers located at Tier-2 and below. You are considering how best to manage the sourcing of these sub-components, in particular the allocation of sourcing responsibilities between your company and the Tier-1 electronics supplier.

3. Scenario Manipulation

1) Behavioral uncertainty regarding the Tier-1 supplier's cost performance

a) High behavioral uncertainty

In reviewing the Tier-1 supplier's performance you note they have consistently met requirements for quality, delivery, and flexibility over the last three years. Importantly, however, their performance in meeting target cost goals in previous projects has been unpredictable, and you are unsure whether they will achieve the target cost for the new entertainment system.

b) Low behavioral uncertainty

In reviewing the Tier-1 supplier's performance you note they have consistently met requirements for quality, delivery, and flexibility over the last three years. Importantly, they have also consistently met target cost goals in previous projects, and you are confident that they will also achieve the target cost for the new entertainment system.

2) Lower-tier familiarity

a) High familiarity

As the purchasing manager for the in-car entertainment system, you understand the bill of materials (BOM) structure of the module to be purchased and have basic knowledge about the key sub-components that comprise the system. You are also familiar with the potential sub-component suppliers at Tier-2 and below, and have prior experience of working with them.

b) Low familiarity

As the purchasing manager for the in-car entertainment system, you understand the bill of materials (BOM) structure of the module to be purchased and have basic knowledge about the key sub-components that comprise the system. However, you are not very familiar with the potential sub-component suppliers at Tier-2 and below, and have very little experience of working with them.

3) Interpersonal trust between the supply manager and the Tier-1 supplier's sales representative

a) High interpersonal trust

In working with the Tier-1 supplier, you have maintained a close relationship with their sales representative. You consider the sales representative to be trustworthy and fair in negotiations with you. The sales representative can always be counted on to act as you expect and will not take advantage of you.

b) Low interpersonal trust

In working with the Tier-1 supplier, you have maintained an arm's length relationship with the sales representative. You consider the sales representative to be not very trustworthy and has not always been fair in negotiations with you. The sales representative cannot always be counted on to act as you expect and may take advantage of you.

4. Decision making questions

1) Based on the case described, which of the following statements best reflects your view of the degree of direct sourcing control you wish to exercise over the Tier 1 supplier? More control by your company requires more managerial and organizational resources.

(1) Full control by the Tier-1 supplier

(2) Extensive control by the Tier-1 supplier

(3) Moderate control by the Tier-1 supplier

(4) Control evenly shared by your company and the Tier-1 supplier

(5) Moderate control by your company

(6) Extensive control by your company

(7) Full control by your company

2) Based on the case described, please select an option below which best reflects your supplier selection strategy. The options require increasing levels of managerial and

organizational resources; with the first option the least, followed by the second option, and then the third option.

A. Request that the Tier-1 supplier select its sub-component suppliers from your company's existing approved vendor list.

B. Mandate the Tier-1 supplier use specific sub-component suppliers as selected by your company from the existing approved vendor list.

C. Negotiate directly with key sub-component suppliers regarding pricing and other specifications, and then require the Tier-1 supplier to work with these specific suppliers.

4. Manipulation checks

(All items use the following scale: Strongly disagree 1 2 3 4 5 6 7 Strongly agree)

1) It is difficult to predict the Tier-1 supplier's cost performance.

2) You are familiar with the potential sub-component suppliers.

3) You trust the sales representative of the Tier-1 supplier.

5. Background information

1) How many years of work experience do you have?

2) How many years of work experience are in the supply management profession?

3) What is your current industry?

4) How many employees are in your entire company or organization?

5) How many employees are in your supply management organization?

6) What is your gender?

7) What is your age?

6. Personal risk propensity

Please indicate how much you agree or disagree with the following statements about yourself.

(All items use the following scale: Strongly disagree 1 2 3 4 5 6 7 Strongly agree)

1) I prefer to avoid risks.

2) I take risks regularly.

3) I really dislike not knowing what is going to happen.

4) I view myself as a risk seeker.

APPENDIX B

IRB APPROVAL

EXEMPTION GRANTED

Thomas Kull
Supply Chain Management
480/965-6125
Thomas.Kull@asu.edu

Dear Thomas Kull:

On 2/8/2016 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Behavioral Investigation of the Supply Chain Make-Buy Decision Making
Investigator:	Thomas Kull
IRB ID:	STUDY00003826
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• ChaeSurveyDesign.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • HRP-503a-TEMPLATE_PROTOCOL_SocialBehavioralV02-10-15.docx, Category: IRB Protocol; • ChaeConsentLetter.pdf, Category: Consent Form; • ChaeSurveyDesign.pdf, Category: Recruitment Materials;

The IRB determined that the protocol is considered exempt pursuant to Federal Regulations 45CFR46 (2) Tests, surveys, interviews, or observation on 2/8/2016.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,