Complexity and Modularity in the Brazilian Automobile Supply Chain

Abstract

Global markets are becoming increasingly challenging due to the rapid changes in technology and heterogeneous customer expectations. In pursuit of capturing these changing preferences, firms such as assembly plants are required to face substantial manufacturing obligations due to this increasing product complexity. In the automobile industry, modularization has been suggested as an effective approach to manage this complexity. Our study focuses on the moderating effect of modularity and supplier-buyer integration on the relationship between firm performance and product portfolio complexity. Based on our study in the Brazilian automobile industry, we empirically test the argument that product modularity and supplier-buyer integration could mitigate the negative influence of complexity on firm performance.

Keywords: complexity, modularization, supplier-buyer integration, knowledge-based view

INTRODUCTION

Since the roots of intellectual debate in Ancient Greece, philosophers and scientists have recognized the pervasive and relentless state of change in which we exist. The ability to recognize and adapt to change creates opportunities for firms to establish a competitive advantage. Firms' ability to adapt to technological change (Porter, 1985) and changes in consumer preferences (MacDuffie et al., 1996), in particular, are two prominent determinants of comparative performance. Modularization is one-instrument firms have implemented to position themselves for success as modern technology becomes increasingly complex (Baldwin & Clark, 1997). Indeed, modularity itself can be defined as, "a very general set of principles for managing complexity" (Langlois, 2002). Research has proposed that modularization can act as a catalyst for transfer of knowledge between assemblers and suppliers and consequently improve strategic positional advantages. While relationships between interfirm knowledge transfer, product complexity, modularization and performance, have been conceptually explored in extant literature, a definitive, empirically supported model incorporating all these constructs has not yet been established. Prior research suggests that modularity indirectly improves performance when mediated by high model variety (Warren et al., 2002). This model however, seems to contradict findings that product variety increases various manufacturing costs (Anderson, 1985; Heide & John, 1990). Thus, we seek to answer the question, how do modularization, product complexity, and performance interact in manufacturing networks?

To answer our research question, this paper utilizes data from manufacturing firms within the automotive industry's supply chain. This setting is advantageous for addressing our topic for several reasons. The automotive industry is characterized by high market uncertainty (Dyer & Chu, 2000). This market uncertainty in turn may increase the prevalence of radical innovation for customer relationship and technology oriented firms (Han et al. 1998; Sainio et al., 2012). Indeed, relatively high levels of radical innovation have been identified as a feature of the automotive industry (Howell, 2003). Radical innovation in an existing market leads to major process innovation (Tushman et al., 1997) where architectural knowledge is preserved while component knowledge is destroyed (Chandy & Tellis, 1998). This radical innovation is a result of capability development proceeded by knowledge creation (Popadiuk, & Choo, 2006). Ultimately, innovation can directly create a competitive advantage for a firm (Nonaka & Takeuchi, 1995). Within the automotive supply chain, modularization allows knowledge and technology to transfer between assemblers and suppliers, reducing costs derived from tacit knowledge management (Kotabe et al., 2007) and allows firms to implement production through flexible modular organization structures (Sanchez & Mahoney, 1996; Kotabe et al., 2007). Previous research indicates that modularity spurs innovation in product design (Baldwin & Clark, 1997), and we propose that modular design itself an instrument in firms' knowledge creation following Nonaka & Takeuchi's circular knowledge creation framework (2002) by facilitating transformation of tacit knowledge to explicit knowledge.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

Complexity

A complex system is described by Simon (1962:195) as "one made up of a large number of parts that interact in a nonsimple way. In such systems the whole is more than the sum of the parts, not in an ultimate, metaphysical way but in the important pragmatic sense that given the properties of the parts and the laws of their interaction, it is not a trivial matter to infer the properties of the whole". In Simon's seminal piece, the hierarchic structure is highlighted as an effective way to address complexity as the original integral system can be decomposed into a small number of subsystems (Simon, 1962). These subsystems are interrelated to each other, but a much denser interaction may occur in different components across levels (Augier, 2000; Simon, 1962). In a nondescomposable system, failure in one component may lead to the overall failure of the entire system (Cantwell & Howard, 2010). As such, restricting the interactions between these subsystems is the key to reduce system-wide failure. And the principle of *decomposable system* has been raised as a prescription to reduce complexity for managers (Langlois, 2002; Simon, 1962).

In past decades, the theory of complexity has been applied into operational management field. A number of studies have identified various antecedents of complexity derived from either product or process. For example, Kotha and Orne (1989), in their manufacturing structure typology, proposed measuring interconnection with variety of final product and level of mechanization. Likewise, Jacobs and Swink (2011) found that multiplicity, diversity, and interrelatedness of products within the portfolio could lead to negative performance. Indeed, manufacturing industry is considered to be a good context for complexity research because the product and process is becoming much more complex today considering the increasing technology improvement and heterogeneous customer demands. In the meantime, the difficulties of coordination associated with managing various subsystems could impede production efficiency (Hobday, 1998; Novak & Eppinger, 2001) in that the greater number of parts the business needs to manage, the greater the logistical requirements of material flow and administrative requirements (MacDaffie et al., 1996).

In this context, modular system is a suitable solution for problems related to complexity, a "*nearly decomposable system*" (Simon, 1962). Indeed, a number of studies have suggested that modular system is an effective way to address complexity. Baldwin and Clark (1997, 2000) suggest that to decompose a system into modules reduce complexity. In a similar vein, Langlois (2002:20-21) suggest that to "reduce the number of distinct elements in the system by grouping components into a smaller number of subsystems." Even though the idea of modularization has been highlighted in prior research, few attempts have been made to empirically examine the important role of modularization. In this study, we will empirically test the moderation effect of complexity on the relationship between modularization and business unit performance. We will focus on product variety and interdependence as two types of product complexity which echoes Langlois's (2002:20) definition of complexity "a matter both of the sheer number of distinct parts the system comprises and of the nature of the interconnections or interdependencies among those parts."

Product portfolio complexity. Product portfolio complexity refers to the diversity of product portfolio offered toc customers (Choi et al.,2016; Gupta & Lonial, 1998). Product variety refers the number of final product variants offered to customers (Gupta & Lonial, 1998). It allows firms to offer customers a wide array of options so as to increase customer satisfactions (Fang, 2008; MacDuffie et al., 1996; Choi et al., 2016). However, such a decision is likely to bring about a number of challenges to the performance of operations (Salvador, 2005). Product variety tends to generate coordination cost increases during the product development stage because the increased number of models is also associated with higher levels of difficulty in operational assembly and manufacturing systems, which, in turn, negatively influence the performance of assembly systems (Flynn & Flynn, 1999). The underlying logic is that the asset specificity associated with product variety will increase transaction costs in the entire manufacturing process (Anderson, 1985; Heide & John, 1990). For example, more model variants give rise to an increase in the number of platforms and body styles, increasing the set-up costs due to switching between platforms and bodystyles. In addition, production workers needs to deal with more complicated array of different parts (MacDaffie et al.,1996). As a result, it is much more difficult to balance the assembly line for consistent cycle times at each work station because of the varied models and option combinations.The invariable diversification of some purchased product components (Fisher et al., 1999) tends to generates higher unit costs, relatively lower production volume in a product line, and subsequently higher requirements for coordination generate (Worren et al., 2002).

In general, the complexity derived from product variety exists both within the assembly plant (e.g. scheduling machines, parts inspection and delivery, and installations) and in coordinating with suppliers (e.g. scheduling delivery, coordination and communications) (MacDuffie et al., 1996). As such, in the automobile industry, the expansion of product variants has a significant and adverse impact on total labor and overhead hours per car resulting in longer manufacturing lead times (Thnemann & Bradley, 2002). Therefore, product variety, as a primary indicator of complexity, will impede firm performance.

Hypothesis 1 (H1): Product variety is negatively related to business unit performance.

Product architecture complexity. Interdependence reflects the mechanism in which components have to be integrated and connected to each other into final products (Corso et al., 2001). Complexity exists when a large number of elements are interdependent (Lawrence & Lorsch, 1967; Thompson, 1967; Larsen et al., 2013). Complexity derives from multiple interactions among components or subsystems (Khurana, 1999). Making changes to one component results in changes to others, because such components are tightly coupled and interconnected in a system (Novak & Eppinger, 2001, Worren et al., 2002). This ripple effect is likely to enhance the complexity during the product development and manufacturing process (Zhou, 2011). For example, in the automobile industry, adding additional modules in the doors and body, requires additional electronic testing, validation, tracking and design (Novak & Eppinger, 2001).

A variety of interactions between components/modules increases the production program complexity (Blecker, Abdelkafi, Kaluza & Kreutler, 2004). Indeed, the interdependence between different components also increases the interaction and coordination between suppliers and assemblers. The associated coordination communication, information processing, and decision making tend to enhance overall transaction costs (Marschak & Radner, 1972). In this paper, we proposed that interdependence will have an adverse impact on business unit performance.

Hypothesis 2 (H2): Interdependence is negatively related to business unit performance.

Knowledge Based View

Knowledge based view (KBV) is rooted in the resources-based perspectives (Barney, 1991) and considers knowledge as the most essential strategic resources of the firm (Grant, 1996). The firm itself becomes an institutional actor fostering knowledge integration (Demsetz, 1991; Grant &Baden-Fuller, 1995) through the discrete processes of creating and applying knowledge (Kogut & Zander, 1992; Nonaka, 1994; Udo & Kogut, 1995; Grant & Baden-Fuller, 1995; Modi & Mabert). The importance of knowledge for firms is frequently highlighted in interfirm relationship studies. For example, knowledge transfer among organizations demonstrably facilitates mutual learning and inter-firm cooperation, generating opportunities for innovation and enhanced firm performance (e.g. Kogut & Zander, 1993; Tsai, 2001). Kotabe et al (2003) suggest greater technical exchange and technology transfer between suppliers and buyers could eventually contribute to suppliers' performance. Indeed, organizations can obtain a long-term competitive advantage by creating knowledge (Kogut & Zander, 1992) and by integrating organizational knowledge (Grant, 1996).

Knowledge based perspective suggests explicit and tacit knowledge are the major two types of knowledge in use for organizations (Nonaka, 1994; Polanyi, 1962). Explicit knowledge refers to knowledge that can be codified and easily transferred (Grant & Baiden-Fuller, 1995). Tacit knowledge is obtained through personal experience and thus is hard to articulate and formalized such as technology and know-how (Nonaka, 1991; Nonaka & Takeuchi, 1995; Polanyi, 1962, 1966). More importantly, tacit knowledge is "rooted in action and in an individual's commitment to a specific context—a craft or a profession, a particular technology or product market, or the activities of a work group or team" (Nonaka, 1991:98). Given these above unique characteristics, tacit knowledge is often more difficult to imitate, substitute, and transfer than explicit knowledge (Grant, 1996). As a result, these features make tacit knowledge an important source of sustainable competitive advantage (Nonaka, 1991; Grant, 1993; Spender, 1993).

Within the knowledge-based view, the theory of knowledge creation holds that knowledge (action-based beliefs and commitment) produced in an organization can be converted between explicit and tacit to facilitate its transfer (Nonaka & Takeuchi, 1995). There are four modes of knowledge conversion, socialization, externalization, combination, and internalization. In practice, firms import tacit knowledge to combine with existing organizational knowledge, convert it to explicit (conceptual knowledge), transfer it within the organization (while exporting a portion to the market) as explicit (systemic) knowledge, and recycle the knowledge within the organization as tacit (operational) knowledge to be combined with new external tacit knowledge, beginning the process anew (Nonaka & Takeuchi, 1995). The importation of tacit knowledge through socialization necessitates interaction between suppliers and buys, as measured in this study. Here, we argue that strategic and product modularization (the creation of systemic architecture that aligns with buyers' higher-level systems) provides direct evidence of effective externalization and combination.

The general stickiness (resistance to being transferred) of tacit knowledge is evident in automobile and auto parts manufacturing. Component and module suppliers are typically provided explicit product specifications through OEMs' online portals, but their proficiency is derived from their capacity for incorporating their accumulated tacit knowledge during the manufacturing process. For example, "the automaker would assign the whole cooling system development to an independent supplier, which will handle radiator, hoses and steel clamps to make sure that the cooling system will work properly as a module. In this case, the design of a modular cooling system will contain all the necessary information required to produce each module at the supplier level, by integrating the tacit knowledge involved in each module" (Kotabe et al., 2007:87). As product variety and interdependence between subsystems increases, the necessity of efficient tacit knowledge transfer increases.

Strategic modularization (modularization) addresses complexity through efficient knowledge outsourcing. Baldwin and Clark (1997, 2000) first suggested partitioning of information as a way to address complexity through which information is disseminated into visible design rules and hidden design parameters. Modularization tends to reduce complexity by isolating tacit knowledge at the suppliers level and integrating tacit knowledge within independent modules that comply with a standard interface designed by the assembler in conjunction with its suppliers (Kotabe et al., 2007). These independent modules interact with one another through standardized interfaces (Langlois, 2000) and the knowledge associated with making up the modules ends up with being isolated to different suppliers. As a matter of fact, the transfer of tacit knowledge in manufacturing to suppliers reflects the nature of modularization in that the process effectively reduces the cost of managing tacit knowledge from the interfaces. In this study, we will look into two aspects of the modularization process -- product modularity and supplier-buyer integration, and see how these two dimensions moderate the relationship between complexity and performance.

The Moderating Effect of Modularity and Supplier-Buyer Integration

Product Modularity. Product modularity refers to a design property of product architecture (Ulrich, 1995). The concept of modularity is usually intertwined with modularization which the latter refers to the process that affects those designs (MacDuffie, 2013). A more applied definition of modularity is that "a special form of design which intentionally creates a high degree of independence or 'loose coupling' between component designs by standardizing component interface specifications." (Sanchez and Mahoney, 1996:65). Product modularity facilitates improving compatibility between product variety requirements and operational performance (Hoekstra & Romme, 1992; Salvador, 2005). The complexity derived from product variety and interdependence can be reduced through this decomposable system. By breaking up a product into subsystems or modules, and even more by recombining modules, most products can be reconfigured to achieve higher variety and reduce development time (Baldwin & Clark, 2002; Parente et al., 2011; Worren et al., 2002). Modules could be changed and improved over time without discounting the functionality of the whole (Baldwin & Clark, 2002). Compared to integral designs, the reuse of standard modules reduces the time and cost of switching between components (Worren et al., 2002). Therefore, different combinations of standard modules are able to form a wide range of new products, encouraging firms to leverage their existing resources and apply them to new uses (Worren et al., 2002).

Product modularity also moderates the negative effect of interdependence and firm performance. In automobile industry, the complexity of the end product necessitates high levels of interdependency among modules and components. In highly interdependent systems, changing one part of the system tends to influence the entire system. Product modularity reduces interdependence between related elements as it allows one-to-one correspondence between subsystems and functions (Takeichi, 2011). This independence allows automakers to adjust product designs without redesign and retest of new components and modules by using pre-designed components (Fujimoto & Nobeoka, 2004). As previously discussed, being capable of ‘mix-and-match’ components enables automakers to offer greater product variety and reduce overall design and production costs (Sanchez & Mahoney, 1996). Cross-module dependencies are effectively managed through standardized interfaces (Srikanth & Puranam, 2014). Based on this common interface and standardized specification, assemblers are able to efficiently integrate the modules into vehicles (Sako, 2003) and coordinate production (Schilling, 2000; Kotabe et al., 2007).

Hypothesis 3a (H3a): Product modularity tends to mitigate the negative relationship between product variety and business unit performance.

Hypothesis 3b (H3b): Product modularity tends to mitigate the negative relationship between interdependence and business unit performance.

Supplier-Buyer Integration. Supplier-buyer integration is also highlighted as one of the important dimensions of strategic modularization (Kotabe et al., 2007). As a matter of fact, the transfer of tacit knowledge between automakers and suppliers plays an important role in alleviating the costs that accompany complexity. In the case of automobile industry, even though assemblers or suppliers are following all the technical specifications for the systems, these components may not work properly together (Kotabe et al., 2007). Such tacit knowledge embedded in this process as certain tasks might need to be performed before others, and more persons may need to share resources at the same time could result in an inefficient outsourcing strategy (Kotabe et al., 2007). As Grant (1996) indicates, tacit knowledge or know-how could be rather difficult to be transferred because tacit knowledge is based on personal and intuitive knowledge—obtainable only through collaborative experience. As a matter of fact,the successful transfer of tacit knowledge requires closer interactions and shared understanding between suppliers and buyers.

Supplier-buyer integration alleviates the negative impacts derived from product variety by facilitating tacit knowledge integration in the manufacturing process. As the number of product models increase, the management of coordination tends to be more complex, making the tacit knowledge to be even harder to transfer. However, greater supplier-buyer integration in the production process creates higher levels of knowledge sharing, which in turn facilitates the transfer of tacit knowledge (Lakshman & Parente, 2008). For example, suppliers will assign key personnel to work near the assembly line in the manufacturing plants or even join the original product design so as to ensure the smoothness of operations (Parente et al., 2011). Furthermore, cross-functional teams that combine the skills and knowledge of OEM and supplier employees can facilitate suppliers' achievement of OEMs' desired product performance. This collaborative effort enables supplier-manufacturer chains to become flexible under heterogeneous customer expectations (Millington et al., 1998; Takeishi, 2001).

Hypothesis 4a (H4a): Supplier-buyer integration tends to mitigate the negative relationship between product variety and business unit performance.

Hypothesis 4b (H4b): Supplier involvement mitigates the negative relationship between interdependence and firm performance.

METHOD

Sample and Data Collection.

We conducted a survey to collect primary data in the Brazilian automobile industry. Brazil is well-suited for this study because it is the only country that has all global car manufacturers (including American, European and Japanese) with facilities to produce vehicles for both domestic and overseas markets. As the largest emerging market in South America (The Economists, 2012), Brazil has the highest predicted development rates in the next two decades and immense FDIs into the automotive, telecommunication, internet, and computer hardware technology sectors (Gouvea, 2004). Enterprises in such emerging markets have been pushed to face strong environmental pressure for change (Hoskisson et al., 2000).

Our qualitative data was collected through secondary sources, observation during plant visits, and in-depth semi-structured interviews. The automobile and suppliers' manufacturers were identified through lists by the Anfavea (Brazilian Automakers Association) and Sindipecas (Brazilian Auto Suppliers Association). We interviewed plant managers, manufacturing supervisors, supply-chain managers, and purchasing managers from four major automakers in Brazil (i.e. General Motors, Volkswagen, Ford, and Daimler Chrysler), in addition to their on-site suppliers in Brazil.

Data collection was accomplished through several steps. The empirical survey data was collected in four separate phases by sending out our survey questionnaire in 2002, 2005, 2008, and again in 2012. Our initial qualitative data was collected in 2002 through secondary sources, observations and in-depth semi-structured interviews. Later in 2008, we conduct another round of in-depth interviews with automotive manufacturers and their suppliers. Finally, we have a total of 256 observations including OEMs, system and component suppliers.

Survey questionnaire development and Validation

Our survey used multi-item measures, except for product variety. We developed a Likert-scale measurement (1=Strongly Disagree, 2=Disagree Somewhat, 3=Neither Agree or Disagree, 4= Agree Somewhat, 5=Strongly Agree) for the constructs in this study and made an effort to take the items based on existing scales and previous research. However, it was difficult to cover entirely existing scales. So we developed new items based on field studies and hired one expert in automobile industry at the University of São Paulo and one executive from a major automaker to provide feedback and refine key constructs. We then pre-tested a preliminary survey with executives in charge of manufacturing facilities at the firms.

We became aware of several limitations during the research, including (1) informant bias and content validity, (2) non-response bias, (3) common method variance, and (4) potential for incorrect answers caused by a single informant response. We were careful to minimize these issues during the survey. The questionnaire was translated into Portuguese and back-translated into English to allow for detection of any misleading items or interpretation difficulties. Based on Armstrong and Overton's (1997) procedure, we evaluated non-response bias by comparing early and late respondents and found no significant differences between these two groups on any of the variables, indicating that non-response bias exists in our survey. We also use Harman's one-factor test to address the effects of common method variances. We conducted a factor analysis on relevant measures. No general factor was apparent in the unrotated factor structure, indicating that no common method variance problems were detected.

We conducted confirmatory factor analysis (CFA) and assess construct reliability (See Appendix 1). The CFA included measures for our hypothesized theoretical constructs: interdependence, product modular architecture, supplier involvement and business unit performance. The results of CFA demonstrates that this model has a good fit ($\chi 2$ =199.09; RMSEA=0.038; CFI= 0.97205; GFI=0.92406; NFI=0.90385; $p<.005$). The composite reliabilities measured by Cronbach's alpha are well above the cutoff of 0.70 (Straub, 1989). The estimated correlations between factors are not particularly high, thus supporting convergent and discriminant validity (Fornell & Larcker, 1981).

Construct measurement

Our dependent variable is the business unit performance, a typical measure for a dependent variable in international business and strategy research (e.g., Zhang, 2006). We use ROI, return on sales and overall financial performance as measures for business unit performance construct according to prior established items (Narasimhan & Kim, 2002; Worren et al., 2002). The two independent variables are product variety and interdependence. Product variety is a count of the number of various models introduced by the firm in the last 12 months. Therefore, we use standardized items for further analysis. The measure of interdependence is developed based on the framework suggested from previous studies (See Kotha & Orne, 1989). Two moderators are product modular architecture and supplier-buyer integration. We measure product modular architecture based on past established constructs (Worren et al., 2002). The supplier involvement measures supplier and buyer integration (e.g., Dyer & Singh, 1998; Kaufman et al., 2000; Takeishi, 2001). One control variable has been included in this study: firm size. Firm size has been a widely acknowledged control in the dynamic capabilities studies (e.g., Helfat, 1997;

King & Tucci, 2002). Consistent with the previous studies, we use log of firm sales volume as a proxy to firm size.

Results

Table 1 presents descriptive data and the correlation matrix for the variables used in this study. The model was tested with the OLS hierarchical linear regression. Table 2 shows the regression coefficients used where variables were entered sequentially and significance for all the main effect and interacting hypotheses. Hypothesis 1 states that product variety will lead to negative firm performance. We found support in Model 2 (β=-0.143**). Hypothesis 2, which states that interdependence will lead to negative firm performance, is not supported. In Model 3, we test the full model incorporating independent variables and four moderating variables. Hypothesis 3a, 3b, 4a, and 4b test the interacting effects of supplier involvement and modularity in mitigating product variety and interdependence. We found support for H3b (β=-0.185**) and partial support for H4a (β=-0.006) in Model 3. But H3a and H4b are not supported.

[Insert Table 1 and Table 2 about here]

Discussion/Implications

In this study, we explore the impact of modularity and supplier-buyer integration on mitigating the negative relationship between complexity and firm performance. Our findings indicate that product variety, as a major indicator of complexity, is negatively associated with firm performance. Complexity increases coordination costs, but these costs may be reduced through the development of capabilities through knowledge creation (expressed as modularization). This study extends the current research in operational management, demonstrating the benefits of modularity and supplier-buyer integration from a knowledge based view. Implementation of modular architecture and supplier-buyer integration are manifestations of knowledge creation and act to reduce costs generated by complexity, improving profitability. We suggest that modularization reduces complexity by isolating knowledge into different modules and making the manufacture process easier to manage. This knowledge isolation allows the assemblers to increase flexibility and independence.

Our study has implications for further theory development and future research. It suggests that practicing managers should consider deploying a strategy that incorporates modularity to reduce the costs generated from product complexity. Future research could extend this study by examining the impact of supplier-buyer integration in reducing process complexity (as we focus solely on product-level complexity in this study). Scholars could also examine the impact of modularity and supplier-buyer integration on supply chain complexity. Factors such as customer demand variability and long supplier lead times (Zhu et al, 2008) may also increase the degree of uncertainty and cost of coordination. Finally, instead of focusing on static business unit performance, businesses should consider whether their approach to product and process configuration enables is compatible with *sustainable* performance. Thus, future research could investigate whether high modularity and supplier-buyer integration lead to increased performance persistence.

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Table 1

Summary Statistics and Pearson correlations.

	Mean	S.D.	1	2	3	4	5	6
Business Unit Performance	3.904	0.671	1					
Firm Size	19.2	1.925	0.182*	1				
Product Variety	0	1	0.132	0.085	1			
Interdependence	4.041	0.596	0.292**	0.117	0.112	1		
Product Modularity	4.165	0.632	0.380**	0.028	-0.164*	0.320**	1	
Supplier Involvement	4.069	0.7	0.293**	0.004	-0.373**	0.081	0.423**	1

N=256

*p≤0.05; **p≤0.01.

Table 2

Explanatory variables coefficient estimates.

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Firm Size	0.048	0.054	0.056*	0.031	0.027	0.038
Product Variety	0.164**	0.125*	0.131*			0.109†
Interdependence	0.163			0.086	0.135*	0.203*
Product Modularity	0.275**	0.431**		0.161		-0.265
Supplier Involvement	0.252**		0.433**		0.674*	1.207*
Product Variety × Product Modularity		-0.207**				-0.221
Product Variety × Supplier Involvement			-0.130*			-0.007
Interdependence × Product Modularity				0.5		0.145

Interdependence × Supplier Involvement	-0.106	-0.213*

N=256.

† p≤0.10; *p≤0.05; **p≤0.01.