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Abstract

Firms increasingly look outside their organizational boundaries to identify partners that can improve the effectiveness of R&D projects. The strategy for using partners, however, varies significantly across projects. In some, partners are used primarily to lower development costs and/or supplement development capacity; in others they are used to improve the quality of the final product. How should these variations in partnering *strategy* impact the governance and management choices made within projects? We examine this question, using data on 172 R&D projects from six different industries. We test hypotheses that examine first, how a firm's choice of contract—whether fixed price, time & materials, or performance-based—is shaped by its partnering strategy; and second, how this choice subsequently affects the levels of partner integration and partner performance observed in a project. Our results indicate that the choice of contract is a function of a firm's partnering strategy, more flexible contracts being preferred in projects that seek long-run capability-based benefits, and where partnering relationships are broader in scope. These choices, in turn, impact the benefits associated with partner integration. In particular, higher levels of partner integration are *always* associated with higher project costs, but are associated with higher product quality *only* in projects using more flexible contract types. Furthermore, major deviations from the "optimal" choice of contract increase the costs and decrease the benefits associated with partner integration. We end by discussing the implications of our findings, and suggest new directions for future research.

Keywords: Partnering, Outsourcing, Collaboration, Contract Choice, Distributed Teams, Virtual Teams, Product Development, Project Management

Introduction

Over the past two decades, firms have increasingly sought to unbundle their value chain activities and collaborate with partners to meet the challenge of increasingly competitive global markets (Sinha and Van de Ven 2005, Schilling and Steensma 2001). Many of their early efforts were devoted to identifying the choice of sourcing strategy (i.e., make or buy) for manufacturing the components and subsystems that make up a product (Gulati et al. 2005). In the recent years, with partners increasingly moving up the value chain, the focus has shifted more toward examining the critical role such firms are playing in the design and development of these products (Weigelt 2009, Tiwana 2008, Manning et al. 2008). Recent surveys show that nearly 60-80% of firms deploy partners to a significant extent in their R&D projects to achieve their design and development objectives.[1,2]

Firms deploy partners in their R&D projects for a number of different reasons. For many firms, partners primarily represent an opportunity to lower R&D costs, given the wage arbitrage opportunities that exist between different geographical locations with varying factor costs (Carmel and Tija 2005, Rottman and Lacity 2004). In such "outsourcing" relationships, the partner staff is assumed to *substitute* for the in-house staff by providing similar skills and capabilities at a fraction of the in-house costs. In other cases however, firms use partners to enhance product quality. The partner staff is assumed to *complement* in-house resources by providing unique skills and capabilities that are not possessed by a firm internally (Lavie and Rosenkopf 2006, Faraj and Sproull 2000).

This diversity in the roles that partners play in R&D projects raises an important set of questions about how partnering relationships should be managed differently across the projects; both, from the perspective of determining an appropriate governance structure and an effective process for managing project execution (Gerwin and Ferris 2004). Projects focused on lowering development costs are likely to require distinct managerial approaches than projects in which enhancing product quality is the main objective. Adopting a set of partnering "best practices" that works in every situation is therefore infeasible, and may even be hazardous to a firm's long-term survival. These challenges concerning the effective management of partnering relationships in R&D projects are becoming increasingly relevant

[1] 2007 Economist Intelligent Unit Report, "Sharing the Idea: The Emergence of Global Innovation Networks"

[2] 2010 Global R&D Funding Forecast, R&D Magazine; Dec. 2009, p. 21

and require greater attention, given the wealth of recent evidence which indicates that firms are obtaining suboptimal returns from their partnering relationships (A.T. Kearney 2007)

Prior work on governance has highlighted the role of contracts as governance structures in partnered R&D projects, and focused primarily on identifying the choice of contract—from among fixed price and time & material contracts—that is suited to the specific attributes of the R&D project (Banerjee and Duflo 2000, Gopal et al. 2003). Much of this work is founded upon transaction cost economics (TCE) theory, which highlights the role contracts play in establishing suitable incentives for partners while protecting the firm against opportunistic behavior (Williamson 1975, 1985). To date however, little work has been done in terms of understanding how a firm's partnering strategy (i.e., in terms of the objectives and scope of partner involvement in R&D projects) affects the choice of contract.

A number of studies have also explored the question of how partnered R&D projects can be effectively managed (Tiwana 2008, Majchrzak et al. 2004, Chesbrough 2003, Crampton 2001). These studies have tended to focus on the optimal partitioning of tasks between a firm and its partners and identified factors that facilitate the subsequent integration of partners' efforts with the firm. The emerging theme from this literature is that the performance of a partnering relationship is higher to the degree that a firm and its partners dedicate their staff full-time to the project, have lower levels of staff turnover, hold frequent face-to-face meetings, and adopt processes that facilitate knowledge transfer. In short, all else being equal, higher levels of partner integration in an R&D project is likely to be associated with better performance in the project. This scenario rarely reflects the reality of R&D project execution in practice (Haas 2006, Hansen and Nohria 2004). Partnering strategies can vary significantly across R&D projects, and such variations can create differences in payoffs from integration of partners, across projects. Examining the contingencies which impact the payoffs from integration of partners in R&D projects represents a critical step toward effectively managing such projects.

In this paper, we report results from a large sample empirical study of partnered R&D projects. Our aim was to develop an understanding of how variations in partnering strategy across R&D projects impact the governance and management of such projects. Our conceptual framework asserts that different partnering strategies require distinctly different contract choices, and these choices subsequently determine the performance benefits from partnering integration in R&D projects. We test these relationships using primary data from a sample of 172 R&D projects across six different industries.

Our analysis reveals that the choice of contract for an R&D project is a function of (i) the partnering objective, and (ii) the scope of partnering relationship in the project—these two factors, taken together, constitute a firm's partnering strategy for the project. Specifically, firms that deploy partners in R&D projects to achieve the *long-run* objectives of accessing unique skills and technical capabilities of the partners and gain new market knowledge (relative to the *short-run* objectives of minimizing development costs and supplementing development capacity) are likely to choose time & materials or performance-based contracts (relative to fixed price contracts) for their projects. Additionally, firms that involve partners over a broader scope of activities in their R&D projects are more likely to choose time & materials or performance-based contracts over a fixed price contracts for their projects. We also find that while greater levels of partner integration (in terms of partner team staffing, communication, and intellectual property sharing) are *generally* associated with higher project costs, they are associated with higher product quality *only* in projects with time & materials or performance-based contracts. Finally, our results demonstrate that R&D projects in which contract choices are aligned with partnering strategy are likely to see greater performance benefits from partner integration than those in which such choices are misaligned.

Our findings make a number of contributions to the extant literature. First, we extend the prior literature on contracts and partnering in R&D, by articulating the need for alignment between a firm's partnering strategy for an R&D project and the governance and management of partnering relationships in the project. In doing so, we explicitly model the performance trade-offs that come from partner integration across different contract choices, capturing their impact on both project costs and product quality. We can therefore be more precise about the contexts under which different governance and management approaches are beneficial. Second, we extend the analysis of traditional models of contract choices (i.e., fixed price and time & materials) by examining performance-based contracts—a newer, much less studied form of contract in which a partner's reward is contingent on project performance. Finally, in contrast to the prior literature which has mostly examined contracts in samples of projects drawn from a single firm (e.g., Gopal et al. 2003, Mayer and Nickerson 2005, Argyres et al. 2007, Gefen et al. 2008), the empirical analysis in our study is conducted using data from a large sample of projects across multiple firms and multiple industries. This enhances the generalizability of the results from our study.

The remainder of this paper is organized as follows. In the following section, we review the literature on partnering relationships in R&D projects and develop a number of hypotheses that relates partnering strategy to governance and management in such projects. We then move on to the section on research design wherein we describe the data collection approach, the sample, and key variables in our analysis. Next, we outline the econometric approach for carrying out the analysis and present results from our analysis. In the final section, we discuss the results from our analysis and highlight their implications for theory and practice. Limitations of the study and directions for future research are outlined.

Literature Review and Hypothesis Development

The last decade has seen an explosion of interest relating to the use of partners to complement in-house resources and improve the performance of a firm's R&D projects (Oxley and Sampson 2004, Chesbrough 2003, Iansiti1997). Much of the early focus on partnering in R&D projects was on lowering the cost of development, an approach that essentially extended the notion of outsourcing routine manufacturing jobs to R&D projects (Quinn and Hillmer 1995). More recently however, studies have identified a broader variety of different *objectives* for firms' partnering relationships, from the substitution of skilled staff in high cost locations, to the delivery of new capabilities that a firm does not possess internally (Lewin et al. 2009, Koza and Lewin 1998). Indeed, similar changes have been observed with respect to the *scope* of partnering relationships; while many projects focus solely on the execution of specific tasks within R&D, others encompass a much broader relationship that extends to the production or delivery of the final product or service (Khanna et al. 1998). In sum, firms have an increasingly sophisticated array of partnering *strategies* that can be deployed in any given development project.

The diversity observed in partnering strategies suggests that different approaches are likely to be necessary for the governance and management of individual projects. Consider, for example, a project in which a partner provides access to critical new technical capabilities (e.g., designing the composite fuselage of a new aircraft). Such a project is inherently more uncertain than one in which a partner merely provides additional capacity to supplement (or substitute) in-house resources (e.g., testing the cockpit electronics for this aircraft), and is likely to require a different choice of contract than the latter. Furthermore, the potential benefits from integrating the partner's staff more closely into the development team will vary significantly across the projects. In the former, this will likely be essential; in the latter, it may not be necessary. Surprisingly however, while prior studies have explored issues of governance and management within the context of partnered projects, much less is known about the role of partnering strategy as a driver of contract choice in a project. Below, we review some of the main contributions in these areas.

The Governance of Partnered Projects

Contracts have been the subject of considerable theoretical and empirical research in the agency theory and the transaction cost economics (TCE) literature. While agency theorists have examined the role of contracts as a mechanism for aligning incentives and sharing risks between the principal and the agent (Holmstorm 1979, Eisenhardt 1989), TCE scholars have examined the effectiveness of contracts in offering protection against opportunistic behavior (Williamson 1975, 1985). Broadly, much of the extant literature has studied contracts at the firm-level, in the context of industries that require extensive specific investments in physical assets. However, contracts also play a critical role in governing complex inter-organizational transactions in knowledge-intensive industries such as high technology and software industry (Mayer and Nickerson 2005). Such inter-organizational transactions require significant amount of joint technical problem solving and coordination between the firm and its partner(s) and are often governed through the use of contracts (Argyres and Mayer 2007). Given that the majority of these transactions are organized and executed in the form of projects, an understanding of how such transactions can be governed effectively, therefore, requires a closer look at understanding the role of contracts at the project-level in such industries.

A number of studies have made concerted efforts toward this end to examine contracts at the project level (e.g., Banerjee and Duflo 2000, Gopal et al. 2003, Gopal and Sivaramakrishnan 2008, Gefen et al. 2008). Two distinct types of contracts, namely fixed price and time & materials contracts, have been widely examined in this literature. In a fixed price contract, the firm manages the project from afar, i.e., is not directly involved in project execution. The firm provides detailed requirement specifications on the work that is required from a partner as well as delivery timetables. The partner is then obliged to execute the project and deliver the final outputs as per the requirements and agreed-upon timeline for a single fixed payment agreed in advance. Failure to comply often carries a penalty. In contrast, in a time & materials contract the firm plays an active role in managing project execution along with the partner. While there is a general agreement as to the objectives for the relationship, mid course corrections and changes in scope are common. The partner is therefore compensated according to their investments in time and related materials. In addition to the two types of contract mentioned above, a third type of contract that is becoming increasingly prevalent in R&D projects is a *performance-based contract*. In a performance-based contract there is a clear separation between the firm's expectations of partnering performance and how the partner works in the project (Roels et al. 2010, Kim et al. 2007). That is, while the contract broadly identifies the performance expectations of the firm from its partner, the latter has the flexibility to determine how to fulfill those performance expectations (Macfarlan and Mansir 2004).

The main objective of this literature, to date, has been to examine how various contextual attributes of the project (e.g., requirements uncertainty, project complexity, project size, etc.) as well as the attributes of transacting parties (e.g., firm's past experience, firm size) affect the choice of contract. The underlying assumption is that these variables impact the level of uncertainty faced in writing the contract and consequently will impact the ideal type of contract used in a project. For example, Gopal et al. (2003) indicate that as the level of requirements uncertainty and project size increase, firms are more likely to choose time & materials contracts over fixed price contracts. While such a choice increases the possibility of opportunistic behavior by a partner (e.g., performing unneeded work), recent studies (e.g., Kalnins and Mayer 2004, Gefen et al. 2008) show that prior relationships and business familiarity between a firm and its partner can help to reduce this concern, thus increasing the likelihood that a time & materials contract is chosen, all other factors being equal.

A central, often implicit, assumption in this literature is that the partnering strategy (i.e., the objective and scope of partner involvement) is homogenous or invariant across projects. Furthermore, contextual attributes (e.g., project uncertainty, project complexity, project size) are often viewed as exogenous variables that are embedded in the task details and information processing structures of the project. In reality, however, the uncertainty facing a project is also a function of the partnering strategy adopted in a project, an explicit choice made at the beginning of a project. Consider for example, the returns from a partnering strategy which requires access to new technical or market knowledge and involves a greater scope of partner involvement. The returns from such a strategy are likely to be considerably more distant in time and uncertain compared to a project in which partners are used primarily to complete specific tasks at lower cost (Koza and Lewin 1998; Lavie and Rosenkopf 2006). Given that the expected returns from partnering relationships in a project are a function of its partnering strategy, understanding how contract choices—namely, fixed price contract, time & materials contract, and performance-based contracts—can be better aligned with partnering strategy in the project is critical toward ensuring its effective governance. This forms the first major focus of our study.

The Management of Partnered Projects

The rapid growth in the use of partners in new product and service development projects has led to an increase in research that focuses on how to manage such collaborative relationships. In contrast to prior work on the management of R&D, which emphasize the merits of collocated heavyweight project teams drawn from a single organization (Wheelwright and Clark 1992, Allen 1977), these studies start with the assumption that a firm's R&D objectives are often best met in disaggregated organizational structures by combining resources from *different* partners, operating in different regions or countries (Koza and Lewin 1998, Santos and Williamson 2004, Eppinger and Chitkara 2006, Faraj and Sproull 2000, MacCormack and Forbath 2008). While such structures bring the potential for lower costs and/or increased product differentiation, they also present several challenges in effectively integrating partners' efforts across sets of interdependent tasks that are executed concurrently.

A major challenge confronting a firm and its partners in an R&D project relates to their ability to share critical project information in a timely and efficient manner (Cummings 2004). Rarely can all the necessary information to complete an R&D project be specified in advance, or all dependencies between partners removed via clear and stable interfaces (MacCormack et al. 2001, Mishra and Sinha 2010). Toward this end, there is a clear need to develop mechanisms that facilitate inter-organizational communication. Many prior studies have found that project performance is correlated with the frequency of face-to-face meetings (e.g., Kirkman et al. 2004; Hinds and Mortensen 2005, Cummings and Kiesler 2005). In contexts where face-to-face interaction is impractical or costly, performance has been shown to be higher to the extent that project teams employ "real-time" and "high bandwidth" technologies, which capture rich and timely information on content and context, as well as non-verbal cues, such as body language (Malhotra et al. 2000).

Another critical challenge that impacts both the efficiency and the effectiveness with which information is shared between a firm and its partners in an R&D project relates to the staffing policy adopted by partners. In some cases, resources are scheduled on an "as needed" basis, parachuting into a project only for specific tasks; in others, they are allocated to multiple projects simultaneously, allowing them to switch from one to another during downtime (MacCormack and Forbath 2007). Yet such policies generate major challenges associated with creating shared goals, building trust and understanding important contextual information about a project's objectives and methods, much of which is tacit in nature (Jarvenpaa and Leidner 1999, Kayworth and Leidner 2000, Narayanan et al. 2009). Indeed, many studies in the context of distributed project teams have shown that the unpredictable communication patterns resulting from uneven staffing create major problems for such teams (Johansson et al. 1999, Crampton 2001, Huckman et al, 2009).

An additional distinctive challenge for R&D projects that comprise multiple organizations is the management of intellectual property (IP). The activity of R&D is founded upon the need to create new and unique product positions that can be protected from imitation while generating a stream of future profits (Teece 1986). Yet recent work argues that a more open approach to managing IP can produce greater returns (Chesbrough 2003, Lerner and Tirole 2002, West 2003, von Hippel 2005). In collaborative projects, the sharing of firms' existing IP may help partners to complete tasks with lower costs and higher product quality than otherwise (MacCormack et al. 2007). The sharing of IP associated with a project's outputs can also help align incentives across partners and thereby resolve contracting problems associated with incomplete information (Williamson 1985). While such strategies carry a risk of opportunism, especially in regimes of weak appropriability, the value created through greater sharing of IP often exceeds such risks (Hagedoorn et al. 2005, Bessen 2006).

The studies cited above, along with many others in this field, suggest a common theme: the challenges inherent in partnered R&D projects can be mitigated to some extent by managing partners the same way one would manage an internal team of resources. Instead of a transactional relationship, where partners are kept at arm's-length, the aim is greater *integration*, thereby creating incentives and mechanisms to facilitate the sharing of information between teams (Clark and Fujimoto 1991, Iansiti 1997, MacCormack and Forbath 2007). Yet few studies explicitly address the trade-offs associated with such an approach. Specifically, given that firms have a variety of different strategies with regard to their partnering relationships, under what circumstances are the potential costs of greater integration outweighed by the benefits that result? Addressing this question requires analyzing the interplay between project governance on one hand, and project management on the other, providing the second major focus for this study.

Hypothesis Development

Firms partner for multiple reasons; while some seek to exploit existing capabilities or gain cost/capacity advantages, others seek to explore new technologies and learn about new markets (Koza and Lewin 1998). Furthermore, the scope of partnering relationships differs significantly, from a pure focus on R&D to a broader relationship that may encompass production and delivery services (Khanna et al. 1998). Contracts represent a key mechanism for coordinating transactions between a firm and its partners (Vanneste and Puranam 2010, Gulati et al. 2005), and for minimizing risks in such transactions (Grossman and Hart 1986, Eisenhardt 1989). Understanding how different choices of partnering strategy – defined here as comprising both the objective and scope for a partnering relationship – relate to the optimal choice of contract is of critical importance (Bannerjee and Duflo 2000). Furthermore, understanding how these contractual choices, in turn, impact the costs and benefits of different approaches to project management is essential to capture maximum value from these relationships. Below, we develop hypotheses about the nature of these linkages and their association with performance.

Impact of Partnering Objective on Contract Choice

We conceptualize partnering objective of an R&D project on a continuum ranging from a short-run partnering objective to long-run partnering objective. Firms with a *long-run* partnering objective involve partners in their R&D projects to gain access to their unique skills and technical capabilities and to explore new market knowledge. The returns from such an objective are likely to be distant in time and uncertain compared to a *short-run* partnering objective wherein firms focuses on involving partners for minimizing development costs and supplementing development capacity. As partnering objective in a project become increasingly long-run, the task of determining the project's requirements as well as the total cost of executing a project becomes increasingly challenging (Kalnins and Mayer 2004). Since firms with long-run partnering objective are less likely to have a complete understanding of the final output or the expected deliverables at the beginning of a project, the execution of such a project requires considerable trial and error learning and experimentation from partners. As project execution progresses through trial and error learning and experimentation, new information about project tasks may be uncovered that necessitate changes in the project requirements and the expected deliverables from the project (Terwiesch et al. 2002). Under such circumstances, both the firm and its partners are more likely to prefer a contract that allows for greater flexibility in project execution, such as a time & materials or a performance-based contract relative to a fixed price contract.

From a partner's perspective, a time & materials or a performance-based contract shifts the considerable financial and project management risks of experimentation to the firm (Bannerjee and Duflo 2000, Gopal et al. 2003). Further, given that fixed price contracts are typically associated with higher contractual cost of penalties relative to a time & materials or performance-based contract (Gefen et al. 2008), partners are less likely to prefer the former type of contract when uncertainty relating to partnering objectives is high. From the firm's perspective, a time & materials or a performance-based contract gives it the necessary flexibility to incorporate changes and re-specify the project requirements as the project execution progresses. Additionally, given that uncertainty relating to the deliverables from the project is often unknown at the beginning of a project with long-run partnering objective, the risk of opportunistic behavior from the partners is high (Kalnins and Mayer 2004). For example, partners may shirk and not provide the expected level of effort toward implementation and after sales service (Mooi and Ghosh 2010). A time & materials or a performance-based contract for such a project is likely to control the risk of opportunistic behavior by the partners (relative to a fixed price contract) as they are fully compensated for the changes under such a contractual regime, regardless of extent and scope of those changes. Based on the above arguments, we propose the following hypothesis:

HYPOTHESIS 1: *As partnering objective becomes increasingly long-run, the choice of time & materials or performance-based contract supplants that of fixed price contract.*

Impact of Partnering Scope on Contract Choice

A key decision relating to the organization of an R&D project involves determining the functional or 'vertical' scope of partner involvement in a project (Gerwin and Ferris 2004, Oxley and Sampson 2004). Establishing the scope of partner involvement, hereby referred to as *partnering scope*, in a project involves decisions such as whether to restrict partner involvement to key strategic stages of a project, such as the design or testing stages, or to extend it to involve also the production or service delivery phase.

As the extent of partnering scope in a project increases, the overall complexity of partnering relationships in a project increases (Zollo et al. 2002). With greater partnering scope, the partners are accountable for multiple project tasks across the initial design stages as well as the execution stages of a project. Since new interdependencies between tasks that were previously unknown at the beginning of a project are often likely to be uncovered during the downstream stages of a project, initial project requirements may often change and potential for rework will be high (Sosa et al. 2004, Terwiesch et al. 2002). As a consequence, with the partners involved in various project tasks that span multiple stages of a project, a non-trivial amount of their efforts would be spent in carrying rework of upstream project tasks.

From a firm's standpoint, with greater partnering scope, the transaction costs encountered in negotiating, monitoring, and enforcing explicit detailed contracts is likely to be high (Gerwin and Ferris 2004). While a fixed price contract would provide the firm with greater managerial control over the project and reduce transaction costs, creating detailed and verified specifications for a fixed price contract poses a significant challenge to the firm. Because of bounded rationality, it is difficult to foresee or predict all potential contingencies and rework activity relating to partner involvement in a project (Gefen et al. 2008). As Williamson (1985) suggests, under such circumstances the best possible alternative for the firm is to prepare a contract that contains a general set of guidelines for handling unforeseen contingencies. Both time &materials as well as performance-based contracts provide a suitable framework for incorporating such general guidelines. As long as the partners resolve contingencies and accomplish rework in a project, as per the guidelines, they are likely to be compensated for their effort. Based on the above arguments, we propose the following hypothesis:

HYPOTHESIS 2: *As partnering scope increases, the choice of time & materials or performance-based contract supplants that of fixed price contract.*

Impact of Partner Integration on Partnering Performance across Contract Choices

Prior studies on how partnered projects should be managed have shown the potential benefits associated with a greater degree of integration between a partner firm's staff and an in-house development team (Jarvenpaa and Leidner 1999, Kayworth and Leidner 2000, Chesbrough 2003, Kirkman et al. 2004). These relationships have been demonstrated for a variety of practices, including more frequent and richer communication, lower levels of partner staff turnover and higher levels of IP sharing. However, none of these studies consider the potential trade-offs from such approaches, nor their interaction with different types of governance structure. These are important omissions given, a) a higher level of partner integration is more costly for both a firm and its partners, and b) the choice of contract for a project, properly aligned to the partnering strategy of a firm, creates an incentive structure within which decisions are made about how to respond to new or changing requirements. We therefore seek to explore the impact of different management choices on both project costs and product quality; and to examine these dynamics under different contract choices to understand differences between them.

Consider first the situation where a firm is using partners to lower the cost of clearly defined and specified R&D tasks (e.g., routine testing of a software component). As we argue above, such a partnering strategy is best suited to a fixed price contract. Under such a contract, there are no incentives for the partners to devote extra efforts to increasing the product's overall level of quality as the partner is less likely to be rewarded for this effort in such a project. Additionally, given that the task specifications are clearly identified, partners typically have limited opportunities to influence the final level of product quality. All else being equal, managing such a project with a high level of partner integration will therefore incur added costs, for both the partners (e.g., added staffing costs) as well as the firm (e.g., added communication costs) relative to projects in which a lower level of integration is used. Furthermore, these added costs will come without a consequent increase in the overall level of product quality.[3]

[3] The extra costs incurred by partners due to higher levels of integration will likely be reflected in the fixed price set in the contract. The extra costs incurred by the firm however are separate costs that must also be captured to truly evaluate the impact of different practices across projects. It is therefore important to define the costs associated with different approaches more broadly than just the monetary exchange that takes place between the firm and its partners.

Given that contracts serve as governance structures for firms to regulate partnering relationships (Gulati et al. 2005), an increase in the level of partner integration in a project is likely to increase the scale and the scope of the contract for the project. Writing such contracts is not only cognitively burdensome, but also a costly exercise as the firm has to put more effort into documenting the roles and responsibilities of the partners and include additional contractual clauses (Vanneste and Puranam 2010). Hence, we expect project costs to increase with the level of partner integration.

HYPOTHESIS 3: *Under a fixed price contract, an increase in partner integration will be associated with higher cost, but not higher product quality.*

Consider next the situation where a firm is using the partner firm to provide important new technical capabilities on a project (e.g., designing the composite fuselage for an aircraft). As we argue above, such a strategy is best suited to a time & materials or performance-based contract, given the greater flexibility that they provide. Under these circumstances, the partner has both the incentive and the ability to influence the final level of product quality. Projects managed with a higher level of partner integration will therefore be associated with higher project costs, but will also be associated with higher product quality.

HYPOTHESIS 4: *Under time & materials and performance-based contracts, an increase in partner integration will be associated with higher cost and higher product quality.*

Our final pair of hypotheses focuses on the differences in the effect of partner integration across different types of contract. Specifically, while we argue above that the overall cost of partnering will be higher in projects that use higher levels of partner integration, this relationship is likely to be more pronounced in time & materials and performance-based contracts. Fixed price contracts place a cap on the revenues that a partner can earn hence the partner will strive to minimize project costs and increase efficiency (Arora and Asundi 1999, Kalnins and Mayer 2004, Gopal and Sivaramakrishnan 2008). In contrast, under a time & materials or performance-based contract, partners have incentives to seek out additional work not specified in the initial contract, which would improve product quality, and hence increase billable hours, and/or raise the expected return from performance-based bonuses (Gopal and Sivaramakrishnan 2008). Furthermore, these actions are typically aligned with the strategic objectives that firms have for their partnering relationships when adopting such contracts. Hence we argue:

HYPOTHESIS 5: *As partner integration increases, both time & materials and performance-based contracts will be associated with higher cost as compared to a fixed price contract.*

HYPOTHESIS 6: *As partner integration increases, both time & materials and performance-based contracts will be associated with higher product quality as compared to a fixed price contract.*

The conceptual model that results from the above hypotheses is shown in **Figure 1**. In the next section, we describe our approach to testing this conceptual framework.

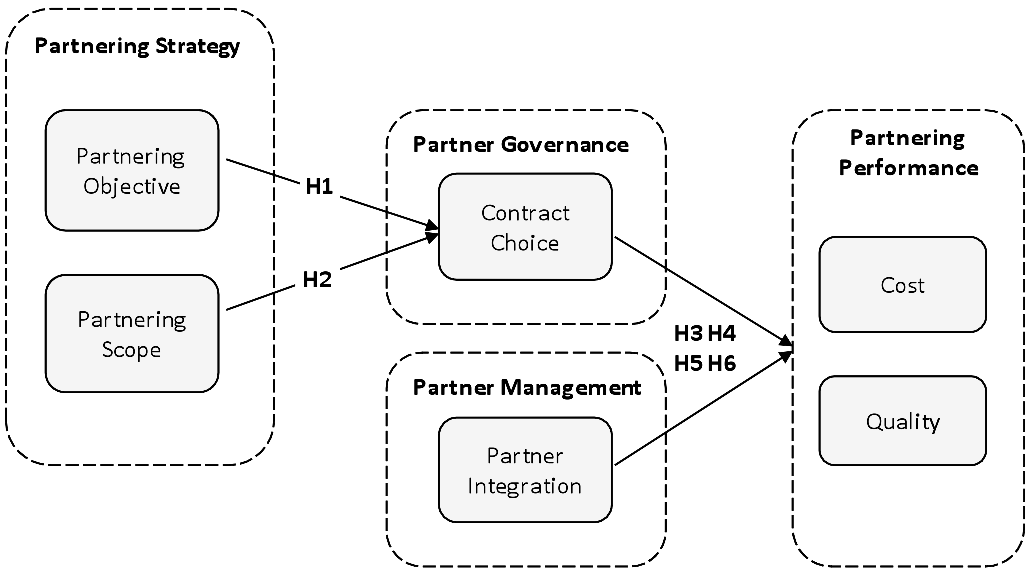

Figure 1: Conceptual Framework

Research Design

Data Collection

The analysis presented in this study is based on fieldwork, followed subsequently by the collection of primary data through a survey of R&D projects. Prior to the launch of the survey, we conducted interviews with managers in R&D projects across multiple firms in different industries to understand the differences in partnering strategies employed in practice, and to identify the critical factors which impact the performance of partnered R&D projects (MacCormack and Forbath, 2008). The qualitative insights developed through the interviews helped in the development of a web-based survey that sought to capture the nuances of partnering relationships in R&D projects through the constructs of partnering strategy, contract choice, partner integration, and partnering performance, among others.

The unit of analysis for our survey is an R&D project. The sample population was defined to be R&D projects that involved at least one remote vendor/partner team of 5 or more people contributing to design or engineering work. This definition purposely excluded contract workers from being classified as partners. A preliminary paper-based version of the survey instrument was designed and pilot-tested first among a set of managers involved in the qualitative interview stage to asses for content validity and clarity of the questions. Following, this phase of pilot testing, we engaged an established market research firm to design and implement the web-based version of the survey instrument. A preliminary web-based version of the survey was pilot tested by the market research firm among a small sample of respondents across six different industries—namely, software, hardware, telecommunications, financial services, automotive, and medical devices. Respondents were screened to ensure they had detailed knowledge of the project and occupied key positions of responsibility within their firm such as a project manager, a program manager, or a senior manager in the R&D or product development function. This round of pilot-testing generated 50 responses, allowing us to test the web-based version of the survey in conditions that would be similar to those in actual survey implementation. Overall, the two rounds of pilot-testing helped us in gauging the initial reactions to the survey, and identify survey questions that were confusing and prone to misinterpretation by respondents. Specific aspects of the survey, such as item-non response, survey dropouts and the time taken to answer the questionnaire, were assessed and modifications were made to the content and the organization of the survey to improve the survey taking experience.

The final web-based version of the survey was implemented by the market research firm in a targeted sampling list (derived from their database) of managers involved in the R&D or product development function within their company, across the six different industries identified above. A stratified sampling technique was adopted to ensure that sure a defined minimum number of responses were obtained from respondents in each industry. Given the greater penetration of partnered R&D efforts in software and hardware, we established a higher target for the number of responses in these industries. We obtained 205 completed surveys. After removing observations that contained incomplete or erroneous data, our final sample comprised of responses from 172 projects. Table A1 in the appendix reports the survey questionnaire items that were used in this study.

Sample Characteristics

In terms of the respondent profile, approximately 63% of the respondents were project managers or program managers while the remaining 37% were senior managers who currently managed the R&D, engineering, or product development department within their firm. All the respondents indicated that they have had past experience of managing or supervising a project where external partners performed substantive design or engineering work in the project. The respondent profile suggests that the respondents were likely to be knowledgeable not only about their project but also about the broader domain of project management, thereby increasing our confidence in the quality and the accuracy of the data (Li et al. 2007).

With respect to the demographic characteristics of the projects, the median project team size was 52 members with projects reporting a median duration of 9.5 months and a median budget of $3 million dollars. Additionally, the median percentage of a project's budget that was allocated to the work performed by partners was 32.5% and the median number of partners involved in a project was 2.5. The sample of projects fell into three broad product categories: Electronic Hardware (e.g., Computer Server, Telecommunications Equipment) – 36% of the total sample; Software (e.g., Enterprise Software, Real Time Systems Software) – 44% of the total sample; and Other Physical Product (e.g., Medical Device, Automobile) – 20% of the total sample.

Dependent Variables:

Partnering Performance: We assessed the impact of partner involvement in a project across three key dimensions: project completion time, project costs, and product quality (i.e., quality in terms of potential revenue generated by the project). The use of multiple performance dimensions to measure partnering performance reflects the notion that R&D projects have multiplicity of performance objectives that need to be taken into account to obtain a holistic assessment of partner contribution to the project (Bercovitz et al. 2006, Hoegl et al. 2004, Faraj and Sproull 2000). Specifically, respondents rated the impact of involving partners in their projects across each dimension by specifying the % increase (or decrease) in values across each dimension. That is, increases in project completion time, project costs, and product quality were denoted by positive % values and vice-versa. Given that the measures of project completion time and project costs both reflected a project's ability to efficiently utilize input resources and were highly correlated with each other, we combined these two measures using principal component analysis to create a single measure: cost. The empirical analysis in this study, therefore, utilizes two dependent variables to measure the impact of partnering relationships in a project: *Cost* and *Quality*. Given that a respondent's perception of partnering performance in a project may be influenced by the overall performance of the project, we carried out analysis to assess the impact of overall project performance and confirm the robustness of partnering performance measures. The details of this analysis are provided in the section on checks for robustness on p. 28.

Contract Choice: Contract choice is a categorical variable in our study that reflects the governance structure for the project. We examine three different choices of contract in our study: fixed price contract, time & materials contract, and performance-based contract.

Independent Variables:

Partnering Objective: To evaluate the partnering objective of a project, we first asked respondents to provide a relative ranking of the importance of four dimensions in their project. Specifically, respondents were asked to rank the importance of the following dimensions on a 1-4 scale (1-most important, 4- least important): (i) to lower the cost of labor and resources, (ii) to supplement development capacity, (iii) to access technical expertise or other skills not possessed in-house, and (iv) to access knowledge about the local market and/or relationships with local organizations. The first two dimensions relating to lowering cost and enhancing development efficiency reflected *short-run* objectives for a project, whereas the remaining two objectives relating to accessing superior technical knowledge and market knowledge reflected *long-run* objectives for a project. Given that the different dimensions were ranked relative to each other, greater importance to the first two dimensions (e.g., a rank of 1 or 2) was indicative of lower importance to the last two dimensions (e.g., a rank of 3 or 4). We, therefore, developed a continuous measure of partnering objective for a project by averaging the rankings across the first two dimensions; this measure had numerical values ranging on a scale from 1.5 to 3.5, with increasing values on the scale representing an increase in the long-run orientation for a project.

Partnering Scope: To assess the extent of partnering scope in an R&D project, we asked respondents to indicate whether partners were involved in (i) Development only (coded as '0') or (ii) Development and Production (coded as '1'). Higher values, thus, indicated greater partnering scope in a project.

Partner Integration: As indicated earlier, partner integration captures the extent to which partner staff worked closely with the internal project team and were involved in the project. To measure partner integration in a project, respondents were asked to rate the extent to which partner staff were involved in the project across three dimensions:(1) the extent to which partner staff were allocated to the project [full-time = 1, part-time = 0], (2) the extent to which partner staff were included in internal project team communications [included in all internal project team communication = 1, included only in relevant internal project team communications or not included at all = 0] , and (3) given access to intellectual property [full and open access to intellectual property = 1, selective or no access to intellectual property = 0]. The responses across each of these three dimensions were summarized to yield a composite measure of partner integration with values ranging from 0 to 3.

Control Variables

Project Characteristics: External factors pertaining to the characteristics of a project could create potential variation in partnering performance outcomes. Hence, we controlled for several such project characteristics in our analysis.

- *Project Team Size*: Project team size captures the total number of employees belonging to a firm and its partners that were directly involved in the execution of the project. We included the natural logarithm of this variable, *ln[Team Size]* ,in our analysis.
- *Project Duration*: Project duration measures the total duration of a project in months and is an indicator of the time input as well as the manpower or labor input in the project. We included the natural logarithm of this variable, *ln[Duration]*, in our analysis.
- *Project Budget*: Project budget represents the total budgetary allocation for a project. We asked respondents to indicate the actual cost of the project (in millions of US dollars). We included the natural logarithm of this variable, *ln[Budget]*,in our analysis
- *Project Type*: Following past studies (e.g., Atuahene-Gima 2003, Vanneste and Puranam, 2010), we controlled for the effect of project type on partnering performance by creating two dummy variables (*Software* and *Electronic Hardware*) and including them in our analysis.
- *Partnering Budget:* Partnering budget represents the percentage of the overall budget of the R&D project which was allocated to partnering relationships in the project.

Respondent Characteristics: To minimize respondent biases (Kirsch et al. 2002), we controlled for heterogeneity among respondents by: (i) creating a dummy variable to represent their role in the project (*Project/Program Manager* or *Head of R&D/Engineering/Product Development*) and (ii) by creating dummy variables to represent their functions within the organization (*Management, Product Development, Product Management, Program Management, Engineering, Finance, Marketing, Sales, Others*).

Firm-level Heterogeneity: Finally, we also controlled for firm level heterogeneity in our analysis by including the following control variables to reflect firm level characteristics:

- *Firm Partnering*: Firm partnering captures the percentage of development projects in a firm's product development portfolio that makes significant use of partners to perform design and development work. We included the natural logarithm of this variable, *ln[Firm Partnering]*, in our analysis
- *Firm Size*: Firm size captures the number of employees in the firm. We included the natural logarithm of this variable, *ln[Firm Size]*,in our analysis
- *Industry*: We control for heterogeneity in industry type in our analysis by including dummy variables for the six industries that are represented in the study sample (*Software*, *Hardware*, *Telecommunications*, *Financial Services*, *Automotive*, and *Medical Devices*)

4. Empirical Results

Table A2 in the appendix reports the summary statistics and pair-wise correlations for the variables in our analysis. A review of the pair-wise correlations indicated that multicollinearity was not a significant concern in the analysis. Nonetheless, we calculated the variation inflation factors (VIF's) for all estimated models as a precaution, and these were within acceptable limits.

The analysis is carried out in two stages. In the first stage, we examine the impact of partnering strategy on the choice of contract for a project. In the second stage, we examine how the choice of contract then affects the relationship between partner integration and partnering performance.

Contract Choice Model

The choice of contract for a project in our sample represents a nominal categorical variable with three choices—fixed price, time & materials, and performance-based contracts. We therefore specify a multinomial probit model with contract choice as the dependent variable and the partnering strategy variables, partnering objective and partnering scope, as independent variables, along with the control variables described previously:

$$Contract\ Choice = \beta_0 + \beta_{1\text{-}22} \,.\, [Control\ Variables] + \beta_{23} \,.\, Partnering\ Objective + \beta_{24} \,.\, Partnering\ Scope \qquad \text{---------} \ (1)$$

The results of the multinomial probit model predicting contract choice are presented in Table 1. Fixed price contract is denoted the reference category in the analysis. The coefficients of the independent variables in the contract choice equations predicting the choice of time & materials contract and performance-based contract represent the marginal effect of the independent variables in predicting these contract choices *vis-à-vis* the choice of a fixed price contract.

Table 1: Multinomial Probit Model for Contract Choice

	Fixed Price Contract	**Time & Materials Contract**	**Performance-based Contract**
Constant	Base Category	-7.143***	-4.976**
Industry:			
Software		2.287**	-0.482
Hardware		2.282**	-1.738**
Telecommunications		2.446***	-1.839**
Financial Services		1.868**	-2.497***
Automotive		1.370	-1.762**
Respondent Functions:			
Management		0.439	1.917***
Product Development		0.681	2.190***
Product Management		-1.100**	-2.772***
Program Management		-0.406	-0.739
Engineering		-0.117	0.864*
Finance		-0.659	0.361
Marketing		0.154	-1.540
Sales		-0.794	-0.076
Project/Program Manager		-0.118	1.166***
ln[Team Size]		-0.111	0.287
ln[Budget]		0.176	-0.255*
ln[Duration]		0.047	-0.759**
Partnering Budget		0.004	-0.014
Software		-0.068	0.796
Electronic Hardware		-0.683	0.303
ln[Firm Size]		0.159*	-0.167
ln[Firm Partnering]		0.211	0.448
Partnering Objective [PO]		0.550***	0.486***
Partnering Scope [PS]		0.666**	0.790**
Log-Likelihood			-134.04
Chi-Square			109.55 ***
AIC			368.07
Sample Size (N)			172

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

Hypothesis 1 predicts that both time & materials contract and performance-based contract will supplant the choice of fixed price contract, respectively, with increasing long run orientation of partnering objective. Consistent with these predictions, the probit model results indicate significant positive effects of partnering objective on the choice of time and materials contract ($\beta = 0.550$, $p < 0.01$) and performance-based contract ($\beta = 0.486$, $p < 0.01$), indicating support for Hypothesis 1. Taken together, these findings highlight an increasing tendency for managers to choose time and materials or performance-based contract over a fixed price contract as partnering objective becomes increasingly long-run.

Hypothesis 2 predicts that both time & materials contract and performance-based contract will supplant the choice of fixed price contract, respectively, with increasing partnering scope. . Consistent with these predictions, the probit model results indicate significant positive effects of partnering scope on the choice of time & materials contract ($\beta = 0.666$, $p < 0.05$) and performance-based contract ($\beta = 0.790$, $p < 0.05$), indicating support for Hypothesis 2. Taken together, these findings suggest an increasing tendency for managers to choose time and materials or performance-based contract over a fixed price contract with increasing scope of partnering relationships in a project.

Partnering Performance Model

The choice of contract represents an endogenous self-selected variable in our conceptual framework that is driven by the partnering strategy for a project. Standard OLS regression, where the predictor variables are assumed to be exogenous, can lead to biased estimates when examining the interrelationship between contract choices, partner integration, and partnering performance. To correct for endogeneity, we use a "treatment-effects" model (Maddala 1983, Hamilton and Nickerson, 2003). The treatment effect model involves running separate regressions on each contract choice (or "treatment") to estimate the impact of partner integration on partnering performance. Each individual regression also includes a variable called the *Inverse Mills Ratio*, which corrects for the endogenous self-selection of the project into its observed contract choice. The inverse mills ratio variable for each contract choice is constructed using the predicted probabilities for that contract choice from the first stage multinomial probit choice model shown in equation (1). The inclusion of the inverse mills ratio variable can often create significant multicollinearity issues when the set of control variables do not differ across the two stages (Hamilton and Nickerson 2003). Therefore, to circumvent this issue, we removed the control variables for industry and respondent function from the analysis.[4] The partnering performance model for each contract choice is specified as follows:

$$Cost_i = \gamma_{0i} + \gamma_{1\text{-}9i} \cdot [Control\ Variables] + \gamma_{10i} \cdot Partner\ Integration + \gamma_{11i} \cdot Inverse\ Mills\ Ratio \quad \text{---------} (2)$$

$$Quality_i = \gamma_{0i} + \gamma_{1\text{-}9i} \cdot [Control\ Variables] + \gamma_{10i} \cdot Partner\ Integration + \gamma_{11i} \cdot Inverse\ Mills\ Ratio \quad \text{---------} (3)$$

where i Є {Fixed Price Contract, Time and Materials Contract, Performance-based Contract}

We use the seemingly unrelated regression (SUR) technique (Zellner 1962) to estimate the effect of partner integration on the dependent variables of cost and product quality, for each contract choice. SUR is the appropriate technique for estimating the coefficients in regression equations when the errors from the equations are correlated with each other. Since the data for the regression equations in the partnering performance model are collected from the same set of projects, it is likely that the error terms in these equations may be correlated with each other. Hence, we use the SUR technique to estimate the regression coefficients in these equations. The effects of contract choice on the relationship between partner integration and partnering performance is then detected by comparing the coefficients of partner integration in the regression equations representing fixed price contract to those in the regression equations representing time & materials and performance-based contract. The results representing the effect of partner integration on partnering performance for each category of contract choice are represented in Table 2. The appropriateness of the SUR technique in our analysis is confirmed by the Breusch-Pagan ($\chi 2$) test for independence which indicates significant correlation between the error terms across the regression equations for each contract choice.

[4] We also carried out the analysis in the second stage by including the control variables for industry and respondent function. Despite the presence of multicollinearity among the control variables, the parameter estimates of the partner integration variable were consistent with those from our main analysis in the paper.

Table 2: SUR results for Partnering Performance Model

	Fixed Price Contract		**Time & Materials Contract**		**Performance-based Contract**	
	Cost	Quality	Cost	Quality	Cost	Quality
Constant	-17.840	9.054	-34.543	-40.821	-33.751	-22.481
Project/Program Manager	-1.014	-0.954	-4.121	11.084**	-12.021**	-6.461
ln[Team Size]	1.172	3.526*	-1.436	-1.804	0.671	-1.800
ln[Budget]	0.623	0.668	4.695***	3.721**	4.343*	5.455**
ln[Duration]	0.923	-6.475**	-1.557	4.030	10.006***	7.659*
Partnering Budget	0.148	0.122	-0.172	0.081	0.376*	0.037
Software	1.404	3.740	-0.996	5.286	6.185	-3.213
Electronic Hardware	-7.918	-4.428	-2.764	7.946	7.477	-5.111
ln[Firm Size]	-1.668	-1.838	-0.904	1.990	-8.772***	-9.750***
ln[Firm Partnering]	7.026	3.751	12.461**	2.595	13.834*	19.411**
Partner Integration	6.294***	1.316	7.623***	10.778***	14.529***	13.372***
Inverse Mills Ratio (λ)	-2.847	0.577	4.178	0.603	1.454	16.708*
R-Square	0.322	0.254	0.430	0.392	0.688	0.643
Chi-Square	37.06***	26.57**	45.22***	38.61***	74.87***	61.29***
Sample Size (N)	78		60		34	
Breusch-Pagan (χ2) Test for Independence	18.483***		2.742*		10.863***	

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$

Hypothesis 3 predicts that fixed price contracts will be associated with increasing costs but no effect on product quality as partner integration increases. The regression results indicate that partner integration has a significant positive effect on cost (β = 6.294, p < 0.01) but no effect on product quality (β = 1.1316, p > 0.10). Hypothesis 3 is therefore supported in our study. In contrast, Hypothesis 4 predicts that both time & materials and performance-based contracts will be associated with an increase in costs as well as an increasing in product quality as partner integration increases. As the regression model results for time & materials contract indicate, partner integration not only has a significant positive effect on cost (β = 7.623, p < 0.01) but also a significant positive impact on product quality (β = 10.778, p < 0.01). An examination of the regression results for performance-based contract reveals a similar trend—i.e., partner integration has a positive impact on both cost (β =

14.529, $p < 0.01$) and product quality ($\beta = 13.372$, $p < 0.01$) in a project. Hypothesis 4 is, therefore, supported in our study.

Hypothesis 5 predicts that partner integration will be associated with higher costs in the presence of time and materials contract and performance-based contract, respectively, compared to a fixed price contract. The procedure for testing this hypothesis involves comparing the coefficients of partner integration on cost across the different contract choices and conducting a statistical t-test to evaluate the differences in coefficients. A comparison of the coefficient of partner integration across fixed price and time & materials contract does not indicate any significant differences ($\beta = 1.328$, $p > 0.1$). That is, the effect of partner integration on cost does not differ across fixed price and time & materials contract choices. In contrast, a comparison of the coefficient of partner integration across fixed price and performance-based contract indicates significant differences ($\beta = 8.235$, $p < 0.01$). This indicates that partner integration has a stronger positive effect on cost in the case of performance-based contract compared to fixed price contract. Hypothesis 5 is therefore partially supported in our analysis. Figure 2 illustrates effect of partner integration on cost across the different contract choices.

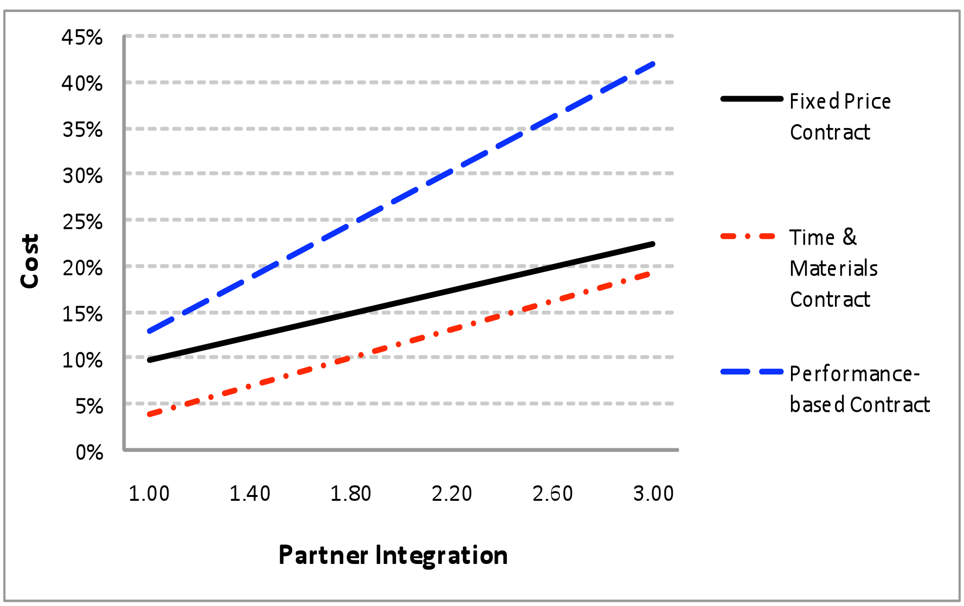

Figure 2: Effect of Partner Integration on Cost across the different Contract Choices

Hypothesis 6 predicts that partner integration will be associated with higher product quality in the presence of both time & materials contract and performance-based contract as compared to a fixed price contract. A comparison of the coefficients of partner integration on product quality across time & materials ($\beta = 9.463$, $p < 0.01$) and performance-based ($\beta = 12.056$, $p < 0.01$) contract to that in fixed price contract reveals significant differences. That is, partner integration has a stronger positive effect on product quality in the presence of a time & materials and performance-based contract compared to a fixed price contract. Hypothesis 6 is therefore supported in our analysis. Figure 3 illustrates effect of partner integration on cost across the different contract choices.

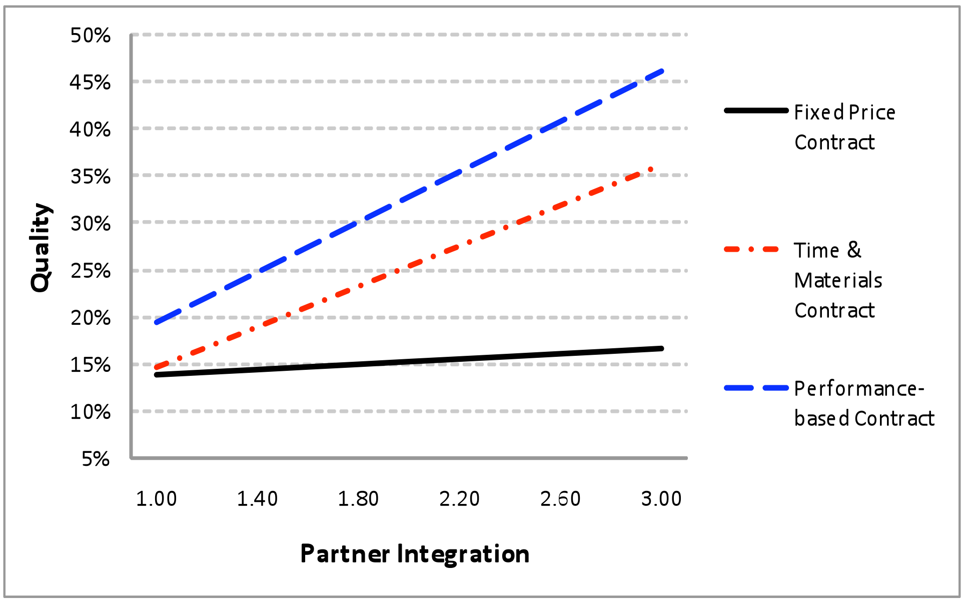

Figure 3: Effect of Partner Integration on Product Quality across the different Contract Choices

Impact of (Mis)alignment between Partnering Strategy and Contract Choice

We carried out additional analysis to examine the performance consequences when partnering strategy and contract choice in a project were not aligned, i.e., when observed contract choice for a project was not consistent with the theoretically predicted contract choice from the partnering strategy of the project. The predicted contract choice for a project was determined by taking into account the predicted probability values associated with each contract choice for the project. A comparison between the observed and the predicted contract choice for a project highlighted four distinct categories of projects:

- **Category 1:** Observed contract choice = Predicted contract choice = Fixed price contract (n = 55 projects)

- **Category 2:** Observed contract choice = Fixed price contract, Predicted contract choice = Time & materials/Performance-based contract (n = 23 projects)

- **Category 3:** Observed contract choice = Time & materials/Performance-based contract, Predicted contract choice = Fixed price contract (n = 36 projects)

- **Category 4:** Observed contract choice = Predicted contract choice = Time & materials/Performance-based contract (n = 58 projects)

We then examined the effect of partner integration on cost and product quality across these four categories. Our analysis revealed some intriguing findings which are documented in Figure 4.

		Predicted Contract Choice			
		Fixed Price		T&M/Performance -based	
Observed Contract Choice	T&M/Performance-based	Category 3: 36 projects (Misalignment)		Category 4: 58 projects (Alignment)	
		Cost	**Quality**	**Cost**	**Quality**
		11.586*** (2.360)	6.600** (3.399)	8.752*** (2.623)	12.286** (2.823)
	Fixed Price	Category 1: 55 Projects (Alignment)		Category 2: 23 projects (Misalignment)	
		Cost	**Quality**	**Cost**	**Quality**
		5.882*** (2.397)	1.060 (2.517)	8.481** (4.187)	1.861 (4.489)

*Coefficients represent the effect of Partner Integration (standard errors in parentheses)

Figure 4: Effect of (mis)alignment between partnering strategy (i.e., predicted contract choice) and observed contract choice on partnering performance

Specifically, a comparison of the results across samples of projects in categories 1 and 3 indicated that partner integration had a higher impact on cost when managers chose a time & materials or a performance-based contract ($\beta = 11.586$, $p < 0.01$) for a project instead of the predicted choice of fixed price contract ($\beta = 5.882$, $p < 0.01$) for the project. The difference in the effect of partner integration on cost across these two categories was statistically significant ($\beta = 5.704$, $p < 0.05$). However, despite the incremental impact on cost, an unintended benefit that arose out of increasing levels of partner integration in the sample of projects in category 3 was the accompanying improvement in product quality ($\beta = 6.600$, $p < 0.01$).

In contrast, a comparison of the results across samples of projects in categories 2 and 4 indicated that while partner integration had statistically similar impact on cost across these categories ($\beta = 8.481$, $p < 0.01$ in Category 2; $\beta = 8.752$, $p < 0.01$ in Category 4), it had no impact on product quality ($\beta = 1.861$, $p > 0.1$) when managers chose a fixed price contract for a project instead of the predicted choice of time & materials or performance-based contract. Taken together, the findings across the sub-samples indicate that the penalty for choosing a contract that is not aligned with the partnering strategy for a project is asymmetric across contract choices. The performance consequences of such a misalignment is particularly severe in projects where a fixed price contract is chosen instead of the predicted choice of time & materials or a performance-based contract—not only does the misalignment render partner integration ineffective in improving product quality but also make it 'counter-productive' when it came to managing the costs of the project.

Checks for Robustness

Assessing the Impact of Overall Project Performance on Partnering Performance: The overall performance of a project may influence a respondent's perception of partner contribution to the project and bias evaluations of partnering performance. We carried out analysis to assess whether the inclusion of measures for overall project performance in the partnering performance model has any impact on the relationship between partner integration and partnering performance, across the different contract choices. Specifically, we included two variables that measure the overall performance of a project in terms of % overrun in the project's budget (*Budget Overrun*) and the project's duration (*Duration Overrun*), in the partnering performance model. The analysis using this additional set of control variables yielded results that were consistent with the main analysis in Table 2.

Assessing the Impact of Common Method Variance: Our study uses self-reported data collected from a single respondent for each project in our sample. This raises concerns that common method variance (CMV)—the amount of spurious covariance shared among variables that can lead to inflated correlations among the variables—could bias our findings. We used several procedural techniques, as suggested by Podsakoff et al. (2003), to reduce biases arising from CMV. Specifically, we focused on reducing CMV during the survey design stage by: (i) maintaining anonymity of respondents and assuring them of confidentiality, which increased their willingness to participate and provide accurate responses; (ii) ironing out vague concepts and ambiguities in survey questions through pilot testing with actual managers; (iii) using separate response formats for measuring each of the variables in our conceptual framework. Additionally, for the following reasons identified below, we believe that CMV is less likely to bias our results.

First, given the non-linear nature of the majority of our hypothesized relationships—Hypotheses 1 and 2 are tested using a multinomial probit model whereas Hypothesis 5 and 6 involve interaction effects—respondents are less likely to make systematic attributions between the independent and dependent variables (Cook and Campbell 1979, Siemsen et al. 2009). Second, key informants within the project were approached to respond to our survey. As our respondent profile indicates, nearly 63% of the respondents were project managers or program managers while the remaining 37% were senior level managers who currently managed the R&D, engineering, product development department within their firm. These managers were actively involved in the project, interacted frequently with the partner staff and had credible and deep knowledge about the responses. The practice of using a key informant within a firm to examine the dynamics of partnering relationships at the project level is consistent with the approach used in recent empirical studies (e.g., Tiwana 2008, Bercovitz et al. 2006, Li et al. 2007, Goo et al. 2009). Finally, the objective measures of partnering performance (i.e., cost and quality) used in our study are likely to correspond closely to the actual metrics used by managers to evaluate the contribution of partners to project performance. This is in marked contrast to subjective measures of partnering performance captured on Likert scales that have been frequently used in the recent literature to capture partnering performance (Bercovitz et al. 2006, Gulati et al. 2005). While subjective measures of partnering performance are likely to tap into a manager's perceptions of partnering performance and could potentially incorporate some of their biases, objective measures (such as those used in this study) are less likely to incorporate such biases as they are often directly estimated from recorded observations in a project. Collectively, the above arguments suggest that CMV does not pose a major threat to our study and is less likely to bias our results.

Alternative specification for the Partner Integration Variable: As mentioned previously, each of the three components of partner integration—namely, (1) the extent to which partner staff were allocated to the project, (2) the extent to which partner staff were included in internal project team communications, and (3) the extent to which partner staff were given access to intellectual property—were coded on a binary scale (0, 1) and summarized to yield a composite score of partner integration with values ranging from 0 to 3. We tried an alternative specification for partner integration for testing Hypotheses 3-6 wherein each of its underlying dimensions were coded on an ordinal scale from 1 to 3. For example, partner staff allocation in a project was coded as 1 if partner staff worked part-time on this project during the periods their skills were needed, 2 if partner staff worked full time during the period their skills were needed, and 3 if partner staff worked full-time on this project for the entire project duration. Consequently, the composite score for partner integration now contained values ranging from 3 to 9. The analysis using this alternative specification of partner integration variable yielded results that were consistent with the main analysis in Table 3.

Discussion and Conclusions

Our results, in general, confirm the hypotheses that we develop earlier in this paper. Specifically, we show that the choice of contract for an R&D project is associated with the partnering objective and the scope of partnering relationship for the project. As discussed earlier, these two factors, in combination, constitute a firm's partnering strategy for a project. Firms that deploy partners in their R&D projects to achieve the *long-run* objectives of accessing unique skills and technical capabilities of the partners and gain new market knowledge (relative to the *short-run* objectives of minimizing development costs and gain production/capacity advantages) are likely to choose a time & materials or a performance-based contract (relative to a fixed price contract) for the projects. Additionally, firms that involve partners over a broader scope of activities in their R&D projects are more likely to choose a time & materials or performance-based contract over a fixed price contract for the projects. The choice between a time & materials and a performance-based contract, in turn, relates more to specific industry and respondent characteristics, than to project-level variables. In essence, all else being equal, firms that that employ broad, capability-based partnering relationships in their R&D projects are equally likely to choose either type of contract.

We also find that an increased level of partner integration is always associated with increased costs; but is only associated with increased product quality in projects that use time & materials or performance-based contracts. In essence, the choice of contract establishes an incentive regime within which partners make decisions about the level of effort to expend. This contract also reflects the specific objectives that a firm has for the partners. In a fixed price contract, partners are typically asked to deliver a product of equivalent quality at lower cost. The partners have neither the incentive, nor the responsibility, to improve product quality. By contrast, under more flexible contracts such as a time & materials or performance-based contracts, partners are often asked to contribute unique skills and capabilities to the project. The partners not only have the incentive then, but also the responsibility to improve product quality. While higher levels of integration can help partners to identify improvements in product quality, our results emphasize that such improvements are more likely to be seen under flexible contracts.

Finally, we show that when firms choose the wrong type of contract, thereby creating a misalignment between their partnering strategy and their governance structure, they incur a penalty in terms of both cost and product quality. The penalty for misalignment, however, is asymmetric, depending upon the type of misalignment. Specifically, choosing a fixed price contract in a project best suited to a more flexible contract type such as a time & materials or a performance-based contract eliminates any association between partner integration and product quality. Conversely, choosing a more flexible contract type in a project best suited to a fixed price contract substantially increases the cost of integration. However, we also see a gain in product quality. This suggests that in projects with short-run partnering objective and narrow scope of partnering relationship, partners are still likely to be able to identify opportunities to improve the final product, despite that not being their primary objective.

Findings from this study have distinct implications for practitioners. In particular, we highlight the importance of aligning the governance and management decisions that are made within a project with the firm's overall partnering strategy. In many firms, there is temporal and structural separation between these decisions which increases the likelihood of their misalignment. Specifically, while decisions relating to partnering strategy are typically framed by top management at the higher echelons of a firm, before the start of a project, decisions relating to the governance and management of projects are often made by project managers at the lower echelons of the firm, during the course of project execution (Gerwin and Ferris 2004, Ethiraj et al. 2005). As R&D projects often evolve during the course of their execution, the partnering strategy formed before the start of a project may not necessarily be compatible with the subsequent governance and management decisions and lead to dysfunctional perturbations in project execution (Hoegl et al. 2004). Furthermore, some firms develop "umbrella" contract structures for use across many projects or partners, believing this to be more efficient way to control governance. Unfortunately, unless these structures encompass a broad spectrum of contract choices, they are unlikely to suit every type of project. Managers must be educated consumers of such "standard" contracts, and learn to recognize situations in which exceptions are needed.

The second important finding we highlight is that increasing the level of partner integration is not a uniform best practice in project management. Rather, we show that integration is costly, and these costs are only warranted in projects that are governed by flexible contract types such as time & materials or performance-based contracts, where partners have both the responsibility and the incentive to improve product quality. Intriguingly, this result runs counter to much conventional management wisdom, which focuses only on the upside of partner integration, hence argues that "more" is always better. By carefully articulating the types of context in which integration can lead to enhanced quality of the developed product, we help managers (across firms and their partners) assess where and when they should pay for these benefits.

Finally, our results serve to highlight the factors that dictate which of the more flexible contract types a manager might wish to choose, in different situations. We find increased levels of integration are more costly under a performance-based contract than a time & materials-based contract. However, the impact on product quality is also higher. Choosing between these types requires that we assess the trade-off between the marginal costs and benefits for specific contexts of interest. In general, our results indicate that in markets where the returns to product quality are high (i.e., the value of a 10% increase in sales) the choice of a performance-based contract is optimal – given this will create incentives for the partner to maximize product quality. By contrast, in markets where development costs are high and margins are low, we might expect to observe the reverse. Of course, these results must be set against the strong impact of industry-specific factors.

From an academic standpoint, our study contributes to the existing literature in several ways. First, our study introduces the notion of "fit" (Venkatraman 1989) to this literature, by articulating the need for alignment between a firm's partnering strategy, and the manner in which it both governs and manages its partnering relationships in R&D projects. While the extant literature on contracts has primarily examined the role of contextual attributes (requirements, uncertainty, project complexity, project size, etc.) on the choice of contract for a project (Gopal et al. 2003), much less is known about how attributes of the partnering relationship influence the choice of contract for a project. Our study addresses this gap in the extant literature, by examining how factors characterizing the partnering strategy for a project, i.e., partnering objective and partnering scope, shape the choice of contract for the project. Further, our study demonstrates the significance of such an alignment between partnering strategy and contract choice by providing direct empirical evidence of the performance consequences of (mis)alignment. This constitutes an important contribution to the extant literature as it not only validates the logic underlying the TCE theory, but also highlights the performance implications of the theory—a relationship for which limited empirical evidence exists in the literature (notable exceptions include Mayer and Nickerson 2005, Bercovitz et al. 2006, Mooi and Ghosh 2010). As Mooi and Ghosh (2010, p. 105) emphasize, "*direct evidence of the costs of misaligned governance is a crucial test of the logic underlying TCE (Anderson 1988) because lack of such evidence provokes the question: Does governance matter? Substantively, understanding the costs of misaligned governance is critical to managerial practice because the design of appropriate governance structures ties up costly managerial effort and valuable organizational resources.*"

Second, with respect to governance structure in a project, we extend the analysis of traditional contract choices (i.e., fixed price and time & materials) in the extant literature by exploring a newer, much less studied form of contract (i.e., performance-based contract) in which a partner's reward is contingent on performance. Finally, in contrast to much of the prior contracting literature which has primarily examined contracts in samples of projects drawn from a single firm (Gopal et al. 2003, Mayer and Nickerson 2005), our study was designed to capture data from multiple firms across multiple industries. This enhances the generalizability of the results from our study. As Mayer and Nickerson (2005, p. 239) aptly note, *"testing hypotheses at the level of the transaction (i.e., the project level) requires detailed data, which makes data collection from multiple firms very costly. [However] Only by replicating research of this type in a variety of settings can scholars gain confidence that the empirical results apply more broadly."* Also, given that we adopt explicit controls for different firm and industry contexts as well as product-specific attributes (i.e., software, hardware and physical products) in our empirical analysis, our results are likely to be quite robust to heterogeneity across projects.

While we have made significant efforts to eliminate or reduce the impact of key challenges that impact our research design, this work is still subject to several limitations. We capture data from a single respondent; hence our results may reflect the biases that accompany these respondents (we discussed these challenges and our responses earlier). We ask these respondents to estimate the impact of partners on project performance. While we demonstrate that these assessments are independent of overall project level performance, the perceptions of respondents may still have inaccuracies or biases. Finally, our data collection effort was based on a targeted sampling list managed by a market research firm. It is possible that the populations of participants contacted by this firm may not be wholly representative of the general populations in each industry.

Our work opens up a number of important avenues for future work. With respect to contract choice, more work is needed to tease apart the costs and benefits of flexible contract types, especially with respect to different types of performance-based contracts. The world of practice has seen a rise in the popularity of these contracts, yet without a consequent increase in our understanding of their advantages and pitfalls. For example, partners assume increased risk in such contracts, but may lack enough market knowledge to understand these risks, or know how to effectively price them. Further, while our results demonstrate the asymmetric penalties associated with misalignment between a firm's partnering strategy and the choice of contract for a project, we still have limited understanding of why such asymmetric penalties exist. Future research is needed to better understand the theoretical underpinnings for the asymmetric penalties and highlight both the downside risk as well upside benefits of such penalties for managers in R&D projects. Finally, we also see potential in broadening the scope of our enquiry to include other managerial processes that might be contingent on the choice of strategy and/or contract. For example, the choice of development approach (i.e., waterfall or agile project management), and the interaction of such a choice with the design of a product's architecture have proven fruitful areas to probe in prior work. By considering how these decisions can be aligned with attributes of a partnering relationship and contract choice, we should significantly improve our understanding of how to design an effective partnering relationship.

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Appendix

Table A1: Questionnaire Items

Partnering Performance	**Please assess the impact of using partners on the following performance outcomes** Schedule Overrun: Using partners increased total project completion time by ___ % Cost Overrun: Using partners increased total project completion costs by ___ % Quality: Using partners increased product quality by ___ %
Contract Choice	**Which of the following best captures the type of contract for the project:** 1) Fixed Price Contract, 2) Time & Materials Contract, and 3) Performance-based contract
Partnering Objective	**Please rank the objectives of your partnering efforts on this project, in order of importance from 1 – 4.** To lower the cost of labor and resources To supplement development capacity To access technical expertise or other skills not possessed in-house To access knowledge about the local market and/or relationships with local organizations
Partnering Scope	**In general, what was the nature of the relationship with your collaboration partners?** Development only: Partner only helped to design and test the product Development and Production: Partner helped to design and test the product and subsequently produced parts for it
Partner Integration	**Which of the following best captures the way that partner staff was allocated to the project?** Partner staff worked full-time on this project, for the entire project duration Partner staff worked during the periods their skills were needed Partner staff worked part-time on this project, during the periods their skills were needed **Which of the following best captures the degree to which partner staff was included in your internal project team communications (e.g., meetings, emails, etc.)?** Partner staff were included in all internal project team communications Partner staff were included in internal project team communications if relevant to their work Partner staff were not included in internal project team communications **Which of the following best captures the type of access your partner had to your intellectual property during the project?** The partner had full and open access to any and all intellectual property. The partner had access to selected intellectual property based on permissions and authorizations. The partner had no access to intellectual property.
Control Variables	**Industry:** 1) Software (commercial software products), 2) Hardware (computer platforms and systems, storage, consumer electronics and computer peripherals), 3) Telecommunications (data, video and voice), 4) Financial Services, 5) Automotive, 6) Medical Devices **Respondent Functional Role:** 1) Management, 2) Product Development, 3) Product Management, 4) Program Management, 5) Engineering, 6) Finance, 7) Marketing, 8) Sales, and 9) Others **Respondent Role:** 1) Project or Program Manager, and 2) Head of R&D, Engineering, Product Development **Team Size:** Total number of participants in a project **Budget:** Actual cost of the project (In Millions) **Duration:** Actual duration of the project (In Months) **Project Type:** 1) Software (e.g., Enterprise Software, Real Time Systems Software), 2) Electonic Hardware (e.g., Computer Server, Telecommunications Equipment), and 3) Other Physical Product (e.g., Medical Device, Automobile) **Partnering Budget:** Percentage of the overall budget for this project allocated to work performed by partners **Firm Size:** Number of employees in the organization worldwide **Firm Partnering:** Percentage of the organization's development projects that makes significant use of partners to perform design and development work

Table A2: Descriptive Statistics and Correlation Matrix

	Key Variables	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	Respondent Role	0.372	0.485	1.000																
2	ln [TeamSize]	3.894	1.118	-0.058	1.000															
3	ln [Budget]	1.351	1.449	0.025	0.361	1.000														
4	ln [Duration]	2.232	0.730	-0.073	0.118	0.087	1.000													
5	Software	0.430	0.497	-0.135	-0.034	0.023	-0.032	1.000												
6	Electronic Hardware	0.355	0.480	0.184	0.145	0.103	-0.111	-0.644	1.000											
7	Partnering Budget	36.698	21.096	0.060	0.059	0.131	-0.163	-0.101	0.123	1.000										
8	ln [Firm Size]	7.568	1.821	0.060	0.054	0.119	0.179	-0.124	0.049	0.065	1.000									
9	ln [Firm Partnering]	3.785	0.467	-0.015	0.142	0.096	-0.194	-0.030	0.085	0.517	-0.018	1.000								
10	Partnering Objective	4.529	1.105	0.089	0.066	-0.091	0.055	0.030	-0.047	0.018	-0.027	0.052	1.000							
11	Partnering Scope	1.477	0.501	-0.012	0.158	-0.030	-0.168	-0.030	0.047	0.040	0.005	0.111	-0.015	1.000						
12	Fixed Price Contract	0.453	0.499	0.024	-0.126	-0.092	0.059	-0.131	0.106	-0.004	-0.015	-0.074	-0.215	-0.168	1.000					
13	Time & Materials Contract	0.349	0.478	-0.034	0.036	0.070	0.047	0.054	-0.058	0.124	0.125	0.090	0.191	0.059	-0.667	1.000				
14	Performance-based Contract	0.198	0.399	0.011	0.114	0.032	-0.129	0.099	-0.063	-0.144	-0.131	-0.014	0.040	0.140	-0.452	-0.363	1.000			
15	Partner Integration	0.785	1.006	-0.087	0.194	0.130	-0.134	0.046	0.014	0.265	-0.157	0.253	0.014	-0.143	-0.014	0.084	-0.083	1.000		
16	Cost	7.108	20.687	-0.165	0.140	0.190	-0.062	0.127	-0.055	0.206	-0.210	0.280	-0.131	-0.192	0.052	-0.084	0.035	0.504	1.000	
17	Quality	14.785	21.483	0.024	0.111	0.147	-0.102	0.059	-0.002	0.243	-0.071	0.229	-0.024	-0.063	-0.053	-0.001	0.067	0.422	0.546	1.000

$|\rho| \geq 0.13$ significant at 0.10 level, $|\rho| \geq 0.15$ significant at 0.05 level, $|\rho| \geq 0.20$ significant at 0.01 level