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FINDING THE BALANCE BETWEEN OUTSOURCING AND INTERNALIZATION: THE KEY TO INNOVATIVE SUCCESS?

presented by

MICHAEL ANDREW STANKO

has been accepted towards fulfillment
of the requirements for the

Ph.D. degree in Marketing

Major Professor's Signature

May 16, 2008

Date

FINDING THE BALANCE BETWEEN OUTSOURCING AND INTERNALIZATION: THE KEY TO INNOVATIVE SUCCESS?

By

Michael Andrew Stanko

A DISSERTATION

Submitted to
Michigan State University
in partial fulfillment of the requirements
for the degree of

DOCTOR OF PHILOSOPHY

Department of Marketing

2008

ABSTRACT

FINDING THE BALANCE BETWEEN OUTSOURCING AND INTERNALIZATION: THE KEY TO INNOVATIVE SUCCESS?

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This dissertation considers two important questions pertaining to the outsourcing of innovation. First, how is the innovation outsourcing decision different from more traditional sourcing decisions? Since Williamson (1991), there has been speculation that the innovation outsourcing decision is distinct from other governance decisions. This research examines learning as well as appropriability as determinants of the innovation outsourcing decision; both of these additional determinants are found to significantly impact the governance decision.

The second question is: What are the performance implications of outsourcing innovation activities? The outcomes of outsourcing innovation are not yet well understood. Here, it is found that firms governing appropriately (i.e., according to transaction cost predictions) are more innovative than firms governing inappropriately. However, appropriately governing firms also face higher total innovation costs, though the increase in costs is proportionately smaller than is the increase in innovativeness. Further, it is shown that firms which over-contract (i.e., outsource too great a portion of their innovation activities) face higher total innovation costs than firms which under-contract, but firms which over-contract tend to be more profitable.

ACKNOWLEDGMENTS

First, I am grateful to my committee for all their efforts during my time in the doctoral program. Professors Roger Calantone, Cornelia Droge, David Griffith and Jonathan Bohlmann have been of tremendous assistance both to the completion of this project as well as to my own development as an emerging scholar.

Thanks also goes to my family, for supporting me through what must have seemed like an eternity of post-secondary education.

Finally, I would like to thank my fellow students for their friendship, assistance, and camaraderie during my time at Michigan State. Though there are too many dear colleagues to list here, if you have also enjoyed too many Owen Cajun Chicken Sandwiches to count, commiserated over late night econometrics problem sets, shared a pint at the Peanut Barrel or cheered on the Spartans with me – thanks.

PREFACE

The research in this dissertation was conducted while the author was a Special Sworn Status researcher of the U.S. Census Bureau at the Michigan Census Research Data Center (MCRDC). Research results and conclusions expressed are those of the author and do not necessarily reflect the views of the Census Bureau. This paper has been screened to insure that no confidential data are revealed.

This project was supported by Michigan State University's Vice President for Research and Graduate Studies through the Health, Institutions and Policy Initiative, and by the Eli Broad Chair Fund of Roger J. Calantone. Support for this research at the MCRDC from the National Science Foundation (NSF) (awards no. SES-0004322 and ITR-0427889) is gratefully acknowledged.

Thank you to Clint Carter, Maggie Levenstein, and Stan Sedo of the MCRDC, Ray Wolfe of the NSF, as well as Arnold Reznek and Lucia Foster of the U.S. Census Bureau. Their help with the data involved in this dissertation was tremendously valuable.

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CHAPTER 1: INTRODUCTION

Innovativeness is central to competitive success. Innovative new products are key to revenue growth (Sorescu et al., 2003) and future market leadership (Chandy & Tellis, 1998). However, innovation efforts are often unsuccessful and can require tremendous investments (Chandy et al., 2006). Given this, it is not surprising that innovation has been a fundamental issue of late in marketing (Carson, 2007; Hauser et al., 2006; Luca & Atuahene-Gima, 2007; Toubia, 2006). Despite researchers' interest in innovation, the problem of managing the firm's innovation boundaries has not yet been well addressed. This problem is increasingly relevant because many firms today are supplanting internally pursued innovation activities with outsourcing arrangements. Innovative firms in industries as diverse as software, automotive and aerospace, as well as less high tech industries such as consumer packaged goods, are choosing to outsource innovation efforts (Carson, 2007). While firms such as Procter & Gamble are making strategic efforts to develop new products outside their organizational boundaries, other firms have taken steps to protect and even promote their internal development competencies; for instance, upon each iPod is printed "Designed by Apple in California" (Engardio & Einhorn, 2005).

Which is the path to innovative success: internal pursuit of innovation activities or contracting these activities to other firms? Consistent with Transaction Cost Analysis (TCA), this study proposes that external innovation contracting can improve innovative performance, but only if it is appropriate to the conditions in which the firm operates.

TCA has been a major paradigm in marketing, management and other disciplines in past decades (Rindfleisch & Heide, 1997) and has been the theoretical basis for several investigations into innovation-related sourcing and alliances (e.g., Pisano, 1990; Robertson & Gatignon, 1998; Sampson, 2004; Ulset, 1996). TCA has also been used to investigate governance choice in a wide variety of other applications ranging from international entry mode (Zhao et al., 2004) to logistics outsourcing (Bienstock & Mentzer, 1999) to the use of a dedicated salesforce vs. sales agencies (Anderson, 1988). There are also applications outside of typical business relationships such as Hamilton's (1999) investigation of prenuptial contracts.

Why is investigating innovation governance distinct from investigating many of these other applications? Innovation is "an iterative process initiated by the perception of a new market and/or service opportunity for a technology based invention which leads to development, production and marketing tasks striving for the commercial success of the invention" (Garcia & Calantone, 2002 p. 112). As discussed by Williamson (1991, p. 292-293), peculiarities in innovation-related governance require an extension of TCA to capture the complications involved in this type of governance decision. Innovation-related governance is distinct from other types of organizational governance in two particular respects. First, the fear of appropriation (losing intellectual property to partner firms) is heightened, as most firms believe innovation to be central to their core competencies (Coombs, 1996) and future competitiveness (Howells et al., 2003). Second, in certain environments, critical learning is done while performing innovation activities (learning by doing). Since innovation is an iterative process (Garcia & Calantone, 2002), an organization's knowledge continues to build upon itself. When an

organization lacks knowledge in a particular domain, significant time and effort may be needed to develop the needed capabilities internally.

According to Williamson (1991), the first of these peculiarities involves the role knowledge appropriation (leakage) plays in this decision. Firms justifiably fear that by sharing their knowledge with partner firms, they may lose intellectual property or create competitors (Narula, 2001; Veugelers & Cassiman, 1999). The role of knowledge appropriation has been investigated by several researchers (Cesaroni, 2004; Teece, 1986; Veugelers & Cassiman, 1999) and the threat of knowledge leakage has been shown to deter the contracting of innovation activities.

Williamson also notes that when making the innovation governance decision, market governance (i.e., outsourcing) may be selected to facilitate timely development of new products. There are two situations in which firms are likely to pursue outsourcing for this reason: First, "when events are fast moving" and second, "if learning-by-doing is essential" (p. 292). TCA-based research has considered technological uncertainty (e.g., Balakrishnan & Wernerfelt, 1986; Robertson & Gatignon, 1998; Walker & Weber, 1984), which is closely related to Williamson's first timeliness condition. In a technologically uncertain environment, specifications, desired outcomes, as well as requirements for both expertise and equipment are constantly in flux (Howells, 1999). However, the importance of learning has thus far been ignored in the TCA-based innovation governance literature and is the second peculiarity of the innovation governance decision that is of the interest here. The question remains unanswered: How does the necessity of learning by doing impact the innovation governance decision? Asset specificity has been shown to lead to internal governance (Nakamura & Odagiri,

2005; Ulset, 1996). Here, it is argued that this learning-timeliness effect moderates the relationship between asset specificity and governance mode (see Chapter two for detailed hypotheses). For instance, in an environment where learning is critical, a firm whose innovation activities do not require specific assets will be extremely likely to externally contract to speed innovations to market. In this case, the time and costs associated with gaining necessary learning while developing specific assets will strongly deter an internal governance decision.

This study will examine whether the expanded set of transaction cost arguments suggested by Williamson (1991) – including both the threat of knowledge leakage (which, as mentioned previously, has been incorporated in other TCA-based innovation governance studies) and the importance of learning by doing – better explains firms' innovation governance decisions than does the traditional set of transaction cost arguments. It is not sufficient, however, to show that these additional constructs have an impact on firms' governance patterns. TCA not only makes predictions for firms' selection of governance, but also projects performance implications based on the governance choice. Transaction cost logic argues that when the chosen governance mechanism is best suited to the level of transaction costs, performance will be optimal (Williamson, 1985, p. 22-23). As discussed by Geyskens et al. (2006), Rindfleisch and Heide (1997), and Sampson (2004), too often TCA-based studies have been restricted to explaining governance form, without examining performance implications.

Once the antecedents' impacts on innovation governance have been examined, it is then possible to determine whether firms that have the appropriate mix of internal vs. contracted innovation activities (according to TCA predictions) outperform firms that

over-rely or under-rely on external innovation contracting. Previous innovation research has shown that external governance has both tremendous possible benefits as well as drawbacks. Though external innovation governance has been shown to aid innovativeness (Nicholls-Nixon & Woo, 2003), it also tends to increase innovation costs, not only through the direct spending on contracting, but also by increasing internal innovation spending (Veugelers, 1997). In order to examine the impact of external innovation governance on various performance dimensions, it is necessary to analyze performance as a function of appropriate governance given the environmental characteristics. TCA logic holds that there is no one appropriate governance mode: conditions dictate appropriate governance (Sampson, 2004; Williamson, 1985). In this study, in order to capture several dimensions of innovative performance, three distinct outcome variables are examined: innovativeness, total innovation costs, and profitability. Typically, innovation-related projects are judged by a variety of metrics, making a diversity of performance measures imperative to deriving meaningful implications.

Firms that pursue innovation activities via the predicted mix of internalization and contracting (based on the transaction cost arguments put forward herein) are referred to as using "appropriate" governance[1]. Those firms which do not pursue innovation activities via the TCA-predicted mix of internalization and contracting are referred to as using "inappropriate" governance. Inappropriately governing firms can be divided into two categories: those firms which over-rely on external contracting (i.e., overly market oriented governance) and those firms which under-rely on external contracting (i.e., overly hierarchical governance). If the normative aspect of TCA holds, appropriately governing firms will outperform both groups of inappropriately governing firms (all else

[1] Throughout this study, the terms "contracting" and "outsourcing" are used interchangeably.

equal). Further, a comparison of the performance differences across the two different groups of inappropriately governing firms (those which over-contract externally and those which under-contract externally) will prove interesting to both TCA and innovation scholars as well as managers of the innovation process. Previous researchers have speculated that an over-reliance on external contracting can erode a firm's technological competence over time (Cavusgil et al., 2003; Piachaud, 2005). Equally interesting are the potential repercussions of under-contracting. Researchers have speculated that this will deny firms access to outside expertise and efficiencies (Howells, 1999), thereby preventing firms from concentrating on their core competencies and increasing their overall costs. Here, it is hypothesized that under-contracting is more harmful in the short term than is over-contracting, since under-contracting firms face increased short term costs and lack of flexibility. Conversely, it is hypothesized that over-contracting is more harmful in the long term than is under-contracting since over-contracting can lead to a lessening of a firm's absorptive capacity and eventually the erosion of its core competency.

Two recent research findings are central to the discussion of the relative impact of the two varieties of inappropriate governance. In a TCA-based study of R&D alliances, Sampson (2004) found that firms that rely on too hierarchical (i.e., too close to internal governance) an alliance structure are dramatically less innovative than properly aligned alliances. However, firms using a less hierarchical structure (i.e., too close to market governance) than appropriate were only slightly less innovative than properly governing firms. This suggests that the constraints placed on innovation by inappropriate hierarchical governance are more damaging to performance than the costs imposed by

inappropriately selecting a market oriented governance mode. Leiblein et al.'s (2002) findings also suggest performance asymmetry between the two categories of inappropriately governing firms, but their findings suggest that in production outsourcing decisions, firms selecting a less hierarchical than optimal governance structure more severely under-perform than do firms selecting too hierarchical a governance structure. In opposition to Sampson's findings, this suggests that failing to safeguard assets by inappropriately selecting a market oriented governance option more dramatically harms performance than does selecting too hierarchical a governance option.

In general, the management of cross-boundary innovation is of tremendous interest to practitioners and greater scholarly research is needed in this area (Hauser et al., 2006 p. 694-695). More specifically, this research project contributes to the innovation governance and (mis)governance literatures by addressing three distinct and important problems (summarized in Table 1) in addition to several other possible contributions discussed in the next chapter. First, as discussed previously, the role of learning by doing in innovation governance requires examination (Williamson 1991, p. 292). Does the need to learn internally in innovation-related projects determine firm's innovation governance decisions?

Second, at present researchers do not understand the relative implications of using governance structures that either impose excessive bureaucracy or do not provide adequate safeguards from market hazards. Are firms better off over-relying on external contracting or under-relying on external contracting? The possibly asymmetric performance implications of the two forms of inappropriate governance compel further

investigation, and the use of multiple outcome dimensions in this examination will likely add further insights (as called for by Leiblein et al. 2002, p. 830-831).

Finally, TCA-based researchers have also called for longitudinal testing of the relationship between (in)appropriate governance and performance (Macher & Richman, 2006, p. 63). In an iterative process such as innovation, inappropriate governance likely has long term implications, making examination of longitudinal effects on performance critical (Nicholls-Nixon & Woo, 2003, p. 665). Further, by considering multiple outcome dimensions over time, other insights may surface. For instance, it is plausible that over- contracting may have severe long term innovativeness implications, but only short term cost repercussions. Findings such as these could prove extremely valuable to both scholars and managers.

Table 1: Summary of Contributions

Contribution	Called for by:	Hypotheses
Investigating the management of cross-boundary innovation.	Hauser, Tellis and Griffin (2006 p. 694-695)	All
Investigating role of the importance of learning by doing in innovation governance.	Williamson (1991, p. 292)	H2
Examining implications of (in)appropriate governance on multiple outcome dimensions.	Leiblein et al. (2002, p. 830-831)	H7, H8 and H9
Longitudinal testing of the relationship between (in)appropriate governance and performance	Nicholls-Nixon and Woo (2003, p. 665), Macher and Richman, (2006, p. 63)	H7, H8 and H9

CHAPTER 2: LITERATURE REVIEW AND HYPOTHESES

Transaction Cost Analysis

As stated by Leiblein (2003 p. 940), "The basic idea [of TCA] is to match simple exchanges with simple modes of governance and more complex exchanges with more complex forms of organization." TCA views firms and markets as alternative governance structures. Firms will favor internal organization in environments where transaction costs are prohibitive, and economic factors will favor the market (i.e., outsourcing) when transaction costs are low. Under certain conditions, the costs of performing specific activities through the market may exceed the costs of organizing the activities within the firm, in which case firms will internalize the function. On the other hand, where the costs of performing activities through the market is minimal, firms will favor the use of market governance (Williamson, 1975, 1985).

Transaction costs can be divided into three categories: adaptation, safeguarding and measurement (Macher & Richman, 2006; Rindfleisch & Heide, 1997). *Adaptation costs* represent efforts to adjust contracts to changing conditions and are a result of environmental uncertainty. That is, when a firm may have to revise an agreement with a partner company (thus facing substantial penalties) due to an unstable market environment, the firm is likely to perform this function internally (Masten et al., 1991; Ulset, 1996). *Safeguarding costs* characterize the costs of a partner acting opportunistically after investments in the relationship have been made and are the result of transaction specific investments (John & Weitz, 1988; Pisano, 1990). *Measurement costs* represent the expenses associated with confirming that contracts have been completed as specified and are a result of behavioral uncertainty. If it is very difficult to

determine the quality of a contracted good or service, the contracting firm may face substantial costs to estimate quality. When these transaction costs are substantial, internalization will be favored (Anderson, 1985).

When transaction costs are high, internalization is preferred due to three specific characteristics of the firm (Rindfleisch & Heide, 1997; Williamson, 1985). These characteristics of internal organization allow the firm to detect and control opportunism as well as foster adaptation under conditions characterized by high transaction costs. First, under internal organization, firms can measure both output as well as behavior, where typically it is only possible to measure output from contracted firms. Second, internal organization allows for longer term rewards (e.g., promotions) than contracting typically does. Finally, the socialization process in organizations can help foster goal congruence. These mechanisms help to control opportunism and encourage adaptation within an organization.

TCA makes three assumptions (Macher & Richman, 2006; Rindfleisch & Heide, 1997). *Bounded rationality* presumes that decision makers' cognitive abilities are constrained (Williamson, 1996). Managers are constrained in decision making; they cannot consider every possible course of action, nor can they analyze every possible piece of data. *Opportunism* supposes that an exchange partner may act unscrupulously to serve their own interests, and that it is difficult to establish the trustworthiness of potential partners (John, 1984; Wathne & Heide, 2000). *Risk neutrality* is the assumption that firms are neither risk averse nor risk seeking (Williamson, 1975, 1985). All three of these assumptions hold within the innovation governance context.

Innovation Governance

There exists a substantial literature focused on the innovation governance decision (i.e., whether to outsource or internalize research and development (R&D) or new product development (NPD) efforts). There also exist noteworthy research streams pertaining to the structuring of innovation alliances (c.f. Robertson & Gatignon, 1998), learning from customers or lead users (c.f. von Hippel, 1986, 2005) as well as using venture capital and acquisition as alternatives or supplements to traditional internal innovation efforts (c.f. Dushnitsky & Lenox, 2005). Despite the usefulness of this research in understanding the full range of options available in organizing collaborative innovation efforts, the discussion in this dissertation is largely restricted to research pertaining to internally conducted (hierarchically governed) vs. externally contracted (market governed) innovation. Research focusing exclusively on hybrid governance mechanisms (i.e., alliances) is not the focus here.

As shown in Appendices A and B, there has been a good deal of research examining innovation governance over the past 20 years. Searches of the top journals in the Marketing, Management, Economics, and Innovation disciplines uncovered 19 empirical studies (Appendix A), as well as 11 case studies and managerially focused articles (Appendix B). These articles are summarized in the respective appendices and will now be synthesized and reviewed. First, the various antecedents of external innovation governance will be reviewed, followed by discussion of the consequences of external innovation governance.

Antecedents of External Innovation Governance

Often, innovation governance researchers have used transaction cost arguments to support one or several hypotheses, without providing a more complete test of TCA (e.g., Audretsch et al., 1996; Croisier, 1998). Consequently, some TCA arguments have received much more attention than others in the innovation governance domain. First, findings pertaining to each of these TCA tenants as drivers of innovation governance will be discussed. After this, findings related to non-TCA-based drivers of innovation governance will be reviewed. The research consensus (or lack thereof) for each antecedent of innovation governance is presented in Table 2.

Asset Specificity refers to the transferability of assets which support a given transaction (Williamson, 1985). ***Transaction-Specific Investments*** are investments that are specialized to one or a few users or uses (Anderson & Gatignon, 1986). Succinctly stated, where the level of transaction specific investments is high, safeguarding costs will be prohibitive, causing firms to pursue hierarchical governance (internalization). Williamson (1996) identifies six types of transaction specific investments: (1) site, (2) physical asset, (3) human asset, (4) dedicated assets, (5) brand name capital, and (6) temporal (for discussion of each of these categories and their treatment by researchers see Lohtia et al., 1994). Within the totality of the TCA research stream, asset specificity's role in encouraging internal governance has been well established (David & Han, 2004; Geyskens et al., 2006).

Examples of innovation-related transaction-specific investments include laboratory equipment which is not easily transferable to other applications or

accumulated knowledge which is specific to one application (Lohtia et al., 1994). If significant specific investments are made into a contracted research project, the contracted firm may request additional funds before project completion since the market no longer acts as an adequate safeguard. Firms select hierarchical governance when these costs are expected to be prohibitive in order to avoid this type of bargaining situation (Ulset, 1996).

Innovation governance research findings have been consistent and unambiguous in supporting the relationship between asset specificity and internal innovation governance. When specific assets are required, firms tend to internalize innovation efforts due to prohibitive safeguarding costs. There have been a wide variety of approaches used to measure asset specificity in studies related to innovation governance, including sunk costs (Ulset, 1996), the use of proprietary technologies (Cesaroni, 2004), skilled labor (Audretsch et al., 1996), as well as several measures of firm diversification (Nakamura & Odagiri, 2005; Pisano, 1990). Presumably firms that are less diversified have made more specific investments into the technology area. Despite the variety of measures used within the five identified empirical studies examining the relationship between asset specificity and innovation governance, all five studies made similar conclusions: the presence of asset specificity is related to internal innovation efforts. Accordingly, there appears to be consensus that asset specificity is related to internal innovation governance.

Environmental uncertainty refers to "unanticipated changes in circumstances surrounding an exchange" (Noordewier et al., 1990 p. 82). Consistent with numerous researchers (e.g., Heide & John, 1990; Robertson & Gatignon, 1998) since Walker and

Weber (1984), environmental uncertainty is conceptualized here as having two distinct dimensions: market uncertainty and technological uncertainty.

Market uncertainty is the unpredictability of demand in an industry (adapted from Robertson & Gatignon, 1998). Transaction cost logic dictates that constant changes in market demand will lead to difficulties in contracting, as these changes will necessitate renegotiation, together with the accompanying costs of renegotiation. This relationship has been well established in TCA research (Geyskens et al., 2006). With respect to innovation projects, market uncertainty may cause frequent changes to the development portfolio, complicating and adding expense to external contracting. These changes may necessitate renegotiation or cancellation of innovation contracts, which will likely carry prohibitive penalties (a form of transaction cost). These transaction costs promote internalization under high levels of market uncertainty.

Unfortunately, in the innovation governance literature, there have been relatively few empirical findings related to market uncertainty as an antecedent to the governance decision, with many researchers focusing solely on some measure of technological uncertainty (as will be discussed next). Only two identified empirical studies have examined market uncertainty's impact on the innovation governance decision. These two studies (Audretsch et al., 1996; Love & Roper, 2005) each examines the impact that sales growth (one potential indicator of market uncertainty) has on the selection of internal or external R&D governance. However, both studies show nonsignificant results for the sales growth variable. Interestingly, Carson (2007) finds that market uncertainty has a negative impact on two types of control that contracting firms use (but does not examine market uncertainty's impact on the governance decision). This indicates that contracting

firms believe that tumultuous environments require a greater degree of autonomy for contracted firms. The lack of examination of the role of market uncertainty in innovation governance decisions marks a further gap in the literature to be filled by the present study.

Technological uncertainty refers to the firm's inability to accurately forecast technical requirements (Walker & Weber, 1984). As opposed to market uncertainty, which favors internal governance to facilitate adaptation, the dominant view in modern TCA research is that technological uncertainty is managed best through market governance (Geyskens et al., 2006; Macher & Richman, 2006). In technologically uncertain environments, selecting market governance allows firms the flexibility to end relationships should technical requirements shift (Balakrishnan & Wernerfelt, 1986). This is preferable since contracting with a new partner is generally a faster and less involved process than developing a new technical competency internally. In the wider TCA research stream, this relationship between market governance and technological uncertainty has been well supported (Geyskens et al., 2006). However, this relationship has not been clearly established in the smaller innovation governance literature: various studies have shown that technological uncertainty is related to both hierarchical and market governance. As will be discussed, three identified empirical studies (Calantone & Stanko, 2007; Swan & Allred, 2003; Ulset, 1996) find that constructs associated with technological uncertainty are related to external innovation governance, while two other empirical studies (Croisier, 1998; Nakamura & Odagiri, 2005) imply that technological uncertainty is related to internal innovation governance. It appears that in the innovation

governance context, there may be two conflicting effects imposed by technological uncertainty.

First, technological uncertainty may promote external governance through the flexibility afforded by market contracting. Several research findings indicate that technological uncertainty leads to externally governed innovation. Both firm level (Swan & Allred, 2003; Ulset, 1996) and industry level studies (Calantone & Stanko, 2007) have shown that technological uncertainty is positively related to external innovation governance. These findings are in line with the dominant view in TCA research, that technological uncertainty favors external governance (Geyskens et al., 2006).

Conversely, technological uncertainty may also promote internal governance. The process of contracting is complicated by technological uncertainty. That is, where technical requirements cannot be foreseen, it is difficult to describe project requirements contractually, which raises the transaction costs associated with external contracting and leads to internal governance. There exist both case and empirically based studies which support this relationship between technological uncertainty and internalization. For instance, Narula (2001) finds through interviews with innovation managers that one of the most common explanations for not relying more heavily on contracted innovation activities is the difficulty in negotiating and enforcing contracts caused by the technological uncertainty inherent to innovation. In terms of empirical support, Nakamura and Odagiri (2005) find that when the pace of innovation is fast, firms will tend not to externally contract R&D. Further, Croisier's (1998) study includes several distinct findings suggesting that low levels of technological uncertainty encourage external (market) governance. First, Croisier finds that an R&D project being at an

advanced stage (thus having lower technological uncertainty) is positively related to external R&D sourcing. Further, a low number of technologies used and a short project duration (both indicators of low technological uncertainty) are also associated with contracted R&D.

To sum, there have been a diversity of findings with respect to the innovation governance implications of technological uncertainty. In this application, it is unclear whether technological uncertainty raises the transaction costs associated with external contracting by complicating the specification of desired technical details or lowers transaction costs by allowing contracting firms the flexibility to change vendors (or both). At present, the lack of consensus here calls for further examination of the relationship between technological uncertainty and innovation governance.

Behavioral uncertainty is defined as "the degree of difficulty in verifying whether compliance with established agreements has occurred" (Geyskens et al., 2006 p. 525). Transaction cost logic dictates that when behavioral uncertainty imposes substantial performance evaluation costs, internal governance will be favored. This relationship has been supported in the TCA literature as a whole (Geyskens et al., 2006). In the innovation governance domain, behavioral uncertainty would impose significant transaction costs when, for instance, the costs of ascertaining the quality of a development project performed by a contracted supplier are prohibitive. In this case, internalization will be preferred since the costs of controlling and monitoring quality internally will be less than the costs of measuring the finished output from the supplier.

In the innovation governance literature, there have been relatively few findings related to behavioral uncertainty. Apparently, researchers in this area have chosen to use

either a measure of technological uncertainty, behavioral uncertainty or appropriability (which will be discussed next), but few studies have used more than one of these, despite these being distinct constructs which have shown differing effects on governance in other TCA research (Geyskens et al., 2006).

There are two identified empirical studies relevant to behavioral uncertainty's impact on the innovation governance decision. Steensma and Corley (2001) find that the perceived threat of partner opportunism, which is closely related to behavioral uncertainty, makes an internal governance decision more likely. The other study (Pisano, 1990), presents a nonsignificant finding for a variable related to behavioral uncertainty. Additional support for the relationship between behavioral uncertainty and internal governance can be found in the innovation alliance literature, where Robertson and Gatignon (1998) find that firms are more willing to enter into R&D alliances when innovative performance is easily measured. In summary, there have been relatively few examinations of behavioral uncertainty's impact on R&D governance, but these studies suggest that, in line with traditional TCA logic, firms will be more likely to internalize innovation functions when potential evaluation costs are prohibitive.

Appropriability is the extent to which results from innovative activities can be protected and are not easily diffused within an industry (adapted from Veugelers & Cassiman, 1999). The threat of losing intellectual property by involving partner companies in innovation efforts raises the perceived transaction costs of contracting these efforts and motivates firms to internalize innovation efforts under these circumstances.

Weak appropriability (high threat of knowledge leakage) has consistently been empirically shown to have a negative relationship with external contracting of innovation

activities. In fact, all three identified empirical studies support this relationship between weak appropriability and internal innovation governance (Nakamura & Odagiri, 2005; Steensma & Corley, 2000; Veugelers & Cassiman, 1999). Several case studies provide further support for the negative relationship between weak appropriability and external innovation contracting, with appropriability concerns being listed among managers' foremost concerns when making innovation governance decisions (Narula, 2001; Tapon, 1989). There appears to be consensus in both empirical and case based research that weak appropriability negatively influences external technology contracting.

Non Transaction Cost Determinants of Innovation Governance

In addition to the transaction cost dimensions previously discussed, other potential drivers have been considered by researchers, including those suggested anecdotally by managers as well as those called for by other theory bases. Findings related to these antecedents are discussed so as to be inclusive of other potential explanations for this governance decision, though the current study draws upon only the transaction cost dimensions previously discussed[2]. Findings related to these other antecedents of innovation governance will now be briefly examined.

Low cost goals and profit margin. Despite the widely held notion that firms outsource all activities with cost savings as a primary goal (Piachaud, 2005; Quinn, 2000), empirical evidence consistently suggests that a low cost goal is strongly negatively associated with external innovation contracting (Swan & Allred, 2003; Veugelers & Cassiman, 1999). In general, higher profit margins are associated with conducting more

[2] Though transaction cost logic may be used to support arguments for these drivers, they are presented as non transaction cost determinants since they are not among the formal set of transaction cost dimensions.

innovation activities externally (Calantone & Stanko, 2007), though this relationship has been shown to differ across low and high tech industries (Audretsch et al., 1996). That is, high technology industries, high margins are associated with external technology contracting, while in non high tech industries, high margins are associated with internal development. Collectively, this evidence suggests that access to expertise and other appealing characteristics of potential partner firms (i.e., "pull" factors) are more important to decision makers than is cost savings when making innovation governance decisions (Audretsch et al., 1996; Swan & Allred, 2003; Veugelers & Cassiman, 1999).

Firm size has been shown to have an effect on innovation governance habits by a number of researchers. Small firms tend to either exclusively develop technology in house or contract development externally, whereas large firms tend to use a portfolio approach (i.e., both internal and external governance) (Veugelers & Cassiman, 1999). In general, large firms are more likely to pursue contracted innovation activities than are small firms, since larger firms will have a greater number of R&D projects and will tend to contract at least some these (Nakamura & Odagiri, 2005). In addition to firm size, the increasing scale of innovation projects has been noted to promote external contracting for some firms (Howells et al., 2003; Love & Roper, 2002; Narula, 2001).

Other Antecedents. Aside from the antecedents of external innovation governance already discussed, Swan and Allred (2003) examined a number of possible antecedents of innovation contracting which otherwise have not garnered attention from researchers. These researchers found that a goal of product differentiation is negatively associated with external contracting, indicating that managers believe that by contracting innovation activities they will tend to develop commoditized products since competitors

likely have access to comparable technology via contracting. Also, these same authors found that the distance between marketing and R&D operations (in miles) contributed to the likelihood of external contracting.

Table 2: Antecedents of Innovation Governance: Research Consensus

TCA-Based Determinants of Innovation Governance	Consensus from Innovation Governance Literature	Relevant Empirical Findings
Asset Specificity	Positively related to internal governance	Nakamura & Odagiri (2005), Cesaroni (2004), Veugelers (1997), Ulset (1996), Audretsch et al.(1996)
Market Uncertainty	No consensus due to lack of examination	Love and Roper (2005), Audretsch et al.(1996)
Technological Uncertainty	No consensus due to conflicting findings	Calantone & Stanko (2007), Nakamura & Odagiri (2005), Swan & Allred (2003), Croisier (1998), Ulset (1996)
Behavioral Uncertainty	Positively related to internal governance	Steensma & Corley (2001), Pisano (1990)
Appropriability	Weak appropriability is positively related to internal governance	Nakamura & Odagiri (2005), Steensma & Corley (2000), Veugelers & Cassiman (1999)
Non TCA-Based Determinants of Innovation Governance		
Low cost goal	Positively related to internal governance	Calantone & Stanko (2007), Swan & Allred (2003), Veugelers & Cassiman (1999), Audretsch et al. (1996)
Firm size	Negatively related to internal governance	Nakamura & Odagiri (2005), Veugelers & Cassiman (1999)

Consequences of External Innovation Governance

Researchers began to place more emphasis on the outcomes of external innovation governance around 1999-2000, once a base of research addressing the antecedents of external contracting had been established. Consequently, at present, the literature pertaining to the outcomes of innovation governance is relatively underdeveloped compared to the body of research discussing the antecedents of these governance modes. There are only six identified studies which consider performance implications of innovation governance. Some of the outcomes of external innovation governance that have been considered include innovativeness and various performance measures (e.g., project performance, sourcing performance), costs, as well as others. Of the six identified studies focusing on the outcomes of external contracting, half used a single performance measure (for exceptions see Nicholls-Nixon & Woo, 2003; Rothaermel et al., 2006; Steensma & Corley, 2000), meaning that there have not been a great many studies examining any one outcome variable. The impact of external innovation governance on each of these outcomes will now be examined:

Innovativeness/ Sourcing Performance. Research findings surrounding the innovativeness and performance implications of external innovation governance have been mixed. The use of a variety of different types of innovation relationships (e.g., contracting, alliances, etc.) has been shown to be positively related to the number of new products developed (Nicholls-Nixon & Woo, 2003) since different types of linkages can be used to gain different types of knowledge. For instance, partnerships with universities can be used in learning about new advances in scientific knowledge, whereas contracts with design firms lead to knowledge which is then directly applied to commercialization.

Collectively, these types of knowledge contribute to a firm's ability to develop new products. Similarly, the use of contracting for activities which are also performed internally has been shown to foster growth of the product portfolio as well as new product success, since this allows a firm to access knowledge developed outside the firm, while maintaining its competencies (Rothaermel et al., 2006). Other researchers have found that external contracting, and particularly early stage idea contracting, is negatively related to competitive success since contracted ideas will typically be easily imitable (Kessler et al., 2000).

It is difficult to derive consensus from a small group of studies, but it does appear likely that the relationship between innovation governance and performance depends on other factors such as appropriateness of external governance (as is the focus of this study), partner selection (as discussed by Piachaud, 2005), or the type of control mechanisms used (Carson, 2007).

Costs. As discussed previously, though cost cutting is often thought of as the primary rationale for externalizing innovation activities, empirical work has shown that a low cost goal is negatively associated with external innovation contracting. A related question is, what impact does external innovation contracting have on innovation costs? Unfortunately, there are very few empirical findings related to this question, with only two identified empirical studies examining the relationship between innovation governance and costs. In one exception, Veugelers (1997) found that where firms possess an internal R&D capacity, spending on externally contracted R&D tends to stimulate internal expenditures. This seems to indicate that spending on external contracting may place demands on the internal organization in interpreting results from

external sources, and synthesizing them with other findings (both internal and external). Kessler, Bierly and Gopalakrishnan (2000) find no relation between either early or late stage external innovation contracting and new product development costs.

Time to market. Despite the importance of speeding new products to market (Bayus, 1997), there has been little examination of the role of innovation governance on new product development (NPD) speed. In one rare exception, Kessler, Bierly and Gopalakrishnan (2000) find that external contracting (and particularly late stage contracting) is related to slower NPD. This may reflect the extra time required for an external firm's employees to learn about a particular product or application. It is also plausible that when internal development teams struggle to solve late stage technical issues, they may then resort to additional external development to help solve these issues, causing further delays. Case based research, such as Quinn (2000) and Chatterji (1996), indicates that external contracting can be used to help speed products to market.

Appropriate Governance and Performance

The basic *prescriptive* (or normative) premise of TCA is that when governance is appropriate, or well suited to the characteristics of the transaction, performance will be optimal. However, where governance is inappropriate, or not well suited to the characteristics of the transaction, performance will suffer (Williamson, 1985, p. 22-23). As discussed earlier, it is expected that more hierarchical governance modes will be favored when high levels of transaction costs are associated with external contracting. The use of governance appropriate to the transaction's characteristics allows for superior performance through optimal efficiency when compared to other governance alternatives

(Brouthers, 2002). On the other hand, the use of inappropriate levels of governance leads to inefficiencies imposed through either unnecessary bureaucracy or evaluation costs and is associated with inferior performance and organizational failure (i.e., insolvency). Stated differently, "To use a simple mode of governance to manage a complex transaction would be to risk contractual breakdown, whereas to use a complex mode of governance to manage a simple transaction would be to incur costs without gain" (Macher & Richman, 2006 p. 5).

Typically, extant innovation governance research related to performance has examined the direct relationship between external contracting and performance variables (e.g., Kessler et al., 2000; Steensma & Corley, 2000), rather than the relationship between the use of appropriate governance (given the transaction's characteristics) and performance, as is dictated by TCA (Sampson, 2004; Williamson, 1985). Researchers' failure to consider the appropriateness of governance given the characteristics of the transaction may be the underlying reason behind the numerous conflicting results pertaining to performance (as discussed in the previous section).

Appropriate governance has been referred to using various labels: alignment (Leiblein et al., 2002; Nickerson & Silverman, 2003; Sampson, 2004; Silverman et al., 1997), fit (Brouthers, 2002; Brouthers et al., 2003; Leiblein et al., 2002), conformity (Anderson, 1988), transaction cost-enhanced governance (Brouthers et al., 2003), and predicted governance (Shaver, 1998). Several articles refer to it by numerous labels. Throughout the present study the terms "appropriate governance" or "appropriate governance levels" are used (Nickerson & Silverman, 2003).

In order to provide a thorough review of research related to (in)appropriate governance's role in determining performance, searches of top journals in marketing, management and economics were conducted. As well, several published and unpublished reviews of the TCA literature (David & Han, 2004; Geyskens et al., 2006; Leiblein, 2003; Macher & Richman, 2006; Mahoney, 1992; Rindfleisch & Heide, 1997; Zhao et al., 2004) were consulted. In this section, the scope of the review expands to focus on the entire literature surrounding the performance implications of (in)appropriate governance for two reasons. First, though there exist numerous TCA reviews, the small but growing literature surrounding the outcomes of (in)appropriate governance has not yet been well synthesized. Second, the innovation specific portion of this literature is not yet developed enough to warrant review on its own; there are only two identified studies considering (in)appropriate governance's impact on outcomes related to innovativeness (Leiblein et al., 2002; Sampson, 2004). In order to include as many studies as possible, research focusing exclusively on alliances is now included.

Within the larger TCA literature, research progressed similarly to the innovation governance literature previously discussed. Many TCA researchers have examined the antecedents of governance choice, though studies examining the performance implications of governance choice were rare until recently. Seemingly, the literatures pertaining to the antecedents of governance choice and this decision's role in determining performance evolved quite distinctly from one another (for more discussion see Leiblein, 2003). In fact, at present there exist only a handful of empirical studies (Appendix C) focused on the costs and benefits of (in)appropriate governance based on the characteristics of the transaction (Macher & Richman, 2006).

As can be seen in Appendix C, researchers have examined the impact of (in)appropriate governance in a few distinctive settings since Anderson (1988) first examined the role of "observance" with the governance mechanism (reps or direct sales) suggested by characteristics of the firm's sales environment. Though this particular study shows no significant relationship between appropriate governance and sales efficiency, all seven other identified studies examining the performance implications of (in)appropriate governance have shown that the use of appropriate governance is positively related to performance or negatively related to firm failure[3] (Argyres & Bigelow, In press; Brouthers et al., 2003; Leiblein et al., 2002; Masten et al., 1991; Nickerson & Silverman, 2003; Sampson, 2004; Silverman et al., 1997).

Clearly, the most significant contribution from this emerging literature stream has been to show that use of appropriate levels of governance leads to superior performance. Firms which inappropriately select too hierarchical a governance mode suffer the costs of excessive bureaucracy; the competitive market no longer serves to combat inefficiencies. On the other hand, firms which inappropriately select market governance suffer the costs of unchecked opportunism, which can be managed better within firm boundaries where stronger social norms and the ability to measure behaviors (not only outcomes) contend with behavioral uncertainty (Nickerson & Silverman, 2003; Williamson, 1985).

The benefits of selecting appropriate governance have been shown in a variety of contexts, including the governance of automotive manufacturing (Argyres & Bigelow, In press), shipbuilding component production (Masten et al., 1991), semiconductor device production (Leiblein et al., 2002), international entry mode (Brouthers et al., 2003),

[3] Note that while Silverman et al. (1997) do not report a significant relationship between misalignment and firm failure, they do state that raising the minimum firm size for inclusion to $1.2 million in annual sales leads to misalignment reaching statistical significance in its relationship with firm survival.

trucking fleets (Nickerson & Silverman, 2003), and telecom R&D alliances (Sampson, 2004). As can be expected from such a variety of contexts, there has been some diversity in the outcome measures examined. While several scholars have used firm failure as an outcome measure (Argyres & Bigelow, In press; Silverman et al., 1997), one used a perceptual performance measure (Brouthers et al., 2003), and two have used self reported financial measures such as selling efficiency (Anderson, 1988) and organization costs (Masten et al., 1991). The largest group of researchers has used secondary financial and performance measures such as return on assets (Nickerson & Silverman, 2003), transistor density (Leiblein et al., 2002) and patenting (Sampson, 2004).

As research in this area has advanced, another interesting research question has emerged: are the performance implications of inappropriately selecting a market oriented governance method equivalent to the performance implications of inappropriately selecting a hierarchical governance method? Two recent research projects have addressed this question, though they have each reached contrasting conclusions. Sampson's (2004) study of telecom R&D alliances finds that firms relying on too hierarchical an alliance structure are dramatically (231-307%) less innovative than properly aligned alliances. However, firms using a less hierarchical structure than called for are only slightly (4-12%) less innovative than properly aligned firms. This suggests that the effect of too much bureaucracy placed on innovation efforts through over-governance is more damaging to innovativeness than the unchecked opportunism associated with selecting an inappropriately market oriented governance mode. Conversely, Leiblein et al.'s (2002) study of the production of semiconductor devices finds that firms selecting a less hierarchical than optimal governance structure more

severely under-perform than do firms selecting too hierarchical a governance structure. This suggests that failing to safeguard from market vulnerabilities by inappropriately selecting a market governance option more severely negatively impacts performance than does the excessive bureaucracy imposed by inappropriately selecting a hierarchical governance option. Unfortunately, other studies examining inappropriate governance have not reported comparisons between the two groups of misgoverned firms, instead choosing to compare only appropriate vs. inappropriate governance.

To sum, this fledgling research stream has consistently shown that inappropriate governance is negatively related to performance. However, at present researchers do not yet appreciate the relative performance implications of the use of governance structures which impose unnecessary bureaucracy or do not sufficiently safeguard from market hazards.

Hypotheses

Asset Specificity refers to the transferability of assets which support a given transaction (Williamson, 1985). Transaction cost logic holds that where investments are not easily transferable outside of a particular relationship, market forces will no longer serve as adequate safeguards (Williamson, 1975, 1985). In this case, partner firms may use these investments to their advantage in negotiations. For instance, there have been several examinations of TCA with respect to the decision to use a direct (internal) sales force or externalize by using a sales agency (e.g., Anderson, 1988). In the case where the costs of training sales staff represent a specific investment (i.e., the investment made in training staff to sell a particular product is not easily transferable to selling other related

products), this will dictate internalization of the sales function (all other factors held equal). If the firm were to rely on an external agency in this scenario, once this substantial investment in training has been made, the producing firm would then be susceptible to being held hostage in contract negotiations. The sales agency could take advantage of the knowledge that if the producing firm switches agencies, they will need to endure the training costs once again. As previously mentioned, the market no longer acts as an adequate safeguard once these specific investments have been made. In the case of the innovation governance decision, firms that pursue innovation projects requiring investments which are more specific to the use or user will be more likely to pursue internal innovation (Robertson & Gatignon, 1998). More formally stated,

H1: Asset specificity is positively related to degree of internal innovation governance.

Importance of Learning by Doing refers to the extent that significant experience through internal pursuit of innovation activities is necessary to achieving innovative output. As proposed by Williamson (1991), one potential explanation for why firms externally contract innovation concerns learning by doing. In environments where learning by doing is critical, firms are not able to achieve returns from internal innovation efforts until experience has been gained.

As stated in H1, firms that require substantial specific innovation investments will tend to internalize innovation efforts. However, should these firms compete in industries in which learning by doing is necessary in order to achieve returns from internally governed innovation, these firms will be even more likely to internalize innovation activities in order to maintain their current level of knowledge, to take full advantage of

existing investments and to protect their knowledge by limiting interaction with outside firms (Cantwell & Santangelo, 1999). In environments where learning by doing is very important, knowledge is likely to be viewed as key to future competitive success, and intellectual property may be protected more fervently. One method of protecting intellectual property is limiting co-operation with external firms. In this case, the prohibitive transaction costs associated with knowledge that is critical to the firm's competitive success dictate that internal governance will be preferred. Contracting will be complicated by the transaction costs imposed by the combination of specific investments and the necessity of learning by doing.

Again, as discussed in H1, when specific investments are not required, firms will tend to use market governance. In environments in which learning by doing is necessary in order to achieve returns from innovation efforts, those firms whose innovation activities do not require specific investments will be even more likely to use market governance, as the time and costs involved in climbing the experience curve will be prohibitive, particularly where the generality of the investments (i.e., non-specificness) dictates that these activities can be contracted to other firms. More formally stated,

H2: Importance of learning positively moderates the relationship between asset specificity and degree of internal innovation governance. The positive relationship between asset specificity and degree of internal innovation governance will be stronger (weaker) where the importance of learning is high (low).

Environmental Uncertainty. As have previous researchers (e.g., Barney et al., 1992; Robertson & Gatignon, 1998; Walker & Weber, 1984), two dimensions of environmental uncertainty are conceptualized: market uncertainty and technological uncertainty.

Market uncertainty is the unpredictability of demand in an industry (adapted from Robertson & Gatignon, 1998). When market demand is uncertain, contracting is typically hampered by the need for constant adaptation through ongoing renegotiations (Rindfleisch & Heide, 1997), and the firm's internal decision making processes become more appropriate as authority structures are needed in order to more efficiently make decisions in this environment (John & Weitz, 1988). Environments characterized by market uncertainty necessitate renegotiation of contracts, which often involves significant penalties (a form of transaction cost).

In reference to innovation governance, in environments where market uncertainty is high, managers will tend to constantly be re-evaluating new product development goals, meaning that projects may be constantly modified, cancelled and created. This state of flux imposes substantial transaction costs on market contracting, thus favoring internal governance. Conversely, in environments where there is little market uncertainty, contracting is dramatically less complicated since new product development goals will tend to be more stable. More formally stated,

H3: Market uncertainty is positively related to degree of internal innovation governance.

Technological uncertainty is the firm's inability to forecast technical requirements (adapted from Walker & Weber, 1984) and may result from changes in

specifications of the desired component or end product. In this case, it is argued that high levels of technological uncertainty favor market governance – the opposite effect as market uncertainty has on governance (Balakrishnan & Wernerfelt, 1986; Geyskens et al., 2006; Ulset, 1996). In technologically uncertain firms, selecting market governance provides the option of terminating the relationship with the current partner and selecting a new one should the firm undergo a dramatic shift in technical requirements (Balakrishnan & Wernerfelt, 1986). Another possibility, as argued by Swan and Allred (2003), is that in situations where technology is constantly in flux, due to constraints on internal expertise managers may have little choice but to rely on the market to support their innovation efforts.

This relationship between technological uncertainty and governance has not been clearly established in the innovation context. In the innovation governance context, it may be that the contracting difficulties imposed by technological uncertainty overwhelm any potential flexibility benefits gained through the ability to switch partners. Contracting under technological uncertainty is complicated by difficulties specifying technical details which are constantly evolving. Qualitative research (such as Narula, 2001) reports that the difficulty in negotiating and enforcing contracts is a primary reason that firms do not rely more heavily on external innovation contracting. Despite the existence of arguments supporting both possible relationships here, in concert with the bulk of contemporary TCA research, it is hypothesized that high levels of technological uncertainty favor market governance. More formally stated,

H4: Technological uncertainty is negatively related to degree of internal innovation governance.

Appropriability is the extent to which results from innovative activities can be protected and are not easily diffused within an industry (adapted from Veugelers & Cassiman, 1999 p. 65)[4]. Strong appropriability indicates that firms are able to protect intellectual property from innovation efforts and to profit from successful innovations. Traditionally, the pharmaceutical industry in developed countries has been thought of as an industry with strong appropriability (Penner-Hahn & Shaver, 2005). In this type of environment, intellectual property protection laws have been established and are actively enforced. On the other hand, weak appropriability indicates an environment in which firms are less able to protect intellectual property stemming from innovation efforts and are less likely to profit from successful innovations as these gains may be diverted to other firms capitalizing on the intellectual property.

Appropriability is the first of the added problems related to innovation governance noted by Williamson (1991, p. 292). In environments where firms cannot adequately protect their intellectual property, firms will select internal governance so as to most effectively shield knowledge-related investments. The potential consequences of contracting innovation activities where appropriability is weak include creating future competitors from current suppliers and having intellectual capital redirected to current or future competitors. Both these possibilities raise the transaction costs of market governance in industries where appropriability is weak. When the threat of knowledge leakage is high (weaker appropriability) firms will avoid external innovation contracting, relying instead on their stronger ability to protect intellectual property internally. More formally stated,

[4] Consistent with this definition, appropriability ranges from completely appropriable by the innovating firm (strong appropriability) to public (weak appropriability).

H5: Strong appropriability is negatively related to degree of internal innovation governance.

Contracting Experience reflects an organization's previous experience in contracting innovation activities to external organizations and is closely related to a firm's behavioral uncertainty. That is, firms with substantial contracting experience face reduced behavioral uncertainty since they are more accurately able to assess the contracted firm's performance and manage the threat of opportunistic behavior (Gatignon & Anderson, 1988; Leiblein & Miller, 2003; Mody, 1993). When it is very difficult to ascertain the quality of a contracted service or product (i.e., high levels of behavioral uncertainty), substantial measurement costs may be necessary. When these costs are substantial, internal governance will be favored since under internal governance both behaviors and outcomes can be measured.

Firms with greater experience in this type of contracting will face reduced costs involved in market contracting, such as search and co-ordination costs (Pisano, 1990; Powell et al., 1996). Conversely, consider the costs and risks associated with externally contracting innovation activities for a firm with no experience in doing this previously. This firm faces high search costs since this is a new activity, and is prone to opportunism since its lack of experience both prevents it from detecting opportunism as well as hinders it in contracting in ways which best protect itself. More formally stated,

H6: Contracting experience is negatively related to degree of internal innovation governance.

Performance Implications. The normative aspect of transaction cost logic states that when the level of governance is appropriate given the level of transaction costs, performance will be optimal (Williamson, 1985, p. 22-23). Appropriate governance is defined here as governance which is suitable to the characteristics of the transaction as dictated by the contributors to transaction costs discussed herein. Too often scholars have only examined the choice of governance form without investigating its impact on performance (Heide & Stump, 1995; Rindfleisch & Heide, 1997; Sampson, 2004). Before considering potential performance asymmetries between the two varieties of inappropriate governance, first the question of whether firms selecting an appropriate level of governance outperform firms selecting an inappropriate level of governance is examined using multiple outcome dimensions (innovativeness, costs and profits) over time. Firms that choose appropriate governance modes will not have to endure the excessive bureaucracy or unchecked opportunism brought about by inappropriate governance, and are hypothesized to outperform inappropriately governing firms on each outcome dimension.

H7A: Innovation governance inappropriateness is negatively related to innovativeness.

H7B: Innovation governance inappropriateness is positively related to total innovation costs.

H7C: Innovation governance inappropriateness is negatively related to profit.

Performance asymmetry between firms inappropriately over and under-externally contracting. There have been very few empirical findings pertaining to the relative consequences of the two forms of inappropriate governance. However, there exist possible explanations for each category of inappropriate governance being more detrimental to firm performance than the other, along with arguments suggesting a temporal aspect to possible performance asymmetries (see Table 3 for an overview of these hypotheses).

Firms which under-externally contract face several threats, all of which are thought to impact short term performance[5]. First, the failure to contract externally may equate to lost short term flexibility, since it is generally a faster process to switch suppliers than to develop a new technology in-house (Balakrishnan & Wernerfelt, 1986). Further, excessive internal innovation governance may lead to cost inefficiencies as market competition does not serve to keep costs in check. This is particularly important as innovation efforts have become increasingly capital intensive (Narula, 2001). Firms which over-rely on external contracting may be able to avoid these substantial costs. These arguments indicate that firms which under-contract may perform worse in the short term than those firms which over-contract. More formally stated,

[5] Short term refers to performance implications up to one year post governance decision.

H8A: Inappropriately under-externally contracting is more negatively related to short term innovativeness than is inappropriately over-externally contracting.

H8B: Inappropriately under-externally contracting is more positively related to short term innovation costs than is inappropriately over-externally contracting.

H8C: Inappropriately under-externally contracting is more negatively related to short term profit than is inappropriately over-externally contracting.

Conversely, researchers have uncovered numerous drawbacks of over-relying on external contracting (Leiblein et al., 2002). Upon examination, many of these effects are longer term in nature. The over-reliance on external contracting can result in eroding the technological core of an organization (Howells, 1999) leading to the eventual inability to manage innovation efforts as the firm's absorptive capacity dwindles (Lane & Lubatkin, 1998). External innovation contracting has also been shown to be positively related to time taken in developing new products and negatively related to competitive success (Kessler et al., 2000). Firms also risk exposing their knowledge to other firms and possibly creating future competitors (Piachaud, 2005). These potential drawbacks to over-externally contracting are more gradual processes, meaning that the consequences of over-externally contracting may not be severe in the short term, but given time the erosion of a firm's innovation competency will have severe performance implications.

However, in terms of innovation costs, under-contracting is hypothesized to increase costs more than over-contracting across time periods. Firms which under-contract are prone to cost inefficiencies, since the market no longer acts to keep costs competitive. Over time, these cost inefficiencies may become even more pronounced, as the cost implications of excess bureaucracy compound. Over-contracting also has

negative cost implications, as renegotiation costs must often be endured when contracting is used inappropriately. However, these costs will be less than the cost of inefficiency imposed by under-contracting. Firms which over-contract will likely learn to select partners well and structure contracts to avoid renegotiation penalties. However, firms which under-contract will be relatively less able to control inefficient spending.

For these reasons, firms which rely too heavily on innovation contracting will more severely under-perform in terms of longer term innovativeness and profit than will those firms which do not rely enough on innovation contracting. However, firms which under-rely on contracting will face higher innovation costs in both the short term (H8B) and longer term. More formally stated,

H9A: Inappropriately over-externally contracting is more negatively related to longer term innovativeness than is inappropriately under-externally contracting.

H9B: Inappropriately over-externally contracting is less positively related to longer term innovation costs than is inappropriately under-externally contracting.

H9C: Inappropriately over-externally contracting is more negatively related to longer term profit than is inappropriately under-externally contracting.

Table 3: Hypothesized Temporal Outcomes

	Time Periods	
	Short Term	**Longer Term**
Innovativeness	Under-contracting more negatively related	Over-contracting more negatively related
Total Innovation Costs	Under-contracting more positively related	Under-contracting more positively related
Profit	Under-contracting more negatively related	Over-contracting more negatively related

CHAPTER 3: MEASURES AND ANALYSIS OVERVIEW

Data Sources

Several data sets are necessary to test the hypothesized relationships discussed in Chapter 2. The Survey of Industrial Research and Development (SIRD) is the most central to testing these hypotheses. The SIRD is conducted jointly by both the National Science Foundation (NSF) and the U.S. Census Bureau and contains data for over 2000 firms pertaining to R&D costs, R&D employment and R&D outsourcing/collaboration. The SIRD is merged with several other data sets to assemble the necessary set of variables. The Standard Statistical Establishment List (SSEL) is prepared by the U.S. Census Bureau and contains firm information such as sales, industry classification, location, etc. Standard & Poor's Compustat database contains financial data (i.e., balance sheet, income statement, and statement of cash flow items) for publicly traded companies in the U.S. Finally, the National Bureau of Economic Research's (NBER) U.S. Patent Citations Data File contains data pertaining to patenting activity and citations. See Table 4 for a summary of constructs and operationalizations.

These datasets are accessed through the Census Research Data Center (CRDC) where the data can be accessed exclusively by approved researchers. Once analysis is performed, all output to be removed from the CRDC must be approved by Census Bureau staff to ensure disclosure requirements are met.

Construct Operationalizations

Asset Specificity refers to the transferability of assets which support a given transaction (Williamson, 1985). To obtain an indication of the degree to which a firm's innovation assets are closely tied to the individual firm, the citations made by a firm's patent applications are examined (Argyres & Silverman, 2004; Rosenkopf & Nerkar, 2001). Patent applications must cite patents which are used or improved upon (both those patents held by the firm as well as patents held by other firms or individuals). Since innovation is, by definition, "an iterative process" (Garcia & Calantone, 2002 p. 112), the specificness of an organization's innovation assets (including people, property and knowledge) is indicated by the source of the knowledge that the organization builds upon. Here, the average percentage of self citations made (i.e., self citations/all citations) in the firm's patent applications during the past four years is used as an indicator of asset specificity. Companies that build upon (and thus are knowledgeable with regard to) the work of the wider community of firms are said to have more general innovation assets, since the skills and knowledge resident in the innovation organization is less particular to the firm. On the other hand, companies that tend to build on their own knowledge are said to have more specific innovation assets, since the skills and knowledge resident in the innovation organization is more particular to the firm.

Self citation is negatively correlated with the "breadth of impact" the innovation has, meaning that firms which tend to build upon their own work tend to produce innovations that are later built upon only in a narrow range of technology areas (Argyres & Silverman, 2004). Further, Tratjenberg et al. (1992) shows that the percentage of self citation is negatively correlated to total future citations (from both other companies and

the firm itself), but highly positively correlated with the number of future self citations, meaning that (all else being equal) heavily self-citing patents will tend to be less frequently built upon by external firms.

Importance of Learning is the extent that significant experience through internal pursuit of innovation activities is necessary to achieving innovative output. This is measured here as the industry ratio of full time equivalent (FTE) scientists and engineers to sales (in thousands of dollars), which provides an indication of the importance of internal learning by doing in the industry as a whole. The average ratio of FTE scientists and engineers to sales in an industry provides an indicator of the quantity of internal learning required in R&D. An industry level measure is appropriate here since this construct's domain concerns the necessity of internal learning prior to achieving results from innovation efforts within a particular environment (i.e., industry). Firms are responsive to both micro factors (factors pertaining to their organization and individual contracts) as well as macro factors (such as the importance of learning in their environment) when making governance decisions. However, a firm level ratio of FTE scientists and engineers to sales is not appropriate here since that would provide an indication of how much learning the firm has done, and not the importance of learning in that innovation environment.

Market uncertainty is the unpredictability of demand in an industry (adapted from Robertson & Gatignon, 1998). This measure gives an indication of the likelihood and extent of unanticipated shifts in industry demand. Similar to Leiblein and Miller (2003), Levy (1985) and others, autoregressive time series analyses of each industry's

sales over the past five years are performed, with the sum of squared errors divided by industry sales (SSE/Sales) serving as the measure of market uncertainty.

Technological uncertainty is the firm's inability to forecast technical requirements (adapted from Walker & Weber, 1984). The NSF segments R&D into three categories: basic research, applied research and development. Basic research represents original investigation for the advancement of scientific knowledge that does not have specific and immediate commercial objectives. Applied research represents investigation in the discovery of new scientific knowledge that has specific commercial objectives. Finally, development represents technical activity concerned with translating research into products or processes (Wolfe, 2005). Here, a firm level indicator variable is used for technological uncertainty, since firms within the same industry may have substantial differences in their levels of technological uncertainty (and since the domain of this construct concerns "the firm's inability to forecast technical requirements"). Potential projects have varying degrees of technological uncertainty (Raz et al., 2002), meaning that firms have some control over their degree of technological uncertainty through their selection of projects, making it appropriate to measure this variable at the firm level. This variable is coded as 1 if the firm conducts any basic or applied research and coded 0 if only development activities are conducted. Since basic and applied research have a higher level of uncertainty than does development, whether or not a company pursues activities other than development indicates the firm's level of uncertainty in its innovation organization. Howells (1999) discusses the degree of uncertainty in various types of innovation projects, ranging from true uncertainty, which is associated with fundamental research and invention (what is deemed basic research here) to very little

uncertainty, which is associated with activities such as developing new models and making minor technical improvements (which would be classified as development activities here). As research progresses from basic research through development, there become fewer unanswered questions, decreasing the firm's degree of technological uncertainty and making the array of possibilities easier to describe contractually (Croisier, 1998).

Appropriability is the extent to which results from innovative activities can be protected and are not easily diffused within an industry (adapted from Veugelers & Cassiman, 1999 p. 65). Here, this is operationalized as the number of patents issued in an industry divided by the total R&D expenditures in that industry (millions of dollars). An industry's propensity to receive patents reflects the perceived strength of intellectual property protection in a given industry (Kim, 2004). For instance, in industries in which patenting offers little protection of intellectual property, relatively few firms will endure the time and costs required to file patent applications. Conversely, in industries which offer a reasonable level of intellectual property protection, firms will tend to be diligent in applying for patents on any development which may potentially be valuable (Penner-Hahn & Shaver, 2005).

Firm's prior contracting experience is an organization's previous experience in contracting innovation activities to external organizations. This is measured here using the historical ratio of externally contracted R&D to total R&D (internally pursued R&D and externally contracted R&D). This provides an indicator of the firm's experience in contracting innovation activities, which is closely related to its ability to contract successfully and detect and control partner opportunism. Previous researchers have used

a count of the number of previous relationships in preceding years (Powell et al., 1996; Robertson & Gatignon, 1998). Pisano (1990) used the historical ratio of internally conducted R&D projects to the total number of R&D projects at time t-4. Here, the mean historical ratio from 3 and 4 years prior to the governance decision is used. The t-3 value is normed to have the same mean value as does the t-4 value. These two values are then averaged for those firms sampled in both years, with the single year response used for firms sampled only once. By using the mean of t-3 and t-4, this allows for a larger sample size, as firms need only be included in the SIRD in one of those years to have a valid measure. This use of this historical measure also helps to avoid simultaneity with the governance variable. That is, fewer of the contracted R&D projects at t-3 and t-4 will remain in progress at t than projects at (for instance) t-1. This minimizes the impact of projects which continue into the focal year.

Control variables. Firm size is measured using the log of the number of domestic employees. The industry classifications adopted for this study are those which the National Science Foundation uses in their publicly available data. Groupings of two digit SIC codes are used to classify firms into fifteen industries.

Degree of internal innovation governance is operationalized as the percentage of total R&D spending (both internal and contracted) on internally pursued R&D. As discussed by Rindfleisch and Heide (1997 p. 41), a continuous degree of internal integration (i.e., 0% to 100%) has been used by numerous governance researchers, including the percentage of components manufactured internally (Walker & Weber, 1984), and the percentage of trucking miles driven by company drivers vs. the total of

company drivers and owner/operators (Nickerson & Silverman, 2003; Silverman et al., 1997).

Innovation governance inappropriateness is operationalized as the absolute value of the residual from the regression analysis predicting the degree of internal innovation governance (H1-H6), which will be referred to as the stage one regression analysis (the two stage approach taken here will be discussed in detail in the next section). Residuals are interpreted here as the degree to which a given firm deviates from TCA predictions in its organization of innovation governance. As stated by Nickerson and Silverman (2003, p. 33): "If transaction cost economics is correct in its prescriptions, and if the theory has any consequence, then we expect larger deviations to be associated with diminished performance." This measure is equivalent to those measures used by Silverman et al. (2003) and Nickerson and Silverman (2003), who used a continuous governance measure (as does this study).

The first stage dependent variable (degree of internal innovation governance) is constrained in range from 0 to 1, necessitating the use of a first stage estimation technique which accommodates censored dependent variables, such as Tobit analysis (estimation techniques will be discussed in depth in the following chapter). As discussed by Breen (1996), when performing Tobit analyses, the estimated parameters can be interpreted with respect to four types of expected values. Here, the expected, unconditional value of the realized variable (internal innovation governance) is used as the expected value in calculating the residual (actual internal innovation governance-predicted). The predicted value is constrained to the range of realizable values (ranging from 0 to 1). For calculation details, please see Breen (1996, p. 27). This differs from

the typical method of calculating predicted values from regression analyses, simply calculated as $E(y_i|x_i)=X_i\beta$, which could lead to predicted values outside the range of realizable values.

This approach is also conceptually consistent with the work of other researchers who have used dichotomous governance modes (typically make or buy) and examined the residuals from probit or logit analyses as measures of inappropriate governance (Anderson, 1988; Brouthers et al., 2003; Leiblein et al., 2002; Masten et al., 1991; Sampson, 2004).

Innovativeness is operationalized as the log of citation weighted patents received for patents applied for in the focal year and the subsequent 3 year period, similar to Sampson (2004) and Dutta et al. (2005). The four year period is used due to the time required for innovators to recognize the potential value of an innovation and prepare patent applications. Previous research has shown that patents are highly related to inventions as well as new products developed (Grilliches, 1990; Sampson, 2004). However, patents relate to a wide variety of innovations, ranging from those with tremendous value to those with very little, meaning that patenting is an imprecise indicator of innovativeness. Future patent applications must cite patents which are used or improved upon, meaning that patent citations provide an indication of the influence of an innovation. Prior research has shown that weighted patent citations are highly related to the value of an innovation (Hall et al., 2001; Trajtenberg, 1990), providing a more meaningful measure of innovativeness than does patenting alone.

It is important to distinguish between forward patent citations (citations received in the future) and backward citations (past work cited). In this study, forward patent

citations are drawn upon for the innovativeness measure (to assess the future evaluation of a company's innovations) whereas backward citations are used for the asset specificity measure.

Weighting is done as follows. First, the average number of citations received by all the patents in the entire sample is calculated for each year. Next, the number of citations assigned to each patent is then divided by this average number of citations, providing the weight for each particular patent. The summed value of citation weights for all a firm's patents provides the innovativeness indicator (Dutta et al., 2005).

Total innovation costs. To assess both the internal costs (e.g., payroll, training, supplies, equipment, etc.) as well as the cost of contracting innovation activities externally, the reported costs (in thousands of dollars) for internal R&D as well as contracted R&D are summed, with the log of this total serving as the measure of total innovation costs.

Profit is the focal year's before tax profit (in millions of dollars).

Table 4: Constructs and Operationalizations

Construct	Measure	Year(s)	Dataset
Asset specificity	Average percentage of patent self-citations made	1992-1995	NBER
Market uncertainty	Sum of squared errors from autoregressive analysis of industry sales from previous 5 years divided by industry sales	1991-1995	Industry Level SIRD
Technological uncertainty	Indicator variable – 0 if firm's R&D efforts are entirely development, 1 otherwise	1995	SIRD
Firm's prior contracting experience	Historical ratio of external/ total R&D	1991, 1992	SIRD
Importance of learning	Industry average R&D headcount/sales	1995	Industry Level SIRD
Appropriability	Industry level ratio of number of patents divided by total R&D expenditures in that industry. Patent intensive industries are said to have higher levels of intellectual property protection.	1995	Industry Level NBER
Degree of internal innovation governance	Firm level ratio of internal R&D/ total R&D spending	1995	SIRD
Innovation governance inappropriateness	Residual from stage one regression.	--	--
Outcomes			
Innovativeness	Log of citation weighted patents applied for in 4 year period	1995-1998, 1996-1999, 1997-2000	NBER
Total innovation costs (both internal and external)	Log of Internal + External spending on R&D	1995, 1996, 1997	SIRD
Profit	Profit	1995, 1996, 1997	Compustat
Control variables			
Firm size	Log of domestic number of employees	1995	SSEL
Industry	2 digit NAICS groupings	1995	SSEL

SIRD: Survey of Industrial Research and Development
SSEL: Standard Statistical Establishment List
NBER: National Bureau of Economic Research's U.S. Patent Citations Data File

Analysis Overview

There are two stages of analysis, consistent with previous studies examining inappropriate governance's impact on performance (Anderson, 1988; Brouthers et al., 2003; Nickerson & Silverman, 2003). For the first stage, the dependent variable is the degree of internal innovation governance. For the second stage analyses, the dependent variables are performance variables. This overview is intended to briefly summarize the analyses; significantly more detail pertaining to the analyses is disclosed in the following chapter.

Stage One: Determinants of Governance

The initial analysis examines which variables significantly impact firms' governance decisions and provides the residuals, which indicate each firm's deviation from predicted governance. Since the stage one independent variables are at both the firm and industry levels, regression with nested effects (also known as multilevel modeling) is employed (Luke, 2004).

Multilevel modeling has become commonplace in the social sciences, including marketing (e.g., Olson et al., 2005). In this case, the analysis predicts values of the dependent variable (degree of internal innovation governance) based on predictor variables at both the firm (level 1) and industry (level 2) levels. Additionally, since the variable "firm's prior contracting experience" is an inverse lagged form of the stage one dependent variable, maximum likelihood (ML) estimation is used for the stage one analysis. ML remains consistent under this scenario, unlike some other estimation techniques.

Dependent variable:	
Degree of internal innovation governance	(level 1)
Independent variables:	
Asset specificity	(level 1)
Market uncertainty	(level 2)
Technological uncertainty	(level 1)
Appropriability	(level 2)
Firm's prior contracting experience	(level 1)
Importance of learning	(level 2)
Asset specifity*Importance of learning	
Control variables	
Firm size	(level 1)
Industry	(level 2)

Stage Two: Inappropriate Governance's Performance Implications

Next, the impact of the magnitude and valence of the first stage residuals on the outcome variables is examined. For both analyses described below, three outcome variables are examined over three distinct time periods (see Table 5). Examining the temporal effects of inappropriate governance provide an indication of the effect persistence. As mentioned previously, four year timeframes are examined for the innovativeness measure. Contemporaneous (year zero), year one and year two analyses are conducted for both total innovation costs and profit. For the purposes of H8 and H9 (the time based hypotheses) the contemporaneous and year 1 analyses will be considered "short term", while the year 2 analysis will give an indication of longer term effects.

Table 5: Outcome Measures Over Time

Innovativeness	Total Innovation Costs	Profit
• Focal year and subsequent 3 years, as done by Sampson (2004). • Years 1-4 • Years 2-5	• Focal year (year 0) • Year 1 • Year 2	• Focal year (year 0) • Year 1 • Year 2

Two distinct analyses are performed to assess the implications of (in)appropriate governance:

First, absolute residuals from the stage one regression are used as an independent variable (with control variables) to examine if appropriately governing firms outperform inappropriately governing firms across the three outcome variables. Analysis using only absolute residuals assumes performance symmetry between firms under-relying on external contracting and those over-relying on external contracting, since the absolute residuals do not reveal valence of inappropriate governance, only the magnitude of inappropriateness. This is necessary to determine whether appropriately governing firms outperform inappropriately governing firms (H7). Next, this symmetry assumption is relaxed.

Dependent variables:	
Innovativeness	(level 1)
Total innovation costs	(level 1)
Profit	(level 1)
Independent variable:	
Innovation governance inappropriateness	(level 1)
Control variables:	
Degree of internal innovation governance	(level 1)
Firm size	(level 1)
Industry	(level 2)

The valence of the residual (negative or positive) is employed to examine performance differences between the two varieties of inappropriateness via an indicator variable. The coefficient for this variable can be interpreted as the effect of under-contracting. This variable is used alongside the variables from the previous set of analyses to predict the three outcome variables of interest.

Dependent variables:	
Innovativeness	(level 1)
Total innovation costs	(level 1)
Profit	(level 1)
Independent variables:	
Under-contracting	(level 1)
Innovation governance inappropriateness	(level 1)
Control variables:	
Degree of internal innovation governance	(level 1)
Firm size	(level 1)
Industry	(level 2)

CHAPTER 4: DATA PREPARATION, ANALYSIS AND RESULTS

Preparing Stage One Data

The data used to test the first stage model is assembled as follows. First, the 1995 Survey of Industrial Research and Development (SIRD) is linked to earlier year's editions of the SIRD (1991 and 1992). The 1995 SIRD provides the measures for several of the constructs in the first stage analysis, while the 1991 and 1992 editions of the SIRD are needed for the contracting experience variable. The year 1995 is selected as the focal year for the stage one analysis since it is the most recent year that allows for the availability of subsequent longitudinal performance measures. Specifically, the most current version of the NBER patent database provides coverage through 2002 (Hall et al., 2006). This time lapse allows for the three distinct four year patenting windows and for citation of these patents afterwards, both of which are necessary to measure innovativeness.

The SIRD is conducted at the parent company level ("establishments under common ownership or control") (Wolfe, 1999, p. 10) making it imperative that other data sets used here are consistent. The National Bureau of Economic Research's Patent Citation Data File (NBER) is reported at business entity level (Hall et al., 2001) necessitating that results for all business entities making up a parent company be combined prior to merging the SIRD with the NBER. To amalgamate business entity data to the parent firm level, the NBER is first linked to the Standard Statistical Establishment List (SSEL) using a naming algorithm similar to that described in Kerr and Fu (2006). The SSEL is a comprehensive listing of all U.S. business establishments. The algorithm used removes punctuation, spaces and trailing company information such as

"Company", "Inc." and "Ltd" so that (for instance) a listing of "J. K. R. Biochemicals Incorporated" would be successfully linked with a listing of "JKR Biochemicals Inc". Once the SSEL and the NBER have been linked by this naming algorithm, patent data are summed for parent companies using the ownership information resident in the SSEL, and parent company patent data are merged with the NBER.

The dataset is then filtered so that it contains only U.S. based companies. This is necessary as many of the variables in the SIRD pertain solely to R&D operations within the U.S. This filter removes a potential confound from non U.S. based companies who may perform a portion of their R&D activities in the U.S. (which may be captured in the SIRD), but whose innovative output is largely a function of operations outside of the U.S. (not captured by the SIRD).

Industry level measures are assembled from the publicly available industry-level version of the SIRD (Wolfe, 1999), as well as by summing the NBER data by industry classification. Prior to analysis, the data are examined to ensure all values are within reasonable boundaries. This resulted in 359 usable observations (i.e., observations with no missing data) for the stage one analysis (see Table 6). Correlations and descriptive statistics for first stage variables are shown in Table 7.

Table 6: Industry Classifications

Industry	**SIC codes**	***n* (Stage One)***
Food, kindred, and tobacco products	20,21	15
Textiles and apparel	22,23	<10
Lumber, wood products, and furniture	24,25	<10
Paper and allied products	26	<10
Chemicals and allied products	28	37
Rubber products	30	18
Stone, clay, and glass products	32	<10
Primary metals	33	17
Fabricated metal products	34	23
Machinery	35	50
Electrical equipment	36	47
Transportation equipment	37	13
Professional and scientific instruments	38	33
Other manufacturing industries	27,31,39	14
Nonmanufacturing	07-10,12-17, 40-42,44-49, 50-55	64
Total		359

*Note that ranges are reported instead of *n* for small industries due to Census Bureau disclosure policy.

Preparing Stage Two Data

To perform the second stage analysis, performance measures must be assembled and merged with the first stage data set, which contains the residuals from the first stage analysis. The second stage analysis requires more recent editions of the SIRD for the innovation costs variable, the NBER patent citation data for innovativeness data and Compustat for profitability. Note that the NBER is linked using the same procedure as in preparing the stage one analysis (i.e., the naming algorithm). Correlations and descriptive statistics for second stage variables are shown in Table 8.

As will be discussed in detail with respect to each individual analysis, sample size varies for each stage two analysis since data are not consistently available for every

second stage dependent variable. Most firms in the stage one analysis are active in the patent database (used for the innovativeness measure) in all three time periods in question. As expected, sample size decreases over the three time periods in question. When using the SIRD data as a performance measure (innovation costs), there is a more significant loss of data in ensuing years, as not all firms are re-sampled in the SIRD annually (Wolfe, 1999). Finally, when using the Compustat data (profitability measure), only publicly traded firms are listed in this dataset, resulting in a markedly smaller sample for these final analyses.

Table 7: First Stage Correlations and Descriptive Statistics

	Mean	Std. Dev.	1	2	3	4	5	6	7	8
1 Internal Innovation Governance	0.935	0.158	1.00							
2 Asset specificity	0.0672	0.0944	0.12**	1.00						
3 Importance of learning	0.239	0.177	0.018	0.094*	1.00					
4 Market uncertainty	5.208	3.510	-0.17***	0.047	0.0066	1.00				
5 Technical uncertainty	0.652	0.477	0.012	.012**	-0.040	-0.11**	1.00			
6 Contracting experience	0.0421	0.113	-0.78***	-0.068	-0.066	0.15***	-0.037	1.00		
7 Appropriability	0.307	0.257	.18***	0.19***	0.079	0.20***	-0.015	-0.14***	1.00	
8 Firm size	7.680	1.530	-0.23***	0.012	-0.28***	0.063	.15***	0.29***	-0.16***	1.00

N=359

* p < .1 ** p < .05 *** p < .01

Table 8: Second Stage Correlations and Descriptive Statistics

	Mean	Std. Dev.	1	2	3	4	5	6
1 Innovativeness	2.554	2.0592	1.00					
			n=321					
2 Innovation costs	8.775	1.923	0.72***	1.00				
			n=321	*n*=359				
3 Profit	515.531	1048.90	0.37***	0.47***	1.00			
			n=73	*n*=77	*n*=77			
4 Innovation governance inappropriateness	0.0547	0.0849	-0.070	0.044	0.018	1.00		
			n=321	*n*=359	*n*=77	*n*=359		
5 Internal innovation governance	0.935	0.158	0.0082	-0.14***	-0.14	-0.79***	1.00	
			n=321	*n*=359	*n*=77	*n*=359	*n*=359	
6 Firm Size	7.680	1.530	0.53***	0.63***	0.44***	0.20***	-0.23***	1.00
			n=321	*n*=359	*n*=77	*n*=359	*n*=359	*n*=359

* $p < .1$ ** $p < .05$ *** $p < .01$

Note that the earliest measurement for the three outcomes (1995-1998 for innovativeness, 1995 for innovation costs, and 1995 for profit) is used to build the correlation matrix.

Stage One Analyses

A multilevel model is employed (using SAS Proc NLMixed) since both firm and industry level variables are used. This analysis accounts for the right censorship of the stage one dependent variable (innovation governance), since many firms in the sample performed 100% of their innovation activities internally. The estimation is analogous to a Tobit analysis with random industry effects. This type of mixed model for censored or truncated data has been used previously in biomedical (Thiébaut & Jacqmin-Gadda, 2004) as well as ecological (Brophy et al., 2007) research. The SAS code used for estimating the full model is in Appendix D.

To separately observe the effects of the firm level variables, industry level variables and random industry effects, the model is first estimated with random industry effects only, followed by the random industry effects with industry level variables, then random industry effects with firm level variables and finally the full model (Table 9). The full model will not converge, with the gradient indicating that the random industry effects are preventing convergence of the model. Given that the full model with random industry effects did not converge, and these random effects are nonsignificant ($p > .05$) when included alongside either the firm level or the industry level variables, it is logical to conclude that industry-level variation is largely explained through the industry level variables included in the model; there do not appear to be any significant unexplained industry idiosyncrasies. Thus, the model can be estimated using a standard Tobit model without random industry level effects.

Table 9: Stage One - Results of Mixed Models

Dependent Variable: Degree of internal innovation governance

	Only Random Industry Effects	Random Industry Effects and Industry Variables	Random Industry Effects and Firm Variables
Alpha	1.0734*** (0.02929)	1.0327*** (0.4410)	1.2059*** (0.05330)
Asset specificity			0.1990* (0.1115)
Importance of learning		-0.06780 (0.1242)	
Market uncertainty		-0.00619 (0.006985)	
Technical uncertainty			-0.03632 (0.02091)
Contracting experience			-1.2455*** (0.08079)
Appropriability		0.2005* (0.1043)	
Firm size			-.01435** (0.006571)
Random variance parameter	0.006979* (0.003690)	0.003611 (0.002616)	0.000801 (0.000802)
Random industry effects	1 Industry *** 1 Industry ** 13 Nonsignificant	1 Industry * 14 Nonsignificant	15 Nonsignificant
N	359	359	359
-2 Log likelihood	227.4	223.7	31.3
AIC	233.4	235.7	45.3

Ustandardized parameter estimates
(standard errors in parentheses)

* $p < .1$ ** $p < .05$ *** $p < .01$

Stage One Results

The first stage Tobit results (Table 10) indicate good model fit, with a Dhrymes R^2 of 0.554 (Veall & Zimmermann, 1996). Multicollinearity does not appear to be a serious concern, as there are no correlations among these independent variables above |.30| with the highest variance inflation factor at 1.24, well below the standard cutoff of 10 (Neter et al., 1996). Residual plots do not reveal patterns indicative of heteroscedasticity, and estimation of the model using the Tobit with heteroscedasticity option in PROC QLIM did not materially affect the results, indicating that heteroscedasticity is not a concern.

The asset specificity coefficient is positive but does not reach a standard level of statistical significance (p=.102), failing to support H1. While no direct relationship between the importance of learning and innovation governance was hypothesized, a significant negative effect is observed ($p < .05$). As hypothesized (H2), a positive interaction between asset specificity and importance of learning is observed ($p < .05$). The effect of market uncertainty is nonsignificant, failing to support H3. Conversely, H4 is supported, as technical uncertainty has a negative relationship ($p = .0506$) with internal innovation governance. Appropriability was hypothesized to have a negative effect on internal innovation governance, but a significant ($p < .01$) positive impact is found here, contradicting H5. Contracting experience was hypothesized to have a negative impact on internal innovation governance (H6), which is confirmed by this analysis ($p < .01$). Finally, the control variable firm size had a significant ($p < .01$) negative effect.

Table 10: Stage One - Tobit Results

Dependent Variable: Degree of internal innovation governance

Construct	Result	Hypothesized Relationship	Result
Intercept	1.187*** (0.0552)		
Asset specificity	0.182 (0.112)	+ (H1)	Not supported
Importance of learning	-0.131** (0.0526)	NA	
Asset specificity x importance of learning interaction	1.369** (0.662)	+ (H2)	Supported
Market uncertainty	-0.0010 (0.0028)	+ (H3)	Not supported
Technological uncertainty	-0.0404* (0.0207)	- (H4)	Supported
Appropriability	0.117*** (0.0444)	- (H5)	Contradicted
Contracting experience	-1.244*** (0.0781)	- (H6)	Supported
Firm size	-0.0162** (0.0066)	NA	
N	359		
Log likelihood	-7.82		
Null model log likelihood	-127.44		
Dhrymes R^2	0.554		

Tobit coefficients
(standard errors in parentheses)

* p < .1 ** p < .05 *** p < .01

Stage Two Analyses

In the second stage analyses, the first stage residuals are used alongside control variables to predict three performance variables – innovativeness, innovation costs, and profit. Similar to Brouthers et al. (2003) and Leiblein et al. (2002) (both of which use discrete first stage dependent variables), OLS regression is used to estimate the second stage analyses, and the first stage dependent variable (internal innovation governance) is also used as a control in the second stage. This ensures that any performance effects attributed to governance inappropriateness are not simply a byproduct of the level of internal innovation governance. For instance, consider a firm which is severely over-contracting (having a low level of internal innovation governance): by examining both the effects of a high level of contracting (via the level of internal innovation governance) as well as the level of inappropriateness, the effects of the inappropriateness of the governance can be discerned from any potential effect from having a high level of contracting.

For all second stage analyses, multicollinearity is not a concern (as shown by variance inflation factors below 5 for all analyses). Further, for each second stage analysis, the White test was performed to test for heteroscedasticity. No significant heteroscedasticity was detected in any of the stage two analyses. Stage two analyses are performed both with and without an "undercontracting" indicator variable as can be seen in Tables 11, 12 and 13. This variable is used to examine whether there are performance asymmetries between the two forms of inappropriate governance, and is discussed further below as H8 and H9 are examined.

As previously mentioned, for purposes of these analyses, short term will refer to contemporaneous (t) and the subsequent (t+1) analysis, while the latest outcomes (t+2) provide an indication of longer term effects.

Innovativeness

The first dependent variable of interest in the second stage is innovativeness, measured using the log of weighted patent citations for patents applied for during a four year timeframe. Three distinct four year windows are examined, 1995-1998, 1996-1999 and 1997-2000. The large majority of firms in the stage one sample are actively patenting during each time period. However, firms do not appear in the patent database with greater frequency in the latter time periods (1995 n=321, 1996 n=294, 1997 n=273). To ensure that there is a sufficient sample for each industry, firms are reassigned to "other manufacturing industries" in the rare case when sample size in a particular industry drops below 5 (sample size for "nonmanufacturing" is consistently adequate).

The results of the initial second stage analyses (Table 11) show a persistent negative relationship between innovation governance inappropriateness and innovativeness. Innovation governance inappropriateness has a highly significant negative relationship with innovativeness in the 1995-1998 timeframe ($p < .01$), with this negative relationship persisting into the 1996-1999 ($p < .05$) as well as 1997-2000 ($p < .05$) timeframes. With significant negative effects in each of the three timeframes examined, H7A is supported by these results.

Under-contracting (i.e., too much internalization) was hypothesized to be more negatively related to innovativeness than is over-contracting in the short term (H8A), but

less negatively related to innovativeness in the longer term. When the under-contracting dummy is used in this analysis, no significant effects are detected in any of the three time periods of interest. This indicates that there are no significant asymmetrical innovativeness repercussions of under or over-contracting, failing to support both H8A and H9A.

Table 11: Stage Two - Innovativeness Results

	Innovativeness (1995-1998) Contemporaneous (t)		Innovativeness (1996-1999) t+1		Innovativeness (1997-2000) t+2	
Intercept	-4.623*** (1.202)	-4.725*** (1.225)	-4.034*** (1.339)	-4.240*** (1.353)	-4.077*** (1.438)	-4.185*** (1.451)
Innovation governance inappropriateness	-5.312*** (1.860)	-5.244*** (1.868)	-4.838** (2.237)	-4.648** (2.244)	-5.241** (2.439)	-5.142** (2.447)
Under-contracting		-0.119 (0.262)		-0.284 (0.269)		-0.171 (0.280)
Internal innovation governance	-0.111 (0.993)	0.106 (1.103)	-0.182 (1.102)	0.325 (1.202)	-0.0559 (1.176)	0.234 (1.271)
Firm Size	0.894*** (0.0663)	0.895*** (0.0664)	0.836*** (0.0688)	0.837*** (.0688)	0.822*** (0.0727)	0.822*** (0.0728)
Industry Controls	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
N	321	321	294	294	273	273
R^2	0.447	0.447	0.420	0.423	0.405	0.406
Adjusted R^2	0.417	0.416	0.387	0.387	0.370	0.369
F	15.32***	14.40***	12.54***	11.88***	11.67***	10.94***

Unstandardized coefficients
(standard errors in parentheses)

* $p < .1$ ** $p < .05$ *** $p < .01$

Innovation Costs

The next performance measure of interest is innovation costs, measured by the log of total R&D costs (both internal and external) for each of three years: 1995, 1996 and 1997. Since 1995 data are also used for the stage one analysis, the full sample (n=359) is available for this period. However, the sample sizes are considerably smaller for 1996 (n=229) and 1997 (n=181), as only firms which completed the Survey of Industrial R&D again in these years can be included (see Wolfe (1999) for a description of the SIRD's sampling procedures). Again, as discussed with respect to the innovativeness analysis, in the case where the sample size in any particular industry drops below 5 due to data unavailability, these firms are reassigned to "other manufacturing industries" (sample size for "nonmanufacturing" is consistently adequate).

Innovation governance inappropriateness was hypothesized to have a positive relationship with total innovation costs (H7B), meaning that appropriately governing firms are hypothesized to realize a cost savings. However, in all three time periods examined (1995, 1996, 1997) there is a strong negative relationship between innovation governance inappropriateness and innovation costs ($p < .01$ in 1995, $p < .05$ in 1996 and 1997). These results (Table 12) contradict H7B, and show a strong, persistent negative effect of innovation governance inappropriateness on total innovation costs. Firms that govern "appropriately" actually face higher innovation costs than do firms governing inappropriately.

Under-contracting was hypothesized to be more positively related to innovation costs over all time periods of interest (H8B, H9B) than is over-contracting. However, the results show a strong negative relationship between under-contracting and total

innovation costs, persisting over all three time periods of interest ($p < .01$ in 1996, $p < .05$ in 1995 and 1997). Tests of R^2 change between models with and without the under-contracting indicator variable show a significant increase in variance explained by including the additional explanatory variable in all three periods ($p < .05$ in 1995, $p < .01$ in 1996 and 1997). The analyses including the under-contracting indicator variable indicate that under-contracting firms face lower total innovation costs (contradicting both H8B and H9B). Conversely, those firms which over-contract face higher total innovation costs.

Table 12: Stage Two - Innovation Costs Results

	Innovation Costs (1995) Contemporaneous (t)		Innovation Costs (1996) t+1		Innovation Costs (1997) t+2	
Intercept	3.472*** (0.859)	3.193*** (0.887)	2.140** (0.953)	1.870** (0.945)	1.469 (1.021)	1.272 (1.007)
Innovation governance inappropriateness	-3.886*** (1.347)	-3.827*** (1.338)	-3.125** (1.445)	-3.133** (1.424)	-3.115** (1.498)	-3.031** (1.475)
Under-contracting		-0.487** (0.198)		-0.580*** (0.216)		-0.599** (0.235)
Internal innovation governance	-1.433* (0.732)	-0.695 (0.786)	-0.465 (0.732)	0.322 (0.779)	-0.924 (0.789)	-0.107 (0.840)
Firm Size	0.859*** (0.0500)	0.865*** (0.0497)	0.960*** (0.0610)	0.972*** (0.0603)	1.016*** (0.0688)	1.017*** (0.0677)
Industry Controls	Yes***	Yes***	Yes***	Yes***	Yes***	Yes***
N	359	359	229	229	181	181
R^2	0.572	0.579	0.647	0.659	0.673	0.686
Adjusted R^2	0.550	0.557	0.622	0.633	0.646	0.657
F	26.78***	26.00***	26.05***	25.58***	24.42***	23.98***

Unstandardized coefficients
(standard errors in parentheses)

* $p < .1$ ** $p < .05$ *** $p < .01$

Profit

The final performance variable of interest is profit. Since the profit data used here comes from the Compustat database, data are only available for publicly traded companies that can be successfully matched to firms in the first stage dataset. This results in a markedly smaller dataset (n=77 (1995), n =79 (1996), n = 83 (1997)), which cannot accommodate indicator variables for all 15 industries. Accordingly, a variable indicating either manufacturing or non-manufacturing industry is used. The limitations when drawing conclusions from such a small sample are discussed in the final chapter.

Innovation governance inappropriateness was hypothesized to have a negative impact on profitability (H7C). Though the analyses for all three time periods show a negative coefficient for inappropriateness (see Table 13), standard statistical levels of significance are not reached (1995 p=0.134, 1996 p=0.218, 1997 p=0.277) , failing to support H7C.

Under-contracting was hypothesized to more negatively affect profit in the short term than does over-contracting (H8C), but less negatively affect profit in the longer term (H9C). Analysis of the 1995 data reveals a nonsignificant coefficient for the under-contracting variable, though there are significant ($p < .05$) negative effects in both the 1996 and 1997 analyses. Further, tests of R^2 change between the models with and without the under-contracting variable indicate that models including the under-contracting variable explain significantly more variance in both 1996 and 1997 ($p < .05$ in both years). With a significant negative effect observed in one of the short term time periods (1996), H8C is partially supported. In the final time period examined, under-

contracting is more negatively related to profit than is over-contracting, contradicting H9C. See Table 14 for an overview of the second stage findings.

Table 13: Stage Two - Profit Results

	Profit (1995) Contemporaneous (t)		Profit (1996) t+1		Profit (1997) t+2	
Intercept	-316.61 (1224.84)	-165.60 (1223.41)	-885.32 (1456.10)	-612.75 (1426.30)	-743.32 (1684.92)	-472.87 (1644.05)
Innovation governance inappropriateness	-2859.05 (1884.34)	-2907.71 (1874.45)	-2786.11 (2243.26)	-2854.21 (2189.06)	-2853.36 (2603.46)	-2832.80 (2533.89)
Under-contracting		-425.71 (318.33)		-805.70** (370.63)		-956.63** (413.86)
Internal innovation governance	-1699.21* (950.21)	-1245.89 (1004.01)	-1577.77 (1131.11)	-707.15 (1174.09)	-1520.61 (1315.57)	-448.61 (1361.81)
Firm Size	279.02*** (66.69)	264.71*** (67.18)	346.93*** (79.03)	319.83*** (78.11)	320.61*** (90.44)	290.35*** (88.99)
Manufacturing Control	198.95 (268.72)	59.55 (286.87)	188.45 (318.97)	-69.38 (333.07)	216.81 (367.22)	-96.59 (382.25)
N	77	77	79	79	83	83
R^2	0.238	0.257	0.237	0.284	0.1606	0.215
Adjusted R^2	0.200	0.204	0.196	0.234	0.118	0.164
F	5.62***	4.90***	5.75***	5.78***	3.73***	4.22***

Unstandardized coefficients
(standard errors in parentheses)

* p < .1 ** p < .05 *** p < .01

Table 14: Summary of Stage Two Findings

A. Governance inappropriateness and performance:

	Hypothesized Relationship	**Result**
Innovativeness	Inappropriate Governance negatively related (H7A)	Supported
Total Innovation Costs	Inappropriate Governance positively related (H7B)	Contradicted
Profit	Inappropriate Governance negatively related (H7C)	Not supported

B: The two varieties of inappropriate governance's performance implications over time:

	Time Period			
	Short Term Contemporaneous (t) and t+1		Longer Term t+2	
	Hypothesized Relationship	**Result**	**Hypothesized Relationship**	**Result**
Innovativeness	Under-contracting more negatively related (H8A)	Not supported	Over-contracting more negatively related (H9A)	Not supported
Total Innovation Costs	Under-contracting more positively related (H8B)	Contradicted	Over-contracting less positively related (H9B)	Contradicted
Profit	Under-contracting more negatively related (H8C)	Partially supported	Over-contracting more negatively related (H9C)	Contradicted

CHAPTER 5: DISCUSSION, MANAGERIAL IMPLICATIONS, AND FURTHER RESEARCH DIRECTIONS

Discussion

Determinants of Governance

The examination of the determinants of the innovation governance decision strongly confirm Williamson's (1991) suggestion that additional apparatus is required to understand the outsourcing decision in the innovation context. Both the importance of learning by doing and appropriability are shown to substantially impact firms' governance decisions. Further, this study demonstrates that the governance decision is impacted by both firm level factors as well as environmental (i.e., industry-level) factors as will be discussed below.

These results indicate that specific assets only promote internalization in an environment where learning is important. That is, firms requiring specific innovation assets operating in an environment where learning is important are likely to internalize. The specificity of the company's activities, coupled with the necessary time and expenses involved in learning dramatically increase the costs of externalization. In this environment, once a contracted firm possesses specialized assets and has conducted substantial learning, the contracting firm would be at a tremendous disadvantage in a renegotiation situation. Contracted firms will demand prohibitive compensation to develop specific assets and draw upon their significant learning (Ulset, 1996). Further, in this scenario firms desire to develop and protect their specific investments, which act as a deterrent to potential competitors in an environment where learning is very important. Conversely, in environments where learning is less important, the presence of asset specificity is shown here to not significantly promote internalization. In this situation,

specific assets unaccompanied by the need for learning do not act as a deterrent to outsourcing. In environments where learning is less important, specific innovation assets can be developed relatively quickly, without dramatically slowing down the process of getting new products to market, meaning that contracting firms will not be at the same disadvantage in renegotiation. This finding improves the understanding of asset specificity's role in the innovation governance decision; this role has previously been examined without the moderating role of the importance of learning (Audretsch et al., 1996; Ulset, 1996).

The significant direct effect of the importance of learning indicates that (all else equal) in environments in which significant learning is required before companies can see benefits from innovation efforts, they are more likely to outsource in order to bypass this learning curve entirely (Quinn, 2000; Ulset, 1996). A high importance of learning appears to be a likely indicator of industries likely to have an established network of innovation services contractors, which have developed to support companies' need to speed products to market in this environment (Chiesa et al., 2004).

The finding that market uncertainty did not have a significant impact on the governance decision is not completely surprising given the lack of consensus in this area (see Table 2: Antecedents of Innovation Governance: Research Consensus) and previous findings of nonsignificance (Audretsch et al., 1996; Love & Roper, 2005). It is possible that market uncertainty may have conflicting effects, making its true outcome ambiguous. As per traditional TCA logic, environments characterized by market uncertainty may complicate the process of contracting because fluctuating product requirements make documenting project requirements problematic (Geyskens et al., 2006). On the other

hand, highly uncertain environments may also promote outsourcing as firms wish to manage the risks of this uncertainty by keeping headcount low (Howells et al., 2003; Steensma & Corley, 2000). The findings of nonsignificance in this study (and others studying the governance of innovation) suggest that the effect of market uncertainty may be another area in which the innovation governance decision deviates from more typical governance decisions. This will be discussed further below as future research directions are considered.

Technological uncertainty is found here to have a negative relationship with internal innovation governance. Under technological uncertainty, firms favor contracting because it is quicker and less expensive to change contracting partners then to develop new internal competencies (Balakrishnan & Wernerfelt, 1986). This supports previous empirical findings in the innovation governance area (Calantone & Stanko, 2007; Swan & Allred, 2003; Ulset, 1996), and is in agreement with the consensus from the larger TCA literature, suggesting that the innovation governance decision does not differ from other sourcing decisions in this respect.

The finding that contracting experience is negatively related to internal innovation governance indicates that contractually inexperienced firms are less apt to outsource. These firms face greater search costs due to inexperience as well as an inability to properly structure agreements and protect themselves from opportunism, raising the transaction costs associated with contracting and making it logical to perform more of these activities internally (Pisano, 1990; Steensma & Corley, 2000). Contractually inexperienced firms face greater behavioral uncertainty and, accordingly, tend to refrain from outsourcing innovation activities.

It was posited here that in environments characterized by weak appropriability, firms will be less willing to work with other organizations (i.e., contract providers), since their intellectual property cannot adequately be protected in these relationships (Nakamura & Odagiri, 2005; Steensma & Corley, 2000; Veugelers & Cassiman, 1999). However, the opposite effect is observed here. This indicates that in industries in which intellectual property protection is strong, firms choose to pursue innovation activities internally, so as to have full control over the valuable knowledge accrued. Conversely, where intellectual property protection is weak, firms tend to outsource innovation activities since technological competence is not viewed as a viable path to greater profitability (Narula, 2001). Where there is no opportunity to develop sustainable advantage (whether due to weak appropriability or other factors), firms will favor outsourcing over internalization (Steensma & Corley, 2001). In fact, the desire to imitate competitors has been discussed as one of the explanations for the growth of innovation outsourcing (Chatterji, 1996). In line with Swan and Allred's (2003) finding that a differentiation goal is negatively associated with outsourcing, and Bardhan's (2006) assertion that outsourcing is appropriate when innovations become commoditized, these results indicate that in environments in which firms' competencies can easily be appropriated by competitors (making differentiation through intellectual property unachievable), firms opt to outsource.

Performance Implications

Prior to discussing the impact of governance inappropriateness on various outcome measures, it is important to call attention to the consistently nonsignificant ($p > .05$) relationship between internal innovation governance and all three dimensions of performance considered here. These consistent nonsignificant effects across the three sets of performance analyses support transaction cost logic in that there is no one correct form of governance. That is, neither outsourcing or internalization inherently result in superior performance (Leiblein et al., 2002). Rather, performance is a function of selecting the form of governance most appropriate to the firm's environment (Sampson, 2004; Williamson, 1985). It is noteworthy that this holds across the three outcome variables of interest, despite innovation governance inappropriateness having differing relationships depending on the outcome variable. This suggests that the notion of their being no correct form of governance may be universal across performance dimensions.

As hypothesized, appropriately governing firms are shown to be more innovative than inappropriately governing firms. This adds to the findings of Sampson (2004) who found that properly aligned alliances are more innovative, as well as several other studies finding that appropriately governing firms outperform inappropriately governing firms using other single performance outcomes (see Appendix C). With respect to innovativeness, Williamson's (1985) contention that appropriate governance is related to optimal performance is supported here. Appropriately governing firms do not suffer from the effects of governance mechanisms that either insufficiently safeguard or impose unnecessary bureaucracy. The effect of this inappropriateness is shown to persist through all three time periods of interest here. This indicates lasting innovativeness repercussions

stemming from inappropriate governance, meaning that inappropriate outsourcing decisions will likely harm an organization's innovativeness for years to come.

In terms of the asymmetrical innovativeness implications of under and over-contracting, the results from this study do not reveal asymmetric effects from under or over-contracting. When viewed in light of the previous finding that inappropriateness is negatively related to innovativeness, these findings can be interpreted to suggest that governance inappropriateness is negatively related to innovativeness, regardless of the variety of inappropriate governance employed (under or over-contracting). This finding is in contrast with both Sampson (2004) and Leiblein et al. (2002) who find asymmetrical innovativeness implications from the two forms of inappropriate governance (though as discussed in Chapter 2, these two studies make opposing conclusions in this regard).

In terms of total innovation costs, innovation inappropriateness is shown here to have a negative effect which persists over all three timeframes of interest. This indicates that appropriately governing firms face higher total costs than do firms governing inappropriately. This finding represents a significant departure from the existing literature, as no previous studies (see Appendix C) have found any negative consequence relating to appropriate governance.

There appear to be additional costs associated with governing appropriately, and although (as discussed previously) appropriately governing firms are more innovative, there is a cost associated with this innovativeness benefit. To reveal the relative effects on innovativeness and innovation costs, supplemental comparisons of the respective coefficients for both the innovativeness and innovation costs analyses are conducted. Coefficients from the various analyses forecast that a firm governing 1% from predicted

governance would face a penalty equivalent to 11.51%, 10.54% and 11.37% of total weighted patent citations (in the three periods respectively), while lowering dollar costs by 8.56%, 6.94% and 6.92% (again in the three periods respectively), as compared to a firm governing as predicted (all other variables held constant)[6]. While there is a cost to governing appropriately, the benefit to innovativeness is disproportionately greater. To illustrate one potential explanation for this finding, consider firms that inappropriately utilize an "internal only" approach to innovation by choosing not to outsource any innovation activities. While avoiding the additional costs associated with a "hybrid" innovation organization (those firms which conduct both internal and contracted innovation activities), these firms would also likely be less innovative. This finding is in line with both Veugelers (1997) who found that in firms conducting internal R&D, spending on outsourcing actually acts to stimulate internal costs, as well as Narula (2001) who found that an internal competency must be maintained to successfully contract innovation activities.

There are also asymmetries in the total costs that under-contracting and over-contracting firms face. Under-contracting firms face lower total costs than do over-contracting firms, with this effect persisting over time. As discussed by Swan and Allred (2003) and Veugelers and Cassiman (1999), low cost goals have been found to be negatively associated with innovation outsourcing. In situations where firms are primarily concerned with cost savings, it is difficult to gain approval for external

[6] Innovativeness calculations are performed as follows (cost calculations performed in the same manner): Coefficients from second stage analyses are multiplied by mean values for independent variables with the exception of the inappropriateness variable, which is first fixed to 0.00 (representing predicted governance) then 0.01 (representing governance 1% from the prediction). A percentage is then calculated using the ratio of the difference in the number of expected weighted patent citations to the number of expected weighted patent citations predicted at appropriate governance (note that this is the antilog of the innovativeness measure).

contracting. Similarly, in the present study, firms that over-contract may be less concerned with cost savings (due to labor shortages, sales growth, or other factors) thus subjecting themselves to higher total costs.

As mentioned previously, there are decidedly smaller sample sizes for the profit analyses. These results need to be held to greater scrutiny than other results found here, and replication of these profit results with a larger sample (including control variables for industry) would likely prove fruitful in further research. The current study did not find a significant relationship between inappropriate governance and profitability. It may be that profitability is too "noisy" a performance indicator; there may simply be too many contributors to firms' profitability to isolate this effect here. While appropriately governing firms are more innovative, they face higher total innovation costs, with no significant profit effects detected.

Over-contracting firms are shown to be more profitable ($p < .05$) in the two latter years analyzed, with no significant difference between under-contracting and over-contracting firms in the contemporaneous analysis. The results from the latter years indicate that under-contracting firms are expected to be on average (all other variables held equal) $806 million less profitable in year t+1 and $957 million less profitable in year t+2, when compared to firms that are over-contracting[7]. Though it is difficult to make conclusions based on results from such a small sample, it does appear that the negative effects of under-contracting are more damaging to profitability than are those of over-contracting. Under-contracting is thought to harm performance in two ways, each of which negatively impacts profit. Under-contracting firms do not expose their

[7] Note that the coefficients for the profit analyses can be interpreted directly; the profit variable is not logged as are the other two performance variables.

company to outside expertise, thus missing valuable learning opportunities (Howells, 1999; Howells et al., 2003; Kessler et al., 2000). Further, the loss of flexibility suffered by under-contracting firms is detrimental to performance (Balakrishnan & Wernerfelt, 1986; Chesbrough & Teece, 1996).

The emergence of this effect in the latter two time periods indicates that there may not be an immediate negative consequence to under-contracting. There are two possible explanations surrounding the time elapsed before the profit repercussion is significant. First, products take substantial time in the development process; projects may not impact a company's revenues for years after the corresponding spending on R&D occurs (Bayus, 1997). Second, it is also feasible that failure to expose the internal innovation organization to outside expertise may not have a negative effect in the short term, but continued lack of exposure over time (whilst technologies continue to change) has a significant negative profit impact.

Managerial Implications

Knowledge of the drivers of innovation governance can be useful to managers in two respects. First, by understanding these factors, managers may better forecast demands on both the internal innovation organization as well as the need to manage contractors and accompanying spending. Secondly, these factors will also be of interest to managers in contract innovation services businesses. Through understanding the factors that make companies more likely to outsource innovation services, firms seeking to attract this business can better target potential customer organizations as well as tailor their service offerings. Specifically, the findings here suggest that both firm and

environmental characteristics define the situations in which firms are most likely to outsource innovation efforts:

1. Firms not possessing specific assets operating in environments characterized by a high importance of learning.
2. Firms facing high technological uncertainty
3. Firms possessing high levels of contracting experience
4. Environments characterized by a high importance of learning
5. Environments characterized by weak appropriability

Through understanding the performance findings here, managers can better understand the short and longer-term implications of their decisions to internalize or outsource innovation activities. First, there is no one correct form of governance. Neither outsourcing nor internalization inherently lead to performance (Leiblein et al., 2002; Sampson, 2004). As is confirmed here, performance is a function of selecting governance appropriate to the conditions within which the firm operates. Appropriately governing firms are generally more innovative than those firms governing inappropriately. However, appropriately governing firms also face an increase in costs which is proportionately smaller than the gain to innovativeness.

Understanding the effects of over and under-contracting should also prove valuable to managers of innovation organizations (see Table 15). In terms of innovativeness, the nature of the inappropriateness (under or over-contracting) does not have a significant effect, though as discussed previously, appropriately governing firms are more innovative than those inappropriately governing. However, under-contracting firms face lower total innovation costs than do over-contracting firms. In cost-conscious

organizations it may be easier to gain approval for internally conducted projects (Swan & Allred, 2003). Firms which are over-contracting may be less concerned or simply have less control over costs due to unexpected growth, tight labor markets or other factors. In terms of profitability, over-contracting firms are more profitable, though this effect does not become significant until the year after the governance decision. This indicates that under-contracting firms tend to be less profitable due to lack of exposure to external competencies.

Table 15: Performance Implications

	Innovativeness	Innovation Costs	Profit
Governance Inappropriateness	Negative effect	Negative effect	No effect
Under-contracting	No asymmetric effect	Negative effect	Negative effect
Over-contracting	No asymmetric effect	Positive effect	Positive effect

Conclusions

This study examines the factors contributing to the outsourcing of innovation activities using a sample of 359 U.S. firms. Further, the implications of the appropriateness of the chosen level of governance are considered with respect to innovativeness, innovation costs, and profit. The management of cross-boundary innovation is of interest to both scholars and managers, and these findings advance our understanding in several specific ways (see Table 1: Summary of Contributions).

First, the role of the importance of learning by doing in the innovation governance has been established (Williamson, 1991). The understanding of both the direct impact of the importance of learning as well as its interaction with asset specificity is shown here to

be relevant to this governance decision, and indicates a distinction between the innovation governance decision and more typical governance choices.

The use of multiple outcome dimensions in this study allows a much richer understanding of the implications of appropriate (and inappropriate) innovation governance (as called for by Leiblein et al., 2002). Here it is shown that governance inappropriateness is negatively related to innovativeness, yet positively related to costs. Though the effect of inappropriate governance on innovativeness is proportionately greater than its effect on costs, there is a tradeoff associated with the additional innovativeness realized by appropriately governing firms. Appropriately governing firms do not outperform inappropriately governing firms across all possible outcomes. Further, under-contracting companies are shown to have lower total innovation costs, but also lower profitability when compared to over-contracting firms. When viewed together, these findings begin to provide a more complete understanding of the implications of inappropriate governance, and provide a foundation for future researchers to develop further. It is hoped that the results from this study provoke greater theoretical and empirical questioning of the relationships between governance appropriateness and various dimensions of performance, so that transaction cost analysis can grow as a theory base to make strong predictions with respect to the relationships between the various breeds of governance inappropriateness and different dimensions of performance.

Finally, this study examines the relationship between (in)appropriate governance and performance over time (Nicholls-Nixon & Woo, 2003). Here, the persistence of these effects has been shown, and in the case of profitability, an effect which does not take effect until time elapses is observed.

Limitations

There are several limitations of this research project. First, this project relies exclusively on the use of secondary data. Though primary data collection at one point in time would not allow for the analysis of performance over time as has been done here, primary data collection could amplify or corroborate the first stage results obtained here (particularly the findings with respect to the importance of learning and appropriabilty). For instance, it is possible that the level of appropriability may change over the course of the product development cycle across industries. That is, there may be differences in the propensity for new product ideas or partially developed technologies to leak outside of the firm in various industries, though the measure for appropriability employed here only considers those innovations which have progressed to the point of patent application.

Though the examination of multiple outcome measures over time here marks progress from previous research, examination of three sequential time periods is likely insufficient to discern long term effects such as those stemming from the loss of absorptive capacity or intellectual property (which will be discussed under future research directions).

The profit analyses conducted here were particularly limited in terms of the sample size (and thus, the control variables which could be used). Several industry indicator variables are significant in the innovativeness and innovation costs analyses, meaning that potential industry profitability idiosyncrasies have not been accounted for by the use of the manufacturing indicator variable in the profit analyses. In short, it is not possible to rule out the confounding effect of industry in this set of analyses.

The current study drew a sample of US companies only, and only examined these companies' domestic outsourcing. Examining the outsourcing habits of companies around the world, as well as both their domestic and international innovation contracting is necessary to gain a more complete understanding of the performance implications of these innovation contracting decisions (see Bardhan, 2006).

Future Research Directions

The finding that appropriately governing firms face higher innovation costs suggests an agenda for future research. First, managers will prioritize various aspects of performance differently across organizations and environmental conditions: Under what conditions would the (proportionately smaller) cost savings observed by inappropriately governing firms be more valued than the (proportionately larger) penalty to innovativeness? Presumably this cost savings would be more valued in organizations with a shorter term perspective, such as firms with liquidity issues or a focus on short term cost savings. The firm's temporal perspective has been shown to influence the relative importance of various new product outcomes (Hultink & Robben, 1995) as has firm strategy (Griffin & Page, 1996) and stage of the development process (Chiesa & Frattini, 2007). The potential role of outcome prioritization in determining governance appropriateness necessitates further research. For instance, incentives based upon short term metrics may motivate inappropriate governance decisions, which as shown here may have a severe impact on innovativeness.

Further, which (if any) other performance dimensions are harmed by appropriate governance? Here, costs are shown to be positively related to governance

appropriateness. Other outcomes need investigation in the future – such as speed to market, flexibility, and product quality. If there are other performance outcomes that are negatively related to appropriate governance, what are the commonalities between these performance dimensions? For instance, it is conceivable that dimensions more closely related to the resulting innovation (e.g., innovativeness, product quality) will be improved by appropriate governance, while it may be possible to improve upon dimensions related to the process of developing the innovation (e.g., development costs, development time) through inappropriate governance. Only through future initiatives observing a wide variety of outcomes can this and similar research questions be addressed.

This study used three distinct timeframes for each performance variable of interest. Though this was sufficient to discern the persistence of effects, longer term analyses may reveal findings not uncovered in the current study. Some of the long term effects that were thought to result from over-contracting include a loss of absorptive capacity, as well as the loss of intellectual property to partner firms. It is probable that these sort of long term effects do not reveal themselves without a lengthier performance view. Argyres and Bigelow (In press) found that the effects of inappropriate governance selection may take up to 20 years to observe, depending on the maturity of the industry. Extending the present findings over a significantly longer time span is another area for fruitful future research.

Finally, there remain unresolved issues with respect to the determinants of innovation governance. Particularly, the effects of appropriability and market uncertainty require further inquiry in the innovation governance context. Environments characterized by strong appropriability were hypothesized to encourage outsourcing, as firms can be

more assured when working with partner firms in environments where intellectual property is better protected (Nakamura & Odagiri, 2005; Steensma & Corley, 2000). However, it was found here that in environments where appropriability is strong, firms will favor internalization, as this represents an opportunity to develop an inimitable competence (Bardhan, 2006). Under which conditions does strong appropriability encourage firms to work with partner organizations, and under which conditions does it discourage this behavior? For instance, it is possible that the nature of the outsourcing relationship and the types of control used by the contracting company (Carson, 2007) could make outsourcing arrangements more effective under strong appropriability. It is also possible that appropriability impacts the supply-side of the market. That is, where intellectual property is well protected, contract innovation services organizations may be less prevalent; necessary knowledge may only exist within traditional organizations as this knowledge has not widely diffused to other organizations such as contract innovation services firms.

The possibility of two opposing effects stemming from market uncertainty in the innovation context requires further examination. Market uncertainty may complicate outsourcing by requiring frequent renegotiation with contracted firms, but also encourage outsourcing; firms in uncertain markets may be forced to outsource to keep up with quickly changing market needs. Thus far, no known studies have found a significant effect of market uncertainty in the innovation governance context, with the current study and two previous studies (Audretsch et al., 1996; Love & Roper, 2005) finding the effect of market uncertainty to be nonsignficant in the innovation context. Interestingly, the TCA literature as a whole finds this to be a significant effect (Geyskens et al., 2006),

suggesting yet another distinction to the innovation governance decision. Future researchers may find it helpful to consider market uncertainty as two separate dimensions, as suggested by the previous speculation of conflicting effects stemming from market uncertainty. Through examining the differential effects of both the extent to which contracting is made difficult due to market unpredictability and the extent to which market unpredictability favors risk management through outsourcing, market uncertainty's impact on the innovation governance decision may be better understood.

APPENDIX A

Appendix A: Empirical Innovation Governance Research

Authors / Journal	Independent Variables	Dependent Variable(s)	Moderators	Context and unit of analysis	Findings
Carson (2007) Journal of Marketing	Creative nature of the task, client skills, transaction specific investment, market uncertainty, input uncertainty, history of relationships, relationship duration, supplier task performance (2 dimensions - supplier's creativity, contribution of the technology)	Type of control used (ex ante or ex post), supplier performance	Numerous 2 and 3 way interactions examined as predictors of supplier performance. Creative nature*ex post negatively interact, nature*ex ante positively interact, client skills*ex post positively interact and creative nature*client skills interact ($p < .10$)	147 clients sponsoring NPD outsourcing arrangements	Ex post control (and not ex ante control) has a direct positive impact on supplier performance. Creative nature of the task has a positive impact on supplier performance and client skills has a negative impact on supplier performance. In determining client control, creative nature and market uncertainty each have negative impacts on both forms of control; relationship history has a positive impact on ex ante control.
Calantone and Stanko (2007) Journal of Product Innovation Management	Exploratory research performed, inventory turnover, profit margin, employee sales efficiency (sales/employees), number of scientists/firm	Contracted R&D spending/firm	None	Industry level analysis 46 U.S. industries (both manufacturing and non-manufacturing)	Both contemporaneous and 1 year lagged analyses are performed. Exploratory research is positively related to external sourcing in both analyses. Profit margin is positively related to external sourcing in both analyses. Inventory turnover is significantly negatively related to external sourcing, but only in the lagged analyses. Employee sales efficiency has a strong positive effect in the contemporaneous analysis, but is nonsignificant in the lagged analysis.

Authors / Journal	Independent Variables	Dependent Variable(s)	Moderators	Context and unit of analysis	Findings
Rothaermel, Hitt and Jobe (2006) Strategic Management Journal	Strategic outsourcing quasi (not of activities performed by firm), strategic outsourcing taper (activities both contracted and performed internally), level of vertical integration. Control variables: Firm age, competitive intensity, patents, U.S. firm (dummy), Public firm (dummy), dominant industry, mergers and acquisitions,	Size of firm's product portfolio, firm revenues, product success (expert ratings)	Vertical integration interacts with both forms of outsourcing (taper and quasi).	123 microcomputer firms studied via securities data and press releases	Taper outsourcing is shown to be positively related to the size of the product portfolio and new product success. Strategic outsourcing quasi is not clearly shown to be significantly related to either of these outcomes.
Nakamura and Odagiri (2005) Economics of Innovation and New Technology	Both firm and industry level variables are used: Firm: R&D intensity, size, vertical integration, diversification, cash flow, parent control Industry: Appropriability, information flow, speed of innovation	Expenditure on any R&D (>0 or not), expenditure on commissioned R&D (both >0 or not and level of commissioned R&D)	None	14,000 Japanese manufacturing firms	1st step (R&D expenditure or not): Sales, vertical integration, diversification and appropriation have positive impacts on likelihood of expending on R&D, while parent control and speed of innovation have negative impacts. 2nd step (expenditure on commissioned R&D): R&D intensity, vertical integration, diversification and appropriation are positively related to expenditure on commissioned R&D, while only speed of innovation has negative impact.
Chiesa, Manzini and Pizzurno (2004) R&D Management	NA	NA	NA	Identify product development services firms in North America and Europe	Identifies 200 firms seeking product development contracts, categorizing them by country and services offered. Industrial design is the most common service. Almost half (47%) of all

Authors / Journal	Independent Variables	Dependent Variable(s)	Moderators	Context and unit of analysis	Findings
					companies identified are in the U.S.. Discusses Managerial list of pros and cons for accessing external sources of innovation.
Cesaroni (2004) Research Policy	Number of potential technology suppliers (licensors), supplier size, company size, percentage of plants owned by the firm using proprietary technology, R&D intensity, sector dummies	First analysis: three level index: the technology is either newly licensed, repeatedly licensed or developed by internal staff. Second analysis: whether a compound produced is new to the company.	None	Process outsourcing decision in 934 global chemical plants from 96 chemical corporations based in U.S., Europe and Japan	When there are a larger number of technology suppliers, the probability of technology outsourcing increases. Firms that heavily invest in R&D competency and proprietary technologies tend not to pursue outsourcing. The second analysis shows that the availability of technology licensors increases the likelihood that a company will diversify into the production of this compound.
Nicholls-Nixon and Woo (2003) Strategic Management Journal	Investment in internal R&D, technological breadth, type of technology alliances, number of alliances of each type	Biotechnology patents, biotech products, reputation	None	26 firms in the U.S. pharmaceutical industry 1981-1991	Mixed support for a positive relationship between internal biotech R&D and technical output. No relationship between breadth of R&D activities and technical output. Mixed support for positive relationship between the number of different types of alliances entered and technical output. Partial support for positive relationship between number of technology sourcing linkages used and technical output.

Authors / Journal	Independent Variables	Dependent Variable(s)	Moderators	Context and unit of analysis	Findings
Swan and Allred (2003) Journal of Product Innovation Management	Differentiation goal, low-cost goal, distance between marketing and R&D, product dynamism, competitive intensity	External product technology sourcing, external process technology sourcing	None significant, though all possible interaction combinations of independent variables were examined in exploratory analysis	187 U.S. business units across industries (largely manufacturing). Parent companies are mostly U.S., with 69 international.	External product technology acquisition is associated negatively with differentiation goals, positively with product dynamism, negatively with low cost goal, positively with increased distance between marketing and R&D. External process acquisition is associated negatively with differentiation goals, positively with product dynamism, and positively with high competitive intensity.
Love and Roper (2002) International Journal of the Economics of Business	R&D staff, plant employment, sectoral R&D intensity, graduate employment percentage, production type, concentration ratio, plant market share, plant sales growth, minimum efficient scale	Undertaking R&D (external only or internal/ external), cost of internal R&D per innovation	None	1722 UK plants	R&D employment positively influences propensity to internally pursue R&D, plant size has a negative effect (though squared and cubed terms are negative), concentration ratio has a positive effect, minimum efficient scale has a negative effect, and market share has a positive effect. In terms of unit cost of R&D, R&D employment has a positive impact (though there are non linear negative effects), plant size has positive effect (also with non-linear negative effects). Both R&D intensity graduate employment have direct positive effects.
Steensma and Corley (2001) Academy of Management Journal	Threat of opportunism, threat of commercial failure, opportunity for sustainable advantage, firm risk preference, management stockholdings, organizational	Governance mode (licensing or acquisition)	Management stockholding and risk preference each interacted with threat of opportunism, threat of commercial	123 public U.S. companies which had announced technology licensing or acquisition.	Threat of opportunism explains firm behavior when management stockholdings are low, and when slack resources are high. The opportunity to develop sustainable advantage has a more significant impact when there are lower

Authors / Journal	Independent Variables	Dependent Variable(s)	Moderators	Context and unit of analysis	Findings
	slack, acquisition history, licensing history, industry		failure and opportunity for sustainable advantage. Each was at least somewhat significant except for threat of commercial failure*risk preference. Also threat of opportunism*recoverable slack and opportunity for sustainable advantage*recoverable slack are significant.		levels of recoverable slack and a higher risk orientation. Acquisition history and licensing history are both significant predictors.
Steensma and Corley (2000) Academy of Management Journal	Technological uniqueness, imitability, uncertainty, dynamism, absorptive capacity. Type of technology sourcing partnership (licensing, acquisition, joint development)	Capability development, attainment of objectives, estimated ROI, composite sourcing performance	Acquisition and licensing each interact with uniqueness, imitability, commercial uncertainty and dynamism, adding significant explanatory power to regressions on all 4 dependent variables	208 sourcing projects within firms announcing licensing, joint development or acquisitions. 95 respondents were attained for a subsequent performance measurement 3-4 years later.	Regressions on all four performance measures suggest that the degree of coupling moderates the relationship between uniqueness, imitability, uncertainty and dynamism with performance. For instance, licensing is associated with high sourcing performance, but only under high dynamism. Acquisition only leads to high sourcing performance under difficult imitability or unique technology.

Authors / Journal	Independent Variables	Dependent Variable(s)	Moderators	Context and unit of analysis	Findings
Kessler, Bierly and Gopalakrishnan (2000) R&D Management	External sourcing, external sourcing of ideas, external sourcing of technology, innovation speed, development costs, competitive success	NA – only correlations were examined	NA	75 NPD projects in 10 large U.S. companies across industries.	External sourcing is positively related to time taken to develop new products (particularly late stage sourcing). External sourcing has negative relationship with competitive success (particularly sourcing of ideas). External sourcing has no relation with costs (regardless of sourcing of ideas or technology)
Veugelers and Cassiman (1999) Research Policy	Size, appropriability, Importance of internal information, importance of competitor information, resistance to external innovations, costs and risks as obstacles, cost reductions goal	Internal, external or hybrid technology sourcing, Innovator status	None	748 Belgian Manufacturing Firms	Small firms are more likely to either exclusively develop technology in house or source technology externally, whereas large firms tend to use both internal and external sourcing. Firms valuing internal information are more likely to use a hybrid strategy. Firms highly concerned about costs and risks avoid exclusive external sourcing. Importance of cost reduction is negatively linked to exclusive external sourcing. Where appropriability is high, firms are less likely to exclusively externally source.
Nagarajan and Mitchell (1998) Strategic Management Journal	Encompassing technological change ("radical alteration of core activities"), complementary ("radical alteration of complementary activities that do not also involve radical alteration of core activities"), incremental ("adjustments to core or complementary activities")	Methods of acquiring technology (equity based relationships, nonequity relationships, Internal R&D)	None	44 projects during technological change in medical lithotripters industry (devices to fragment kidney and gall bladder	Encompassing technological change innovations tend to stem from equity based relationships. Complementary technological change innovations tend to stem from non equity relationships. Incremental technological innovations tend to stem from internal R&D.

Authors / Journal	Independent Variables	Dependent Variable(s)	Moderators	Context and unit of analysis	Findings
				stones) between 1989 and 1991.	
Croisier (1998) R&D Management	R&D stage (basic vs. development), number of technologies in the project, number of parties to the project, geographical scope, duration, industry	R&D governance structure: market, hybrid, or hierarchy	None	2012 external technology projects between firms globally.	Advanced R&D stage, low number of technologies, low number of parties, low geographic scope and low duration are associated with market organization (R&D contracting). Differences across industries are also significant.
Veugelers (1997) Research Policy	Firm size, multinationality, diversification, industry dummies, government support, spending on contracted R&D, collaborative R&D participation, acquisition of external technology	Internal R&D expenditure	Size and multinationality interact positively. Presence of internal research capability interacts with both co-operative activity and outsourcing in increasing internal R&D.	290 Flemish R&D performing companies	Size is the most important variable in explaining internal R&D. All industry dummies are significant. Government subsidies are significant. R&D outsourcing has a positive impact on internal R&D, but only where there is an existing R&D ability. Co-operative R&D engagement has no impact on internal R&D unless there is an internal R&D ability, in which case R&D spending is increased.
Audretsch , Menkveld, and Thurik (1996) Journal of Institutional and Theoretical Economics	R&D spending, firm size, concentration ratio, small business presence, capital intensity, price cost margin, market growth, skilled labor, high or low tech environment	External R&D (yes or no), Internal R&D (yes or no)	Differences are shown between low and hi tech R&D	1106 Dutch manufacturing firms	R&D spending is positively related to external and internal R&D (both low and hi tech). Capital intensity is positively related to both external and internal R&D (but only in low tech environment). Price cost margin is negatively related to external R&D (low tech env.) but positively related to internal R&D (low tech) and external R&D (high tech). Skilled labor is negatively related to external R&D (low tech) but positively related to internal R&D (low tech). Findings suggest that in high tech industries, internal and external R&D are

Authors / Journal	Independent Variables	Dependent Variable(s)	Moderators	Context and unit of analysis	Findings
					complementary, but in low tech industries they are substitutes.
Ulset (1996) Journal of Economic Behavior and Organization	Technical novelty, potential sunk costs, expected resale value	Client's administrative control rights, client's property rights, client's decision of vertical integration	None	80 IT based R&D projects, 40 carried out by external non profit research institutes, and 40 by the client's own employees.	Potential sunk costs has a positive relationship with vertical integration. Contractual incompleteness, Fixed price contract and client's administrative control rights have a negative relationship with vertical integration. Administrative control rights are positively related to potential sunk costs. Vertical Integration is positively related to potential sunk costs. Client's property rights are negatively related to technical novelty, negatively related to resale value of R&D outputs.
Chatterji and Manuel (1993) Research Technology Management	Effort to utilize outside labs, how long, priority, future change, geographic scope, use of metrics, success, problem areas	NA – survey results are simply reported with no statistical analysis	NA	Survey of 130+ R&D executives at U.S. and international firms.	Most companies make an effort to use external technology sources to complement internal R&D and have done so for years, though this is seen as a growing priority. Typically, responsibility for external sourcing is not done by a dedicated sourcing team, but is normally treated as an extension of internal responsibilities. R&D metrics are only used by approximately 20% of respondents to measure their sourcing efforts. Pharmaceutical firms appear to have assigned sourcing a higher priority using more formal processes and have achieved greater success here.

Authors / Journal	Independent Variables	Dependent Variable(s)	Moderators	Context and unit of analysis	Findings
Pisano (1990) Administrative Science Quarterly	Small number bargaining conditions (number of new biotechnology firms with R&D programs in the same application), product market rivalry (number of rivals), sourcing history (number of own R&D products in development/all R&D products in development in past year), experience (number of completed projects in category), focus (percentage of business attributable to pharma), sales	In house or collaborative R&D	None	92 pharmaceutical biotechnology R&D projects across 30 firms	A concentrated (few suppliers) R&D supply, R&D experience, greater degree of firm focus are positively related to internalization. There are also significant differences across national boundaries. Rivalry had no impact. Historical propensity to procure R&D internally had no impact.

APPENDIX B

Appendix B: Case Study and Managerial Focused Innovation Governance Research

Authors / Journal	Context	Findings
Bardhan (2006) Human Systems Management	Foreign outsourcing and offshoring of R&D activities	Modern firms seek locational advantage for every business activity. Discusses background factors contributing to globalization of R&D, separated into push factors (lower returns to R&D, technology downturn, increased competition) and pull factors (supply of technological graduates in emerging countries – China, India and Russia, growing global markets). Develops five pairings of dichotomous concepts and generalizations related to them: 1. Drastic vs. Marginal Innovation. Work related to drastic innovations is kept close to headquarters, whereas marginal innovation can be outsourced internationally. 2. Systemic vs. Autonomous Innovation. Decentralized organizations are better suited for autonomous innovations, whereas innovations which work together (systemic) are better suited for centralized innovation organizations. 3. High vs. Low Occupational/Skill specificity. Where skill specificity is high internalization is preferred. 4. Input Market vs. Output Market. Markets for labor as well as the company's products impact R&D organizational strategy. For instance, where innovations become commodities, outsourcing is appropriate. 5. Intra-firm vs. Arm's length internationalization. Unpredictability in R&D favors intra firm organization.
Piachaud (2005) Research Technology Management	Cross-contextual guidelines for technology sourcing	Discusses managerial challenges in external sourcing. Managers must remember that by outsourcing, they largely trade the problems of managing internal development for the problems related to managing an external vendor. Several criteria are presented for outsourcing vendors: 1. Compatibility 2. Technology 3. Expertise 4. Objectives 5. Human Resources 6. Costs 7. Capabilities (contracted firm) 8. Contract Criteria for outsourcing: 1. Activity is of low significance 2. Supplier has proprietary knowledge 3. Quality and/or cost benefits 4. Specialty expertise 5. Requirement for external accountability
Barragan, Cappellino, Dempsey and Rothenberg	Observations and guidelines based on semi-structured interviews with multiple team members of 3 product	The authors observe that decisions about outsourcing were commonly left to technical personnel, tended to not make strategic decisions (focusing only on the primary goal of reducing new product costs), and struggled with the balance between flexibility and control, as well as often lacking relationship and knowledge management skills. The authors present a decision making framework in 4 steps.

Authors / Journal	Context	Findings
(2003) Supply Chain Management	development teams in the same organization.	1. Assemble the expertise 2. Analyze strategic position 3. Identify appropriate arrangement 4. Plan for knowledge migration
Howells, James and Malik (2003) R&D Management	Factors behind external sourcing of new technological knowledge (rather than, say licensed knowledge) based on interviews with managers in the UK.	The authors describe several factors behind the changing nature of the research process (movement away from internal governance) Push factors: 1. Increasing complexity of R&D and costs and risks associated 2. Products are becoming more sophisticated, with the number of technologies per product (TPP) increasing in consumer and business products. Many firms do not have necessary resources to cope with additional technologies. Pull factors: 1. Attractiveness of expertise 2. Enhancement of capabilities 3. Enable learning and networking with wider research community 4. Government incentives 5. Existence of firms to take over subcontracted, low value added research The authors also differentiate long term and short term knowledge sourcing initiatives across several attributes and discuss different approaches to core competences in technology sourcing.
Odagiri (2003) Managerial and Decision Economics	Discussion of motives of 10 major pharmaceutical companies in Japan. Some empirical examination is done – but largely case focused.	The authors describe the various forms of R&D undertook by the 10 large Japanese firms, including outsourcing, technology acquisition, commissioned research, joint research and national projects. These 10 firms use a diversity of R&D sourcing options. In an empirical portion of the paper, the authors test TCA propositions against RBV propositions and find very weak support for the RBV argument that firms ally with firms with stronger capabilities, rather than the TCA argument that firms select alliance types which minimize transaction costs. It must be noted that the author appears to be making interpretations based on nonsignificant coefficients. However, the author supports this viewpoint with anecdotal evidence from interviews.
Narula (2001) Technology Analysis & Strategic Management	Observations and guidelines for external R&D sourcing Interviews with 32 senior R&D managers of European technology firms.	Findings from interviews with R&D managers are presented on many topics surrounding external R&D: Discusses the growth of multi-technology firms and the use of non internal R&D for several reasons: 1. Greater capital intensity of R&D 2. Technological competence no longer associated with greater profitability 3. Decline in transaction costs for extra firm relationships.

Authors / Journal	Context	Findings
		Why is outsourcing of R&D not more popular? 1. Uncertainty 2. Tacit nature of R&D 3. Appropriation Interviews revealed that three times more spending was done on outsourcing than on alliances. Firms must maintain minimum competency to utilize outsourced R&D results. Governance decision trees (in house R&D vs. Alliance vs. outsourcing) are presented.
Quinn (2000) Sloan Management Review	Discussion of innovation outsourcing ranging across industries and R&D stages.	Author estimates that outsourcing can lower innovation costs and risk 60-90% while decreasing cycle times. Cisco is discussed at length – they could not rely on internal manufacturing or hiring capabilities to keep up with growth rate. 4 reasons why timing is right for outsourcing innovation: 1. Growing global demand 2. Growing global stock of scientists 3. Interaction capabilities 4. New incentives (tax rates, privatization, etc.) Why outsource innovation? 1. Resource Limits 2. Specialist Talents 3. Manage risks 4. Attract talent 5. Speed Examples are provided from basic, early and development stages. In service industries for instance (e.g., auditing) consultants have typically been more innovative than their customers. The author also discusses how to attract partners and best manage relationships.
Howells (1999) Industry and Innovation	Discussed contract R&D trends based on national research report and other secondary literature as well as 20 interviews with managers in technology	The author discusses the growth of contract R&D and the state of the contract research market. Uncertainty in various types of innovation ranging from fundamental research (true uncertainty) to minor technical improvements (very little uncertainty). The importance of not contracting core competencies is discussed. Next is a discussion of factors pushing R&D outside the firm (complexity, cost, risk) and factors "pulling" companies towards contracting (enhancing the scope of activities, accessing outside abilities, networking). The author concludes with a discussion of contract R&D and national innovation systems.

Authors / Journal	Context	Findings
	companies.	
Chesbrough and Teece (1996) Harvard Business Review	Guidelines for managers along with examples from the business press.	The authors argue that outsourcing can give corporations greater flexibility, which is critical to innovation in fast changing environments. However the type of innovation desired is critical in determining the role of outsourcing. Autonomous innovations can be created separately from other innovations. In this case, the virtual organization is appropriate to speed technologies independently to market. Systemic innovations generate value in concert with complementary innovations and require a centralized, fully integrated organization to ensure co-ordination. The authors advocate a portfolio approach, mixing virtual and integrated organization based on the desired innovation type.
Chatterji (1996) Research Technology Management	Findings from discussions with a group of 20 Industrial Research Institute member companies	The author attempts to answer the question: Why is their increasing interest in accessing external technology sources? Several explanations are presented, grouped into demand and supply side. Demand Side 1. Increased global competition and need for faster development, lower costs. 2. Lack of technical expertise. 3. Risk Sharing 4. Imitating competitors. Supply Side 1. Scientific knowledge growing globally. 2. Numerous startup firms 3. Displaced talent from downsizing. The advantages and drawbacks of 8 types of R&D arrangements ranging from contracting to equity alliances are discussed. Typical managerial challenges in these relationships include: unclear strategic priorities, fluctuating resources, unclear responsibilities, limited international presence, evaluating technical and commercial merit as well as successfully integrating sourced technology. These managerial challenges are typically caused by one of these root sources: sourcing is not managed as a strategic business process; failure to have constancy of purpose over time; unequal emphasis on all stages of sourcing process; people issues. The author presents an 8 stage model of the sourcing process, along with best practices.

Authors / Journal	Context	Findings
Francis Tapon (1989) Journal of Economic Behavior and Organization	Discussion of underlying causes of external R&D in large pharmaceutical and chemical firms.	The author uses a case based, transaction cost approach and argues that three factors are behind increasing pursuit of R&D outside traditional firm boundaries: 1. Effectiveness of patents 2. Rising importance of basic research in innovation 3. Relative failure of traditional, in house labs (pharmaceutical firms spend more than any other industry's firms on R&D, yet pharmaceutical innovation has weakened). Problems include unwillingness to abandon projects and the continuous use of previously used research methods, as well as compensation and bureaucracy (among others). The author makes TCA arguments (site specificity, human asset specificity, dedicated assets, opportunism) based on case observations.

APPENDIX C

Appendix C: Empirical Governance Appropriateness Research

Authors / Journal	Research Setting (governance modes)	Outcome Variable	Determinants of alignment	Method and Findings Related to Appropriate Governance
Argyres and Bigelow (In press) Management Science	U.S automobile industry 1917-1933 (either manufactures part internally or uses supplier)	Organizational failure	Engine uniqueness, firm age, firm size, whether or not the firm produces more than one car	Misalignment is operationalized as the residual from the governance decision (difference between predicted probability of governance mode and the mode chosen). Prior to an industry shakeout, misaligned firms have the same survival rate as aligned firms. During the industry shakeout, misaligned firms fail at greater rates than aligned firms. The authors speculate that it may take as long as a 20 year lag before transaction cost economizing begins to have an impact during the early stages of an industry, but dramatically shorter lag is required during a shakeout or a mature industry.
Sampson (2004) Journal of Law Economics and Organization	Telecom R&D alliances (either pooling contracts or equity alliances)	Innovativeness (patents weighted by citations) over ensuing four years	Alliance scope, number of parties, breadth of activities beyond R&D, diversity of partner technological capabilities, prior links, alliance experience, intellectual property regime, judicial efficacy, rule of law, political risk, culture	Results from initial Probit analysis provide misalignment variable. Overall, misaligned governance results in 61% lower rate of weighted patent citations. In the case where a more hierarchical alliance mode is selected than is called for, properly aligned firms are 231-307% more innovative than misaligned firms. However, in the case where a less hierarchical alliance mode is selected, only a 4-12% reduction in innovativeness is seen over misaligned firms. The author speculates that this differential may mean that the costs of bureaucracy may exceed the costs of uncontrolled opportunism.

Authors / Journal	Research Setting (governance modes)	Outcome Variable	Determinants of alignment	Method and Findings Related to Appropriate Governance
Brouthers, Brouthers and Werner (2003) Strategic Management Journal	International entry mode decision of Dutch, German and British firms. (joint venture or wholly owned subsidiary)	Performance (subjective perceptual measure)	Asset specificity, economic uncertainty, behavioral uncertainty, economic uncertainty*asset specificity, firm size, experience, legal restrictions, industry type	Probit estimates used to predict entry mode choice. Firms selecting "transaction cost enhanced" or "fit firms" (aligned) entry modes perform better than "unfit firms".
Nickerson and Silverman (2003) Administrative Science Quarterly	U.S. Trucking firms (proportion of employee drivers vs. owner operators)	Return on Assets	Share of less than truckload (LTL), advertising, haul lengths, haul weights, total number of hauls, unionization, freight categories, region categories	Residuals from Tobit model (since governance is a proportion) are used to provide residuals, which are interpreted as the degree to which the carrier's governance of its driver force deviates from the prescriptions of TCE. Driver misalign is used along several other variables (leverage, less than truckload share, size, and several others control variables). Misalign has a significant and negative relation with ROA. Analysis of two forms of misalignment is not reported, but a comment is made that examining each group separately or grouping both varieties together "does not change results". Adaptation to misalignment over time is found.
Leiblein et al. (2002) Strategic Management Journal	Production of semiconductor devices (outsource or internalize)	Technological performance (transistor density)	Firm tenure, firm size, ex ante number of suppliers, demand uncertainty, asset specificity, demand uncertainty*asset specificity	"Governance misfit" (as determined from initial probit model) negatively impacts those firms which incorrectly make a "buy" decision, but does not significantly impact those firms which incorrectly choose the "make decision".

Authors / Journal	Research Setting (governance modes)	Outcome Variable	Determinants of alignment	Method and Findings Related to Appropriate Governance
Silverman et al. (1997) Strategic Management Journal	U.S. Trucking firms (proportion of employee drivers vs. owner operators)	Firm Failure	Proportion of LTL carriage, several haul characteristics, advertising, series of control variables	Misalignment is not significantly related to performance (though the authors note that as they raise the minimum firm size, misalignment gradually becomes more significant, reaching $p > .05$ at a revenue floor of 1.2 million).
Masten et al. (1991) Journal of Law Economics and Organization	Production of component (internally or supplier)	Costs of organization	Importance of schedule, human asset specificity, asset specificity, complexity, engineering effort, labor/capital intensity, load leveling dummy, costs of directing	Probit estimations are made for the make or buy decision. Then the same variables, plus the inverse mills ratio are used as predictors of organization costs. It is then shown that these costs would have risen dramatically if firms had selected the opposite governance structure. They show that costs increase ~300% when switching from make to buy, but only ~70% when switching from buy to make. They do not expand on this and claim that "no particular significance should be attributed to the asymmetries" since these are sensitive to the distribution.
Anderson (1988) Management Science	Sales forces in various districts (company sales force or representative)	Selling efficiency (sales/selling costs)	Measurability, need for nonsales support, confidential nature, need for training, attractiveness of product line, sales predictability, transaction specific assets, size of the firm, environmental uncertainty, travel requirements, specialized knowledge. Importance of key accounts, time needed for sales	Once the "index of observance" has been computed from results of logistic regression, this is used with company size, travel requirements and technical sophistication to predict selling efficiency. The index of observance is not significant, all other covariates are significant.

APPENDIX D

Appendix D: SAS Proc NLMixed Code For Stage One Estimation

```
/*SAS code for censored ML estimation*/

PROC NLMIXED DATA=TEMP1 OPTCHECK;
/* USE RESULTS OF PROC MIXED FOR STARTING PARAMETERS*/
      PARMS BETA1=? BETA2=? BETA3=? BETA4=? BETA5=? BETA6=? BETA7=?
BETA 8=?;
      PI=2*ARSIN(1);
      MU= ALPHA + A_I + BETA1*ASSETSPECIFICITY +
BETA2*IMPORTANCEOFLEARNING + BETA3*INTERACTION +
BETA4*MARKETUNCERTAINTY + BETA5*TECHNICALUNCERTAINTY +
BETA6*APPROPRIABILITY + BETA7*FIRMSIZE;

/*OBSERVED (OBS=1) RIGHT CENSORED (OBS=0)*/
      IF OBS=1 THEN LL=(1/(SQRT(2*PI*SIGSQE)))*EXP(-(IG-
MU)**2/(2*SIGSQE));

      IF OBS=0 THEN LL=PROBNORM((MU-IG)/SQRT(SIGSQE));
      L=LOG(LL);

      MODEL IG ~ GENERAL(L);

      RANDOM A_I ~ NORMAL([0,S2A_I] SUBJECT=LGINCIDID OUT=RANDOM1;
      PREDICT MU OUT=OUT;

      RUN;
```

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