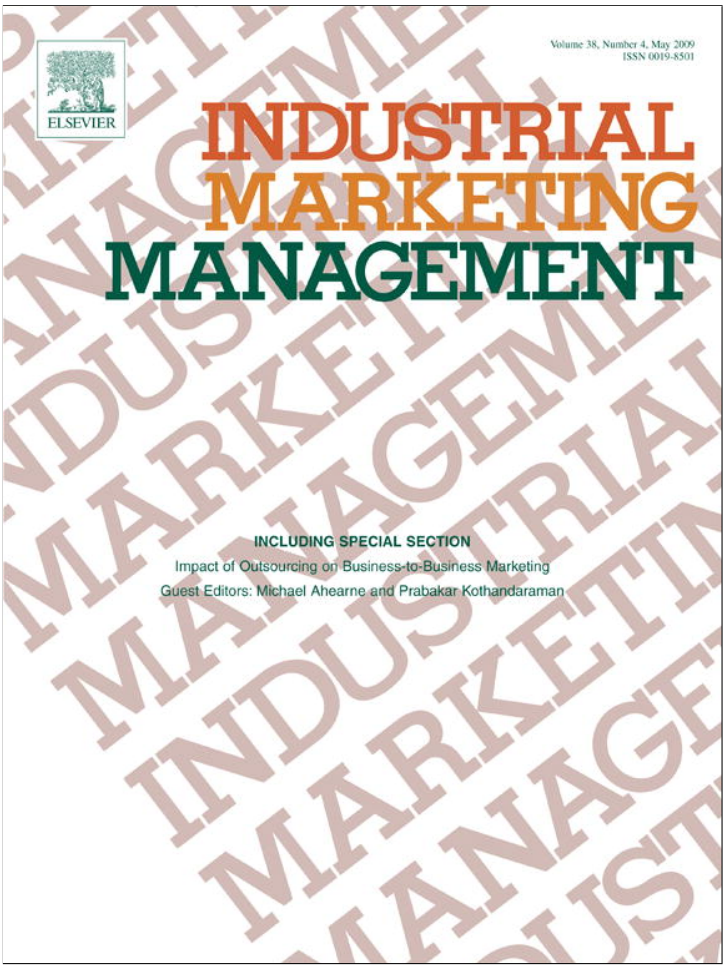

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Portfolio of controls in outsourcing relationships for global new product development

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ABSTRACT

Due to increasing globalization and technological discontinuities, firms strive to develop new product capabilities and flexibilities by engaging in outsourcing activities and adopting modular systems. However, these strategies contain *risks* of opportunistic expropriation of tacit knowledge and *costs* related to monitoring sourcing partners who are geographically and culturally distant. This study examines the antecedents of control mechanisms through which firms manage the risks and costs associated with outsourcing relationships in global technology-intensive markets. Modularity in design is hypothesized as a moderator of model relationships because it can serve as a substitute for formal or informal controls in a "controls portfolio".

1. Introduction

Technological advances and increasing globalization characterize the current business milieu and have radically transformed the competitive landscape. Consequently, firms increasingly strive to develop new product development (NPD) capabilities and achieve strategic flexibility through outsourcing and adopting modular systems (Carson, 2007; Garud & Kumaraswamy, 1993; Schilling, 2000). The phenomenon of downstream buyers cooperating with upstream suppliers to introduce new products and/or components is prevalent across a spectrum of industries including consumer-electronics, textiles, automobiles, metals and pharmaceuticals[1] (Bettis, Bradley, & Hamel, 1992; Kotabe & Murray, 1990, 2004). Furthermore, the popular press has increasingly documented the prevailing use of outsourcing, and it appears that organizations are increasingly turning to globally sourcing their components and/or designs instead of spending millions of dollars to design and develop them internally. According to the Quarterly Index from outsourcing advisory firm TPI (15 February 2006 in The Economic Times), the value of major outsourcing contracts was $75+ billion worldwide in 2005. In 2006, the major players in global sourcing deals include IBM Corp., Accenture Ltd., Electronic Data Systems Corp., Computer Sciences Corp. and HP Co. — all have signed contracts exceeding $1 billion in value (12 July 2006 in The Wall Street Journal). Most importantly, such a rise in offshoring of new product development activities create the possibility of shifts in the global power structure and thus entail significant consequences for the world economy (Ernst, 2006).

Meanwhile, the study of interfirm relationships in technology-intensive (TI) markets has attracted significant research attention in the new product, marketing and management literatures (Dutta & Weiss, 1997; John, Weiss, & Dutta, 1999; Teece, 1988; Wuyts, Dutta, & Stremersch, 2004). In the extant literature, the term 'high technology' has typically been used to define markets characterized by rapid technological change (Bourgeois & Eisenhardt, 1988) and as John et al. (1999) suggest, "significant amounts of scientific and technical know-how" (p. 79). An understanding of TI markets requires a focus on the presence and transfer of know-how and the difficulties related to knowledge transactions (Glazer, 1991; Kogut & Zander, 1992; Teece, 1988). Rapid technological change and global competition create the risk of obsolescence of knowledge and capabilities, and thus such markets enduce buyers to engage in sourcing activities and supplier relationships on a global scale (Harrigan, 1985; Kotabe & Murray, 1990; Swan & Allred, 2003; Weiss & Heide, 1993). Many successful companies depend on outsourcing to remain agile in coping with market dynamics as well as to expand their global operations. Outsourcing, primarily perceived and employed to reduce costs, recently has become a widespread and fundamental tool for competitive advantage. However, these supplier relationships also entail additional threats such as the potential leakage of tacit know-how and (over)reliance on suppliers' resources and capabilities (Dutta & Weiss, 1997; Heide & Weiss, 1995; Kotabe & Murray, 2004). As documented in the business press, such risks can be mitigated by monitoring supplier operations during and assessment of supplier performance prior to and after the outsourcing transaction process (13 January 2005 in Legal IT).

Another important feature of TI markets is the increased utilization of modular product architectures as the basis for new product designs and development (Katz & Shapiro, 1994; Sanchez, 1995; Schilling, 2000; Stremersch, Allen, Benedict, & Ruud, 2003). Modularity is created by standardizing the interfaces between functional components and

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[1] According to the McKinsey Co. 2005 quarterly report, automotive components, fabricated metals, and pharmaceutical industries are among the manufacturing sectors that are increasing share in offshoring.

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specifying greater reusability and commonality of components among product families (Staudenmayer, Tripsas, & Tucci, 2005; Sanchez & Mahoney, 1996; Wilson, Weiss, & John, 1990). The benefits include the ability to increase product variety offered, accelerate the speed-to-market and reduce the marketing and technological resources required to commercialize new products. More important, these systems provide a structure that coordinates the loosely coupled activities of component developers reducing switching costs, the risk of marketing and technology know-how leakage and the need for close monitoring of agents' behavior (Garud & Kumaraswamy, 1993; John et al., 1999; Prahalad & Bettis, 1986). Modular systems enable the coordination of a loosely coupled organizational structure linking geographically dispersed component developers (Kogut & Kulatilaka, 1994), thereby making outsourcing of research and development activities possible (Howells et al., 2003; Mikkola, 2003; Pisano, 1990). Thus, interfirm modularity not only brings operational advantages, but also enhances the firms' capability in managing their relationships.

Prior research on buyer behavior in global high-technology markets has focused on specific outcomes (make versus buy decisions) as opposed to buyers' underlying processes (Kotabe & Murray, 1990; Walker & Weber, 1984; Weiss & Heide, 1993). Hence, there is lack of research on the formal and informal controls the buyers exert on their suppliers in their outsourced new product projects to prevent risks, such as marketing and technological know-how leakage and diffusion to competitors. Buyers generally strive to minimize the likelihood of opportunistic expropriation of tacit technological knowledge, eliminate the difficulties related to monitoring their partners due to geographical or cultural distance, and avoid switching costs tied to their suppliers; these risks are especially high when many external linkages and dependencies exist (Pisano, 1990; Tidd, 1995). As cited in an article in BusinessWorld, 'if done right, outsourcing can be a powerful business tool' (January 13, 2005). Therefore, it is critical to understand how buyer firms manage their NPD outsourcing relationships in global TI markets. Relevant diverse streams of research include *agency*, *resource dependence* and *transaction cost theories* (Ouchi, 1979; Pfeffer & Salancik, 1978; Williamson, 1985; Eisenhardt, 1985; Rindfleisch & Heide, 1997).

This research particularly focuses on the unique opportunities, risks, and control portfolios associated with modular systems designs, which have also been suggested as a possible solution to the challenges associated with global sourcing by Kotabe and Murray (2004). Modularity enables the coordination of loosely coupled and flexible organizational structures linking geographically dispersed component developers via standardized interface specifications and feasible divisions of tasks in functional specification (Mikkola, 2003; Schilling, 2000; Wilson et al., 1990). Hence, through standardization and flexibility achieved, such interface management systems may allow firms to adopt different control portfolios in managing their NPD outsourcing activities and provide design-embedded control reducing monitoring costs and enforcement difficulties (Sanchez, 1999; Staudenmayer et al., 2005).

Overall, grounded in the new product, marketing, and management literatures, the primary contribution of this research is to provide a conceptual framework that explicates the antecedents of the control portfolios that buyers exert on their suppliers in global TI markets. The key questions can be summarized as:

(1) In global technology-intensive markets, what are the portfolios of control mechanisms that buyers exert on their suppliers in outsourced new product projects (with modular architectures)?
(2) What determines the particular combinations of controls utilized in these buyer–supplier relationships? That is, what are the antecedents of control portfolio utilization?
(3) How does modularity impact the relationships between control mechanisms in control portfolios and their antecedents? Does modularity serve as a substitute for formal or informal controls?

The paper is organized as follows: first, different types of control mechanisms potentially employed in a buyer's portfolio are introduced. Then the theoretical framework of antecedents of controls in outsourcing relationships for global NPD is explained. Finally, the role of modularity in moderating the relationships of these antecedents with the buyer's portfolio of controls is examined.

2. Conceptual development: types of control mechanisms

Control is defined as behavioral, that is, 'attempting to ensure individuals or teams act in a manner that is consistent with achieving desired goals' (Anderson, 1985; Eisenhardt, 1985; Ouchi, 1979). Control mechanisms are broadly divided into formal versus informal (Jaworski, 1988; Jaworski & MacInnis, 1989). Formal controls rely on written mechanisms that influence behavior through performance evaluation and rewards. In contrast, informal control mechanisms (such as social norms, peer pressure, shared beliefs and experiences) utilize social strategies to reduce goal differences between the principal (i.e., buyer) and agent (i.e., supplier). Based on various criteria, these two broad categories of controls are also disaggregated into subcategories with distinguishing characteristics (Jaworski, Stathakopoulos, & Krishnan, 1993).

Two types of formal controls, i.e., outcome and behavior controls, differ based on the degree of supervision, the objectivity of the evaluation procedures, and the time window (Eisenhardt, 1985; Oliver & Anderson, 1994; Krafft, 1999). Outcome control is typified by the principal's (i.e., buyer) focus on the outputs of the NPD project. Buyers that employ such mechanisms evaluate their suppliers based on desired project goals or outcomes and reward them for meeting those goals (e.g., functional specifications, target implementation date, performance of the product or component). As an illustration, to control other companies' copying of their products and processes, Sharp assembles parts it orders from different suppliers evaluating them based on the performance of these parts (16 December 2003 in The Wall Street Journal). In behavior control, on the other hand, the buyers seek to influence the process, or the means of goal achievement. By explicitly prescribing rules and procedures and closely observing the suppliers' behaviors, buyers reward their suppliers based on the extent to which they follow stated procedures (e.g., development methodology, placing buyer personnel on supplier premises, or weekly progress reports) (Eisenhardt, 1985; Jaworski & MacInnis, 1989; Stump & Heide, 1996). For example, some companies like Xoceco choose to send teams of audits to monitor the supplier's processes and development methods (16 December 2003 in The Wall Street Journal). Therefore, due to their emphasis on process behaviors over outcome results, behavior-oriented controls involve greater supervision and contact, more subjective evaluation methods, and tend to have a longer time perspective.

Informal controls have been categorized based on whether they are implemented by (or exert an influence on) a social group versus an individual. Clan control is implemented through mechanisms that minimize the differences between preferences (Eisenhardt, 1985) by transmitting common values, beliefs, and philosophy within the clan (Ouchi, 1979; Wathne & Heide, 2000). Examples include structuring the relationship so that it is strategic to both parties and socializing by executives through regular joint meetings. To protect their own reputation or the relationship with the buyer, the supplier may practice self control engaging in behavior consistent with the best interests of the buyer without formal controls. The supplier determines both the goals and the actions through which they should be achieved (as in self-regulated teams). For instance, in the NPD context, members of the supplier team may determine the specific process through which a new system is to be developed, or a specific timeline for new product or module delivery, and then monitor their own compliance with the self-prescribed behaviors and/or outcomes. Allegro Manufacturing, a provider of capital equipment systems

integration and manufacturing outsourcing services, gives high importance to trust building in their partnerships and invests on heavily on delivering the quality to their buyers (18 January 2006 in Business Times Singapore).

Although the various classes of control mechanisms are distinct in the actions or the approach required for their execution, controllers often use both in combination, creating a portfolio of controls (Jaworski, 1988; Oliver & Anderson, 1994; Stump & Heide, 1996). In past literature, most researchers have examined one type of control in isolation (e.g., Ouchi, 1979; Thompson, 1967). However, Jaworski et al. (1993) and others advocated focusing simultaneously on multiple controls. For example, Ouchi (1979)'s original conceptual work focused on each control independently, but acknowledged that the "problem of organization design is to discover that balance of socialization and measurement which most efficiently permits a particular organization to achieve cooperation among its members" (p. 846). Controls may combine synergistically to influence the achievement of a given objective and may be most effective when formal and informal techniques are bundled.

3. Conceptual development: theoretical model overview

Past research has suggested that the problems in high-technology markets are of two different kinds from a buyer's perspective. First, these markets are characterized by considerable uncertainty due to (1) heterogeneous and rapidly changing technologies, and (2) lack of relevant prior marketing and technological experience on part of the buyers (Dosi, 1988; Glazer, 1991; Teece, 1988; Von Hippel, 1986). Thus, buyers may choose to outsource their NPD activities and engage in partnerships with their suppliers in order to combine resources, capabilities, and knowledge bases (Kotabe & Murray, 1990; Pennings & Harianto, 1992; Wuyts et al., 2004). Buyers aim to enhance flexibility and market competitiveness, and to lower transaction and production costs (Ragatz, Handfield, & Scanell, 1997; Vickery, Calantone, & Droge, 1999). The second problem is switching costs as a result of earlier buyer commitments to particular product technologies or suppliers (Heide & John, 1988; Heide & Weiss, 1995). As a result, even though past relationships constitute avenues for interfirm learning and increase firms' adaptability, they create a degree of supplier–buyer interdependence (Carson, 2007; Mikkola, 2003; Wasti & Liker, 1997). Overall, the costs and consequences of outsourcing for buyers include external dependence, functional mismatches, and coordination difficulties, along with the gradual loss of design, manufacturing, marketing and other knowledge-based capabilities (Appleyard, 2003; Swan & Allred, 2003; Wilson et al., 1990). The most important risk–one that can lead to rapid loss in competitive power–is leakage through suppliers of both technical and marketing know-how to competitor firms (especially at the design stage) (Kotabe & Murray, 2004; Mikkola, 2003; Wagner & Hoegl, 2006).

In summary, buyers are faced with the necessity to implement certain control mechanisms to govern the risks and dependencies in their supplier relationships, which they initiate due to external threats and dependencies. These arguments are embedded in *agency theory* (Eisenhardt, 1985, 1989; Ouchi, 1979; Thompson, 1967), *resource dependence theory* (Anderson & Narus, 1990; Heide & John, 1992; Pfeffer & Salancik, 1978) and *transaction cost economics* (Rindfleisch & Heide, 1997; Walker & Weber, 1984; Williamson, 1975, 1991). Transaction cost and agency theories are consistent with resource dependence theory in that they both view non-market governance and controls as a response to *task characteristics* (or the factors that contribute to the risk of the suppliers' engaging in opportunistic behavior), *environmental uncertainty*, and *dependence* (Heide & John, 1990; Bergen, Dutta, & Walker, 1992; Weiss & Heide, 1993). Agency and transaction cost theory are also complementary: both theories examine the efficiency aspects of how firms organize relationships, and focus on the appropriate control mechanisms that reduce transaction and relational costs (Anderson, 1985; Bergen et al., 1992; Heide & John, 1988; Krafft, 1999; Rindfleisch and Heide, 1997). A synthesis of the three theories implies that transaction-specific investments, the expertise and skills of the buyer and the supplier, monitoring and risk-bearing costs, and technological uncertainty all determine the efficiency and effectiveness of the controls for a particular relationship (Barney & Ouchi, 1986; Heide, 1994; Stump & Heide, 1996).

The primary assumptions of agency and transaction costs theory can be summarized as *environmental uncertainty* (i.e., inability to specify ex ante the conditions surrounding an exchange which gives rise to adaptation problems), *information asymmetry* (i.e., the lack of complete information one party holds as to what the behavior of the other will be), *behavioral uncertainty* (i.e., uncertainty related to the outcome of the agent's behavior creating performance evaluation problems), and *opportunism* (i.e., the self-interest seeking features and divergent goals of the parties that create safeguarding problems) (Anderson, 1985; Bergen et al., 1992; Pfeffer & Salancik, 1978; Rindfleisch & Heide, 1997; Williamson, 1975, 1991). The basic premises of resource dependence theory, on the other hand, are based on the assumption that the lack of sufficient resources and/or capabilities to complete a task creates dependence on the parties from whom the resources are obtained and introduces uncertainty into a firm's decision making (Ganesan, 1994; Heide & John, 1988, 1992). This uncertainty occurs to the extent that the resource flows are not subject to the firm's control, and may not be predicted accurately. These notions are applicable to NPD outsourcing relationships that are usually initiated due to the buyers' need to control key technologies in the value chain and manage the technological turbulence they face in their operating environment.

The buyer–supplier link constitutes a market exchange mechanism in transaction costs terminology, but can also be viewed as an agency relationship as the buyer (i.e., the principal) attempts to gain accurate product/component information and desired benefits from a supplier (i.e., the agent) (Bergen et al., 1992). If (1) the relationship is supported by transaction or relationship specific investments, (2) the buyer firm lacks the expertise necessary to evaluate the quality of the outsourcing service, (3) the buyer's knowledge frequently becomes obsolete due to rapid change, and/or (4) the supplier's capabilities with the activity to be outsourced makes the relationship irreplaceable or replace at a cost for the buyer firm, the supplier may be tempted to exhibit opportunistic behavior in the forms of moral hazard[2], adverse selection[3] and/or imperfect commitment (Ouchi, 1979; Barney & Ouchi, 1986; Rindfleisch & Heide, 1997; Wathne & Heide, 2000). In the case of NPD outsourcing relationships, such behaviors may be detrimental particularly in instances where certain factors, such as non-modular (i.e., tightly integrated) systems and high supplier involvement, increase know-how leakage. These conditions bring about the need for control mechanisms and realignment of incentives of both parties (Anderson, 1985; Houston & Johnson, 2000; Stump & Heide, 1996; Williamson, 1975). NPD relationships may be controlled in two primary forms: (1) through ex ante contracts (i.e., development agreements), or (2) through complementing formal contracts with ex post or on-going control portfolios (Carson, 2007; Stump & Heide, 1996). Research suggests that ex ante contractual agreements play relatively limited in role in

[2] The *moral hazard problem* occurs as a result of shirking or evasion of obligations in the ongoing relationship. These are considered forms of opportunism since one of the parties to the exchange is purposely withholding effort or somehow refraining from performing agreed-on actions (Wathne and Heide, 2000).

[3] *Adverse selection* indicates a situation where one party/supplier deliberately committing to a contract that they know they would not be able to fulfill. This may be viewed as opportunism in the sense that one party purposely withholds critical information (Wathne and Heide, 2000).

safeguarding against the mentioned risks, as they increase the buyers' difficulty of contractually defining and accurately assessing supplier performance (Carson, 2007; Pisano, 1990; Wathne & Heide, 2000; Williamson, 1994). Accordingly, this research examines the determinants of the buyers' choice of ex post control mechanisms to manage their NPD outsourcing relationships.

On the whole, this study draws upon *agency*, *resource dependence* and *transaction cost theories* as anchors for a model of the antecedents of the buyer's choice of control mechanisms (in global TI markets, with NPD outsourcing strategies). Fig. 1 depicts the theoretical framework of the determinants of the formal (i.e., behavior and output) and informal (i.e., clan and self) control mechanisms buyers employ. The antecedents of control mechanisms that contribute to their effectiveness and/or efficiency in a particular NPD outsourcing relationship, are classified into three broad categories: (1) *task characteristics*, i.e., the strategic importance of the development project (P1), geographic distance (P2), cultural proximity (P3), and project-related knowledge of the buyer (P4); (2) *environmental uncertainty*, i.e., technological heterogeneity (P5) and discontinuity (P6); and finally, (3) *switching costs*, i.e., component purchase concentration (P7), degree of supplier involvement (P8) and supplier capabilities (P9). This research incorporates aspects of each of these three factors (and also proposes moderating effects). It is hypothesized that task characteristics, uncertainty and switching costs perceived by the buyer firm determine the efficiency of the control portfolios to prevent the supplier from shirking, evading the relationship obligations or withholding information. Finally, all paths are proposed to be moderated by modularity (P10), which regulates interfaces through design.

4. Conceptual development: antecedents to control mechanisms

4.1. Task characteristics

Strategic importance of the component: This construct represents the impact of the development or acquisition of the component on the buyer organization's productivity by providing advantages over its incumbent technology and building competitive advantage (Weiss & Heide, 1993; Robertson & Gatignon, 1986). MNCs like GM, Volkswagen, Federal Mogul, Toyota and Mico have turned particularly to India as a base for sourcing auto components, manufacturing and R&D facilities (14 March 2003 in The Economic Times). AB Electrolux signed a $13-million component sourcing deal with a group of Indian companies (10 May 2004 in The Economic Times). Volkswagen co-develops valves for its new VW engine with Engine Valves. Daimler Chrysler has an R&D hub in India, which is involved in applied research in avionics, simulation and software development.

As TCE and agency theory predict, the closer a particular activity is comes to the firm's technological core, the higher its asset specificity (Swan & Allred, 2003; Teece, 1988; Wasti & Liker, 1997). This brings about the reluctance to relinquish control over the activity and/or the necessity for safeguarding and control mechanisms. As Pfeffer and Salancik (1978) suggest "asymmetry is the true source of power, a result of unequal concentration of resources or unequal perception of the importance of the exchange" (p.52). Moreover, the higher the importance of the new component, product or project, the more inclined buyers will be to protect their tacit technological knowledge against threats of opportunism (Dutta & Weiss, 1997; Wagner & Hoegl 2006). This can be achieved by close monitoring (i.e., behavioral

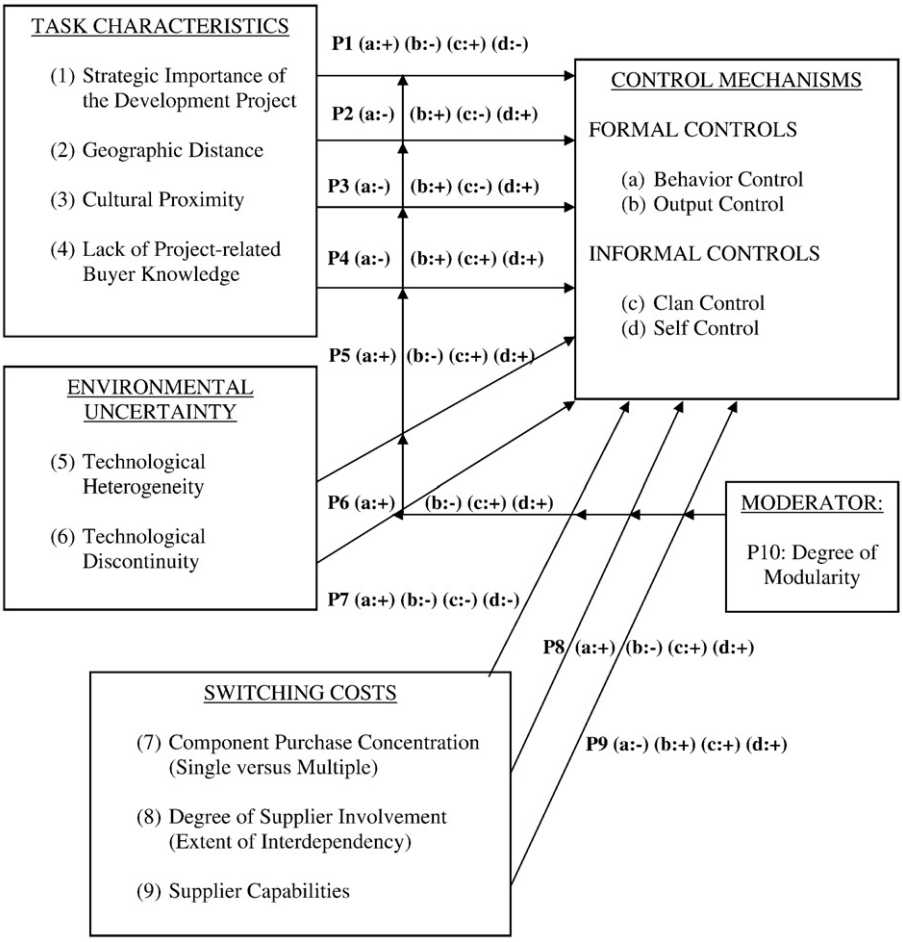

Fig. 1. Conceptual framework.

control) and/or consensus building (i.e., clan control), but output and self control may not suffice. Thus:

P1. *The greater the strategic importance of the component, (a) the greater the use of behavior control, (b) the lower the use of output control, (c) the greater the use of clan control and (d) the lower the use of self control.*

Geographical distance: Many companies are increasingly outsourcing their new product development to suppliers in most cost-effective offshore locations to maintain quality standards and increase speed to market (Carson, 2007). For instance, General Motors plans to increase its sourcing of automotive components from India to nearly US$50 million by 2014, and parts from China to US$4 billion by 2009 (30 April 2004 in Indian Business Insight).

Geographical distance refers to the distance between the physical locations of the buyer and the supplier firm's operations. Despite firms' increasing interest and strategic expectations from offshoring, communication is hindered as spatial separation increase between the buyers and suppliers. A dispersed configuration of outsourcing relationships may increase the difficulty and the cost of coordinating product development activities (Swan & Allred, 2003). Moreover, socialization, shared experiences, beliefs, and common goals may be more difficult to achieve, particularly if the supplier is remotely located. Hence, geographic distance between the buyer and supplier not only escalates operational costs, but also transaction costs (Ghemawat 2001; Rindfleisch and Heide, 1997). Distance may be a barrier to achieving project goals, giving rise to information asymmetry or behavioral uncertainty conditions (Anderson, 1985; Krafft, 1999). As a solution, Chinese apparel suppliers established a 'supply-chain city' to work closely with their buyers, provide them with timely services at the right cost through integrating their operations (13 August 2004, The Wall Street Journal). This led companies like Liz Claiborne to move their designers to these locations and establish fewer, but closer relationships with their suppliers. On the contrary, geographical distances may hinder the implementation of behavioral and clan control, and thus, may lead the buyer firms to employ output and self control mechanisms (e.g., through employing IT technologies and evaluating suppliers' performances based on project/task outcomes). Therefore:

P2. *The greater the geographical distance, (a) the lower the use of behavior control, (b) the greater the use of output control, (c) the lower the use of clan control and (d) the greater the use of self control.*

Cultural proximity identifies the match between the national culture of the buyer and the supplier firms in an outsourcing relationship (Kogut & Singh, 1988; Shenkar, 2001). The basic assumption of agency theory (i.e., self-interest in the presence of diverging goals) tends to be emphasized in individualistic countries (Hofstede, 1980; Sharp & Salter, 1997). Transaction cost researchers indicate that cultural differences may increase the buyers' transaction risks due to their lack of understanding of the norms and institutions that shape the social exchange in such cross-border markets (Brouthers, 2002; Merchant, 2003; Shane, Venkataraman, & MacMillan, 1995). High cultural distance may hinder the buyer's ability to monitor supplier performance and to implement cooperative agreements, increasing transaction costs and the chances of opportunism (Brouthers & Brouthers, 2001). On the contrary, cultural proximity may facilitate goal congruence, relaxing the 'divergence of preferences' assumption of agency theory and reducing the need for behavior and clan control. Thus:

P3. *The greater the proximity of the supplier's culture, (a) the lower the use of behavior control, (b) the greater the use of output control, (c) the lower the use of clan control and (d) the greater the use of self control.*

Project-related knowledge of the buyer: Project-related knowledge of the buyer refers to the marketing and the technical expertise, experience and competence of the buyer in executing the development project (Stremersch et al., 2003). A knowledgeable buyer will possess more confidence and be inclined to specify the exact process the supplier should follow. Thus, a buyer's project-related knowledge should facilitate behavior control (Eisenhardt, 1985; Jaworski & MacInnis, 1989). In contrast, a less knowledgeable buyer may rely on the supplier's abilities and knowledge, thereby reducing the incentive to implement behavior control and increasing the use of outcome control or self control. However, this lack of knowledge (or information asymmetry) may lead to vulnerability on the part of the buyer. When buyers have less marketing and technological know-how than suppliers with which to evaluate the suppliers' performance, buyers incur monitoring costs and face performance ambiguity. This will reduce a buyer's ability to assess the operational capabilities of the suppliers or the value of the technology (Bergen et al., 1992; Ouchi, 1979; Stump & Heide, 1996). Additionally, supplier skills and other characteristics, if perceived as unobtainable through substitutes, may appear irreplaceable in the eyes of the buyers. Since behavior control is difficult to implement, the buyer may resort to relationship and consensus building, attempting to implement clan control. Hence:

P4. *The greater the lack of project-related knowledge of the buyer, (a) the lower the use of behavior control, (b) the greater the use of output control, (c) the greater the use of clan control and (d) the greater the use of self control.*

4.2. Environmental uncertainty

An important determinant of buyer decision making is environmental uncertainty because particular market conditions impose demands on a buyers' information processing capacity, are difficult to predict, and are beyond the control of either principal or agent (Achrol & Stern, 1988; Buvik & John, 2000; Weiss & Heide, 1993). In a general sense, perceived uncertainty in the environment leads to uncertainty related to a task; i.e., the difference between the amount of know-how required to complete a task and the amount already possessed. In the context of TI markets, technological heterogeneity and discontinuity create uncertainty regarding developing the component (due to changes in component specifications), as individuals struggle to understand new and incompletely specified processes or products (Burkhardt & Brass, 1990; Tushman & Anderson, 1986; Rindfleisch & Heide, 1997).

Technological heterogeneity refers to a lack of a common technological standard (Garud & Kumaraswamy, 1993; Staudenmayer et al., 2005; Sanchez & Mahoney, 1996). One defining feature of high-technology markets is the presence of multiple, frequently discrepant product standards and lack of a single dominant design (Tushman & Anderson, 1986; Teece, 1988; Bourgeois & Eisenhardt, 1988). Buyer firms may have a higher preference for close monitoring and relationships with their suppliers (i.e., behavioral and clan control) under conditions of high technological heterogeneity, because they want to minimize the information they need to process to cope with uncertainties associated with such complexity.

Technological discontinuity: High-technology markets also represent considerable uncertainty for buyers due to technological discontinuity, which represent increasing speed and magnitude of technological change. As stated by Von Hippel (1986), a buyer's prior technologies, experiences and capabilities are often 'rendered obsolete' in such markets (p. 796). According to Tushman and Anderson (1986), high-technology markets tend to be 'competence destroying', constituting a shift in the locus of technical expertise from industry incumbents to new entrants (Heide & John, 1990; Pisano, 1990; Weiss & Heide, 1993). The introduction of fundamentally different technologies or competence-destroying discontinuities can lead to major

changes in the distribution of power and control. Because of resource limitations, firms turn to and eventually become reliant on external sources in developing new product and/or process technology (Kotabe & Murray, 1990; Swan & Allred, 2003). In resource dependency terminology, this will lead the buyer to become dependent upon the supplier for its NPD operations and performance.

Overall, environmental uncertainty involves not only a lack of knowledge of precise costs and outcomes associated with different alternatives, but often also a lack of knowledge of what the alternatives even are. This increases the specificity of the supplier's and the buyer's interdependence, and therefore the buyer may prefer behavior control (Stump & Heide, 1996; Wasti & Liker, 1997; Wilson et al., 1990). However, in such conditions, evaluation based on both behavior and outcomes may become ambiguous, leading to the use of more informal controls (Lawless & Price, 1992). More formally stated:

P5. *The greater the technological heterogeneity, (a) the greater the use of behavior control, (b) the lower the use of output control, (c) the greater the use of clan control and (d) the greater the use of self control.*

P6. *The greater the technological continuity, (a) the greater the use of behavior control, (b) the lower the use of output control, (c) the greater the use of clan control and (d) the greater the use of self control.*

4.3. Switching costs

Buyer switching costs may arise as a result of prior commitments to (1) a technology (transaction-specific assets) and/or (2) a particular supplier (relationship specific assets). Asset specificity means the buyer firm has specialized knowledge or tools having little or no use outside the transaction (Stump & Heide, 1996; Rindfleisch and Heide, 1997; Williamson, 1991). Moreover, as a result of the prior transactions and investments, buyers may have invested in assets that are incompatible with new products. In addition to compatibility problems, buyers may face switching costs because of established relationships with particular suppliers (Heide & John, 1988).

The general effect of both types of switching costs for a buyer is a disincentive to explore new suppliers (Heide & Weiss, 1995; Swan & Allred, 2003). Consequently, buyers will be motivated to stay in existing relationships to economize on switching costs. Essentially, switching costs constitute a form of dependence, which is described by the extent of replaceability of the exchange partner (Heide & John, 1988; Heide, 1994). Agency theory predicts that the purchase of products or services that cannot be closely monitored will lead to shirking by suppliers (Bergen et al., 1992; Wasti & Liker, 1997). As a general rule, the buyer firm would try to detect opportunistic behavior by the suppliers through heavy monitoring. Knowing that it is being monitored would make the supplier less likely to shirk. Closer ties and socialization through clan control may also minimize opportunism (Eisenhardt, 1985; Ouchi, 1979). In the NPD outsourcing context, below examined are three constructs related to these dependence and control issues.

Component purchase concentration: Most major global brands of electronics (such as Sony-Ericsson, Nokia, HP and Dell) are partnering with at least a couple of contract manufacturers and electronics manufacturing suppliers (28 August 2004 in Financial Express). The presence of open standards for the interfaces between components allows the system components to be sold by multiple suppliers. The buyer need not buy all system components from the same supplier, regardless of whether the buyer outsources the integration function; instead buyers mix and match components from different manufacturers, reducing their dependence on a single supplier. Thus the buyer's decision involves whether to purchase all system components from a single supplier (high concentration) or from multiple suppliers (low concentration) (Stremersch et al., 2003; Tidd, 1995; Wilson et al., 1990). The buyer's position is strengthened the greater the number of alternate sources of supply and the less the transaction costs involved in switching to another supplier (Heide & John, 1988; Rindfleisch and Heide, 1997). This would reduce the threat of opportunism and the necessity of monitoring; behavior control diminishes and the use of output and self control may suffice (Eisenhardt, 1985; Pfeffer & Salancik, 1978). Moreover, buyers may also develop closer ties and implement clan control that foster interdependence with their suppliers and reduce the threat of opportunism. Hence:

P7. *The lower the component purchase concentration, (a) the lower the use of behavior control, (b) the greater the use of output control, (c) the greater the use of clan control and (d) the greater the use of self control.*

Degree of supplier involvement: Supplier involvement in NPD may be determined by the extent to which the supplier influences decision making during the early stages of product development, the amount of control the buyer retains over the design, and the frequency of design-related communication between the buyer and the supplier (Carson, 2007; Wasti & Liker, 1997). As supplier involvement increases in earlier stages (e.g., idea generation, concept development) as opposed to later stage activities (e.g., product testing, production), the intangibility of tasks and the diffusion risk of tacit know-how or core technologies increase (Wagner & Hoegl, 2006). Critical marketing and technical information at the idea generation, design and planning stages that leaks to competitors through the supplier's use of the same or similar designs for different customers can constitute a serious detriment to a buyer's competitive power (e.g., Wagner & Hoegl, 2006). The unfavorable consequences of outsourcing of product designs and entrusting product specifications and trade secrets to suppliers include intellectual property leakage and even counterfeit (Houston & Johnson, 2000).

A recent Fortune article describes how New Balance has been a victim of and has put up a battle against counterfeit production (1 May 2006 in Fortune, p.108). After they ceased their agreement with their offshore supplier that they shared the designs and specifications of product line with, the supplier refused to stop — not only continued to produce, but also launched its own line of sneakers under its own brand. Suppliers across other technology-intensive industries, such as in automotive, pharmaceutical, medical and electronics, offer buyer firms services across the entire product cycle from the initial concept and design phase to the final phases of commercialization (March 21 2005 in BusinessWeek). Accordingly, companies like Dell, Motorola and Phillips and other chemical, pharmaceutical, and information technology companies that buy complete designs from offshore developers and spend billions to set up offshore R&D facilities may also be prone to IP thefts. The examples provided in Fortune cite how an employee of an offshore service provider stole a new industrial process for manufacturing a chemical, while another took research on nanotechnology. The solution that New Balance found, according to the article is heavy monitoring and enforcing of strict contract clauses. On the whole, buyers may be concerned about multi-client suppliers' transmission of marketing and technical information to potential competitors and may opt for close monitoring (i.e., behavioral control) and the building of relational ties (i.e., clan control). In most cases however, despite legal agreements, buyer will have to rely on the supplier's moral integrity (i.e., self control). Therefore:

P8. *The higher the degree of supplier involvement, (a) the greater the use of behavior control, (b) the lower the use of output control, (c) the greater the use of clan control and (d) the greater the use of self control.*

Supplier capabilities: A supplier's successful performance history (i.e., reputation) gives the buyer an indication of the behavioral tendencies of the supplier, reduces the need for behavioral monitoring and allows the buyer to utilize outcome-based contracts to a greater extent (Buvik & John, 2000; Wathne & Heide, 2000; Wasti & Liker, 1997). Many of the top Asian supplier companies have global networks,

advanced technologies and considerable experience (28 August 2004 in Financial Express). All these advantages enable suppliers such as Flextronics to provide low cost, high quality and high volume manufacturing services to their buyers. Accordingly, supplier reputation may play an important role for the buyer firms in their selection and certification of a supplier for the particular new product project (Houston & Johnson, 2000; Wathne & Heide, 2000). Through this process, the buyers obtain the opportunity to monitor the potential suppliers on a trial basis, hence to reduce the likelihood information asymmetry related to supplier skills. On the other hand, suppliers may feel obligated to demonstrate their willingness, expertise and integrity to maintain their reputation as well as to be recruited by the buyer. Accordingly, reputation may constitute a safeguard against opportunistic shirking or engaging in immoral actions through (1) reducing the need for buyers' close monitoring of suppliers' development processes (i.e., behavioral control), and (2) fostering performance based (i.e., output) control and suppliers' self control.

On the other hand, factors such as supplier's development cost advantages, ability and funding to conduct R&D, skill and competitiveness in product development, number of patents and other facilities may lead to certain asymmetries in the exchange relationship, thus escalating dependence at the buyer's expense (Clark & Fujimoto, 1991; Wasti & Liker, 1997). Furthermore, Aberdeen's 'Outsourced Manufacturing Strategies Benchmark Report' states that many buyer firms fail to attain expected market benefits because they do not implement supplier performance management programs (12 October 2004 in Business Wire). When outsourcing, it is particularly necessary in pharmaceutical and dietary supplement companies to ensure that the essential part of the business–the products–comply with regulatory standards. An article in Nutraceuticals World suggests communication vital to ensure that all of the aspects of manufacturing a product are met (1 September 2003). In other words, asymmetries and dependencies may lead the buyers to resort to building intimate and reciprocal relationships; that is, buyers rely on clan control rather on the supplier's self control. When sourcing the design for the electronics for its first flat-screen TVs from Pixelworks, an acknowledged supplier for LCD and plasma TV electronics designs, Xoceco worked closely with the supplier team to build a relationship, to monitor their processes as well as to learn about the technology (16 December 2003 in The Wall Street Journal). Thus:

P9. *The higher the supplier capabilities, (a) the lower the use of behavior control, (b) the greater the use of output control, (c) the greater the use of clan control and (d) the greater the use of self control.*

5. Conceptual development: moderation by modularity

Schilling (2000) defines modularity as "a continuum describing the degree to which a system's components can be separated and recombined and the extent to which the system architecture enable the mixing and matching of components" (p. 312). Systems are said to have a high degree of modularity when their components can be disaggregated and recombined into new configurations with little loss of functionality (Mikkola, 2003; Schilling, 2000; Schilling & Steensma, 2001). Such components are relatively independent of one another; however, they require compatibility with the overall system architecture to be easily recombined (Garud & Kumaraswamy, 1993; John et al., 1999; Sanchez, 1995). The degree of modularity is important because modularity reduces the likelihood of NPD design leakage by suppliers, functional mismatches, and the buyer's switching costs and external dependence. Since these factors entered into the rationale underlying the present model of control portfolios, the degree of modularity may have an impact on propositions P1 through P9 discussed previously (a moderating impact is proposed). The remainder of this section explains how modularization can be a designed-in substitute for formal or informal controls.

Systems become increasingly modular when firms begin to substitute loosely coupled forms for traditional tightly integrated systems or structures. A change in the design of one component within an integrated, tightly coupled assembly of components will require compensating changes in the designs of other components, making these product architectures difficult, costly, and time-consuming to modify (Orton & Weick, 1990; Sanchez & Mahoney, 1996; Staudenmayer et al., 2005). Schilling (2000, p. 316) refers to this as 'synergistic specificity,' which can be reduced through modularization and the development of standardized interfaces. Through specifying and standardizing the nature of an activity and the terms of exchange, a standard interface makes assets non-specific (Garud & Kumaraswamy, 1993; Sanchez, 1995; Schilling, 2000). Modular systems also involve less disclosure of information about design plans, and market and technical data (outside of specification of the interfaces). Modularity, in other words, provides a structure that serves to coordinate the loosely coupled activities of component developers, while reducing the risk of technology know-how leakage and the need for close monitoring of behavior (Staudenmayer et al., 2005; Sanchez, 1999). As an illustration, Toyota manages its global operations through integration and standardization in those components and supplies its components and parts from multiple offshore locations (Kotabe & Murray, 2004). Loose coupling of components facilitates greater specialization in particular activities, and thus suppliers can enjoy greater autonomy in the development of components while buyers still have some control of the suppliers' outputs (Orton & Weick, 1990). Shared standards present a form of embedded control that reduces monitoring and enforcement difficulties and allows outcome measurability (e.g., the assessment of the performance of the components) (Sanchez & Mahoney, 1996).

In outsourced development projects, modularity provides a medium that supports the implementation of control portfolios dominated by evaluations based on project (or market) outcomes and/or supplier self assessment (Orton & Weick, 1990; Sanchez & Mahoney, 1996; Staudenmayer et al., 2005). Such systems and structures reduce the necessity to exert managerial authority (i.e., behavioral control) to achieve coordination of development processes through enabling the evaluation of the required outputs (i.e., output control) and the autonomous development of components (i.e., self control) (Orton & Weick, 1990; Sanchez, 1999). Meanwhile, a buyer may not prefer to outsource a product or component on a global basis that is highly customized since changing supply sources for that product may create high switching costs. Buyers may invest in relationship-building (i.e., clan control), which bind the supplier and buyer by making them highly interdependent and thus by increasing the ease of implementation of clan control. Hence, modular systems lessen the need to implement certain types of controls (i.e., behavior and clan control) *in response to* task complexity, uncertainty, and dependence, and moderate the relationships between control mechanisms and the model antecedents. More formally stated, the following proposition will be explored:

P10. *As the degree of modularity increases, the strength of the relationships between the antecedents (i.e., task characteristics, environmental uncertainty and switching costs), and*

(a) the use of behavior control should be significantly weaker,
(b) the use of output control should be significantly stronger,
(c) the use of clan control should be significantly stronger, and
(d) the use of self control should be significantly stronger.

6. Implications for theory and practice

Global firms in TI markets increasingly engage in outsourcing relationships due to rapid technological developments (which

increase technological complexity) and amplified international competition (which leads to environmental hostility). In particular, many firms engage in outsourcing relationships in order to gain adaptability, market responsiveness and competitive advantages against their rivals. Another important trend in TI markets is modularization, which allows components to be flexibly recombined into multiple end-product configurations, links geographically dispersed component developers, and brings about important leverage in global ventures. Despite benefits, such global NPD relationships entail certain costs and threats for the buyer. These relationships may lead to asymmetries in dependence due to task specific qualities, switching costs, and the perceived dynamics of the market and technological environment. Thus monitoring and coordination mechanisms become necessary to prevent opportunistic supplier behavior and the expropriation of buyers' technology know-how and commercial secrets. However, the standardized component interfaces in modular product architectures provide a form of design-embedded coordination and control that greatly diminishes switching costs and dependencies, and reduces the need for other control mechanisms. Thus, NPD outsourcing within the context of modular architectures constitutes a unique and important case, which is the central focus in this study of the antecedents of control portfolios.

The topic proposed in this research is novel and has not been widely studied. For theoretical grounding, this study draws primarily upon agency, resource dependency, and transaction cost theories which have been discussed in the new product, marketing, and management literatures. This research contributes to extant literature through providing at least partial answers to the following three questions:

(1) In global technology-intensive markets, what are the portfolios of control mechanisms that buyers exert on their suppliers in outsourced new product projects (with modular architectures)?

The supplier in a NPD relationship may have an incentive to behave opportunistically, when the buyer has imperfect knowledge (due to technological obsolescence or information asymmetry), the supplier has specialized knowledge or technologies, and/or the goals of the buyer and supplier are incompatible (Houston & Johnson, 2000; Rindfleisch & Heide, 1997; Stump & Heide, 1996). These conditions bring about the need for control mechanisms and realignment of incentives of both parties (Anderson, 1985; Williamson, 1975). From the literature four broad control mechanisms have been identified: behavior control and output control (both of which are formal control mechanisms), and clan control and self control (which are informal). Specific controls descriptions were researched with two goals in mind: contribution to the research on outsourcing of new product development and creation of a complete managerial typology. The managerial typology may serve to be very useful to practitioners, especially those who fear knowledge leakage from NPD suppliers and are seeking options to counter the potentially devastating consequences.

(2) What determines the particular combinations of controls utilized in these NPD outsourcing relationships? That is, what are the antecedents of control portfolio utilization?

As the proposed conceptual framework in Fig. 1 shows, three categories of antecedents were proposed: *task characteristics*, comprising strategic importance of the project, geographic distance, cultural proximity, and project-related knowledge of the buyer; *environmental uncertainty*, consisting of technological heterogeneity and discontinuity; and *switching costs*, comprising component purchase concentration, degree of supplier involvement, and supplier capabilities. Nine propositions were developed, each proposition specifying an antecedent's impact on each of the four types of control mechanisms.

Testing the proposed model could lead to: (1) from a theoretical perspective, the (dis)confirmation of the theoretical rationales connecting the proposed antecedents with control portfolios in interfirm relationships; and (2) from a managerial perspective, the delineation of contextual gestalts in which some control mechanisms are more important or useful than others. Thus, an empirical analysis of this study may benefit practitioners by offering insights that may guide them in coordinating their supplier relationships and maximizing the value of their outsourcing initiatives. Researchers who wish to empirically examine the proposed framework should take into consideration other possible influential factors. For instance, the duration of the outsourcing relationship should be controlled for since the asymmetric dependence or the interdependences between the partners may develop due to the relation-specific investments they make over time. Finally, since little is currently known about NPD outsourcing, the area of portfolio of controls in global TI markets also merits a qualitative approach, such as field interviews and case studies.

(3) How does modularity impact the relationships between control mechanisms in control portfolios and their antecedents? Does modularity serve as a substitute for formal or informal controls?

The final issue examined is whether any of the proposed paths are moderated by modularity. Modularity regulates component interfaces through design. The degree to which a modification in the design of one system component requires compensatory changes in the designs of other components can be minimized through modularization (Orton & Weick, 1990; Schilling, 2000). Through the standardization of component interfaces, modularity allows the buyers and the suppliers to function independently and reduces the buyers' reliance on a particular component for the continuation of operations. If different suppliers are restricted to knowing only their particular interfaces of their particular components, then the likelihood of knowledge leakage of the entire product is minimized. This makes the buyers' investments less transaction or relationship specific as well as leads to less disclosure of information about data and design plans to the suppliers (Garud & Kumaraswamy, 1993; Sanchez & Mahoney, 1996; Heide & Weiss, 1995). In this way, modularization is a substitute for controls; that is, control is embedded in the design and thus other controls may be less necessary in response to task characteristics, environmental uncertainty, and switching costs. Theoretically, control through designed interfaces has received little if any attention. Managerially, control through the designed interfaces of modular architectures may provide the avenue for simultaneously tapping into the knowledge bases of suppliers through close NPD partnerships and avoiding the risks of knowledge leakage or (over)dependence on any supplier.

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