The Cost of Misaligned Governance in R&D Alliances

Rachelle C. Sampson
New York University

Transaction cost economics argues that aligning transactions with governance structures leads to more efficient outcomes. While empirical evidence demonstrates that firms choose governance consistent with transaction cost predictions, the performance implications of governance choices are less well explored. Here I examine the cost of misaligned governance in the context of research and development (R&D) alliances. Two costs of misalignment are evaluated: excessive contracting hazards and excessive bureaucracy. Using a sample of R&D alliances in the telecom equipment industry, I find that alliance governance selected according to transaction cost arguments improves collaborative benefits substantially over governance not so selected. Interestingly, governance misalignments imposing excessive bureaucracy reduce collaborative benefits more than misalignments imposing excessive contracting hazards. These results provide empirical evidence of the cost of misaligned governance and have implications for research on the limits of internal organization and links between organizational form and innovation.

1. Introduction

A central tenet of transaction cost economics is that a discriminating alignment of transactions with governance leads to more efficient outcomes via reduction of transaction costs (Williamson, 1985:22–23). Empirical evidence to date shows strong support for the premise that firms choose governance consistently with transaction cost predictions.[1] However, we have less evidence of the performance implications of governance choice. As Joskow (1991:81–82) notes, we have little information on what firms gain from the best versus next best governance alternatives. In this article, I examine the cost of misaligned governance in the context of research and development (R&D) alliances.

I thank Bernard Yeung, Scott Masten, Joanne Oxley, Witold Henisz, Tom Pugel, Mike Lenox and seminar participants at Columbia Law School, University of California–Berkeley, and Harvard University for their helpful comments on this article. The thoughtful suggestions of Oliver Williamson and two anonymous reviewers are also gratefully acknowledged. The Ameritech Foundation and the Center for International Business Research at the University of Michigan provided partial funding for this research. All remaining errors are my own.

1. See Shelanski and Klein (1995) for a review of the literature.

The Journal of Law, Economics, & Organization, Vol. 20, No. 2,

doi:10.1093/jleo/ewh043

Firms frequently collaborate on R&D in response to the increasing pace of technological change and the rising costs of new product development. Competition in many industries now turns on the ability of firms to create knowledge in a timely and cost-efficient fashion, and alliances represent a means of shortening development times, acquiring new capabilities, and spreading development costs. However, casual empiricism and survey-based research suggest that many alliances fail to live up to partner firm expectations.[2] In addition, scholarly research suggests that the termination rate of joint ventures is higher than can be explained by successful attainment of a joint goal (Kogut, 1989).[3]

One possible explanation for this performance difference across alliances is variation in alliance governance; specifically, whether alliance governance is aligned with the characteristics of the transaction. Firms entering into alliances face considerable moral hazard problems, since partner firm behavior is often unobservable and the costs of opportunism are potentially high (see e.g., Oxley, 1997). These problems are particularly pronounced in R&D alliances, where valuable knowledge and technologies may be exposed. Firms may have difficulty cooperating under such circumstances.

Alliance governance serves to mitigate these concerns, since the governance selected ultimately determines firm incentives to cooperate. However, the structure of collaboration—or alliance governance—is often overlooked by managers when negotiating collaborative R&D. Collaborative ventures are frequently the brainchild of senior executives who, after negotiating what capabilities each firm brings to the alliance, leave further details unaddressed.[4] I argue that leaving alliance governance to chance or otherwise failing to align governance limits collaborative benefits. Using transaction cost logic, I argue that a discriminating alignment of transactions with governance improves firm benefits from collaboration. More specifically, firms that choose alliance governance so as to minimize hazards of opportunism without imposing excessive bureaucracy are better positioned to realize collaborative benefits than firms that fail to do so.

---

2. For casual empiricism, see, for example, Levine and Byrne (1986), *The Economist* (1990, 1992), and Sparks (1999). For survey-based research, see for example, Bleeke and Ernst (1993), who find that more than 40% of all alliances fail to live up to partner expectations. Of course, the failure of alliances to live up to expectations is not unique to this organizational form. For example, the acquisitions literature repeatedly shows that most acquisitions fail to add value to the acquiring firm (see, e.g., Wernerfelt and Montgomery, 1988; Lang and Stultz, 1994; cf., Villalonga, 2002).

3. "The significant number of terminations of joint ventures in the early years suggests, however, that many of these terminations are a result of business failure or a fundamental instability in governance" (Kogut, 1989:184).

4. These issues are analogous to those noted in recent merger waves:

> "Too many managers. . .duck the hardest questions until after the deal has gone through. . . .Companies that agree on a clear strategy and management structure before they tie the knot stand a better chance of living happily ever after"
>
> (*The Economist*, January 9, 1999:16).

While these arguments apply generally, R&D alliances represent a particularly suitable context to examine the cost of misaligned governance for two reasons. First, alliances allow us to move beyond a key impediment to examining the effects of more hierarchical governance on performance. Data for internal transactions are difficult to obtain, while considerably more information is available on a firm's alliance activities.[5] Second, outcomes from R&D alliances can be measured in terms of new technology, a readily available and perhaps less noisy measure than financial performance.

With a sample of 464 R&D alliances in the telecommunications equipment industry, I find strong support for these arguments. Alliance governance selected according to transaction cost arguments improves collaborative benefits substantially—by an average of 138% over governance not so selected. Interestingly, the magnitude of this result depends on the type of misalignment. Collaborative benefits are diminished most by selection of governance that imposes excessive bureaucracy rather than governance that allows excessive opportunism hazards. This result has important implications for research on the limits of internal organization as well as that linking organizational form and innovation. More bureaucratic organizational forms appear to have high costs; excessive bureaucracy appears to dampen innovative activities more substantially than uncontrolled hazards of opportunism. Contractual governance thus appears to be more efficient in all but the most extreme cases.

Below, I discuss firm motivations for collaborating in R&D and the hazards that may interfere with effective collaboration. Alliance governance alternatives and how firms choose among these alternatives are discussed. Performance implications of two types of misaligned governance selection are then explored. I outline my empirical approach, followed by a description of the data, measures, and statistical techniques. Results and discussion conclude.

2. Motives for R&D Collaboration

The promise of increased competitiveness, whether through more efficient manufacturing processes or the introduction of new products that allow firms to charge a price premium for their goods, spurs many firms to invest substantially in exploration of new technologies and processes. Given the knowledge-intensive nature of such activities, firms often organize these activities internally (e.g., Pisano, 1990). Internal organization of R&D activities has the desirable feature of limiting leakage of intellectual property to other firms and reducing coordination difficulties (see, e.g., Liebeskind, 1996).[6] Notwithstanding these advantages, internal

5. As Shelanski and Klein (1995:354) note, "the effects of internal organization on firm performance have been subject to relatively few empirical TCE studies. One possible reason is that data for internal transactions are difficult to obtain."

6. The unified ownership of knowledge and complementary assets within a firm and the enhanced powers of control over employees lead to greater incentive alignment, control, and ultimately, better protection of intellectual property (Liebeskind 1996:97).

organization entails nontrivial costs that may impede a firm's innovative progress. Internal operating and investment decisions are politicized to a greater degree, since the disciplining forces of the market are absent within the firm (Williamson, 1985:140). Further, the rules and rigidities inherent in bureaucratic restraints may discourage more creative ideas, such that more unfamiliar and creative projects are rejected (Holmstrom, 1989:323). In this sense, bureaucracy may be hostile to innovation. Contracting for R&D reduces bureaucratic costs but introduces hazards that may similarly impede innovative progress. Market contracts for R&D are costly to negotiate and enforce, and are inevitably incomplete (Klein, 1980; Liebeskind, 1996). Such incomplete contracting introduces substantial moral hazard problems, including free riding and leakage of valuable knowledge.

As an alternative to both internal organization and more arms-length governance forms, alliances often represent an attractive way to organize R&D activities. Alliances are not burdened with the same bureaucratic costs of internal organization, and as such, may be more nimble and better able to innovate (Williamson, 1991; Oxley, 1997). When compared with market contracting, alliances offer enhanced coordination and control (Williamson, 1991; Oxley, 1997). Alliances also offer real-time access to resources not available or easily developed in-house, as well as economies of scale and scope in R&D (see, e.g., Tripsas et al., 1995). Alliances are not, however, all of one kind. Below, I consider two alliance governance alternatives: pooling contracts and equity joint ventures.

3. Alliance Governance Alternatives and Selection

Within the broad rubric of "alliances" there exist a staggering number of governance or organizational alternatives (see, e.g., Powell, 1990). For example, firms may choose to cross-license technologies, enter into more complex contractual arrangements for technology development, or incorporate a separate entity for their collaborative efforts—the equity joint venture.[7] I focus here on two such alternatives: the pooling contract and the equity joint venture.[8] A pooling contract is a contractual arrangement where partner firms combine their capabilities for the purposes of collaborative R&D, but do not form a separate legal entity for the alliance.[9] Firms also combine capabilities under the equity joint venture,

7. See Contractor and Lorange (1988) and Powell (1990) for more thorough descriptions of the myriad forms an alliance may take.

8. While other, more fine-grained categories of hybrid modes exist, the evaluation of additional governance alternatives would preclude effective differentiation between these alternatives. It is necessary to clearly distinguish between the governance characteristics of alternative modes in order to suggest linkages between particular alliances and the mode that best reduces transaction costs. While the modes I have selected, the pooling contract and the equity joint venture, both involve significant within-mode variation in terms of governance attributes, this variation is less than the between-mode variation (Williamson 1991; Oxley 1997).

but in this case a new entity is created, jointly owned and operated by two or more collaborating firms (e.g., Pisano et al., 1988). On the market to hierarchy continuum of organizational forms, the pooling contract is close to market, while the equity joint venture is more hierarchical and closer to internal organization.

As the alliance governance form is closer to market, the pooling contract retains some of the incentive characteristics of markets while providing enhanced monitoring and improved coordination (Oxley, 1997:390).[10] Partner firms typically share the outcomes of the alliance in a pooling contract, which leads to stronger incentive alignment relative to more unilateral contracts.[11] Firms also often form cross-organizational teams in such alliances (Shuen, 1994), improving information flow between partners.[12] Decision making in these alliances on all but the most critical decisions is typically decentralized (i.e., partner firms make their own judgments on how to best meet their obligations under the alliance agreement), in contrast to the equity joint venture described below. For example, in the alliance between Ramtron and Fujitsu for the joint development of ferroelectric technologies, each firm is largely responsible for the work conducted at its own facility. The alliance agreement provides that:

> Ramtron shall provide the Program management for that portion of the program that takes place at the [Ramtron] facility ... All of such items and services shall be provided by Ramtron at Ramtron's actual cost ...

---

9. More unilateral forms of alliance governance are inappropriate for consideration here because they do not encompass pooling activities. Unilateral alliances primarily involve one-way transfer of technology in return for cash payments and present a different coordination problem than the one highlighted in the paragraphs below.

10. The pooling contract is roughly equivalent to the bilateral contract in Oxley's (1997) study, except that the pooling contract includes alliances with more than two partner firms, while the bilateral contract is restricted to two partner firms.

11. For example, in the alliance between Ramtron Inc. and ULVAC for the development of thin-film process systems and materials used in FRAM technology, both firms retain intellectual property (IP) rights for their respective technologies developed prior to the alliance, while IP rights on inventions by either party during the alliance are shared equally. Clause 11(c) provides: "Ramtron and ULVAC shall jointly own, in equal and undivided shares, all right, title and interest in and to any improvements, enhancements and/or inventions made by either party during the terms of this Agreement ..." All agreement terms illustrated are taken from SEC filings, unless otherwise indicated.

12. In the alliance between Ramtron and ULVAC, the partners agree to form a joint development team to assist in decision making: "From time to time when necessary during the term of this Agreement, there shall be a meeting of the joint development technology committee, which shall consist of the Project Leaders and one (1) additional member appointed by each of Ramtron and ULVAC..." The joint development alliance agreement between ST Microelectronics (formerly SGS-Thomson) and Benchmarq Microelectronics also provides for a joint development team: "Each party agrees to commit no less than 5 employees to a joint product definition team. Each party shall appoint a coordinator (the "Champion") for its employees committed to the team through whom all communications shall be made."

The agreement contains an identical provision for Fujitsu to provide management and resources for all work undertaken at the Fujitsu facility. Thus decision making in pooling contracts is typically more decentralized and may be faster, but can lead to undesirable outcomes when coordination is required.

Relative to the pooling contract, the equity joint venture has some fairly consistent governance attributes that enhance information flow and allow greater control over alliance activities. As noted by Oxley (1997), equity joint ventures are typically characterized by a joint board of directors, which allows for greater partner communication and control and often requires firms to come to a consensus on strategic-level decisions. For example, the following provision is made in the joint venture agreement between SICPA Industries and Flex Products:[13]

> Specific tasks to be undertaken by SICPA Industries and Flex shall be determined by the unanimous vote of the committee. Neither SICPA Industries ... nor Flex ... shall have any obligation to perform tasks or projects except as authorized and directed by a unanimous vote of the Committee.

In this case, the "Committee" is the joint venture governing body consisting of equal numbers of members from Flex Products and SICPA Industries. Both firms have the explicit right of veto over any activities of the joint venture; this facilitates coordination between joint venture partners on strategic-level decisions by forcing consensus.

Notwithstanding this joint governance over strategic-level decisions, the equity joint venture typically has day-to-day management that is at least partially independent from each of the parent firms. Such independent management allows greater "self-determination" by the joint venture, relative to the pooling contract, such that resources contributed to the alliance are more likely to be used in a fashion that is consistent with alliance goals (i.e., joint) rather than parent objectives (i.e., individual). Ideally alliance goals and parent objectives are aligned, but in situations where these diverge, separation of alliance management from partner firms credibly enforces the notion that the joint goals take precedence over individual goals. For example, in the joint venture agreement between Parlex Corporation and Shanghai Radio Factory, formed to develop, manufacture, and market flexible printed circuits, the partners stipulate that a general manager is to be appointed to and compensated by the joint venture and that the general manager is responsible for the day-to-day management of the alliance.[14] This form of day-to-day autonomy from the partner firms is a characteristic truly unique to the equity joint venture. By

13. This agreement can be accessed at the CORI database at http://cori.missouri.edu.

14. Clause 12.3: "The functions and responsibilities of the General Manager shall be ... to organize and lead the daily management and operation of the Joint Venture Company and to establish the sales strategy and pricing of products sold by the Joint Venture Company" This

functioning as a separate legal entity, the joint venture can have at least partially independent management, since these employees can be directly on the payroll of the joint venture and need not be direct employees of the partner firms.

Equity joint ventures can also function as repositories for contributed resources. While all alliance agreements specify the contributions required by partner firms to some extent, only contributions to alliances structured as equity joint ventures can become the legal property of the alliance until dissolution. These contributions may be in cash or in kind and use is often restricted to the alliance activities.[15] Contributions sometimes extend beyond physical or capital-based assets to employees, who often become employees of the joint venture rather than the parent company.[16] Further, recall of such employees back to the parent company can be (and often is) explicitly limited.[17] This separation of control between partners and the joint venture over day-to-day activities and allocation of contributed resources to tasks means that partners are required to coordinate in order to make adjustments over the life of the alliance. Ultimately this may slow adjustments because of the mechanisms in place to ensure that all partner interests are taken into account, but coordination is greatly enhanced.

Finally, partners have a greater incentive to work through disputes privately under an equity joint venture than under a pooling contract. Since the use of a more bureaucratic form of alliance governance (like the equity joint venture) relieves partners from full contractual specification, courts have less information on the intentions of the partners, which makes efficient court resolution more difficult. In response, firms typically provide dispute resolution mechanisms that lead to greater coordination in case of a dispute.

---

responsibility is extended beyond day-to-day responsibilities to major problem solving and execution of contracts on behalf of the joint venture: "The major issues of the Joint Venture Company shall be decided through consultations among the General Manager and Deputy General Manager... The General Manager... shall have the authority to execute contracts and other instruments on behalf of the Joint Venture Company."

15. For example, the joint venture agreement between eNote.com Inc. and Seafont Pty. Ltd. (to develop and launch a TV e-mail service in Australia and New Zealand) specifies that cash contributions to the joint venture may only be used for the purposes of the alliance. Clause 4.1 stipulates: "Capital Contributions. On the closing date, each Party shall contribute Two Hundred Fifty Thousand Dollars ($250,000) in immediately available funds to the account of [the joint venture]... The contributed capital shall be used only for the payment of approved expenditures contained in the [joint venture] Business Plan."

16. In the joint venture agreement between Read Rite Corporation and Sumitomo Metal Industries to develop, manufacture, and market thin-film heads for disk drive manufacturers, Clause 10.2 provides the following: "Employees. The parties agree that after the incorporation of the [joint venture], the day to day operation of the [joint venture], ... shall be carried out mainly by employees dispatched by [Sumitomo] who shall become employees of the [joint venture] as soon after their dispatch to the [joint venture] as is practicable."

17. Clause 10.2, continued: "[Sumitomo] will not recall a dispatched employee without the consent of the President of the [joint venture] and the employee involved."

Table 1. Alliance Governance Form Attributes

	Governance Form	
	Pooling contract	Equity joint venture
Decision making	Semi-independent (decentralized)	Consensus (centralized)
Day-to-day management	Partner firms (decentralized)	Joint venture (centralized third party)
Asset ownership	Partner firms	Partner firms and joint venture
Setup costs	Low	High
Adaptive advantage	Local (autonomous)	Global (coordinated)

These characteristics mean that the equity joint venture ultimately allows for more efficient coordinated adaptation to unanticipated contingencies that arise over the course of the alliance relative to pooling contracts. Such enhanced coordination and control, however, come at a cost. The costs of administrative controls, negotiation, and setup of an equity joint venture far exceed those of the pooling contract (Pisano et al., 1988). Further, the very mechanisms that facilitate greater coordination and control in an alliance also introduce bureaucratic costs. For example, while a joint board of directors allows for greater control over alliance decision making, this control slows the decision-making process. The attributes of the pooling contract and equity joint venture are summarized in Table 1.

Given these additional costs, use of the equity joint venture is reserved for those situations where the benefits of enhanced coordination and control are sufficient to outweigh the inevitable costs of setup and bureaucracy imposed by this alliance governance form. This is more likely the case when partners cannot adequately control hazards of opportunism—including free riding and knowledge leakage—via contract. Threats of free riding and leakage are particularly pronounced in R&D alliances; given the knowledge-based nature of inputs into such transactions, firms have difficulty assessing partner contributions and cannot easily infer contributions by examining results, since the link between effort and results is highly variable. Full specification, monitoring and enforcement of partner rights, and obligations to protect against such threats via contract are most difficult when alliance activities are highly uncertain and/or complex (Oxley, 1997). For example, we expect that specifying inputs and outputs for an alliance involving incremental improvements over existing technology (e.g., "customized software applications for industrial customers") is easier than for an alliance involving development of more radical innovations (e.g., "next-generation integrated circuits").[18] As a result, contracts

18. These examples are taken from the SDC database on Joint Ventures and Alliances. Oxley (1997) operationalizes several other sources of contracting difficulties in alliances, which are discussed in the empirical analysis below.

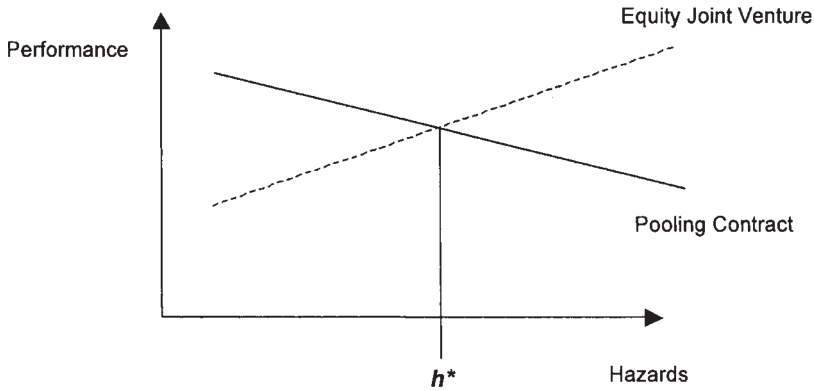

Figure 1. Selecting alliance governance.

will inevitably be less complete in the latter case, leaving firms vulnerable to leakage of valuable knowledge to their partners and losses through free riding. As contracting difficulties increase, the costs of uncontrolled opportunism rise when compared to the relatively fixed costs of bureaucracy, implying a move toward the equity joint venture.[19] This trade-off between opportunism and bureaucracy—along with the implications for alliance governance choice—is set out in Figure 1; at hazard levels below the threshold level, h^*, the pooling contract is best, while at hazard levels above h^* the equity joint venture is preferable.

4. Performance Implications of Governance Misalignment

Whether or not firms select alliance governance according to the level of contracting difficulties has important implications for collaborative benefits. Misaligned governance selection imposes either uncontrolled opportunism or excessive bureaucracy on the alliance. Thus I focus on two types of misalignment: use of a pooling contract for alliances with "high opportunism hazards," and use of an equity joint venture for alliances with "low opportunism hazards." In either case, collaborative benefits are reduced.

By focusing on these two types of governance, two types of misalignment are effectively disallowed: the use of a pooling contract for transactions that should be organized through the market, and the use of an equity joint venture for transactions that should be internally organized. Firms choosing to ally have ruled out more market-based modes of organization and integration within the firm. Inevitably some firms are mistaken in this choice; however, I assume that most firms have made this choice correctly

19. I assume that the alliance features that increase contracting difficulties do not simultaneously increase the costs of bureaucracy. The costs of bureaucracy are a function of governance mechanisms chosen and are, relative to contracting difficulties, treated as independent of alliance characteristics.

and that most misalignments are as between the pooling contract and equity joint venture. It is likely easier to choose among more differentiated organizational forms, such as market, hybrid, and hierarchy than to make finer-grained distinctions on performance attributes of organizational modes within these three broad categories. Thus I focus on misalignment between the pooling contract and equity joint venture in the discussion and analysis below.

Where a pooling contract is chosen for an alliance with high hazards (i.e., where hazards exceed h^* in Figure 1), the risk of ex post opportunism is high because free riding and leakage hazards may be insufficiently controlled. These uncontrolled hazards frustrate performance potential since firms may hesitate to commit resources at the optimal level. Concerns over leakage of intellectual property may prevent partners from pooling their best technologies and most skilled labor. In an extreme case of uncontrolled hazards, where (for example) technologies are required for collaborative activities but cannot be contributed because of concerns over leakage, the alliance may be prematurely terminated. Alternatively, firms that free ride may encourage their partners to do the same. While these steps may not be inconsistent with the contract in a strict sense, actions taken to protect against opportunism may dampen alliance performance.[20]

The consequences of selecting an equity joint venture when opportunism hazards are low stem from the costs associated with the equity joint venture. The key benefit associated with the equity joint venture is the enhanced coordination it provides. However, the mechanisms that improve coordination also introduce bureaucratic costs, as discussed above. For example, bureaucratic controls on employee behavior may impair individual incentives to pursue more innovative ideas. Decision-making processes that enhance coordination often also slow decision making, which may depress incentives to innovate and slow progress considerably. Politicization of decisions on which R&D projects to pursue and which to abandon may then reflect individual preferences rather than the preferences of the partners collectively. Consequently the alliance may fail to make the best use of the partners' pooled resources. Where hazards are low (i.e., hazards below h^*), these costs are incurred without commensurate benefits and hamper collaborative R&D.

In the course of selecting governance for their alliance activities, partner firms must therefore balance the need to preserve both incentives to innovate and responsive decision making with the desire to control opportunism and adapt efficiently to unforeseen contingencies. For alliances with hazards in the region of h^*, the cost difference between alliance governance

20. We can think of a multitude of examples where such actions may dampen performance. For instance, firms may hesitate to provide sensitive information to suppliers when those suppliers also work with the firm's competitors, if appropriate safeguards are not in place. Failure to provide this information may diminish the supplier's ability to develop a suitable product or service for the firm.

choices is small. However, at hazard levels well above or well below h^*, costs of misalignment are high. It is in this sense that selection of governance mode affects alliance performance. Aligned governance efficiently balances the threat of opportunism against the costs of bureaucracy, allowing firms to spend more time on improving collaborative outcomes and less time controlling hazards on a day-to-day basis. This argument does not mean that aligned governance ensures alliance success, but rather that firms avoid the cost of misaligned governance and therefore improve chances for alliance success.

Despite the hypothesized benefits of alignment, not all allying firms select aligned alliance governance. Empirical evidence in the psychology literature suggests that individuals do not always make rational decisions under uncertainty (see, e.g., Tversky and Kahneman, 1981; Kahneman et al., 1982). Individuals frequently employ heuristics to deal with uncertainty and these heuristics often lead to biases in decision making. Hubris may also contribute to improper selection of alliance governance; for example, firms may be overconfident in their ability to manage alliance activities via contract and fail to fully consider the need for more formal governance. Finally, bounded rationality may also preclude complete assessment of contractual hazards and, consequently, aligned governance selection (Simon, 1982).

This argument, that firms may make mistakes in choice of governance, suggests a nonequilibrium state. Although transaction cost economics is an equilibrium theory, disequilibrium states are not ruled out. Firms, in response to competitive pressures, slowly adopt more efficient governance modes. This shift requires visible outcomes from prior transactions in order to link outcomes with choices made. Thus, in the short run, misaligned selection may occur, though in the long run firms converge on equilibrium (Williamson, 1985:22–23).

In summary, I expect collaborative benefits to be greater when governance selected is aligned with the level of hazards than when governance is not so chosen. Two hypotheses follow from this logic:

Hypothesis 1. At lower levels of hazards, the contribution of an alliance to partner firm innovation is greater with a pooling contract than an equity joint venture.

Hypothesis 2. At higher levels of hazards, the contribution of an alliance to partner firm innovation is greater with an equity joint venture than a pooling contract.

5. Empirical Analysis

5.1 Empirical Design

To empirically test whether misaligned governance dampens performance, I measure how much a firm has to gain (or lose) by choosing aligned over misaligned governance, according to transaction cost-based arguments.

To examine this hypothesized link between alliance governance and collaborative benefits, I employ a two-stage strategy. I first estimate a governance selection model via probit. In this model I estimate the probability that partners select a pooling contract or equity joint venture as a function of alliance contracting difficulties and relevant controls. Measures of contracting difficulties and controls are based on the attributes of the R&D alliance (i.e., transaction characteristics) and are similar to those measures used in prior estimations of alliance governance choice (e.g., Pisano, 1989; Oxley, 1997, 1999). In this first stage, the unit of analysis is the alliance. In the second stage, I estimate collaborative benefits, that is, firm technological innovation after alliance commencement, under each governance mode as a function of variables capturing inputs into the firm innovation process and relevant alliance characteristics. Since firms likely choose alliance governance systematically, I correct for self-selection in this performance estimation using the Heckman (1979) technique, modified for a count model following Greene (1997a) and Murphy and Topel (1985).[21] The unit of analysis in the second stage is the firm.

I then compare firm innovative performance in alliances with misaligned governance with the expected performance of the alliance had the partners chosen aligned governance. Since my arguments linking governance and firm innovative performance are conditional on the level of opportunism hazards, we need to assess the extent of these hazards in each alliance. With an appropriate categorization of low and high hazards, we can then identify alliances with misaligned governance and estimate the cost of misaligned governance. Since opportunism hazards arise out of the inability to control for risks of leakage and free riding via contract, we can proxy for these hazards via an assessment of contracting difficulties. These contracting difficulties are captured by the independent variables in the governance choice estimation. Assessing the overall level of contracting difficulties in an alliance, however, is not straightforward since contracting difficulties are multidimensional and therefore cannot be captured easily in a single variable.

One approach is to stratify the observations into groups and subgroups—"bins" on a matrix—based on the value of each independent variable. Observations that fall within each bin have comparable contracting difficulties, since they have the same values along the vector of independent variables. We can then examine the effect of misaligned governance, conditioning on the level of hazards. However, the obvious

21. A key assumption of the transaction cost economics literature is that firms choose a governance mode based on the perceived performance attributes of that mode. If we simply estimate performance as a function of governance selection, parameter estimates will capture not only the effects of governance, but also the firm and transaction characteristics that led to selection of a particular governance mode in the first place. That is, estimates will likely be biased by self-selection. Failure to correct for this may lead to incorrect conclusions that governance does (or does not) affect performance. See Masten (1993) for a more thorough discussion of self-selection in the context of governance choice.

limitation of this method is that it requires a sufficiently rich sample, such that no bin is without observations from both governance types (i.e., equity joint ventures and pooling contracts). For example, if there are n independent variables capturing contracting difficulties, there will be 2^n possible values for the vector of independent variables. As the number of variables increases, the number of bins increases exponentially, reducing the likelihood of observations from both governance types in the same bin.

Rosenbaum and Rubin (1983) propose a solution to this "curse of dimensionality" through the use of propensity scores—that is, the probability of "treatment" given the vector of independent variables. One particularly attractive feature of using such a probability estimate is that it allows comparison between observations across multiple dimensions. The propensity score theorem demonstrates that if the treatment assignment is conditionally independent of the vector of independent variables, then it is also conditionally independent of the propensity score. More specifically, if the probability of receiving treatment is

$$p(X_i) \equiv \Pr(Treatment = 1 \mid X_i) = E(Treatment \mid X_i),$$

then $(Y_{i1}, Y_{i0}) \perp (Treatment_i \mid X_i) \Rightarrow (Y_{i1}, Y_{i0}) \perp (Treatment_i \mid p(X_i)$. That is, if we can ignore treatment selection conditioning on X, then we can also ignore treatment selection conditioning on the propensity score, $p(X)$, the probability that treatment is received (Rosenbaum and Rubin, 1983). Thus the propensity score theorem implies that observations with the same propensity score have the same distribution across the vector of independent variables. The dimensionality of the problem is reduced, allowing the use of a scalar to construct comparable groups, rather than allocation across n-dimensional space.[22]

The propensity score can be applied to the problem under consideration here, albeit with a slightly different interpretation. In the current context, the probability of treatment in this setting is the probability that firms choose the equity joint venture for their alliance activities, which is based on the level of alliance contracting difficulties. Thus low hazard and high hazard alliance groups are constructed via the probability that firms choose to organize their alliance activities via equity joint venture. Given that alliances with the same probability of choosing an equity joint venture have the same distribution over the full vector of variables capturing alliance characteristics, we can have confidence in the comparability of alliances within each hazard category. Note that this categorization of alliances into low and high hazard groups relies on the expected probability of selecting an equity joint venture, which is a function of *observable* variables. These observable variables capture contracting difficulties, including alliance characteristics such as measures of alliance

22. Dehejia and Wahba (2002) more thoroughly discuss the use of propensity scores to construct control groups. For a recent illustration using propensity scores in a different context—whether a diversification discount exists—see Villalonga (2002).

technology breadth, the number of partners, and different activities in the alliance, as well as relevant aspects of the institutional environment described below. If low and high hazard alliances were identified by the residual term, this would introduce a bias into the results, since selection would be based on unobservables that potentially also drive performance as well, rather than observables that have been included in the estimations.

The use of probability estimates to capture the overall level of alliance hazards is a novel approach that relies heavily on the theoretical underpinnings of the governance selection model for its validity. I assume that those variables that increase the selection probability of an equity joint venture are fundamental drivers of contracting difficulties and, consequently, opportunism hazards. The use of probability estimates is valid only to the extent that this assumption holds. Given the consistency of my governance selection findings with prior empirical work in the transaction cost economics literature, this may well be a reasonable assumption. As one meaningful way to identify low and high hazard alliances, this approach allows us to move beyond what has been a key impediment to testing the link between governance and performance.

5.2 Data and Sample Description

For these empirical tests, I constructed a dataset comprising the alliance and patenting activities of firms in the telecommunications equipment industry.[23] The convergence of the telecommunications equipment with computer and microelectronics markets in the late 1980s substantially accelerated the pace of technological development (e.g., *The Economist*, 1997). Product life cycles shortened, while the cost of development increased (Pisano et al., 1988). To gain access to complementary capabilities, reap economies of scale, and spread the risk and expense of development, firms in this industry frequently collaborate in their R&D activities (Pisano et al., 1988).

I constructed this dataset from two main sources: the Securities Data Company (SDC) Database on Joint Ventures and Alliances and the Micropatent database. The SDC database contains information on all types of alliances and is compiled from publicly available sources including Securities and Exchange Commission (SEC) filings, industry and trade journals, as well as news reports. SDC has collected information on alliances back to 1970. However, consistent data collection efforts by SDC extend primarily from 1988 onward. Coverage of alliances formed after 1988, while more comprehensive than pre-1988, is still inevitably incomplete, since firms are not required to report alliance activities. Nevertheless,

23. The telecommunications equipment industry consists of SIC classes 3661, 3663, and 3669.

the dataset is among the most comprehensive sources of information on alliances and is one of the only sources available for large-scale empirical studies on alliance activity.[24]

The alliance sample includes all R&D alliances for firms in the telecom equipment industry that commenced during the years 1991–93, inclusive.[25] Each alliance involves joint R&D activities either exclusively or in addition to marketing, production, and/or supply activities. These criteria led to selection of 464 R&D alliances, involving 487 firms across 34 nations.[26] Of the sample firms, 85% are from the United States (60%), Japan (12%), and Europe (13%). This pattern is consistent with prior observations (Hergert and Morris, 1988; Oxley, 1999). The sample includes both same-nation alliances (48%), where all partner firms are headquartered in the same nation, and international alliances (52%), where all partner firms are not headquartered in the same nation. The high incidence of international alliances is not surprising, since leading firms in the telecommunications equipment industry are widely distributed across countries.[27]

I combine this alliance data with the Micropatent database, which contains all information recorded on the front page of every U.S. patent granted since 1975, including assignee name, inventor name, and patent technological classification. From this data, I construct a firm's

24. While the SDC data are among the most comprehensive sources for information on alliances, the data suffer from important limitations. First, to the extent that firms overstate or understate their alliance activities, variables capturing alliance activities, such as alliance scope described below, will contain error. Fortunately, only the alliance scope variable relies heavily on the verbal descriptions of alliance activities. These categorizations are fairly broad, involving discrete "jumps" between categories, which to some extent minimizes the impact of any such error in reporting. Further, as long as any error is not systematically correlated with the dependent or independent variables, such over-or understatement will be random noise that will not bias the estimates, but will increase the standard errors and make it more difficult to show significance. The second limitation is that the information on alliances is taken at the commencement of the alliance. Updates to reflect changes in governance and/or alliance activities over time are not available. While not ideal, this will only be a problem where changes over time are substantial; small changes over time will not affect the results, since the variables created from the SDC data are coded into discrete categories. Unfortunately both available datasets on alliance activity—including the Cooperative Agreements and Technology Indicators (CATI) database and the SDC database used here—suffer from the same limitations. Notwithstanding these limitations, these datasets still represent important information on a firm's alliance activity, however imperfect. Many recent studies have made use of these datasets, including Mowery et al. (1996), Oxley (1997, 1999), and Anand and Khanna (2000).

25. This time period provides more comprehensive alliance samples than earlier time periods, but still allows sufficient time to track post-alliance patents. For patents issued during the years 1975–97, 81% were issued within 2 years of application, while 96% were issued within 3 years of application.

26. Of sample firms, 69% were involved in only one R&D alliance during 1991–93, 13% were involved in 2 alliances, 6.5% were involved in 3, and the remaining 11.5% were involved in anywhere from 4 to 62 alliances during the time period.

27. For example, Motorola is American, Vodafone is British, and Ericsson is Swedish. All three firms are leaders in the telecommunications equipment industry with substantial market shares.

patent portfolio. Since firms do not always assign patents to the subsidiary where the innovation took place, patents assigned to the entire firm rather than a single subsidiary must be measured. For example, of the patents assigned to firms in my sample, 73% were assigned to the ultimate parent firm, while 27% were assigned to various levels of subsidiaries. Failure to capture patents assigned to all units in the corporate structure leads to an extremely noisy measure of firm capabilities and, consequently, biased parameter estimates (Kennedy, 1992). To avoid this I constructed a patent portfolio for firms based on patents assigned to the parent firm as well as all of its subsidiaries. First, I used the *Directory of Corporate Affiliations* to identify all subsidiaries of firms in the sample. I then drew all patents from the Micropatent database assigned to any of these parents or subsidiaries and aggregated the patents drawn to the entire firm, or corporate, level.

Ideally we would measure only those patents that are clearly linked to specific R&D collaborations. However, given the obstacles to obtaining information on the intellectual origins of specific patents, linking patents with specific collaborations poses a serious challenge. One alternative to capturing all patents assigned to allying firms is to classify individual patents as related or unrelated to a specific alliance, based on the alliance activities. Such classification, in theory, should allow more precise parameter estimates, since we can better attribute patents to alliance activity and are less likely to capture those patents that arise from firm R&D activities unrelated to the current alliance. However, such a classification is highly subjective and inevitably arbitrary. As Hall et al. (2001:13) note with respect to assigning patents to aggregate technology categories, an issue analogous to the assignment of patents to an alliance, "there is always an element of arbitrariness in devising an aggregation system and in assigning the patent classes into the various technological categories, and there is no guarantee that the resulting classification is 'right,' or adequate for most uses." While each approach has its limitations, here I rely on strong firm controls and alliance variables to empirically tease out the firm versus alliance effects rather than attempting to identify specific patents attributable to specific alliances.

5.3 Measures

Stage 1: Alliance Governance Selection

Dependent Variable: Alliance Governance (*Governance*). Based on information provided by SDC, I create a dummy variable to capture the alliance governance mode. *Governance* equals one when the alliance is organized by equity joint venture, and zero when organized by pooling contract.

Independent Variables: Alliance Scope (*Narrow Scope, Intermediate Scope, and Broad Scope*). R&D alliance activities range from very narrow projects, where the focus is on development of new products based on existing technology, to very broad projects where firms seek to develop the "next generation" of a particular product. I expect contracting difficulties to be greater for very broad, ambitious projects than for very narrow projects, since full specification and monitoring of partner rights and obligations are more difficult for broad projects. As such, I include a measure of alliance scope, which captures the breadth of alliance R&D activities and is based on the synopses of alliance activity provided by the SDC database. I use three dummy variables to capture narrow, intermediate, and broad alliance scope. *Narrow scope* refers to alliance activities focused on development of new products based on existing technology. Activities that go beyond mere customization of an existing product but fall short of developing next-generation technology fall within the *intermediate scope*. Finally, alliance projects for developing next-generation technology fall within the *broad scope*.[28]

Multilateral Alliances (*Multilateral*). Multilateral alliances may be more difficult to manage than bilateral alliances, since monitoring becomes more difficult with the addition of more partners (Oxley, 1997). To capture multilateral alliances, I construct a dummy variable, *multilateral*, which is equal to one if the number of partner firms exceeds two.[29]

Breadth of Alliance Activities (*R&D Plus*). The breadth of alliance activities refers to activities beyond joint R&D. Thus, while scope captures the breadth of R&D activities *only*, *R&D plus* captures whether alliance activities include more than joint R&D. All alliances in the sample involve joint R&D. In addition, joint marketing, production, and supply activities may also take place. *R&D plus*, a dummy variable, is set to one where joint marketing, production, and/or supply also take place.

Diversity of Partner Technological Capabilities (*Tech Diversity*). The above alliance characteristics determine how well partners can safeguard against opportunism hazards via contract. Other alliance characteristics, however, may determine partner *incentives* to engage in opportunistic behavior. Consider, for example, the diversity of partner firm capabilities. As technological capabilities become more diverse among partner firms, each firm has more unique capabilities to lose to the other(s). However, to effectively misappropriate the capabilities of a partner, firms must have related absorptive capacity (Cohen and Levinthal, 1990). The need for absorptive capacity limits the risk of leakage at very high levels of diversity. This suggests that as capability diversity rises, contracting hazards also rise, but at a decreasing rate.

I measure the diversity of partner technological capabilities by examining the degree of overlap between partner patent classes (Jaffe, 1986). This measure effectively captures the technological position of one partner

28. As the most common category, I omit the intermediate scope from the analyses.

29. Of all R&D alliances in the sample, 82% involve only two partner firms. Of the remaining alliances, 9.5% involve 3 firms, 3% involve 4 firms, and the remaining 5.5% involve anywhere from 5 to 12 firms.

firm relative to another. To construct this variable I first generate each partner's technological portfolio by measuring the distribution of its patents across patent classifications, year by year. This distribution is captured by a multidimensional vector, $F_i = (F_i^1 \ldots F_i^s)$, where F_i^s represents the number of patents assigned to partner firm i in patent class s. Diversity of partner firm capabilities is then[30]

$$Tech\ diversity = 1 - \frac{F_i F'_{i'}}{\sqrt{(F_i F'_i)(F_{i'} F'_{i'})}},$$

where $i \neq i'$. *Tech diversity* varies from zero to one, with a value of one indicating the greatest possible technological diversity between partner firms. This measure is not sensitive to the number of patents within a class and captures differences between partners based on diversity rather than volume of patents within the same class. To capture the suggested nonmonotonic relationship, I also include the square of this measure.

Consistent with prior literature (Oxley, 1997, 1999), several other independent variables are included in the governance selection estimation. These variables (as well as those described above) and their sources are set out in Table 2.

Stage II: Innovative Performance Estimation

Dependent Variable: Firm Innovative Performance (*Post Patent*). Using patent data, as compiled above, I measure each firm's innovative output after alliance commencement. Patents are strongly correlated with new products (Comanor and Scherer, 1969), literature-based invention counts (Basberg, 1982), and nonpatentable innovations (Patel and Pavitt, 1997). As such, patents are reasonably reliable indicators of innovative performance and are generally better measures of the output of R&D activities than R&D spending (Comanor and Scherer, 1969; Griliches, 1990).

Of course, simple patent counts do not accurately capture the *value* of the underlying innovation (Comanor and Scherer, 1969; Griliches, 1990). To address this heterogeneity in patent value, I assign a weight to each patent using citations made by later patents. When a patent is granted, the inventor (and/or patent examiner) notes all of the previous patents that the granted patent is based on. These "citations" of previous patents identify the technological lineage of the invention and effectively define the property rights granted by the patent (Jaffe and Trajtenberg, 1997). Empirical evidence shows a strong correlation between the ex post citations of the patent and the estimated value of the underlying invention (e.g., Trajtenberg, 1990; Hall et al., 2003). As such, citation weighting provides a less noisy measure of innovation than simple patent counts (Trajtenberg, 1990; Hall et al., 2003). Thus, I measure firm innovative

30. This measure calculates diversity as between a pair of firms. For alliances involving more than two firms, I calculate this measure for every combinatorial pair of firms in the alliance and take the average of these measures.

Table 2. Stage I Variable Descriptions and Sources: Governance Selection Estimation

Variable	Description	Source	Range
Dependent variable			
Governance	Equals 1 if alliance governed by equity joint venture, 0 if by pooling contract	SDC	0 or 1
Independent variables			
Multilateral	Alliances involving more than two partner firms	SDC	0 or 1
R&D Plus	Activities in addition to joint R&D	SDC	0 or 1
Narrow scope	Alliance with "narrow" R&D activities	SDC	0 or 1
Broad scope	Alliance with "broad" R&D activities	SDC	0 or 1
Tech diversity (squared)	Extent to which partner patent portfolios do not overlap (squared = square of this term)	Micropatent	0.13–1.00
Prior links	Number of previously established alliances among partner firms in focal alliance	SDC	0–4
Alliance experience	Prior alliance experience: minimum number of prior alliances among partner firms	SDC	1–50
Intellectual property regime	Lowest strength of patent protection among partner firm home nations	Ginarte and Park (1997)	1.12–4.52
Judicial efficacy	Least efficient judicial system among partner firm home nations	Business International Corporation	4.75–10.00
Rule of law	Lowest strength of "law and order" among partner firm home nations	International Country Risk Guide	2.08–10.00
Political risk	Highest level of corruption among partner firm home nations	International Country Risk Guide	2.92–10.00
Culture	Cultural distance between partner firm home nations	Hofstede (1991)	0–9.41

performance via citation-weighted, firm patents in a four-year post alliance window, *post patent*. For example, if an alliance commences in 1993, *post patent* is constructed from weighted patents applied for in 1994–97, inclusive.[31] I use the application date, since this date is the earliest point at which we can identify new firm capabilities.[32]

Independent Variables: Pre-alliance Firm Patents (*Pre patent* and *Partner Patent*). To control for factors (other than alliance governance) that may influence firm innovation rates in the second-stage analysis, I include additional variables capturing inputs into the firm R&D process. To control for a firm's R&D efforts, I include a measure of pre-alliance firm patenting. While patents are construed above as an indicator of innovative performance, they are also an indicator of inputs into the firm R&D process. Prior patents capture the impact of technological acquisitions, prior R&D spending, and a firm's propensity to patent (Trajtenberg, 1990), as well as a firm's technological capabilities (Patel and Pavitt, 1997).

For each firm, I measure pre-alliance patents by summing its patents, *pre patent*, in a four-year, pre-alliance window. Since inputs into the alliance R&D process include the partner's patents as well, I also include partner firm patents, *partner patent*, from a four-year pre-alliance window. While it is possible to weight pre-alliance patent counts by citations, Trajtenberg (1990) finds that un-weighted or simple patent counts are a better measure of innovative inputs; R&D spending is more strongly correlated with simple patent counts than with weighted patent counts.[33]

Other independent variables are described in Table 3. Given the difference in the levels of analysis between the governance selection estimation (i.e., at the alliance level) and performance estimation (i.e., firm level), independent variables included in each stage naturally differ. In the first stage, I follow Oxley (1997, 1999) by including variables that capture difficulties in specification, monitoring and enforcement of partner rights

31. I begin with a one-year lag between alliance commencement and firm patenting, since research shows a contemporaneous relationship between R&D efforts and patenting (e.g., Hausman, Hall, and Griliches, 1984).

32. Since my patent data runs only until 1997, ex post citations are necessarily truncated for firms with alliances commencing in later years (i.e., 1993 rather than 1992 or 1991). Patents applied for in 1997, for example, will be cited far less than patents applied for in 1995. While longer citation spans are more ideal than the short span used here, Lanjouw and Shankerman (1999) find that "for the purposes of measuring the initial expectations about the quality of a patented innovation, it is not necessary or even helpful to use very long citation spans" (p. 15). However, to control for the effect of this citation truncation, I include dummy variables for the year the alliance commenced. Later years mean later windows for measuring the dependent variable and inevitably a greater number of patent citations that are yet unobserved in the dataset. These controls are discussed in more detail below.

33. While not reported here, results are substantially similar to citation-weighted versions of these measures.

Table 3. Stage II Variable Descriptions and Sources: Innovative Performance Estimation

Variable	Description	Source	Range
Dependent variable			
Post patent	Citation-weighted firm patents for four years postalliance	Micropatent	0–6420
Independent variables			
Pre patent	Four-year pre-alliance firm patents	Micropatent	0–4822
Partner patent	Four-year pre-alliance partner patents	Micropatent	0–7887
Tech diversity (squared)	Extent to which partner patent portfolios do not overlap	Micropatent	0.13–1.00
Narrow scope	Alliance with "narrow" R&D activities	SDC	0 or 1
Broad scope	Alliance with "broad" R&D activities	SDC	0 or 1
Multilateral	Alliances involving more than two partner firms	SDC	0 or 1
Prior experience	Whether a firm has prior alliance experience	SDC	0 or 1
Other alliance	Whether a firm is involved in more than one alliance concurrently	SDC	0 or 1
International	Whether alliance crosses international borders	SDC	0 or 1
Year (1992)	Alliance commences in 1992	SDC	0 or 1
Year (1993)	Alliance commences in 1993	SDC	0 or 1
Inverse mills ratio	Selection correction index	Calculated from probit analysis	0.47–3.83

and obligations in a contract. For the second stage, the variables change slightly, reflecting the difference in dependent variables and level of analysis. For example, a firm's alliance experience (*prior experience*) is likely to matter more to the performance of that firm than a measure capturing the level of experience of all partners (*alliance experience*), which is more relevant to the governance decision in the first stage. Relevant alliance variables in the second-stage estimation are those that will more directly affect the firm's patenting output from collaboration, such as technological overlap with partners, a partner's stock of technological capabilities, and the breadth of the alliance R&D activities.[34]

Descriptive statistics for all variables are set out in Tables 4 and 5.

5.4 Empirical Results: Alliance Governance Selection

Of the 464 alliances in this sample, 399 are governed by pooling contracts, while 65 are equity joint ventures. Consistent with the commitment required by and expense of setting up such ventures, equity joint ventures are the exception rather than the norm. In Table 6, I present results from four alternative specifications of the selection estimation. Specification (1) includes the primary measures of contracting difficulties, (2) adds alliance controls suggested by prior empirical studies, (3) adds a measure of the strength of the intellectual property regime, and (4) adds other variables capturing the institutional environment.

Results in Table 6 show general support for the transaction cost hypothesis regarding the link between contracting difficulties and governance selection.[35] Allying firms choose the equity joint venture more frequently where the number of allying firms exceeds two and/or alliance activities include manufacturing, marketing, or supply in addition to joint R&D. This result suggests that firms choose a more hierarchical organization when they expect specification and monitoring to be difficult. Specification and monitoring difficulties increase free riding and leakage hazards such that governance characterized by more coordinated adaptation (i.e., the equity joint venture) is required. These results are robust

34. In theory, it is possible to have identical sets of independent variables in the first and second stages of the estimation. The issue is whether the model can be identified; in the case of the Heckman model, the nonlinearity restrictions in the estimation will identify the model and allow identical variables to be included in both stages of the equation. Of course, convergence is generally more difficult in such circumstances. As a robustness check, I reestimate the performance model, including all variables from the governance selection estimation. Parameter estimates reported in Table 7 here are not sensitive to the inclusion of these variables. These additional results are available from the author on request.

35. In Table 6 I use the standard 50% rule to calculate the percentage correctly predicted at the bottom of the table. However, since there are substantially more pooling contracts than equity joint ventures in the sample (more than five to one), one alternative rule is to reduce the threshold to reflect the probability of observing an equity joint venture in the sample (i.e., adjust the threshold downward to 0.20). Greene (1990:652) suggests: "If the sample is relatively unbalanced, that is, has many more 1s than zeros, or vice versa, then by [the 0.50] prediction rule, [the model] might never predict a 1 (or zero). To consider an example, suppose that in a sample of 10,000 observations, only 1000 have $Y = 1$. We know that the average predicted probability in the sample will be 0.10. As such, it may require an extreme configuration of regressors even to produce [a probability] of 0.20, to say nothing of 0.50. . . . The obvious adjustment is to reduce [the threshold]." The percentage of observations correctly predicted under 20%, 30%, and 40% thresholds are 73%, 82%, and 81%, respectively. Of course, these figures represent the overall percentage correctly predicted (i.e., both zeros and ones). As would be expected, as the threshold moves from 20% to 50%, the percentage of pooling contracts correctly predicted increases, while the percentage of equity joint ventures correctly predicted decreases.

Table 4. Descriptive Statistics: Governance Selection Estimation

	Correlations (correlations, significance)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Governance	1.000													
2 Multilateral	0.191	1.000												
	0.000													
3 R&D plus	0.041	−0.221	1.000											
	0.379	0.000												
4 Narrow scope	0.113	−0.020	0.120	1.000										
	0.015	0.660	0.010											
5 Broad scope	0.093	0.112	−0.058	−0.265	1.000									
	0.046	0.016	0.213	0.000										
6 Tech diversity	0.100	−0.090	−0.004	0.081	−0.088	1.000								
	0.031	0.052	0.936	0.081	0.059									
7 Tech diversity,	0.095	−0.110	−0.002	0.081	−0.092	0.992	1.000							
squared	0.041	0.017	0.962	0.081	0.047	0.000								
8 Prior links	0.014	0.258	−0.050	0.037	0.013	−0.252	−0.247	1.000						
	0.760	0.000	0.279	0.432	0.788	0.000	0.000							
9 Alliance	−0.062	0.040	0.007	0.018	−0.036	−0.308	−0.325	0.357	1.000					
experience	0.183	0.389	0.886	0.702	0.439	0.000	0.000	0.000						
10 Intellectual	−0.184	−0.222	−0.003	−0.040	0.073	−0.057	−0.055	−0.001	0.009	1.000				
property regime	0.000	0.000	0.948	0.389	0.118	0.218	0.241	0.982	0.845					

11 Judicial efficacy	−0.146	−0.181	0.005	−0.002	0.014	−0.107	−0.104	−0.003	−0.001	0.485	1.000			
	0.002	0.000	0.910	0.966	0.769	0.022	0.026	0.951	0.982	0.000				
12 Rule of law	−0.180	−0.102	−0.058	−0.009	0.061	−0.025	−0.026	0.041	0.029	0.507	0.567	1.000		
	0.000	0.028	0.214	0.848	0.193	0.588	0.583	0.384	0.540	0.000	0.000			
13 Political risk	−0.056	−0.146	−0.037	−0.010	0.051	−0.054	−0.056	−0.010	0.005	0.322	0.735	0.688	1.000	
	0.232	0.002	0.432	0.827	0.272	0.247	0.229	0.832	0.919	0.000	0.000	0.000		
14 Culture	0.177	0.055	0.069	0.008	−0.050	−0.114	−0.114	0.063	0.151	−0.413	−0.260	−0.478	−0.291	1.000
	0.000	0.236	0.136	0.870	0.287	0.014	0.014	0.174	0.001	0.000	0.000	0.000	0.000	
Mean	0.1401	0.1853	0.4267	0.3578	0.1121	0.9353	0.8959	1.2047	5.2124	4.0779	9.6094	9.3486	8.4731	1.0961
Median	0.00	0.00	0.00	0.00	0.00	1.00	1.00	1.00	2.00	4.24	10.00	10.00	8.63	0.00
Minimum	0.0000	0.0000	0.00	0.00	0.00	0.2450	0.0600	0.0000	1.0000	1.1200	4.7500	2.0800	2.9200	0.0000
Maximum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	4.0000	50.0000	4.5200	10.00	10.00	10.00	9.4086
Std. Dev.	0.3475	0.3890	0.4951	0.4799	0.3158	0.1344	0.1986	0.7400	7.5260	0.5828	0.9080	1.0794	0.6774	1.4959

$n = 464$

Table 5. Descriptive Statistics: Innovative Performance Estimation

	Correlations (correlation, significance)												
	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Post patent	1.000												
2 Tech diversity	−0.379	1.000											
	0.000												
3 Tech diversity,	−0.380	0.992	1.000										
squared	0.000	0.000											
4 Pre patent	0.833	−0.365	−0.358	1.000									
	0.000	0.000	0.000										
5 Partner patent	0.070	−0.254	−0.294	0.047	1.000								
	0.027	0.000	0.000	0.135									
6 Narrow scope	−0.032	0.076	0.078	−0.038	−0.023	1.000							
	0.311	0.016	0.013	0.228	0.468								
7 Broad scope	−0.018	−0.077	−0.079	0.043	0.097	−0.279	1.000						
	0.562	0.014	0.013	0.177	0.002	0.000							
8 Multilateral	0.031	−0.070	−0.099	0.020	0.496	0.013	0.122	1.000					
	0.334	0.028	0.002	0.537	0.000	0.679	0.000						
9 Year (1992)	0.150	−0.111	−0.108	0.149	0.006	0.009	0.002	−0.008	1.000				
	0.000	0.000	0.001	0.000	0.853	0.771	0.947	0.811					
10 Year (1993)	−0.198	0.095	0.097	−0.086	0.068	−0.113	0.055	0.047	−0.683	1.000			
	0.000	0.003	0.002	0.006	0.032	0.000	0.079	0.141	0.000				

11 Prior experience	0.251	–0.190	–0.199	0.241	0.022	0.016	–0.074	0.043	0.070	–0.083	1.000		
	0.000	0.000	0.000	0.000	0.492	0.607	0.019	0.175	0.026	0.009			
12 Other alliance	0.261	–0.203	–0.211	0.253	0.048	0.014	–0.100	0.069	0.080	–0.080	0.914	1.000	
	0.000	0.000	0.000	0.000	0.127	0.657	0.002	0.029	0.011	0.011	0.000		
13 International	0.083	–0.003	–0.013	0.132	0.167	0.032	–0.011	0.224	–0.030	0.034	–0.024	–0.007	1.000
	0.008	0.920	0.676	0.000	0.000	0.313	0.733	0.000	0.338	0.279	0.453	0.822	
Mean	461.68	0.94	0.90	357.95	1275.84	0.35	0.12	0.34	0.56	0.27	0.71	0.68	0.59
Median	13.00	1.00	1.00	5.00	218.00	0.00	0.00	0.00	1.00	0.00	1.00	1.00	1.00
Minimum	0.00	0.13	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Maximum	6420.00	1.00	1.00	4822.00	7887.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Std. Dev.	974.73	0.14	0.21	771.76	1780.33	0.48	0.33	0.47	0.50	0.44	0.46	0.47	0.49

n = 1005

Table 6. Alliance Governance Selection

	Pr(*Governance* = *EJV*)			
	(1)	(2)	(3)	(4)
Intercept	−3.472*	−3.340	−1.899	−3.185
	(2.087)	(2.217)	(2.131)	(2.186)
Multilateral	0.741***	0.761***	0.621***	0.682***
	(0.187)	(0.200)	(0.208)	(0.213)
R&D plus	0.293*	0.292*	0.290*	0.272
	(0.161)	(0.161)	(0.163)	(0.168)
Narrow scope	0.408**	0.409**	0.398**	0.383**
	(0.164)	(0.165)	(0.167)	(0.173)
Broad scope	0.544**	0.545**	0.632***	0.668***
	(0.232)	(0.233)	(0.236)	(0.240)
Tech diversity	3.253	2.964	3.310	2.694
	(5.717)	(5.755)	(5.631)	(5.382)
Tech diversity, squared	−1.343	−1.159	−1.510	−1.008
	(3.709)	(3.740)	(3.669)	(3.537)
Prior links		−0.033	−0.018	−0.014
		(0.117)	(0.118)	(0.121)
Alliance experience		0.002	0.001	−0.001
		(0.013)	(0.013)	(0.014)
Intellectual property regime			−0.360***	−0.069
			(0.124)	(0.162)
Judicial efficacy				−0.190*
				(0.155)
Rule of law				−0.299**
				(0.099)
Political risk				0.471***
				(0.168)
Culture				0.0140**
				(0.058)
n	464	464	464	464
Log likelihood	−172	−172	−168	−159
χ^2	31.89***	31.97***	40.34***	57.79***
df	6	8	9	13
% correct	86	86	86	86

Probit regression model. Dependent variable is alliance governance mode. Positive coefficients indicate greater likelihood of choosing an equity joint venture.
*,**,***indicate significance at 10%, 5%, and 1% levels, respectively, for two-tailed tests. Standard errors appear in parentheses.

across specifications and are consistent with the findings of Pisano (1989) and Oxley (1997).[36]

The scope of R&D activities influences alliance governance selection, although not in consistent ways. As predicted, broad R&D activities

36. Both Pisano (1989) and Oxley (1997) find that alliances involving more than one type of activity are more likely to use equity links than are alliances involving only one activity. Oxley (1997) also finds that increasing the number of partners may exacerbate monitoring difficulties and induce a choice of more hierarchical governance.

increase the probability that an equity joint venture is selected. This result is consistent with Oxley (1997), who finds that firms in alliances with a broader technology scope anticipate greater monitoring difficulties and therefore select more hierarchical governance. However, counter to expectations, narrow R&D activities also increase the likelihood of equity joint venture selection.[37] This finding is curious—narrow R&D activities generally indicate lower monitoring difficulties, decreasing the need for an equity joint venture. One possible explanation for this result is that firms collaborating for narrow R&D activities may have attributes that increase the complexity of the alliance activities along other dimensions. For example, upon further investigation, narrow R&D alliances in the sample tend to be international—51% of narrow scope alliances are international versus only 38% of broad scope alliances. In this sense, narrow alliances, on average, require coordination between partners across international borders. As such, these alliances with narrow R&D activities may be complex in ways different from alliances with broad R&D activities and require the superior adaptive mechanisms of the equity joint venture.

The strength of the intellectual property regime affects the probability that firms select an equity joint venture as expected in column (3); the stronger the external protections for intellectual property, the less firms need the enhanced coordination and control mechanisms of the equity joint venture. This result is consistent with the findings of Oxley (1999). Other measures of the institutional environment are added in column (4) and imply that external legal regimes make the pooling contract a more viable governance alternative. The coefficients on *judicial efficacy* and *rule of law* are both negatively signed. This result suggests that pooling contracts can more efficiently control free riding and leakage hazards when strong external enforcement exists and is consistent with the transaction cost framework. However, the effect of the intellectual property regime becomes nonsignificant when these additional variables are included. One possible interpretation of this change is that what matters for governance selection is the strength and efficacy of the legal regime rather than the intellectual property regime specifically. If this is the case, when variables capturing the strength of the legal regime generally are not included, the intellectual property regime measure proxies for the legal regime. Consequently, when variables more specific to the external legal environment are included, the explanatory power of the intellectual property regime is reduced.

Coefficients on both *political risk* and *culture* are positive and significant, suggesting two relationships. First, since *political risk* essentially captures the threat of government corruption, a positive coefficient

37. While not immediately apparent, this result does not conflict with Oxley (1997). The measure of scope used here has three levels, while the measure in Oxley (1997) is dichotomous. Re-estimating Table 5 with two levels of scope instead of three yields consistent results—broad scope positively and significantly influences the probability that an equity joint venture is chosen. These results are available from the author on request.

indicates that as this threat increases, legal regimes that support the pooling contract become less reliable. As such, allying firms place less reliance on external enforcement of alliance agreements and embed their knowledge-based assets in more protective governance structures. Second, as cultural distance increases, the need for more substantial monitoring and integration increases, suggesting that unfamiliarity with the local environment effect outweighs the difficulty in integrating management from diverse cultures.

Contrary to expectations, *technological diversity* between partners does not seem to affect the probability that an equity joint venture is selected. *Prior links* is positive, but not significantly different from zero. This contrasts with the prior empirical results of Gulati (1995), where prior and concurrent alliances decreased the need for more hierarchical governance. Finally, allying firms selected equity joint ventures less frequently when they have higher prior alliance experience in general. *Alliance experience* is negative and significant in both models, as expected, suggesting that greater prior alliance experience may enable allying firms to better specify and monitor alliance activities such that the enhanced controls of the equity joint venture are not required.

The coefficients shown in Table 6 are consistent with the arguments that contracting difficulties arise out of (1) more complex alliance activities, such as where multiple firms and multiple activities are to be managed, and (2) weak external institutional supports. As these contracting difficulties increase, the need for the coordinating mechanisms of the equity joint venture rises. Using a simple likelihood ratio test, specification (4) fits the data better than (1), (2), or (3). It is this specification (Table 6, column (4)) that I use to identify low and high hazard alliances and construct the selection correction index for the second stage of my analysis.

5.5 Empirical Results: Alliance Governance and Performance

Since I measure alliance innovative performance via citation-weighted, firm patenting (*post patent*), the empirical model must accommodate the nature of these counts: nonnegative, integer values with a high frequency of zero and small integer values. To account for these issues, I use a negative binomial specification (Hausman et al., 1984). Zero and small values of the dependent variable are naturally incorporated into the model.[38] The negative binomial model is

$$\Pr[\textit{Post patent} = p] = \frac{e^{-\lambda}\lambda^{p}}{p!}, \tag{1}$$

38. While there are a large number of zero patenting observations in the dataset, the data are neither censored nor truncated. Patents are naturally bounded at zero, unlike censoring where the independent, but not dependent, variables are observed beyond a certain range, and unlike truncation, where the independent and dependent variables are unobservable beyond a certain range. One statistical possibility is to use a zero-inflated negative binomial model,

where *post patent* is the citation-weighted patent count for a four-year post alliance period; λ is $e^{\beta' X+\varepsilon}$; X is a vector of alliance characteristics and inputs into the firm innovation process; and β is a vector of parameters.[39]

I estimate the effect of alliance governance by estimating Equation (1) separately for observations involving pooling contracts and those involving equity joint ventures. That is, I estimate two regressions: one for firms allying under pooling contracts, and one for firms allying via equity joint ventures. This approach allows parameter estimates to vary by governance mode.

As mentioned above, this approach may provide biased estimates of the effect of alliance organization mode on performance if firms select alliance governance systematically (Masten, 1993). Expected performance given pooling contract (PC) or equity joint venture (EJV) selection is (Cameron and Trivedi, 1986:33)

$$E[Post\ patent \mid Governance = j] = e^{\beta_i' X} + E[\varepsilon_i \mid Governance = j],$$

where $\{j = PC,\ EJV\}$. These estimates will be unbiased only if $E[\varepsilon_i \mid Governance = j] = 0$. If factors influencing governance selection also influence performance, that is, managers select governance systematically, $E[\varepsilon_i \mid Governance = j] \neq 0$. In general, $E[\varepsilon_i \mid Governance = j] = 0$ only where firms select alliance governance randomly, or we include all determinants of firm patenting and governance choice in the performance model. Failing to fulfill one of these two criteria leads to an omitted variables bias (Heckman, 1979).

To correct for this potential bias I use the common Heckman (1979) technique that corrects for self-selection, modified for the negative binomial model. Results from the first-stage probit model (Table 6) are used to generate a selection correction index, the inverse Mills ratio,

$$\Lambda = \frac{f(z)}{F(z)},$$

where z is the estimated value from the first-stage organization model and f and F are the standard normal density and cumulative distribution functions, respectively (Heckman, 1979).[40] This index is then included in the second-stage estimation (i.e., Equation (1)) as an independent variable. Thus estimates from this second-stage performance model are negative

which goes beyond the traditional negative binomial to take into account an even higher proportion of zeros. However, such a zero-inflated model is not appropriate here, since we are not looking at the patenting activities of firms that do not engage in R&D, but the patent activities of firms that do engage in R&D, even if only via their collaborations (see, e.g., Greene, 1997b:943–44).

39. λ follows a gamma distribution with parameters (γ, δ), where $\gamma = e^{\beta'} X$ and δ is common across firms. This treatment essentially controls for unobserved heterogeneity in λ by adding an error term (i.e., $\lambda = e^{\beta'} X + \varepsilon$).

40. That is, $z = \frac{X_i \beta_i}{\sqrt{\sigma_{ii}}}$, where X_i and β_i are the independent variables and coefficients for the organization choice estimation.

binomial estimates, corrected for possible selection bias via inclusion of this term.[41]

Note that in this model, not all disturbances are independent. Some firms have multiple observations representing their participation in multiple alliances, since I include an observation for each alliance a firm is involved in. I correct for this lack of independence between some observations, using a technique by Huber (1967). Where firms are involved in more than one alliance during the sample period, I sum the likelihood scores for that firm to create a "super observation" (Huber, 1967). Thus each group of observations for a firm is reduced to a single observation for the purpose of calculating standard errors.[42] No adjustment to parameter estimates is necessary as maximum likelihood estimates are still unbiased and consistent when the assumption of independence is violated (Greene, 1990).

Using these techniques I estimate the impact of alliance governance on firm innovative performance. More specifically, I regress citation-weighted firm patents on the independent variables described above, with observations split according to the governance mode actually selected. These performance estimates are set out in Table 7.

Several patterns that are not sensitive to the governance mode chosen emerge from this analysis. Prior firm patenting, not surprisingly, has a

41. Standard errors are also corrected, following Murphy and Topel (1985). An alternative to the two-step model is the full information maximum likelihood (FIML) estimation. The key difference between the two approaches is that the FIML approach is based on the unconditional distribution of the observations, while the two-step approach is based on the conditional (i.e., $z = 1$) distribution (Greene, 1997a:5). Further, the FIML estimates both equations and all parameters jointly (Greene, 1997b:141). While the FIML estimation has attractive properties, the FIML involves a fairly complex estimation that often fails to produce estimates (i.e., no convergence). Greene (1997b:141) notes two reasons one might prefer the two-step approach to the FIML: "First, it may be straightforward to formulate the two separate log-likelihoods, but very complicated to derive the joint distribution. This situation frequently arises when the two variables being modeled are from different kinds of populations, such as one discrete and one continuous (which is a very common case in this framework). The second reason is that maximizing the separate log-likelihoods may be fairly straightforward, but maximizing the joint log-likelihood may be numerically complicated or difficult." Unfortunately the data used in this article are such that estimation of the joint log-likelihood is difficult. The data for the probit and negative binomial models are pulled from very different kinds of populations, which makes computation of the FIML estimates in this case impossible.

42. Using this correction, the standard variance estimate for maximum-likelihood estimation is

$$\hat{V} = \hat{\mathrm{V}}\left(\sum_{i=1}^{n} u_i^{j\prime} u_i^j\right)\hat{\mathrm{V}},$$

where

$$\hat{\mathrm{V}} = \left(\frac{\partial^2 \ln L}{\partial \beta^2}\right)^{-1} \quad \text{and} \quad u_i^j = \sum_{i \in j} u_i = \sum_{i \in j} \frac{\partial \ln L_i}{\partial \beta}.$$

Here, u_i is the contribution of the ith observation to the scores of firm j and u_i^j is the contribution of firm j to the overall likelihood function.

Table 7. Alliance Governance and Performance by Governance Selected

	Pooling contract	Equity joint venture
Intercept	0.910	−9.163
	(2.419)	(8.854)
Pre patent	0.002***	0.002***
	(0.000)	(0.000)
Partner patent	0.000	0.000
	(0.000)	(0.000)
Tech diversity	11.887***	50.584**
	(3.902)	(21.374)
Tech diversity, squared	−9.499***	−33.943**
	(2.497)	(13.422)
Narrow scope	−0.229	−0.548
	(0.210)	(0.517)
Broad scope	−0.293	−1.134**
	(0.292)	(0.541)
Multilateral	0.264	−1.548***
	(0.252)	(0.598)
Prior experience	0.667	2.154*
	(0.534)	(1.176)
Other alliance	0.670	−0.745
	(0.530)	(0.972)
International	0.074	−0.919**
	(0.272)	(0.455)
Year (1992)	−0.326	−0.493
	(0.225)	(0.537)
Year (1993)	−1.170***	−1.241**
	(0.241)	(0.555)
Inverse mills ratio	0.026	−2.085***
	(0.448)	(0.723)
n	817	188
Wald χ^2	221.18	318.75
df	13	13

Nagative binomial estimation. Dependent variable is citation-weighted patents issued to each firm in a post alliance period. Positive coefficients indicate increased patent output.
*,**,*** indicate significance at 10%, 5%, and 1% levels, respectively, for two-tailed tests. Standard errors appear in parentheses.

positive and significant effect on firm patenting rates after alliance commencement. In contrast, preexisting partner patents do not affect firm innovative performance. The technological diversity between partners has a nonmonotonic effect of firm performance. Initially, diversity has a positive effect on firm patenting. However, at higher levels of diversity this relationship reverses. This effect also holds irrespective of governance mode chosen; however, the magnitude of the effect differs between the two governance modes. For the pooling contract, the effect of technological diversity on post alliance firm patenting is positive until diversity reaches 0.6256,[43] when this relationship becomes negative. This critical level for

43. $\frac{\partial Post\ patent}{\partial Tech\ diversity} = 0$ when Tech diversity = 0.6256.

the equity joint venture is 0.7451, substantially higher than that for the pooling contract. This result suggests that firms benefit more from higher levels of technological diversity between partners when the alliance is governed by equity joint venture rather than pooling contract.

Alliance scope has no significant effect on postalliance patenting, where alliances are governed by pooling contract—neither *narrow scope* nor *broad scope* is significant. However, under an equity joint venture, broad R&D activities reduce post alliance patenting. This finding is somewhat counterintuitive—we expect alliance outcomes to increase with the breadth of the project. However, this result suggests that broad R&D activities may indicate riskier projects with more uncertain or longer term payoffs. That this negative impact is only significant for the equity joint venture is curious. Perhaps alliances with broad scope governed as equity joint ventures are longer term in nature, leading to longer term payoffs.

Where governed by a pooling contract, an alliance with more than two partners has no effect on firm performance post-alliance. In contrast, a multilateral alliance reduces post alliance firm patenting, where this alliance is governed as an equity joint venture. This finding is somewhat counter to transaction cost predictions. We expect monitoring difficulties to rise with the number of partner firms, leading firms to select the equity joint venture for its enhanced monitoring and control abilities. This result, however, suggests that it may be easier to manage alliances with a greater number of partner firms under a pooling contract than an equity joint venture. With a greater number of partner firms, more autonomous decision making may be preferable.

Prior alliance experience has no significant effect on firm benefits from collaboration, where the alliance is governed by pooling contract. Under the equity joint venture, however, prior alliance experience significantly increases post alliance firm patenting. One possible interpretation of this result is that, given the pooled management of the equity joint venture, greater experience in managing collaborative activities directly affects results. The existence of another concurrent alliance has no effect on firm patenting, irrespective of governance mode. Similarly, the fact that an alliance is international (i.e., partners are headquartered in different nations) does not reduce patenting if governed by pooling contract. However, where governed by equity joint venture, patenting is reduced if the alliance is international. This suggests that the pooled management of the equity joint venture may be more difficult to carry out across borders. Finally, the later the alliance commencement, the lower the ex post patenting rates, as expected. The choice of alliance governance does not influence this result substantially, although the magnitude and significance of coefficients differ slightly between modes.[44]

44. Alternative specifications of this model were estimated as robustness checks. For example, firms may use alliances as market entry vehicles even if the stated purpose is

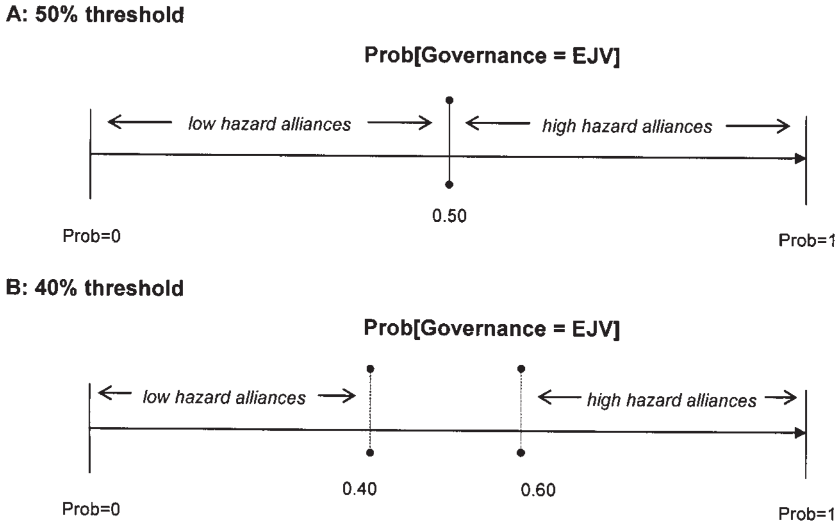

Figure 2. Categorizing Alliance Hazards.

These results, while informative, do not allow us to directly examine the effect of alliance governance, conditional on alliance hazards, on collaborative benefits. To highlight the impact of governance selection under various levels of alliance hazards, I split the sample according to alliance hazards—low hazards and high hazards. Using the probability estimates from the probit model, reported in Table 6, I classify alliances as high or low using two alternative thresholds: top and bottom 40% and top and bottom 50%. For example, if $\Pr[Governance = EJV] = 0.35$, this alliance is categorized as a low hazard alliance under either the 40% or 50% threshold. Analogously, if $\Pr[Governance = EJV] = 0.65$, the alliance is categorized as a high hazard alliance. The primary difference between the 40% and 50% thresholds is that, using the 40% cutoff, part of the sample is excluded (i.e., from $\Pr[Governance = EJV] > 0.40$ to $\Pr[Governance = EJV] < 0.60$ is excluded). This approach is displayed graphically in Figure 2. I use two different thresholds, since the true point at which an alliance shifts from the low to high hazard category is not definitively known. The 40% threshold rule helps to reduce the incidence of misclassification of alliances as low or high hazard, since most misclassifications are likely to occur around

collaborative R&D, particularly in a heavily politicized industry such as telecommunications equipment. If such alliances are formed for market entry rather than collaborative R&D, these alliances might have little effect on the benefits a firm reaps from collaboration. To control for such a possibility, I include a measure of non-tariff barriers in the performance analysis. Results from this analysis do not show a significant effect of non-tariff barriers on post alliance patenting and also do not substantially affect the parameter estimates on other independent variables. These results are available on request from the author.

Table 8. The Cost of Misaligned Governance

Governance selected	40% threshold	50% threshold
(1) Aligned governance	220	231
(2) Misaligned governance	135	143
(3) Difference (1)−(2)	85	88
Percent increase (decrease) of aligned over misaligned governance	62%	61%

Estimates from Table 7 used to compute the cost of misaligned governance on firm patent output. *E*[*Post patent*] calculated at median values of alliances with misaligned governance (i.e., where firms selected governance contrary to predictions from the probit model).

$\Pr[Governance = EJV] = 0.50$. In this sense, the 40% rule yields the most robust estimates.

I then take the median values of the independent variables for the low and high hazard alliances, where firms have selected governance opposite to that predicted by transaction cost arguments. I calculate expected patenting for firms choosing misaligned governance: that is, expected patenting for the median firm that chose a pooling contract in a high hazard alliance and the median firm that chose an equity joint venture in a low hazard alliance. I then calculate what patenting could be for those same firms with aligned governance. This approach allows us to examine how much a firm has to gain (or lose) by choosing aligned over misaligned governance.[45]

To construct these patent counts, I use estimates from Table 7 and evaluate these estimates at the median values described above. For the negative binomial model, $E[Postpatent]=\lambda=e^{\beta' X}$, where X is a vector of independent variables used in Table 7 (Cameron and Trivedi, 1986:33). These calculations are set out in Table 8. Two columns appear—one for each alternative threshold, h^* (i.e., 40% or 50%).

These results provide tangible evidence of the effects of aligned governance. For either threshold, aligned governance provides a substantial improvement in outcomes over misaligned governance. Using a 40% threshold, the median firm that selected misaligned governance (i.e., either a pooling contract in a high hazard alliance or an equity joint venture in a low hazard alliance) realizes a weighted patent count (WPC) of 135 in a four-year period after alliance commencement. If these same firms had selected aligned governance, the WPC would be 220, a 62% improvement. The results using a 50% threshold are almost identical—aligned governance improves outcomes on average 61% over misaligned governance.

45. An alternative to this approach is to vary individual proxies for contracting difficulties such as alliance scope and the number of partners. This approach, however, assumes that each source of contracting difficulties is equally important in determining appropriate alliance governance. Further, this approach makes it difficult to categorize an alliance as having low or high hazards, since there is no composite measure of contracting difficulties. Based on a combination of continuous and categorical variables, it is not clear how to quantify the exact level of alliance hazards.

Table 9. The Cost of Misaligned Governance According to Hazard Levels

	40%		50%	
Governance selected	Low hazard	High hazard	Low hazard	High hazard
(1) Pooling contract	107	109	107	111
(2) Equity joint venture	26	113	32	124
(3) ABS (difference)	81	4	75	13
Percent increase (decrease) of aligned over misaligned governance	307%	4%	231%	12%

Estimates from Table 7 used to compute the cost of misaligned governance on firm patent output. *E[Post patent]* calculated at median values of low and high hazard alliances, where firms have selected governance contrary to predictions from the probit model.

These results support the hypothesis that an alignment of transactions with governance, according to transaction cost logic, improves performance. Misaligned governance exacts a toll on collaborative benefits from R&D alliances.

To explore whether the effects of misalignment vary between low and high hazard alliances, I calculate the difference between aligned and misaligned governance in low and high hazard alliance groups. These calculations are set out in Table 9.

These results confirm those set out in Table 8, but provide additional insight into the costs of misaligned governance. In the low hazard case, the median firm that selected an equity joint venture (i.e., misaligned governance) realizes a (WPC) of 26, using a 40% threshold, in the four-year period after alliance commencement. If these same firms had aligned governance (i.e., pooling contract), the WPC would be 107. This results in a WPC difference of over 80—more than three times the WPC with misaligned governance. The results for firms involved in high hazard alliances are consistent; with misaligned governance (i.e., pooling contract) the WPC is 109, while with aligned governance (i.e., equity joint venture) the WPC is 113. Use of the 50% threshold yields similar results for both low and high hazard alliances. Thus firms can expect a minimum of 4% more with aligned governance.[46]

Thus Table 9 provides additional support for the hypothesis that aligned governance improves outcomes. However, several additional observations from Table 9 are worth noting. Misaligned governance exacts a far greater toll in the low hazard than in the high hazard alliance. This appears to arise

46. Note that the cost of misalignment (as shown in Tables 8 and 9) is measured as a weighted patent output for the allying firm. The cost of misalignment is therefore the reduction in innovative output for a firm rather than a composite measure of firm profitability or welfare. While citation-weighted patents have been strongly linked to firm value (e.g., Hall et al., 2003) and misalignment may lead to welfare losses, such an analysis is beyond the scope of this article.

from the fact that pooling contract estimates vary little between the low and high hazard case, while the equity joint venture estimates vary significantly between these two states. There are several possible interpretations for this asymmetry in the cost of misaligned governance. First, the costs of bureaucracy may well exceed the costs of uncontrolled opportunism, particularly in the context of R&D alliances. Benefits from improved coordination are likely outweighed by the negative effects of bureaucracy on innovative activities when contracting difficulties are not high.[47]

It is also possible that uncontrolled opportunism may not dampen performance as much as expected, given that there is little difference in pooling contracts across low and high hazard cases. Firms may have implicit mechanisms for protecting against these opportunism hazards. For example, firms may separate tasks in the R&D process, whereby each partner is responsible for distinct stages. In this sense, firms utilize implicit controls that may compensate for the inability to fully contract to reduce risks of leakage.[48] Alternatively, firms may be willing to take the risk of uncontrolled opportunism if they value the features of the pooling contract more than the enhanced coordination that the equity joint venture provides. For example, timely decision making may compensate for unmitigated opportunism hazards in some alliances. If partners in one alliance value timeliness more than partners in another (perhaps because the firms in the first alliance are losing market share and would like to introduce a new product quickly), then the costs of the pooling contract will be lower relative to the equity joint venture for the first alliance even if both alliances are equivalent in all other dimensions.[49] This may explain in part the

47. Alternatively, the costs of bureaucracy may be overstated; projects undertaken in equity joint ventures may be longer term in nature, with outcomes that are not captured in the time window used here. The fact that the variable capturing broad R&D activities is negative and significant for the equity joint venture, but not significant for the pooling contract lends some credence to this argument. It is possible for an alliance to be categorized as low hazard, even with broad R&D scope, if other alliance characteristics suggest a low hazard alliance; the marginal effect of broad R&D scope on the probability that allying firms select an equity joint venture is 0.1632, using parameter estimates from Table 6, column (4). While in the short to medium term, choice of the equity joint venture for low hazard alliances exacts a substantial toll, this may or may not be the case in the longer term.

48. Such controls are implicit, in the sense that they are not expressly included in the alliance agreement even though the existence and importance of these controls are likely well understood during the initial alliance negotiation process.

49. That is, the costs of bureaucracy are higher for firms in the first alliance. Lack of timeliness is one of the costs of bureaucracy; the attributes of the equity joint venture, such as decision making by consensus and other bureaucratic constraints on behavior, slow responsiveness to new information and unanticipated contingencies. In the analysis above, these bureaucratic costs are treated as an artifact of the equity joint venture and thus as fixed from alliance to alliance. In most cases, this assumption is likely valid, since firms within an industry are exposed to similar technology changes and competitive pressures. However, if these costs of bureaucracy vary based on partner characteristics as described here, then the costs of bureaucracy will differ between alliances even when those alliances are identical in all other dimensions. This means that a pooling contract is more attractive at higher hazard levels when timeliness is an issue (i.e., in Figure 1, h^* shifts to the right since the equity joint venture

dramatic difference in the implications of misalignment between low and high hazard alliances; that is, high hazard alliances organized under pooling contracts are penalized less for their misalignment than low hazard alliances organized as equity joint ventures. For some allying firms, the gains from being fast to market may be sufficient to outweigh the potential cost of coordination breakdowns.

Notwithstanding the different interpretations of Table 9 that are possible, the analysis provides support for the central hypothesis tested here: misalignment according to TCE criteria, namely opportunism hazards, imposes costs. Clearly these results—particularly those in Table 9—are provocative and warrant further investigation. With finer measures of the governance mechanisms used to minimize opportunism hazards, and better identification and measurement of the drivers of bureaucratic costs, we may be able to conclusively support or refute the above logic.

6. Conclusion

In this article, I examine the cost of misaligned governance in the context of R&D alliances. Empirical results on a sample of 464 R&D alliances in the telecommunications equipment industry provide strong support for the hypothesis implicit in the transaction cost literature: that governance selected ultimately affects transactional performance. Specifically, misaligned governance dampens innovative performance, measured by firm patenting. Results from the analysis above confirm that firms choosing misaligned governance suffer performance penalties of 61% on average. Further analysis reveals that the magnitude of this patent performance penalty depends on the type of misalignment.

Two types of misaligned choice are identified in the analysis: excessive opportunism hazards and excessive bureaucracy. Where allying firms choose a less hierarchical governance mode for an alliance with substantial threats of opportunism, partners may take other steps to protect against such threats by, for example, contributing fewer or less valuable inputs to the alliance. Excessive bureaucracy imposes different costs. Bureaucracy may dampen incentives to pursue more innovative ideas. Decision making may be slowed and politicized such that choices on which R&D project to pursue and which to abandon are influenced by self-interested parties. Where threats of opportunism are low, the added costs of more hierarchical governance are not offset by improvements in coordination and control. In either case of misaligned choice, innovative performance is

---

performance curve shifts downward). Ideally we would identify those alliances where timeliness is a pressing issue. Unfortunately, assessing the importance of timeliness has much to do with unobservable firm strategies, such as how to best respond to competitive pressures given a firm's industry position rather than observable alliance characteristics. Notwithstanding this, desire for timeliness does not appear to drive the results, but rather may explain the otherwise apparently anomalous difference between the two types of misalignment; there is still a cost of misaligned governance using hazards as the means to identify misalignment.

reduced. While the performance penalty is measured here in terms of patent output rather than firm profitability per se, the results here have strong implications for firm value, given recent results linking firm citations to value; an extra citation per patent boosts market value by 3% according to recent research (Hall et al., 2003).

Of interest is that the results also suggest that the costs of bureaucracy far exceed the costs of high opportunism hazards. This may be because partners have implicit means of protecting against free riding and leakage when contracting is difficult that substitute for the more formal mechanisms of the equity joint venture. At the same time, excessive bureaucracy may be more hostile to innovation than excessive hazards. Preservation of incentives to innovate and less bureaucratic decision making may be more important where innovation is the goal than where, for example, production or supply is.

Of course, care must be taken when generalizing these results. Firms may choose misaligned governance for a multitude of reasons. Miscalculations, hubris, and changing industry conditions may explain why we observe misalignment. However, unobserved firm and alliance heterogeneity may also lead to observed misalignment; partners may choose governance that optimizes along dimensions not considered here (i.e., according to criteria other than opportunism hazards). For example, firms may be willing to trade off the enhanced coordination of the equity joint venture for more timely decision making and responsiveness to changing conditions. This would perhaps be the case where allying firms are facing severe competitive pressures and, consequently, value speed to market highly enough to outweigh the potential costs of misalignment. Given that there is still a cost of misaligned governance using hazards as the means to identify misalignment, however, desire for timeliness does not appear to drive results, but may explain the difference between the costs of various types of misalignment. Further investigation of how firm characteristics alter the costs of bureaucracy and unmitigated opportunism would substantially refine this analysis.

Characteristics of the industry chosen may also affect whether we observe misaligned governance. Firms frequently collaborate in the telecommunications industry, yet no dominant standard for organizing such collaborations exists in this industry, in contrast to industries such as pharmaceuticals. As such, we see more variation and are perhaps witnessing an adaptation period, where firms are observing outcomes from past alliances and moving toward a more optimal form of organization. In other industries where technological development is slower and collaborations have been commonplace for a long time, we are less likely to observe firms choosing misaligned alliance governance. Similarly these results may not generalize to other types of transactions, such as alliances for manufacturing or supply. R&D alliances present unique challenges that arise from the idiosyncratic nature of R&D activities and the type of environment necessary to foster more creative and risky ideas. As such, bureaucracy likely has more impact on performance in R&D collaborations than in collaborations involving less creative activities.

Another limitation relates to my approach in capturing contracting difficulties and, consequently, opportunism hazards. While my approach represents one way of operationalizing this latent variable, its validity is tied heavily to the theoretical underpinnings of the governance selection model. Identifying misaligned governance is less accurate, to the extent that this model is incomplete. However, given the consistency of these results with prior empirical studies (e.g., Pisano 1989; Oxley 1997, 1999), we can have some confidence in identifying the level of opportunism hazards and, consequently, misaligned governance with this approach. Since the fundamental transaction cost hypothesis linking governance with performance is conditional on the threat of opportunism, this approach has real potential to improve the state of empirical transaction cost research.

These results may explain in part the failure of many alliances to live up to expectations. Casual empiricism suggests that many firms leave the details of a deal, such as organizational structure, unaddressed. Such omissions may precipitate the failure of the alliance to achieve its potential. Thus these results imply a true normative role for transaction cost economics—firms that choose an organizational form consistent with transaction cost logic improve performance from alliance participation substantially. This is not to imply that selection of aligned governance ensures alliance success, however. Alliances may fail even where firms choose aligned governance. For example, poor partner selection, mishandled management of a project, or selection of a low-potential R&D project can lead to failure, even with carefully selected governance. Rather, the results of this analysis suggest that firms selecting aligned governance are not burdened with the avoidable error of misalignment that could reduce the ability to fully realize collaborative benefits.

The above arguments are not limited to the present context, since the failure of a transaction to meet expectations is not unique to alliances. Prior literature documents failures in a multitude of investment types—perhaps the most common being the failure of mergers and acquisitions to add value (e.g., Wernerfelt and Montgomery, 1988). In this sense, the arguments here have broader applicability; choosing the right organizational form likely has important performance implications for all types of transactions. A useful avenue for further research would be to examine additional empirical settings to confirm (or refute) this generalization.

These results also have implications for the management of innovation and, more broadly, the costs of internal organization. Following Aghion and Tirole's (1994) findings,[50] bureaucracy (or integration) is particularly

50. Aghion and Tirole (1994:1206) state the following as one of the main insights of their analysis: "research will more likely be conducted in an integrated structure if (a) capital inputs are substantial relative to intellectual inputs—in contrast, when intellectual inputs dominate as for software and biotechnology, research will often be performed by independent units. . .."

harmful to innovation when intellectual inputs are relatively more important than capital inputs. It follows that where an equity joint venture is chosen for an alliance where the emphasis is on research rather than development, the incentive dampening effects of more hierarchical organization are more harmful to progress than the lack of control over potential opportunism. Thus a useful extension to this work would be to examine a set of R&D projects where more detailed (and verifiable) information is available on the R&D activities, so as to identify whether intellectual or capital inputs are relatively more important. Further work to better identify the sources of bureaucratic costs and which are most deleterious to innovation would be a useful extension to this analysis.

Notwithstanding these limitations, the results broadly demonstrate the implications of misaligned governance selection and contribute to a greater understanding of the performance benefits from careful governance selection. The challenge that lies ahead is to broaden our empirical evidence of the performance implications of alignment. Given the difficulty in obtaining transaction-level data and appropriate performance measures, this is not a trivial exercise. However, the potential for improving the state of the literature and deepening our understanding of the limits of organization suggests that such efforts are worthwhile.

References

Aghion, P., and J. Tirole. 1994. "The Management of Innovation," 109 *Quarterly Journal of Economics* 1185–209.

Anand, B. N., and T. Khanna. 2000. "The Structure of Licensing Contracts," XLVIII *Journal of Industrial Economics* 103–35.

Basberg, B. L. 1982. "Technological Change in the Norweigian Whaling Industry: A Case Study in the Use of Patent Statistics as a Technology Indicator," 11 *Research Policy* 163–71.

Bleeke, J., and D. Ernst. 1993. *Collaborating to Compete*. New York: Wiley.

Cameron, A. C., and P. K. Trivedi. 1986. "Econometric Models Based on Count Data: Comparisons and Applications of Some Estimators and Tests," 1 *Journal of Applied Econometrics* 29–53.

Cohen, W. M., and D. A. Levinthal. 1990. "Absorptive Capacity: A New Perspective on Learning and Innovation," 35 *Administrative Science Quarterly* 128–52.

Comanor, W. S., and F. M. Scherer. 1969. "Patent Statistics as a Measure of Technical Change," 77 *Journal of Political Economy* 329–98.

Contractor, F. J., and P. Lorange. 1988 "Why Should Firms Cooperate? The Strategy and Economics Basis for Cooperative Ventures," in F. J. Contractor and P. Lorange eds. *Cooperative Strategies in International Business*. Lexington, Mass.: Lexington Books.

Dehejia, R. H., and S. Wahba. 2002. "Propensity Score-Matching Methods for Non-Experimental Causal Studies," 84 *Review of Economics and Statistics* 151–61.

Economist. 1990. "The Latest Business Game," May 5; 16.

———. 1992. "The Marriage of True Minds," September 19: 79.

———. 1997. "A Survey of Telecommunications," September 13: 3–34.

———. 1999. "How to Make Mergers Work," January 9: 15–16.

Ginarte, J. C., and Walter G. Park. 1997. "Determinants of Patent Rights: A Cross National Study," 26 *Research Policy* 283–301.

Greene, W. H. 1990. *Econometric Analysis*. Englewood Cliffs, N.J.: Prentice-Hall.

———. 1997a. "FIML Estimation of Sample Selection Models for Count Data," unpublished manuscript.

———. 1997b. *Econometric Analysis*. Englewood Cliffs, N.J.: Prentice-Hall.

Griliches, Z. 1990. "Patent Statistics as Economic Indicators: A Survey," XXVII *Journal of Economic Literature* 1661–707.

Gulati, R. 1995. "Does Familiarity Breed Trust? The Implications of Repeated Ties for Contractual Choice in Alliances," 38 *Academy of Management Journal* 85–112.

Hall, B. H., A. B. Jaffe, and M. Tratjenberg. 2001. "The NBER Patent Citations Data File: Lessons, Insights and Methodological Tools," Working Paper 8498, NBER.

———. 2000. "Market Value and Patent Citations," Working Paper 7741, NBER.

Hausman, J., B. Hall, and Z. Griliches. 1984. "Econometric Models for Count Data with an Application to the Patents-R&D Relationship," 52 *Econometrica* 909–38.

Heckman, J. J. 1979. "Sample Selection Bias as a Specification Error," 47 *Econometrica* 153–61.

Hergert, M., and D. Morris. 1988. "Trends in International Collaborative Arrangements," in F. J. Contractor and P. Lorange, eds. *Cooperative Strategies in International Business*. Lexington, Mass.: Lexington Books.

Hofstede, G. 1991. *Cultures and Organizations*. London: McGraw-Hill.

Holmstrom, B. 1989. "Agency Costs and Innovation," 12 *Journal of Economic Behavior and Organization* 305–27.

Huber, P. J. 1967. "The Behavior of Maximum Likelihood Estimates Under Non-Standard Conditions," 1 *Proceedings of the Berkeley Symposium on Mathematical Statistics and Probability* 221–33.

Jaffe, A., and M. Tratjenberg. 1997. "Flows of Knowledge from Universities and Federal Labs: Modeling the Flow of Patent Citations Over Time and Across Institutional and Geographic Boundaries," Working Paper 5712, NBER.

Jaffe, A. B. 1986. "Technological Opportunity and Spillovers of R&D: Evidence from Firms' Patents, Profits and Market Value," 76 *American Economic Review* 984–1001.

Joskow, P. L. 1991. "The Role of Transaction Cost Economics in Antitrust and Public Utility Regulatory Policies," 7 *Journal of Law, Economics, & Organization* 53–83.

Kahneman, D., P. Slovic, and A. Tversky. 1982. *Judgment Under Uncertainty: Heuristics and Biases*. Cambridge: Cambridge University Press.

Kennedy, P. 1992. *A Guide to Econometrics*. Cambridge, Mass: MIT Press.

Klein, B. 1980. "Transaction Cost Determinants of 'Unfair' Contractual Relationships," 70 *American Economic Review* 356–62.

Kogut, B. 1989. "The Stability of Joint Ventures: Reciprocity and Competitive Rivalry," XXXVIII *Journal of Industrial Economics* 183–98.

Lang, L. H. P., and R. M. Stultz. 1994. "Tobin's q, Corporate Diversification and Firm Performance," 102 *Journal of Political Economy* 1248–80.

Lanjouw, J. O., and M. Schankerman. 1999. "The Quality of Ideas: Measuring Innovation with Multiple Indicators," Working Paper 7345, NBER.

Levine, J. B., and J. A. Byrne. 1986. Corporate Odd Couples. July 21 *Business Week* 100–105.

Liebeskind, J. P. 1996. "Knowledge, Strategy, and the Theory of the Firm," 17 *Strategic Management Journal* 93–107.

Masten, S. E. 1993. "Transaction Costs, Mistakes, and Performance: Assessing the Importance of Governance," 14 *Managerial and Decision Economics* 119–29.

Mowery, D. C., J. E. Oxley, and B. Silverman. 1996. "Strategic Alliances and Inter-Firm Knowledge Transfer," 17 *Strategic Management Journal* 77–91.

Murphy, K., and R. Topel. 1985. "Estimation and Inference in Two Step Econometric Models," 3 *Journal of Business and Economic Statistics* 370–79.

Oxley, J. E. 1997. "Appropriability Hazards and Governance in Strategic Alliances: A Transaction Cost Approach," 13 *Journal of Law, Economics, & Organization* 387–409.

———. 1999. "Institutional Environment and the Mechanisms of Governance: The Impact of Intellectual Property Protection on the Structure of Interfirm Alliances," 38 *Journal of Economic Behavior & Organization* 283–309.

Patel, P., and K. Pavitt. 1997. "The Technological Complexities of the World's Largest Firms: Complex and Path-Dependent, But Not Much Variety," 26 *Research Policy* 141–56.

Pisano, G. P. 1989. “Using Equity Participation to Support Exchange: Evidence from the Biotechnology Industry,” 1 *Journal of Law, Economics, & Organization* 109–26.

———. 1990. “The R&D Boundaries of the Firm and Empirical Analysis: Choices Between In-house and External Sources,” 35 *Administrative Science Quarterly* 153–76.

Pisano, G. P., M. V. Russo, and D. J. Teece. 1988. “Joint Ventures and Collaborative Arrangements in the Telecommunications Equipment Industry,” in D. C. Mowery, ed., *International Collaborative Ventures in U.S. Manufacturing*. Cambridge, Mass.: Ballinger.

Powell, W. W. 1990 “Neither Market nor Hierarchy: Network Forms of Organization,” in B. M. Staw and L. L. Cummings, eds. *Research in Organizational Behavior*, vol. 12. Greenwich, CT: JAI Press.

Rosenbaum, P. R., and D. B. Rubin. 1983. “The Central Role of the Propensity Score in Observational Studies for Causal Effects,” 70 *Biometrika* 41–55.

Shelanski, H. A., and P. G. Klein. 1995. “Empirical Research in Transaction Cost Economics: A Review and Assessment,” 11 *Journal of Law, Economics, & Organization* 335–61.

Shuen, A. 1994. “Technology Sourcing and Learning Strategies in the Semiconductor Industry,” Ph.D. dissertation, University of California–Berkeley.

Simon, H. A. 1982. *Models of Bounded Rationality*. Cambridge, Mass.: MIT Press.

Sparks, D. 1999. A Partnered World. Oct. 25 *Business Week* 106–12.

Tratjenberg, M. 1990. “A Penny for Your Quotes: Patent Citations and the Value of Innovations,” 21 *Rand Journal of Economics* 172–87.

Tripsas, M., S. Schrader, and M. Sobrero. 1995. “Discouraging Opportunistic Behavior in Collaborative R&D: A New Role for Government,” 24 *Research Policy* 367–89.

Tversky, A., and D. Kahneman. 1981. “The Framing of Decisions and the Psychology of Choice,” 221 *Science* 453–48.

Villalonga, B. 2002. “Does Diversification Cause the “Diversification Discount?” working paper, Harvard Business School.

Wernerfelt, B., and C. A. Montgomery. 1988. “Tobin’s q and the Importance of Focus in Firm Performance,” 78 *American Economic Review* 246–50.

Williamson, O. E. 1985. *The Economic Institutions of Capitalism*. New York: Free Press.

———. 1991. “Comparative Economic Organization: The Analysis of Discrete Structural Alternatives,” 36 *Administrative Science Quarterly* 269–96.