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THE SCOPE AND GOVERNANCE OF INTERNATIONAL R&D ALLIANCES

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Participants in research and development alliances face a difficult challenge: how to maintain sufficiently open knowledge exchange to achieve alliance objectives while controlling knowledge flows to avoid unintended leakage of valuable technology. Prior research suggests that choosing an appropriate organizational form or governance structure is an important mechanism in achieving a balance between these potentially competing concerns. This does not exhaust the set of possible mechanisms available to alliance partners, however. In this paper we explore an alternative response to hazards of R&D cooperation: reduction of the 'scope' of the alliance. We argue that when partner firms are direct competitors in end product or strategic resource markets even 'protective' governance structures such as equity joint ventures may provide insufficient protection to induce extensive knowledge sharing among alliance participants. Rather than abandoning potential gains from cooperation altogether in these circumstances, partners choose to limit the scope of alliance activities to those that can be successfully completed with limited (and carefully regulated) knowledge sharing. Our arguments are supported by empirical analysis of a sample of international R&D alliances involving electronics and telecommunications equipment companies.

INTRODUCTION

In today's fast-paced, knowledge-intensive environment, research and development (R&D) alliances have become a popular vehicle for acquiring and leveraging technological capabilities. However, such alliances also pose particularly thorny challenges related to the protection of technological knowledge, since successful completion of alliance objectives often requires a firm to put valuable knowledge at risk of appropriation by alliance partners. Firms must therefore find the right balance between maintaining open knowledge exchange to further the technological development goals of the alliance, and controlling knowledge flows to avoid unintended leakage of valuable technology. Prior research in transaction cost economics suggests that choosing an appropriate governance structure or organizational form is one mechanism that firms use to promote knowledge sharing *and* protection in an alliance (e.g., Pisano, 1989; Oxley, 1997; Kale, Singh, and Perlmutter, 2000; Sampson, 2004). However, there may be circumstances where even the most 'protective' alliance form (for example, the equity joint venture) does not reduce leakage concerns sufficiently to ensure the level of knowledge sharing required to achieve alliance objectives. Where this is the case, firms must either forego the benefits of collaborative R&D altogether or find alternative means to reduce the hazards of cooperation.

In this paper, we consider the choice of alliance 'scope' as an alternative way to control the threat

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of knowledge leakage and protect technological assets in an R&D alliance. Establishing the scope of activities for an R&D alliance involves decisions such as whether to restrict joint activity to pre-competitive R&D only or to extend it to include manufacturing and/or marketing. Related to this is the question of whether a development project can be effectively 'modularized' and conducted in relative isolation by the partner firms, only to be brought together at the final stages (as contrasted with an arrangement that involves extensive cooperation and knowledge sharing throughout the duration of the project). These scope decisions have important implications for the extent to which alliance partners expose valuable know-how to each other. In circumstances where the costs of knowledge leakage are deemed to be particularly high, one might expect that alliance scope will be narrowed in order to limit exposure.

We develop these ideas in more detail below, and identify circumstances where we expect partner firms to make adjustments to the scope of alliance activities, and in particular to the choice between 'pure' R&D alliances and alliances involving a broader range of activities. We argue that the hazards of knowledge sharing will be most salient when partner firms are direct competitors in end product or strategic factor markets, prompting them to narrow the scope of alliance activities in this case.

We test our ideas in an empirical study utilizing a sample of R&D alliances involving companies in the electronics and telecommunications equipment industries, where profitability depends critically on firms' abilities to create and commercialize new technologies quickly and efficiently. Our empirical results suggest that alliance partners are more likely to limit their joint activities to 'pure' R&D when they are direct competitors in final product and geographic markets. We find that competitors are especially averse to adding joint marketing activities to their R&D collaborations, suggesting that the competitive consequences of market-related knowledge leakage is a particularly salient concern. Alliance scope is also driven in part by the relative absorptive capacity of partner firms, however, which influences their ability to effectively cooperate broadly, particularly in joint manufacturing: the degree of overlap in partner firms' technological assets is a strong predictor of alliance scope along this dimension.

Finally, our empirical analysis explores to what extent alliance scope and governance choices act as substitute mechanisms for protecting technological assets and other firm-specific capabilities in R&D alliances. Consistent with prior research, we find that firms choose a more protective alliance structure (i.e., an equity joint venture) when alliance scope is broad. We also find the reverse effect, where the choice of an equity joint venture encourages alliance partners to engage in joint activities that go beyond 'pure' R&D. Overall, the empirical tests provide support for our arguments that allying firms narrow the scope of their alliance activities in response to competitive threats—perhaps in recognition of the fact that protective alliance governance may be inadequate to control the risk of leakage when partners are direct competitors.

The remainder of the paper is organized as follows: In the first section we discuss how alliance scope fits within a larger dynamic system of alliance formation decisions. We then discuss the scope decision itself and motivate the definition of scope used in our study of R&D alliances. This is followed by our hypotheses regarding the alliance scope decision, and how this relates to the choice of governance structure for the alliance. Our empirical analysis follows, and we conclude with a discussion of implications, limitations, and potential extensions of the research.

ALLIANCE FORMATION DECISIONS

When a firm wishes to undertake an R&D project for which it does not currently possess all of the relevant technical knowledge (or other critical resources), forming an alliance is potentially an attractive solution. Before an alliance is established, however, managers have many important decisions to make: Which firm(s) should we ally with? What range of activities should be performed within the alliance (i.e., what should be the scope of the alliance)? How should responsibilities and authority be allocated? What control mechanisms or governance structure should be adopted?[1] All

[1] There is also of course the question of whether and why firms should form inter-firm alliances in the first place. We abstract from this issue here by focusing on situations where the decision to collaborate in R&D has already been made. See Eisenhardt and Schoonhoven (1996) for a useful review of the strategic and social explanations for alliance formation and an empirical analysis of the industry, firm, and top management team factors explaining rates of alliance formation.

of these questions are interrelated, and each choice made is likely to ripple through the other key decisions, perhaps over varying time horizons. The set of decisions involved in the establishment of an alliance thus represents a complex, dynamic, endogenous system: a system that is analytically and empirically intractable without significant simplification.

In order to render the problem tractable, prior research on alliance formation has, broadly speaking, approached this complex system of alliance decisions by adopting one of two major simplifications. Each of these simplifications has yielded important insights. The first approach has been to look only at the question of which firms are chosen as alliance partners, ignoring the related issues of alliance scope and governance. So, for example, Gulati (1995a) shows that firms choose alliance partners based on 'social structural' considerations, such as prior interactions and other network ties, as well as on considerations of strategic interdependence related to interactions in resource or final product markets. Mowery, Oxley, and Silverman (1998), on the other hand, highlight the importance of knowledge complementarities and partner-specific absorptive capacity in the partner choice decision.

The second simplification, adopted in transaction cost economic treatments of alliance formation, has been to focus exclusively on the governance choice decision, effectively abstracting from decisions regarding partner choice and alliance scope. Key findings from this literature are that certain characteristics of alliance activities are associated with the adoption of more hierarchical or protective governance structures—most notably the equity joint venture (see, Pisano, Russo, and Teece, 1988; Pisano, 1989, for early examples). Joint ventures are particularly prevalent where alliance objectives require partners to share complex and/or tacit knowledge, especially in technologically innovative projects. Transaction cost analysis suggests that this is so because firms have incentives to misappropriate the knowledge assets of alliance partners and/or to free-ride on partners' innovative efforts. Contractual governance of exchanges involving complex, tacit knowledge is particularly problematic as contracts are very difficult to specify, monitor, and enforce in these circumstances. By adopting an equity joint venture structure, the hazards of opportunism can be mitigated, because incentives are more closely aligned when ownership of the venture is shared, and monitoring is enhanced due to the increased disclosure requirements among joint venture partners (Pisano, 1989).

Prior research on alliances by transaction cost economists also provides evidence of a connection between alliance governance and the scope of activities undertaken within an alliance. Empirical associations have been found between increased alliance scope and the adoption of hierarchical governance structures, where alliance scope is defined as the number of technologies or functional activities involved (Pisano, 1989; Oxley, 1997), or as the extent to which innovative projects involve the creation of new technology rather than application of existing technology (Sampson, 2004). However, the reduced-form analysis in this prior work treats the scope of alliance activities as exogenous. Little attention has been given to alliance scope as a decision variable, despite the fact that the *Alliance Analyst* (a newsletter for participants in inter-firm alliances) suggests that determining alliance scope is 'one of the most important tasks [alliance] partners will undertake ... The partners must establish boundaries of geography, product categories, customer segments, brands, technologies, and fixed assets between the new entity and the parents. They must identify the activities in which the alliance may engage and those reserved for the parents.'[2]

In the analysis presented below we remedy this oversight by exploring the determinants of alliance scope. In particular we examine the implications of partner characteristics for the scope of activities included in the alliance *and*, consequently, for the choice of governance structure.[3] We also explore the nature of the relationship between alliance scope and governance as alternative means for firms to protect knowledge resources in R&D alliances.

[2] *The Alliance Analyst*, 15 July 1997, quoted in Khanna (1998).

[3] In formulating our approach to the problem in this way, we take the choice of alliance partner as exogenous. Fully endogenizing the partner choice decision is a useful direction for future research but is beyond the scope of this paper. We nonetheless checked for potential selection bias in our empirical results by also estimating a model of partner choice using a randomized sample of 'non-alliance pairs' generated from our sample firms. This robustness check is discussed at the end of the Results section.

DEFINING ALLIANCE SCOPE

Choosing the scope of activities to include in an alliance linking a particular set of firms establishes both the probability and the cost of opportunistic behavior by alliance partners. The more extensive, interdependent, complex, and uncertain are the activities performed in the alliance, the greater is the potential risk of opportunism. This is because the extent of coordination and more intimate face-to-face contact necessary to achieve success increases along these dimensions (Kogut, 1988; Kogut and Zander, 1992; Gulati and Singh, 1998) and uncertainty raises the costs of monitoring and assessing partner behavior (Pisano, 1989). Attaching and enforcing claims on technological knowledge contributed to or generated by joint activities is also more difficult when activities are complex and interdependent.

Unfortunately, as the *Alliance Analyst* quote above suggests, alliance scope is a multidimensional construct, which poses significant challenges for theoretical and empirical analysis. Furthermore, many aspects of the scope of alliance activities, such as the number of product categories or customer segments involved, or the dollar value of a joint project, are not reported by alliance participants and so are unavailable through secondary data sources such as press announcements of new alliances. This may explain the dearth of prior research on alliance scope.[4]

The most accessible dimension of alliance scope in terms of conceptual clarity and data availability is the functional or 'vertical' scope of the alliance, i.e., to what extent the partners combine multiple and sequential functions or value chain activities within the alliance, such as R&D, manufacturing and/or marketing. An increase in the vertical scope of an alliance predictably exacerbates the complexity of the collaborative challenge, all else equal (Reuer, Zollo, and Singh, 2002). The 'horizontal' scope of activities, related to the size, complexity, and uncertainty of the particular project, also undoubtedly varies within functional areas and across alliances. However, evaluation of horizontal scope is a much more subjective and challenging exercise because, in contrast to vertical scope, these project-specific features cannot be ascertained from available secondary reports of alliance events. In the following we therefore focus attention on a simple measure of vertical scope that is particularly relevant to R&D-related alliances, i.e., comparing alliances that involve R&D activities alone against those that combine R&D with other activities, specifically manufacturing and/or marketing.

When firms consider establishing an R&D alliance they usually do so with the broad technological goal of the alliance already in mind (e.g., development of 'next-generation' integrated circuits, as in the case of a Fujitsu–Analog Devices alliance, or of components for high-speed fiber optical communications in a Hewlett-Packard–IBM alliance).[5] After establishing this overarching R&D goal, partner firms must still decide how to organize the activities needed to bring the planned technologies or products through to commercial-scale production. In particular they must decide whether manufacturing and marketing activities will be reserved for the partner firms in isolation, or whether they will be performed jointly under the umbrella of the alliance. Research in the field of technology and operations management suggests that the key to reducing time-to-market and improving quality of new product introductions is to employ 'activity overlapping, information transfer in small batches, and the use of cross-functional teams' (Loch and Terwiesch, 2000). Interest in this approach to innovation—the so-called 'concurrent engineering' or 'simultaneous engineering' approach—began with the popular work of Imai, Nonaka, and Takeuchi (1985) and Takeuchi and Nonaka (1986) and has since sparked a strong body of research that has demonstrated its benefits in a variety of industrial settings (e.g., Clark and Fujimoto, 1991; Cusumano and Selby, 1995; Sabbagh, 1996). Although the benefits of overlapping activities in some uncertain and 'high-velocity' environments have been questioned (e.g., Eisenhardt and Tabrizi, 1995; Krishnan, Eppinger, and Whitney, 1997), recent empirical work has again confirmed the benefits of an overlapping activities approach to development even in uncertain

[4] Important exceptions are Khanna (1998) and Khanna, Gulati, and Nohria (1998). These papers provide the only theoretical analysis to date of alliance scope and its potential impact on the dynamics of learning alliances. However, the conceptualization of alliance scope used in this prior work is itself multidimensional and abstract and has to date defied empirical operationalization.

[5] Both of these alliances were established in the early 1990s and are reported in the SDC database described in the Data section, below.

environments, this time in the electronics industry (Terwiesch and Loch, 1999). Given the importance of intense, frequent cross-functional communication in the simultaneous engineering approach, the implications for R&D alliances are clear: if the prime concern is to bring the best product to market in the timeliest fashion, then jointly performing R&D *and* manufacturing and marketing activities within the alliance is likely the superior arrangement.

Despite this received wisdom regarding the benefits of overlapping activities and the importance of cross-functional communication, 'pure' R&D alliances are still more common than 'mixed-activity' R&D alliances.[6] What explains this apparent divergence between theory and practice? Why do firms isolate R&D activities organizationally from other aspects of the commercialization process, if there are operational benefits from combining functions such as manufacturing with R&D? We assert, and argue more carefully below, that it is the potential for costly partner opportunism that prompts firms to limit knowledge-sharing requirements by reducing alliance scope in some contexts.

Keeping abreast of technological opportunities and threats and protecting existing technological capabilities are critical activities in formulating an effective technology strategy. Companies increasingly turn to competitive intelligence experts to provide them with the information on latent opportunities and threats that is necessary for proactive strategic response (Klavans, 1993). As a consequence, competitive intelligence activities have become embedded in the fiber of business throughout the world, particularly in technological arenas (Prescott, 2001). This rise in professional competitive intelligence activities poses particular opportunities and threats to companies collaborating in R&D activities. Collaboration in R&D may provide many opportunities for firms to glean competitive intelligence from alliance partners, including: (i) hints about partner strategies and directions of technological search, or the feasibility of particular ideas; (ii) competitive benchmarking data; (iii) identification of key personnel who may be hired away; (iv) codified knowledge (in formulas, designs, and procedures); (v) deep exposure to tacit knowledge in skills and routines.[7] Some of these types of information leakage, especially (i), (ii), and (iii), are arguably unavoidable in any R&D alliance, at least with respect to technologies and processes relevant to alliance activities. Despite this, if an alliance involves only '*pure*' R&D activities, prior evidence suggests that alliance partners are often able to partition the activities such that the exposure of a firm's tacit knowledge in skills and routines to its partners is relatively small, and necessary exposure of codified knowledge can be controlled through appropriate use of contractual safeguards (Pisano *et al*., 1988). This is particularly true for modular designs (Sanchez and Mahoney, 1996), but also appears to apply more generally. As a consequence, 'pure' R&D alliances are predominantly governed via contractual arrangements (Narula and Hagedoorn, 1999).

When the vertical scope of an R&D alliance is increased to encompass other activities (in particular, manufacturing and/or marketing) the extent of knowledge sharing and coordination inevitably rises (Reuer *et al*., 2002). Furthermore, protection of technological knowledge becomes more challenging with increases in alliance scope, as the tacit knowledge embedded in operating routines must be exposed to alliance partners if joint operations are to proceed efficiently. To jointly bring an R&D project through to commercialization requires many more points of contact between the partner firms, with a concomitant reduction in control over information flows across the relevant organizational boundaries (Teece, 1992).[8] Furthermore, operational routines exhibit substantial inseparability, and it is likely that knowledge gained in the course of manufacturing and marketing efforts within the alliance will have important effects on other areas of partner firms' operations. As a result, it is almost impossible to effectively manage mixed activity R&D alliances without extensive sharing of tacit knowledge embedded in

[6] For example, in our sample, described below, 63 percent of the alliances in our sample are 'pure' R&D alliances, while only 37 percent involve 'mixed' activities.

[7] We thank Sid Winter for this categorization of information exposure in R&D alliances.

[8] Of course, the extent of exposure of knowledge assets also depends on the horizontal scope of the alliance activities, as discussed earlier, but we abstract from this issue here. In our empirical analysis we control for one aspect of horizontal scope for which we were able to obtain data—i.e., the innovation type. We anticipate that 'radical' innovations, which require the development of entirely new technologies, pose greater knowledge sharing and control challenges than more incremental innovations (see discussion in section on Innovation type).

operational routines, which in turn may have significant effects on the relative competitive position of partner firms.

Taken together these arguments suggest that the distinction between pure R&D alliances and alliances involving R&D in combination with other operational functions represents a useful and relevant dichotomous measure of vertical alliance scope, with pure R&D alliances being of more narrow scope than mixed activity R&D alliances. We now turn to a discussion of the determinants of the choice of alliance scope in this context.

COMPETITION, CAPABILITIES AND ALLIANCE SCOPE

Although there is only limited systematic empirical evidence of the competitive effects of alliance activity,[9] the general idea that inter-firm cooperation may change the relative competitive position of partner firms is a common theme in commentaries on the rise of international alliances during the 1980s (e.g., Reich and Mankin, 1986; Hamel, Doz, and Prahalad, 1989; Doz and Hamel, 1998). For example, Hamel *et al.* (1989: 135) suggest that when seeking collaborators for technology-related projects firms should target partners whose 'strategic goals converge while their competitive goals diverge.' The rationale behind this prescription is that if alliance partners are competitors in end-product markets (i.e., if their competitive goals 'converge') then each may be so intent on internalizing the other's knowledge—and at the same time limiting access to their own proprietary skills—that the goal of the alliance will be thwarted.

Does this problem mean that competitors cannot effectively collaborate in R&D? Clearly not: One can find examples of R&D alliances linking firms that also compete intensively in almost any industry. In autos, for example, Ford, GM, and DaimlerChrysler collaborated extensively during the 1990s to develop the so-called 'Next-Generation Passenger Vehicle' or NGPV, despite the fact that they are direct competitors. Nonetheless, as highlighted by Khanna *et al.* (1998), if partner objectives include inter-firm learning (as is the case in R&D-related alliances), we will likely observe both competitive and cooperative behavior by participating firms. Furthermore, the balance between competitive and cooperative behavior is determined by relative payoffs; these in turn depend, among other things, on the final product market activities of the partners and in particular on the extent to which partner firms' primary product markets overlap. Where partners are direct competitors in final product markets, then the pay-off from competitive behavior (i.e., free-riding or misappropriation) within the alliance is particularly high. Furthermore, all else equal, the closer the partners' competitive domains come to complete overlap, the closer the knowledge-sharing process approximates a zero-sum game, since knowledge gained in the alliance will be applied by each partner firm in the same competitive arena (see, for example, Branstetter and Sakakibara, 2002).

Given this set of circumstances, even if the alliance activities are embedded in a 'protective' governance structure such as an equity joint venture, the residual hazards of opportunism may be high enough to deter extensive knowledge sharing among alliance participants (Inkpen, 2000). In anticipation of this problem, we hypothesize that alliance partners with substantial competitive overlap will limit the scope of alliance activities so as to allow the general alliance objectives to be achieved with more limited knowledge sharing:

> *Hypothesis 1: The greater the overlap among partner firms' end-product markets, the lower the probability of broad alliance scope.*

End-product markets are not the only source of competitive concerns that partner firms might consider when establishing the scope of alliance activities. Another important source of concern may be competition in strategic factor or resource markets. As emphasized by research on the resource-based view of the firm, sustainable competitive advantage rests on a firm's ability to assemble valuable, rare, and inimitable resources or capabilities (Barney, 1986; Dierickx and Cool, 1989). Specialized technological capabilities are quintessential exemplars of such firm-specific resources; the value and uniqueness of a firm's technological capabilities are protected through patents and other 'appropriability mechanisms' (Levin *et al.*, 1987) and are

[9] See Mitchell and Singh (1996) for a review of the relevant literature and some useful evidence on the effects of collaboration on firm survival. Stuart (2000) and Koka and Prescott (2002) explore and elaborate on the potential benefits generated by a firm's alliance portfolio.

often misunderstood by competitors (Henderson and Clark, 1990), further enhancing inimitability.

One predictable outcome of collaborative R&D is that inter-organizational learning increases the similarity of alliance partners' resources and capabilities after alliance formation (Nakamura, Shaver, and Yeung, 1996; Dussauge, Garrette, and Mitchell, 2000). Furthermore, the greater the extent of knowledge sharing in the alliance, the more that partner–firm capabilities will come to resemble one another over time (Mowery, Oxley, and Silverman, 1996). This implies that inter-firm cooperation predictably undermines the rarity and inimitability of a firm's resources, at least *vis-à-vis* those of alliance partners. As a result, the incentives to team up in technology development projects may be different for leading and lagging firms, in a similar way that the incentives to agglomerate differ (Shaver and Flyer, 2000): market leaders are more likely to want to 'go it alone' to protect firm-specific know-how, while laggards may be willing to team up to try to leapfrog industry leaders. Similar logic suggests that the alliance scope decisions of leaders and laggards may also differ systematically. In particular, firms far behind the industry frontier in terms of technology, human capital, training programs, suppliers, and distributors or other important resources (Shaver and Flyer, 2000: 1176) may be more willing to expose competitively significant know-how to alliance partners if in doing so they can together produce a new product that will improve their competitive position *vis-à-vis* other 'coalitions' in the industry (Gomes-Casseres, 1996). This suggests the following hypothesis:

Hypothesis 2: The probability of broad alliance scope is higher when all partner firms are industry laggards.

In addition to the extent or quality of alliance partners' technological and other capabilities, the positioning of partners' respective technological portfolios in 'technology space' also may have an impact on the scope of activities undertaken within an R&D alliance. We can think of overlap in partner capabilities as lying along a continuum: at one extreme, partners have no areas of technological expertise in common; at the other extreme, partners have completely overlapping areas of technological expertise. In most cases, allying firms will fall at various points along the continuum between these two extremes. As we argue below, placement along the continuum affects both the *willingness* and the *ability* of partners to engage in alliance activities of broad scope.

When there is extensive overlap in alliance partners' areas of technological expertise, partner firms are likely to draw on the same external pools of technological knowledge and thus may perceive of each other as direct competitors in relevant resource markets (including, for example, specialized labor markets). If this is the case then the scope of alliance activities may be restricted to limit exposure of knowledge relevant to competition in strategic factor markets. As the areas of common interest diminish (i.e., as technological overlap decreases), these competitive effects are likely to be less pronounced. This argument implies a negative relationship between technology overlap and alliance scope.

There is, however, a potentially competing effect of low technology overlap on alliance scope, unrelated to leakage hazards. In order to effectively share knowledge, partner firms must possess adequate absorptive capacity, i.e., the 'ability to recognize the value of new external knowledge, assimilate it, and apply it to commercial ends' (Cohen and Levinthal, 1990: 128). When alliance partners are very 'far apart' in terms of their areas of technological expertise, deficiencies in absorptive capacity are likely to limit the objectives achievable within an alliance, so that only those requiring relatively restricted knowledge sharing are feasible (Mowery *et al*., 1996; Park and Ungson, 1997; Lane and Lubatkin, 1998). In the context of the R&D alliances in our study this suggests that, while pure R&D projects may be achievable through modularization of the R&D tasks, the extensive knowledge sharing required to jointly take the project through R&D to commercialization will be more problematic at low levels of technology overlap.

From the arguments above, we might expect the competitive aspects of the impact of technology overlap on alliance scope to dominate when firms are very close in technological space, while the absorptive capacity effect would be more salient when partner firms are technologically distant. This implies an inverted-u shaped relationship between technology overlap and alliance scope. However, whether the net effect of technology overlap is positive or negative in the relevant operational range of actual alliances is an empirical question. We therefore simply note two distinct hypotheses, and test for nonlinearity in the empirical analysis:

Hypothesis 3a: The higher the technology overlap between partners the lower the probability of broad alliance scope (due to factor market competition).

Hypothesis 3b: The lower the technology overlap between partners the lower the probability of broad alliance scope (due to inadequate absorptive capacity).

Although our primary interest in this study is the determination of alliance scope, we are also interested in the relationship between the scope and governance decisions of alliance partners. Prior research, which treats alliance scope as exogenous, suggests that broader alliance scope increases the hazards of contractual alliances and therefore increases the need for more protective alliance governance, such as that afforded by an equity joint venture (Pisano, 1989; Oxley, 1997). Our arguments about the determination of alliance scope are also based on the premise that broad scope increases the hazards of cooperation; following previous research, we would thus also expect firms to be more likely to choose an equity joint venture rather than a contractual alliance in this case. However, in contrast to prior work, we view alliance scope as an alternative means of controlling partner opportunism. Furthermore, we argue that narrowing scope may actually be the preferred alternative when competitive overlap is particularly extensive, since the residual hazards of broad-scope alliances may be too high even when embedded in a protective governance structure. Nonetheless, we expect that more protective governance structures will make firms more confident in broadening alliance scope, all else equal. In this sense, adoption of a protective governance structure and narrowing of alliance scope are substitutes; either may be used to control partner opportunism.[10] This intuition leads to our final hypotheses:

Hypothesis 4a: The probability that partner firms select an equity joint venture is higher when alliance scope is broad.

Hypothesis 4b: The probability of broad alliance scope is higher when partner firms select an equity joint venture.

In the empirical analysis that follows, we test these hypotheses by estimating the relationship between two dichotomous outcome variables—alliance scope and governance—and a series of variables that characterize the competitive and technological positions of the alliance partner firms, as well as other relevant characteristics. By estimating these relationships first in isolation and then jointly (both as a system of seemingly unrelated regressions and in a simultaneous equations model) we are able to shed additional light on the results derived from reduced form governance equations in prior research. Further, we can identify the extent to which the two decisions are truly linked, and to what extent reductions in scope may substitute for adjustments to formal governance mechanisms (i.e., adoption of an equity joint venture structure) in response to competitive concerns.

DATA

For these tests, we use a sample of R&D alliances involving firms in the electronic and telecommunications equipment industries. Recent technological changes in these industries make them ideal for a study of R&D collaboration. In the late 1980s, the electronic and telecommunications equipment industries converged and a period of rapid growth and technological development ensued. To illustrate, a 2000 OECD report noted that 'ICT intensity' (i.e., expenditures on information and communication technology as a percentage of GDP) had reached almost 7 percent on average by 1997 and that the 'rapid consolidation in the ICT industry is having an impact on the competitive structure of this sector' (OECD, 2000: 11). Profitability and survival in this environment became critically dependent on a firm's ability to create and commercialize new technologies quickly and efficiently. As a result, firms began establishing R&D alliances at an unprecedented rate as a way to spread the risk and cost of technological development (Duysters and Hagedoorn, 1996).

[10] Of course, this does not mean that both protective governance and narrow alliance scope cannot be used simultaneously to control alliance hazards, but rather that both mechanisms perform similar functions.

Our primary source of data is the Securities Data Company (SDC) Database on Alliances and Joint Ventures. The SDC database contains information on alliances of all types, compiled from publicly available sources such as SEC filings and news reports, as well as industry and trade journals. While SDC has some information on alliances back to 1970, consistent data collection extends from 1988 onwards, and coverage of alliances after this date is more comprehensive. Coverage is still far from complete, as firms are not required to report their alliance activities. Nevertheless, this database currently represents one of the most comprehensive sources of information on alliances.

Our sample consists of all R&D alliances involving one or more firms in the telecommunications equipment and/or electronics industry commencing in 1996, as reported in the SDC database. Compilation of the sample involved assembling the names of all firms in Compustat listing either SIC 366 (telecommunications equipment) or SIC 367 (electronics) as their primary area of activity in 1996, and searching the SDC database for all R&D alliances involving one or more of these firms. As such, our sample is limited to those involving at least one public company. These criteria led to a sample of 208 R&D alliances (i.e., alliances involving collaborative R&D activities exclusively or in combination with manufacturing and/or marketing activities) representing firms headquartered in over 20 countries. Approximately 85 percent of the sample alliances include at least one U.S. firm; the next most represented nation is Japan, with almost 20 percent of the sample alliances involving one or more Japanese firms. The sample includes both 'domestic' alliances (58%), where all partner firms are headquartered in the same country, and international alliances (42%), involving partners from different nations. The high incidence of international alliances and the concentration of allying firms in the United States and Japan is consistent both with prior observations of alliance activity (e.g., Hagedoorn, 1993; Hergert and Morris, 1988) and with the distribution of firms in the information and communications technology sector.

Information on firms' technological portfolios is taken from the Micropatent database, which contains information recorded on the front page of every U.S. patent granted since 1975, including inventor and assignee names as well as technological classifications. Since firms do not always assign patents to the subsidiary where the technological expertise was created, a corporate-level patent portfolio must be created. To achieve this, we first identified all of the subsidiaries of each firm in the sample via the *Directory of Corporate Affiliations*. Patents assigned to the firm and any of its subsidiaries were then identified for the purposes of constructing our measure of technology overlap, described in detail in the following section.

MEASURES

Dependent variables

Alliance scope

Using information from the SDC database, we create a dummy variable to capture the vertical scope of alliance activities. SCOPE is set to one when alliance activities include manufacturing, and/or marketing *in addition to* collaborative R&D. As argued above, such alliances are broader in scope than alliances involving R&D activities exclusively.

To explore the multidimensionality of alliance scope in supplementary analyses we further categorized the alliances into R&D only, R&D plus manufacturing, R&D plus marketing, and R&D plus both (i.e., R&D plus manufacturing *and* marketing).

Alliance governance

Also using information from the SDC database, we create a dummy variable to capture alliance governance mode. GOVERNANCE equals 0 when the alliance is organized by contract, 1 when organized by equity joint venture.

Independent variables

To capture the extent to which partners may be direct competitors, we use two complementary measures of competitive overlap: product market and geographic market competition.

Product market competition

Measuring the intensity of competition among diversified firms operating in multiple business segments is highly problematic, and no well-accepted method exists. We therefore adopt the most straightforward approach and construct a simple measure capturing whether allying firms have their primary operations in the same industry; while our sample focuses on firms with primary operations in SIC 366 or 367, these firms are allied with partners in a diverse set of industries. MARKET OVERLAP is set to 1 if both partner firms have their primary operations in the same 4-digit SIC code, 0 otherwise. For multilateral alliances (i.e., alliances with more than two partner firms), MARKET OVERLAP is set to 1 if at least two of the partner firms have the same primary 4-digit SIC.

Geographic market competition

We create a dummy variable, GEOGRAPHIC OVERLAP, which is coded 1 for alliances involving firms headquartered in the same country, 0 if allying firms are headquartered in different nations. This measure is used to proxy for geographic market competition based on the assumption that firms headquartered in the same country perceive each other to be more direct competitors when compared with firms originating in different countries. We recognize that this assumption may be less valid in electronics than it is in the telecommunications equipment industry where national firms tend to be favored suppliers to telecommunications providers in that country, many of whom are public organizations. However, in the absence of adequate country-level data on total market presence we must rely on this imperfect proxy. To partially control for alternative interpretations and confounding effects we also include control variables related to the focal industry and the institutional environment of the home countries (see below).

Market leaders and laggards

Market leadership is a highly subjective and multifaceted issue. One approach is to focus on *technological* leadership using a patent-based measure, such as citation-weighted patent counts (e.g., Stuart, 2000). However, given the diversity of the firms involved in our sample alliances, and wide variance in the importance of patenting activity across industries (Levin *et al*., 1987) interpretation of patent counts is problematic. Furthermore, even for R&D alliances, the relevant resources that a firm wishes to protect may go far beyond technological resources to include, for example, human capital, training programs, suppliers, and distributors (Shaver and Flyer, 2000). We therefore use a more qualitative, composite measure of market leadership, based on a 1997 listing of the Top 100 Technology Companies compiled by *Red Herring* magazine. Based on the magazine editors' opinion, this list represents the leading public and private technology firms, in terms of 'revenue, market share, funding, innovativeness of each company's technology and business model, the track record of its venture capitalists, the strength of its partnerships, and the significance of its market' (*Red Herring*, 1997). This description corresponds well to the association suggested in our earlier discussion, i.e., that market leadership in an industry is fundamentally linked to the possession of firm-specific resources. We create a dummy variable LAGGARDS that is equal to one if *none* of the alliance partners appear in the *Red Herring* list of top technology companies, zero otherwise.

Technology overlap

While a patent count is not a particularly useful measure of market leadership, a patent portfolio is nonetheless a useful indicator of a firm's areas of technological expertise. In order for a new technology to be patented (so allowing the inventor to claim exclusive rights over the product or process described therein) the invention must first pass the scrutiny of the patent office as to its novelty and improvement over existing technology. Extensive research has demonstrated the relationship between patents and other indicators of technological capabilities: Strong, positive relationships exist between patents and new products (Comanor and Scherer, 1969), patents and literature-based invention counts (Basberg, 1982), and non-patentable inventions (Patel and Pavitt, 1997). In addition, when a patent is granted, the underlying technology is classified according to the U.S. patent classification system. This classification system provides a means to identify each firm's area of technological expertise. From this, we can examine the extent of overlap among partner firms' technological portfolios (Jaffe, 1986).

To construct our measure of technological overlap, we first generate each partner firm's technological portfolio by measuring the distribution across patent classifications of the patents applied for in the 4 years prior to alliance formation. This distribution is captured by a multidimensional vector, $F_i = (F_i^1 \dots F_i^s)$, where F_i^s represents the number of patents assigned to partner firm i in patent class s. The extent of the overlap among partner firms' areas of technological expertise is then:

$$\text{TECHNOLOGY OVERLAP} = \frac{F_i F_j'}{\sqrt{(F_i F_i')(F_j F_j')}}$$

for all $i \neq j$.[11] TECHNOLOGY OVERLAP varies from zero to one: a value of zero indicates no overlap in partner firms' areas of technological expertise, while a value of one indicates complete overlap. This measure normalizes the length of the within-class vectors to one and essentially captures the angle between the firm vectors. This means that the measure is not sensitive to the total number of a firm's patents within a class.

Control variables

To capture other factors that are predictably associated with risks of knowledge leakage (and hence with either reductions in alliance scope or adoption of an equity joint venture structure) we include several control variables. These are as follows.

Innovation type

R&D projects can run the gamut from those involving development of new products or processes based on incremental modifications of existing technology, to radical, ambitious projects where firms seek to develop the 'next generation' of a particular product. Since the nature of the obstacles to cooperation may differ markedly among projects at different positions along this continuum (Sampson, 2004), we developed a measure of innovation type, based on the synopses of alliance activities provided by the SDC database.[12]

We create a dummy variable, INCREMENTAL, which takes on a value of one if the innovative goal of the alliance represents an incremental modification of existing technology. An innovation is categorized as incremental when the synopsis suggests that alliance activities are focused on development of new products or processes based on existing technologies. This would include, for example, the alliance between 3M and IBM to jointly develop 3M's 'Ecart' 2.4 GB tape cartridges for IBM tape products. The base technology exists (3M's Ecart tape cartridges) and needs only to be customized to a new user (IBM). The omitted category of alliances involves more radical innovations, primarily alliances pursuing 'next-generation' technologies. Examples here include the alliance between Hewlett-Packard and IBM to jointly develop and manufacture advanced fiber optic components designed to provide high-speed fiber optical communications between computers, or the alliance between Fujitsu and Analog Devices for the development of 'next-generation' integrated circuits.

Pisano (1989: 166) argues that projects involving existing technology raise fewer hazards for alliance partners because, 'the preexistence of a product or process technology ... enables parties to delineate property rights at the outset with far less ambiguity than when the relevant technology does not exist.' This argument suggests that incremental innovations raise fewer risks of technology leakage. As such, steps to control partner access to knowledge-based resources by either reducing the scope of the alliance or instituting stronger governance through the equity joint venture are less necessary for incremental innovations.

Multilateral alliance

Prior research suggests that having more than two partner firms in a particular alliance makes monitoring more difficult and so increases the risk of unintended knowledge leakage. Empirical evidence has consistently shown that equity joint ventures are more frequently used to organize such multilateral alliances, all else equal (Oxley, 1997; Sampson, 2004). Increased coordination problems

[11] This measure (adopted from Jaffe, 1986) calculates technology overlap between pairs of firms. For alliances involving more than two firms, we calculate the measure for every combinatorial pair of firms in the alliance and take the average of these values. Use of minimum or maximum values of technological overlap produced qualitatively identical results in the empirical analysis.

[12] This coding scheme was a simplified version of the one used in Sampson (2004), developed in concert with an R&D professional. Coding was executed independently by two coders searching the SDC alliance synopses for references to extension/modification of existing technology vs. those pursuing radical change. Concordance between the two coders exceeded 90 percent; a third coder acted as a tiebreaker in the few cases of disagreement.

associated with multilateral alliances may also prompt a reduction in the scope of activities undertaken. Firms may be less willing to undertake broad alliance activities, given the added complexity of coordinating with multiple partners. To capture these potential effects, we include a dummy variable, MULTILATERAL, which equals one if the number of partner firms in an alliance exceeds two, zero otherwise.

Previous relationship

There is some evidence (albeit mixed) that in repeat alliances between particular partner firms trust develops such that the hazards of opportunism are reduced and contractual governance is preferred over a wider range of alliance activities (Gulati, 1995b). If trust does indeed develop over repeated interactions then one might expect that firms with prior alliance ties will be more willing to engage in alliances of broad scope with extensive knowledge sharing, even if they compete to a significant degree in product or resource markets. We therefore include a dummy variable, REPEAT ALLIANCE, equal to one if there are earlier alliances (of any type) recorded in the SDC database that bring together the same set of partner firms in the 6 years prior to the current alliance, zero otherwise.

Industry controls

We add dummy variables for each of the two focal 3-digit SIC industry codes used as a starting point for the development of our sample of alliances. SIC 366 equals one if at least one partner in the alliance has its primary activities in electronics; SIC 367 equals one if at least one partner has its primary activities in telecommunications equipment. Both dummy variables may equal one if an alliance brings together a partner primarily operating in electronics with one in telecommunications equipment.[13]

[13] Note that these dummy variables are constructed from the SICs of the actual participants in the alliance, as opposed to the SICs of the parent firms. While in all of our alliances at least one partner *or its parent* must have primary operations in SIC 366 or 367, there are cases where neither *partner* in the alliance is directly involved in 366 or 367.

Institutional environment

Following prior research (e.g., Sampson, 2004) we include a control variable designed to capture the integrity of the contracting environment in the allying firms' home countries. This measure, JUDICIAL SYSTEM, developed by *Business International Corporation*, provides an assessment of the 'efficiency and integrity of the legal environment as it affects business, particularly foreign firms' (Business International Corporation). We use the minimum value of this variable (which is scaled from one to ten, with higher scores indicating higher judicial efficiency) among the countries represented in the alliance. This variable controls for the fact that firms may rely more on stronger private governance (such as the equity joint venture) or reduce alliance scope when contract law development and enforcement are inadequate.

We also include a measure of NON-TARIFF BARRIERS in the home countries of the allying firms, to control for increases in alliance scope or local equity participation that may be driven by local content requirements or other investment regulations. In constructing the measure we use UNCTAD data, adapted by the World Bank (Wacziarg, 2001), which captures the non-tariff barrier coverage ratio for the early 1990s. We use the highest value on this measure among the home countries represented in an alliance.

METHODS

In the empirical analysis reported below, we begin by estimating alliance scope as a function of the variables featured in our hypotheses, along with the relevant controls described above. Since alliance scope is a dichotomous variable we use probit analysis for this estimation. We also conduct additional analyses using the multiple alliance scope configurations (R&D, R&D plus manufacturing, R&D plus marketing, R&D plus both manufacturing and marketing) to explore for possible differential effects across categories. We use simple cross-tabulations and multinomial logit for this analysis. Next, we estimate a model of alliance governance selection similar to the dichotomous probit model of scope. Here, we also include alliance scope in the governance equation because, as discussed above, previous studies have found alliance scope to be a relevant determinant of governance choice.

Estimating the scope and governance equations separately in this way allows us to test our primary hypotheses and also to compare our results with those of prior research on alliance governance. However, in order to test our hypothesis that alliance scope and governance are alternative mechanisms to address threats of knowledge leakage, we must allow for potential interdependencies in the relationship. We do so by employing two alternative joint estimation methods. First, we estimate the scope and governance equations as a pair of seemingly unrelated regressions, using a bivariate probit model. The bivariate probit jointly determines parameter estimates for the alliance scope and governance equations based on a partially overlapping set of decision criteria. This joint estimation allows for contemporaneous correlation between the error terms of the scope and governance equations, reflecting our arguments that the two decisions are related. In this way, the bivariate probit model controls for unobservable factors that affect the choice of both alliance scope and governance. The resulting parameter estimates are more efficient, largely because of the increased information available for the estimation (i.e., via the correlation between the errors of the two equations) (Greene, 1997).

Second, we estimate the scope and governance choices via a simultaneous probit specification. This specification allows for endogeneity of one or both of the dependent variables using full information maximum likelihood (FIML) estimation. While the bivariate probit allows for unobservable factors that may affect both scope and governance, the simultaneous system approach is more appropriate if we expect the choice of scope to directly affect the choice of alliance governance, and vice versa. Thus, the key advantage of the simultaneous approach in this case is that we can estimate a non-recursive model, where scope influences governance and governance influences scope. Of course, the drawback of using such an approach is that simultaneous system estimates are very sensitive to specification errors—much more so than bivariate probit estimates (Greene, 1997). For this reason, we estimate both the non-recursive model (as a simultaneous probit) and the recursive (as a bivariate probit) to ensure the robustness of our results.

RESULTS

Table 1 presents descriptive statistics for the sample of 208 alliances included in the empirical analysis. Several interesting features of our alliance sample emerge from a reading of this table: First, with respect to our focal dependent variables, the majority (63%) of the sample alliances have narrow scope, i.e., are R&D-only alliances, while 37 percent involve manufacturing and/or marketing in combination with R&D and are therefore designated as broad scope. Also, 20 percent of the alliances are equity joint ventures, the remainder being contractual alliances. Consistent with prior research, the correlation between scope and governance is positive and significant, at 0.209. Several of the explanatory variables are also correlated but none at levels that prompt concerns about multicollinearity.

Few alliances in our sample (13%) bring together firms that have their primary activities in the same 4-digit SIC code, while the majority (58%) of alliance partners are headquartered in the same country and are industry laggards (60% of the alliances do not include any leading firms). The low mean value for technological overlap (0.079 on a 0–1 scale) suggests that on average alliance partners have quite low levels of overlap in their technological resources (as proxied by patenting activity). Most alliances are not aimed at radical or 'next-generation' innovation: the technological goals of 90 percent of alliances are classified as incremental innovation. These sample characteristics are interesting in themselves; they may also speak to some of the factors considered in the earliest stages of alliance formation, i.e., during partner selection and definition of broad alliance goals. Although consideration of these other alliance decisions goes beyond the scope of the paper, we discuss selection issues related to the robustness of our empirical results at the end of this section.

Our first estimation results are shown in Table 2a, which presents several alternative specifications of a simple probit model of alliance scope. Column 1 includes all of the variables related to Hypotheses 1–3 (i.e., hypotheses on the determination of alliance scope), as well as alliance-level control variables; column 2 adds a square term to test for nonlinearities in the effect of technology overlap on alliance scope. Columns 3 and 4 add industry and institutional environment

Table 1. Descriptive statistics

Correlations (correlation, significance)	1	2	3	4	5	6	7	8	9	10	11	12	13
1 SCOPE	1.000												
2 GOVERNANCE	0.210	1.000											
	0.002												
3 MARKET OVERLAP	−0.069	−0.058	1.000										
	0.322	0.405											
4 GEOGRAPHIC OVERLAP	−0.198	−0.181	−0.123	1.000									
	0.004	0.009	0.078										
5 LAGGARD	0.164	0.170	0.038	−0.142	1.000								
	0.018	0.014	0.590	0.041									
6 TECHNOLOGY OVERLAP	0.104	0.046	0.239	0.064	−0.118	1.000							
	0.137	0.510	0.001	0.360	0.091								
7 INCREMENTAL	0.094	−0.016	−0.229	0.016	0.095	−0.239	1.000						
	0.175	0.823	0.001	0.815	0.172	0.001							
8 MULTILATERAL	0.019	0.153	0.298	−0.123	−0.106	0.285	−0.179	1.000					
	0.791	0.028	0.000	0.078	0.128	0.000	0.010						
9 REPEAT ALLIANCE	−0.011	−0.019	−0.066	0.040	−0.041	0.092	−0.158	−0.118	1.000				
	0.879	0.786	0.342	0.571	0.561	0.187	0.023	0.091					
10 TELECOMMUNICATIONS	−0.113	0.027	−0.002	0.043	0.123	−0.062	0.037	0.032	−0.157	1.000			
	0.105	0.703	0.977	0.536	0.077	0.371	0.594	0.644	0.024				
11 MICROELECTRONICS	−0.017	0.063	0.030	−0.125	0.022	0.067	−0.081	0.030	0.057	−0.237	1.000		
	0.806	0.363	0.672	0.073	0.751	0.339	0.247	0.672	0.412	0.001			
12 JUDICIAL SYSTEM	−0.141	−0.101	−0.089	0.406	−0.057	0.074	−0.029	−0.035	−0.087	0.140	−0.119	1.000	
	0.064	0.183	0.244	0.000	0.456	0.332	0.708	0.645	0.254	0.065	0.117		
13 NON-TARIFF BARRIERS	0.086	−0.125	0.105	−0.226	0.026	−0.067	0.051	−0.118	0.068	−0.045	−0.015	−0.397	1.000
	0.260	0.099	0.165	0.003	0.729	0.376	0.499	0.120	0.372	0.555	0.848	0.000	
Mean	0.370	0.202	0.135	0.582	0.596	0.079	0.913	0.135	0.082	0.216	0.322	9.592	3.891
Median	0.00	0.00	0.00	1.00	1.00	0.00	1.00	0.00	0.00	0.00	0.00	10.00	3.60
Minimum	0.00	0.00	0.00	0.00	0.00	0.71	0.00	0.00	0.00	0.00	0.00	2.50	0.70
Maximum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	10.00	10.90
S.D.	0.484	0.402	0.342	0.494	0.492	0.145	0.282	0.342	0.275	0.413	0.468	0.983	0.378
n	208	208	208	208	208	208	208	208	208	208	208	174	175

Table 2a. Alliance scope

Probit regression model.
Dependent variable is alliance scope
Positive coefficients indicate increased probability that firms select broad alliance scope.

	(1)	(2)	(3)	(4)	(5)
MARKET OVERLAP	−0.513*	−0.476	−0.527*	−0.479	−0.459
	(0.307)	(0.311)	(0.309)	(0.367)	(0.369)
GEOGRAPHIC OVERLAP	−0.553***	−0.556***	−0.547***	−0.560**	−0.546**
	(0.191)	(0.192)	(0.195)	(0.233)	(0.235)
LAGGARDS	0.439**	0.458**	0.498**	0.307	0.364*
	(0.195)	(0.196)	(0.199)	(0.214)	(0.219)
TECHNOLOGY OVERLAP	1.767***	4.573**	1.750**	1.583**	1.579**
	(0.684)	(1.951)	(0.692)	(0.760)	(0.766)
(TECHNOLOGY OVERLAP)^2		−6.290			
		(4.137)			
INCREMENTAL	0.539	0.634	0.506	0.596	0.537
	(0.383)	(0.395)	(0.385)	(0.439)	(0.437)
MULTILATERAL	0.035	−0.053	0.076	0.020	0.001
	(0.300)	(0.307)	(0.299)	(0.328)	(0.326)
REPEAT ALLIANCE	−0.037	−0.151	−0.104	−0.080	−0.141
	(0.344)	(0.356)	(0.349)	(0.382)	(0.388)
TELECOMMUNICATIONS			−0.465*		−0.452*
			(0.243)		(0.266)
MICROELECTRONICS			−0.231		−0.245
			(0.207)		(0.231)
JUDICIAL SYSTEM				−0.064	−0.057
				(0.115)	(0.116)
NON-TARIFF BARRIERS				0.043	0.037
				(0.082)	(0.082)
INTERCEPT	−0.869**	−1.002**	−0.705	−0.378	−0.211
	(0.431)	(0.447)	(0.447)	(1.292)	(1.311)
n	208	208	208	169	169
Log-likelihood	−125.83	−124.61	−123.69	−101.91	−100.21
Chi-square	22.50***	24.94***	26.79***	18.33**	21.74**
d.o.f.	7	8	9	9	11
Prob. > χ^2	0.002	0.002	0.002	0.032	0.026

Significant at * 10%, ** 5%, and *** 1% level for 2-tailed tests.
Standard errors in parentheses.

controls respectively to the specification, and column 5 includes all of these control variables together. This stepwise inclusion of different classes of controls allows us to test for their contribution to the model's explanatory power and so identify an appropriate specification for subsequent analysis.

The model in column 1 provides broad preliminary support for our hypotheses regarding the determinants of alliance scope. First, with respect to product market competition, we find that MARKET OVERLAP has a negative coefficient, as predicted, although only at the 10 percent significance level. Stronger support is found for the predicted effect of the geographic aspect of product market competition: as hypothesized, the coefficient on GEOGRAPHIC OVERLAP is negative and significant. Thus, allying firms that are headquartered in the same country are significantly less likely to engage in activities beyond pure R&D. These results support our contention that firms in the same product market or geographic arena perceive each other to be more direct competitors, making them less willing to risk leakage of competitively significant know-how through extensive knowledge sharing in their R&D-related alliances.

We also find strong support for Hypothesis 2: If the alliance partners are industry laggards the probability of broad alliance scope is increased, suggesting that when laggards team up in an R&D

alliance they are more willing to risk exposing competitively significant know-how to their partners, perhaps in the hope of leapfrogging industry leaders.

Technological overlap is also positively and significantly related to alliance scope, consistent with our absorptive capacity argument. Low levels of overlap among the partner firms' areas of technological expertise appear to hinder their ability to effectively share knowledge to the extent required in broad-scope alliances (Hypothesis 3b). There is no support for the hypothesized heightened factor market competition among firms at high levels of technological overlap (Hypothesis 3a). Furthermore, when we add a square term to the equation (column 2) to test for nonlinear effects, the coefficient on the square term is insignificant and a likelihood ratio test reveals that the inclusion of this variable does not add significantly to the explanatory power of the model ($\chi^2[1] = 2.31$). None of the other coefficients in the model are materially changed, except for a marginal drop in significance of the market overlap variable. This uniformly positive effect of technology overlap is not surprising given the characteristics of our sample, mentioned earlier: the low mean value of technology overlap suggests that the majority of our firms have few if any areas of technological expertise in common. Thus, at least in our sample, competition in technology resource markets does not appear to drive alliance scope. None of the remaining variables in columns 1 or 2 is significant: incremental R&D projects, multilateral alliances and prior alliances between partners do not appear to affect the choice of alliance scope.

When industry controls are added to the specification (column 3), the results reported above remain essentially unchanged and, although the telecommunications dummy variable is significant at the 10 percent level, a likelihood ratio test reveals that the inclusion of these controls does not add significantly to the explanatory power of the model ($\chi^2[2] = 4.29$). Similarly, addition of institutional environment variables, whether alone (column 4; $\chi^2[2] = 0.82$) or in combination with industry controls (column 5; $\chi^2[4] = 4.23$), adds no significant explanatory power. Subsequent estimations of the scope decision therefore use only the variables in column 1.[14]

To further explore the impact of the variables featured in our hypotheses on alliance scope, Table 2b presents a series of sub-sample means for four categories of alliances: R&D only, R&D plus manufacturing, R&D plus marketing, and R&D

[14] Given the fact that the industry control variables are almost significant at the 10 percent level (Prob > $\chi^2[2] = 0.12$), we checked the robustness of the results of all subsequent models with the industry controls included. There were no significant differences in our results with these variables included.

Table 2b. Multiple scope categories: subsample means
Mean of independent variables by scope category

	R&D only $n = 131$	R&D plus manufacturing $n = 19$	R&D plus marketing $n = 37$	R&D plus both $n = 21$
MARKET OVERLAP	0.153	0.263	0.000***	0.143
	(0.032)	(0.101)	(0.000)	(0.077)
GEOGRAPHIC OVERLAP	0.656	0.368**	0.378**	0.667
	(0.042)	(0.111)	(0.080)	(0.103)
LAGGARDS	0.534	0.737*	0.622	0.810***
	(0.044)	(0.101)	(0.080)	(0.086)
TECHNOLOGY OVERLAP	0.067	0.182**	0.062	0.086
	(0.012)	(0.044)	(0.020)	(0.029)
INCREMENTAL	0.893	0.895	0.973**	0.952
	(0.027)	(0.071)	(0.027)	(0.047)
MULTILATERAL	0.130	0.158	0.135	0.143
	(0.029)	(0.084)	(0.056)	(0.077)
REPEAT ALLIANCE	0.084	0.105	0.081	0.048
	(0.024)	(0.071)	(0.045)	(0.047)

Significant at * 10%, ** 5%, and *** 1% level for adjusted Wald (R&D only is comparison group in each case).
Standard errors in parentheses.

plus both (i.e., R&D in combination with manufacturing *and* marketing). There are several points to note here. Of the 77 'broad-scope' alliances, 19 involve only manufacturing in addition to R&D, 37 have marketing only in combination with R&D, and 21 involve R&D, manufacturing, and marketing—the broadest of the categories. The difference in the market overlap variable across these categories is striking. There are *no* R&D plus marketing alliances that bring together firms in the same industry (as indicated by the 4-digit SIC code). This is in stark contrast to narrow-scope alliances (R&D only), where 15 percent of alliance partners are in the same 4-digit industry. Neither of the other two categories of broad-scope alliances (i.e., both of the categories that involve manufacturing) have levels of market overlap that are significantly different from that in narrow-scope alliances, based on adjusted Wald tests of subpopulation means. Geographic overlap, on the other hand, is significantly lower in R&D plus manufacturing alliances and R&D plus marketing alliances as compared with R&D-only alliances, suggesting that firms headquartered in the same country are less likely to engage in these broader alliances, perhaps because of competitive concerns.

Interestingly, very broad alliances, involving both manufacturing *and* marketing in conjunction with R&D, are more likely to involve same-country partners; however, they are also significantly more likely to involve lagging firms. It thus appears that partners in these alliances are less concerned with the impact on inter-partner competition in final product markets, but are focused instead on quickly catching up with industry leaders. This 'catch-up' is likely best achieved through alliances that marry joint R&D with joint manufacturing and marketing, to promote activity overlapping and cross-functional communication, and so compress product development cycles (Loch and Terwiesch, 2000). Finally, technological overlap appears to be a highly significant driver of the decision to add manufacturing activities to a 'pure' R&D agreement, but not for marketing. This reinforces our inference that technological overlap is most important in terms of absorptive capacity, and relates in particular to the ability of firms to effectively engage in joint manufacturing.

Table 2c reports estimation results of two multinomial logit models, both of which have R&D-only alliances as the omitted category, to see whether the patterns observed in our analysis of sub-sample means remain when the coefficients are estimated jointly. The results of the first model, in columns A1 and A2, are indeed very consistent with the simple analysis of means. We cannot estimate the effect of market overlap here because of the lack of variation on this variable in the R&D plus marketing category, but all of the other major regularities discussed above are still evident. Furthermore, if we combine the last two scope categories, so that broad-scope alliances are categorized into R&D plus manufacturing only and R&D plus marketing (whether alone or in combination with manufacturing), we can add market overlap back into the specification (columns B1–B2). Again with R&D only as the omitted category, we see that the results are very consistent with our previous observations.

We next turn our attention to a 'baseline' analysis of the governance decision, in preparation for joint estimation of the scope and governance decisions and testing of Hypotheses 4a and 4b. Our theoretical arguments suggest that the scope and governance decisions are linked in the sense that both may attenuate leakage problems. As such, these two decisions have partially overlapping decision criteria. Applying the logic and findings of previous research nonetheless suggests some departures from the specification and results of the scope model. For example, while prior work argues for the retention of the geographic overlap variable in the governance equation, we remain agnostic about the sign of the effect of this variable on governance choice: For alliances involving firms headquartered in the same country (GEOGRAPHIC OVERLAP = 1), the elevated hazards associated with greater competition may be partially or completely offset by the enhanced ability to enforce contracts in the home nation (an effect that has been observed in previous research on international alliances, e.g., Oxley, 1999) even holding constant the efficiency of the judicial system. We did not hypothesize a parallel effect on alliance scope of enhanced access to the courts because we expect that court ordering tends to be generally ineffective for broad-scope alliances due to the extent of tacit knowledge sharing involved.

In addition, we omit LAGGARDS and TECHNOLOGY OVERLAP from the governance equation. The rationale for these exclusions is as follows: for LAGGARDS, although we argue that lagging firms will be more willing to engage in broad-scope alliances to leapfrog leaders, there is

Table 2c. Multiple scope categories: multinomial regression analysis

Multinomial Logit regression model.
Columns A1, A2, and A3 use a four-outcome dependent variable:
(Scope = 0 if R&D only, = 1 if R&D plus manufacturing only, = 2 if R&D plus marketing only, = 3 if R&D plus manufacturing and marketing)
Columns B1 and B2 use a three-outcome dependent variable:
(Scope = 0 if R&D only, = 1 if R&D plus manufacturing only, = 2 if R&D plus marketing, with or without manufacturing)

	R&D plus Manufacturing (A1)	R&D plus Marketing (A2)	R&D plus Both (A3)	R&D plus Manufacturing (B1)	R&D plus Mktg or Both (B2)
MARKET OVERLAP				0.028	−1.418**
				(0.682)	(0.679)
GEOGRAPHIC OVERLAP	−1.402**	−1.171***	0.177	−1.416**	−0.751**
	(0.565)	(0.400)	(0.518)	(0.568)	(0.341)
LAGGARDS	0.992	0.143	1.389**	0.999*	0.645*
	(0.604)	(0.406)	(0.598)	(0.605)	(0.352)
TECHNOLOGY OVERLAP	5.561***	0.756	1.922	5.452***	1.686
	(1.588)	(1.631)	(1.746)	(1.611)	(1.346)
INCREMENTAL	0.674	1.640	0.989	0.704	0.998
	(0.947)	(1.099)	(1.123)	(0.969)	(0.819)
MULTILATERAL	−0.416	−0.009	0.210	−0.336	0.234
	(0.807)	(0.605)	(0.736)	(0.817)	(0.535)
REPEAT ALLIANCE	0.219	0.254	−0.490	0.234	−0.100
	(0.897)	(0.729)	(1.099)	(0.893)	(0.644)
INTERCEPT	−3.076***	−2.351**	−3.957***	−3.109***	−1.715*
	(1.134)	(1.142)	(1.308)	(1.157)	(0.884)
n		208		208	
Log-likelihood		−199.33		−162.93	
Chi-square		37.48***		34.36***	
d.o.f.		18		14	
Prob. > χ^2		0.005		0.002	

Significant at * 10%, ** 5%, and *** 1% for 2-tailed tests.
Standard errors in parentheses.

no reason to expect that they would employ a non-standard calculus with respect to the governance structure adopted, contingent on this scope decision. For TECHNOLOGY OVERLAP, our argument rests primarily on the feasibility of achieving alliance objectives that require broad knowledge sharing, rather than on appropriability considerations *per se*. Consequently, we include TECHNOLOGY OVERLAP in the scope but not the governance model specification.[15]

Table 3 presents results of our estimation of the governance choice model. Column 1 includes our composite SCOPE measure as an independent variable, and column 2 instead uses two dummy variables: one for the addition of manufacturing activities (MANUFACTURING) and one for addition of marketing activities to the alliance (MARKETING). Constrained models with industry and institutional environment variables omitted were also estimated and compared with the unconstrained models shown, to see if inclusion of the controls is warranted. In each case, likelihood ratio tests indicated that both sets of control variables should be included in the governance specification.[16]

These governance models produce results that are largely consistent with relevant findings from

[15] As a robustness check, we re-estimated the governance model with the addition of these currently omitted variables and found substantially similar results. These results are available from the authors on request.

[16] $\chi^2[4] = 57.74$ and 56.53 for LR tests comparing fully constrained models (with no industry or institutional environment controls) against the models shown in columns 1 and 2, respectively.

Table 3. Governance choice

Probit regression model
Dependent variable is alliance governance form.
Positive coefficients indicate increased probability that firms select an equity joint venture

	(1)	(2)
MARKET OVERLAP	−1.243**	−1.575**
	(0.588)	(0.638)
GEOGRAPHIC OVERLAP	−0.454	−0.664**
	(0.282)	(0.295)
INCREMENTAL	−0.703	−0.669
	(0.466)	(0.483)
MULTILATERAL	0.766**	0.884**
	(0.360)	(0.374)
REPEAT ALLIANCE	0.322	0.346
	(0.460)	(0.471)
SCOPE	0.680***	
	(0.259)	
MANUFACTURING		0.985***
		(0.326)
MARKETING		0.138
		(0.296)
TELECOMMUNICATIONS	0.512*	0.517*
	(0.304)	(0.313)
MICROELECTRONICS	0.030	0.081
	(0.281)	(0.287)
JUDICIAL SYSTEM	−0.145	−0.094
	(0.141)	(0.143)
NON-TARIFF BARRIERS	−0.224**	−0.227**
	(0.112)	(0.110)
INTERCEPT	1.723	1.313
	(1.550)	(1.589)
n	169	169
Log-likelihood	−66.18	−63.65
χ^2	28.73***	33.79***
d.o.f.	10	11
Prob. > χ^2	0.001	0.000

Significant at * 10%, ** 5%, and *** 1% level for 2-tailed tests.
Standard errors in parentheses.

previous studies (e.g., Pisano, 1989; Oxley, 1997). In particular, the coefficient on scope is positive and significant in column 1. Thus, consistent with previous estimation of reduced-form governance models, we find that equity joint ventures are preferred over contractual alliances when alliance activities are broad, i.e., when they include manufacturing and/or marketing in addition to R&D. Interestingly, this result seems to be driven primarily by the addition of manufacturing activities rather than marketing activities. In column 2, the coefficient on MANUFACTURING is positive and highly significant, while for MARKETING the coefficient is not significant.

Also consistent with prior studies, both specifications indicate that equity joint ventures are more likely to be selected when there are more than two partners linked in the alliance (the coefficient on MULTILATERAL is positive and significant). However, in contrast to prior studies, the breadth of innovation sought in the alliance (as proxied by our dummy variable, INCREMENTAL) does not appear to have any effect on alliance governance choice. The presence of prior alliances linking the partner firms also has no discernible effect on alliance governance in either specification.[17]

With respect to market competition variables, there are some interesting and counter-intuitive features of the results. In both specifications, MARKET OVERLAP has a negative and significant effect, suggesting that firms in the same industry are more likely to organize an alliance via contract than to establish an equity joint venture. This runs counter to our argument that greater product market competition increases the competitive impact of knowledge leakage, since in this case we would expect alliance activities involving partners in the same industry to be *more* likely to be embedded in the protective governance structure afforded by an equity joint venture (holding the scope of activities and other relevant alliance characteristics constant). GEOGRAPHIC OVERLAP also has a negative coefficient, but this is only significant in column 2. In this case, we anticipated the possibility of a negative effect because of firms' greater ability to enforce contracts with other domestic companies, relative to foreign-owned entities. This effect might therefore counteract the impact of increased geographic competition and the associated desire to organize the alliance as an equity joint venture (all else equal). We return to this issue and consider alternative explanations for the market overlap results in the concluding section.

Finally, some of the coefficients on the institutional environment variables are also quite counter-intuitive. The efficiency of the judicial system does not appear to affect the likelihood that an alliance will be organized as an equity joint venture, in contrast to findings of previous research (e.g., Sampson, 2004). Even more puzzling, there is a negative association between the extent of non-tariff barriers and the likelihood of an equity joint venture. We would expect a positive effect in this

[17] Repeating the analysis with a count of previous alliances yields similarly insignificant results on REPEAT ALLIANCE and does not change any of the other coefficients in the model.

case since non-tariff barriers may include requirements for local equity participation. Absent any compelling explanation for these results (which are quite robust across the different model specifications and estimation methods reported below) we merely note them as interesting observations for future investigation.

Together with the results of the scope analysis, these findings establish that there are significant areas of overlap in the determinants of alliance scope and governance for the alliances in our sample. This in turn suggests that joint estimation of the two equations may be a more appropriate empirical approach, and one that may provide additional insights over the reduced-form governance equations adopted in prior research. Table 4 displays the results of the first of our alternative methods of joint estimation: the bivariate probit model. This estimation method controls for omitted variables that may affect the scope and governance decisions, but does not allow for non-recursive endogeneity between scope and governance.

The results in columns A1–A2 in Table 4 are generally consistent with those in the simple probit models and in particular reinforce our arguments regarding the determinants of alliance scope: all of the variables that were significant in the simple probit model of alliance scope remain significant when the equation is estimated jointly with the governance equation, with the exception of MARKET OVERLAP, which is no longer significant. Interestingly, few of the variables in the governance equation are significant with bivariate probit estimation, except for alliance scope, which remains positive and highly significant. INCREMENTAL has a negative coefficient (as suggested in previous research such as Pisano, 1989), but is only marginally significant at the 10 percent level.

To tease out the different effects of hazards related to joint manufacturing and joint marketing that were suggested by the earlier analysis of multiple scope categories, Table 4 also presents the results of two additional specifications for alliance scope and governance. The first, in columns B1–B2, replaces the dependent variable in the scope equation with MANUFACTURING, the dummy variable indicating that the alliance includes manufacturing activities in addition to R&D (irrespective of the presence of marketing activities). Similarly, in columns C1–C2 we replace the dependent variable in the scope equation with MARKETING, the dummy variable for marketing activities in the alliance. These alternative specifications yield very interesting results that add significant nuance to our interpretation of the relationship between alliance scope and governance.

Comparing the two modified scope equations (columns B1 and C1) reconfirms the findings from our earlier consideration of multiple scope categories, i.e., that the addition of manufacturing is primarily a capabilities issue: technological overlap is positively and significantly associated with the addition of manufacturing (column B1), but does not have any effect on the decision to engage in joint marketing (column C1). Laggards are also more likely to engage in manufacturing, but there is no discernible effect on the decision to add marketing to an R&D alliance (although we should note that our results may be masking the effect observed in Table 3b, where we saw that alliances involving both manufacturing *and* marketing were the ones most likely to involve laggards.)

Also quite evident when comparing the two modified scope equations is the different effect of market overlap and geographic overlap—both of these variables are negative and significant when predicting the addition of marketing, but have no significant effect on the decision to include manufacturing in the alliance. None of the control variables have any significant effect in either model.

Consideration of the governance equations in columns B2 and C2 adds to this picture of different responses to hazards raised by joint manufacturing and marketing. While the coefficient on MANUFACTURING is positive and highly significant in column B2, the coefficient on MARKETING in C2 does not even approach conventional levels of significance. Indeed, very few of the variables are significant at all in the governance equation in C2, whereas in B2 we see a negative and significant effect for MARKET OVERLAP and a positive and significant effect for MULTILATERAL. These results together suggest that firms decide whether or not to engage in joint manufacturing based on the needs of the project and the capabilities of the partners, and then mitigate the hazards posed by joint manufacturing through choice of an appropriate governance structure. On the other hand, potential hazards raised by joint marketing are primarily mitigated by a reduction of alliance scope—i.e., partners simply avoid joint marketing when they foresee problems—and this decision

Table 4. Alliance scope and governance: bivariate probit models

Bivariate probit (seemingly unrelated) model.
Columns A1 and A2: dependent variables are SCOPE (= 0 for R&D only, = 1 for R&D plus manufacturing and/or marketing) and GOVERNANCE (= 0 for contract, = 1 for equity joint venture)
Columns B1 and B2: dependent variables are MANUFACTURING (= 0 for R&D only, = 1 for R&D plus manufacturing, with or without marketing) and GOVERNANCE
Columns C1 and C2: dependent variables are MARKETING (= 0 for R&D only, = 1 for R&D plus marketing with or without manufacturing) and GOVERNANCE. Positive coefficients indicate increased probability that firms select either broad alliance scope or equity joint venture.

	SCOPE (A1)	GOVERNANCE (A2)	MANF (B1)	GOVERNANCE (B2)	MKTG (C1)	GOVERNANCE (C2)
MARKET OVERLAP	−0.344	−0.512	0.289	−1.327***	−0.828*	−1.048
	(0.329)	(0.343)	(0.348)	(0.448)	(0.491)	(1.160)
GEOGRAPHIC OVERLAP	−0.571***	0.083	0.078	−0.411	−0.399*	−0.405
	(0.199)	(0.223)	(0.232)	(0.261)	(0.220)	(0.607)
LAGGARD	0.400***		0.610***		0.258	
	(0.131)		(0.221)		(0.393)	
TECHNOLOGY OVERLAP	1.213***		1.663**		0.245	
	(0.437)		(0.653)		(1.106)	
INCREMENTAL	0.575	−0.627*	0.297	−0.389	0.707	−0.728
	(0.393)	(0.376)	(0.441)	(0.408)	(0.552)	(0.558)
MULTILATERAL	0.128	0.406	−0.118	0.777**	0.338	0.699
	(0.310)	(0.288)	(0.337)	(0.339)	(0.338)	(0.571)
REPEAT ALLIANCE	−0.270	0.183	−0.135	0.250	−0.155	0.278
	(0.343)	(0.342)	(0.420)	(0.402)	(0.457)	(0.467)
SCOPE		2.142***				
		(0.175)				
MANUFACTURING				2.504***		
				(0.205)		
MARKETING						0.782
						(2.767)
TELECOMMUNICATIONS		0.321*		0.432*		0.455
		(0.186)		(0.239)		(0.300)
MICROELECTRONICS		0.020		0.136		0.012
		(0.107)		(0.200)		(0.277)
JUDICIAL SYSTEM		−0.128		−0.142		−0.175
		(0.108)		(0.131)		(0.148)
NON-TARIFF BARRIERS		−0.166**		−0.198**		−0.216*
		(0.076)		(0.079)		(0.130)
INTERCEPT	−0.805*	0.773	−1.733***	1.225	−1.128*	2.046
	(0.433)	(1.138)	(0.509)	(1.323)	(0.586)	(1.936)
n	169		169		169	
Log-likelihood	−166.58		−138.16		−162.14	
χ^2	160.87***		186.36***		34.97***	
d.o.f	17		17		17	
LR test of rho = $0(\chi^2)$	3.84*		3.51*		0.01	

Significant at * 10% ** 5%, and *** 1% level for 2-tailed tests.
Standard errors in parentheses.

is essentially independent of the choice of governance structure.[18]

Our last set of analyses, reported in Table 5, explores the relationship between the different

[18] The fact that rho, the correlation between the scope and governance error terms, is significant for the estimation shown in columns B1–B2 (i.e., broad scope = R&D plus manufacturing) but not for the C1–C2 estimation (i.e., broad scope = R&D plus marketing) supports this conclusion. That is, the decision to enter into joint manufacturing and the alliance governance choice are linked, while the joint marketing and alliance governance choices do not appear to be so.

Table 5. Alliance scope and governance: simultaneous probit models

Columns A1 and A2. dependent variables are SCOPE (= 0 for R&D plus manufacturing and/or marketing) and GOVERNANCE (= 0 for contract, = 1 for equity joint venture)
Columns B1 and B2. dependent variables are MANUFACTURING (= 0 for R&D only, = 1 for R&D plus manufacturing, with or without marketing) and GOVERNANCE
Columns C1 and C2 dependent variables are MARKETING (= 0 for R&D only, = 1 for R&D plus marketing with or without manufacturing) and GOVERNANCE. Positive coefficients indicate increased probability that firms select either broad alliance scope or equity joint venture

	SCOPE (A1)	GOVERNANCE (A2)	MANF (B1)	GOVERNANCE (B2)	MKTG (C1)	GOVERNANCE (C2)
MARKET OVERLAP	−0.999	−1.078	−0.098	−1.660***	−1.393*	0.090
	(0.745)	(0.584)	(0.761)	(0.624)	0.816	1.458
GEOGRAPHIC OVERLAP	−0.823**	−0.102	−0.198	−0.707**	−0.547*	0.465
	(0.323)	(0.396)	(0.334)	(0.313)	(0.317)	(1.085)
LAGGARD	0.489		0.721*		0.394	
	(0.345)		(0.388)		(0.328)	
TECHNOLOGY OVERLAP	1.892*		2.482**		0.405	
	(1.012)		(1.051)		(0.981)	
INCREMENTAL	0.414	−1.026*	0.133	−0.642	0.541	−1.798
	(0.602)	(0.537)	(0.603)	(0.466)	(0.687)	(1.528)
MULTILATERAL	0.313	0.685	−0.196	0.926**	0.607	0.303
	(0.545)	(0.443)	(0.595)	(0.370)	(0.532)	(0.863)
REPEAT ALLIANCE	0.006	0.350	0.015	0.338	−0.089	0.422
	(0.404)	(0.631)	(0.428)	(0.499)	(0.432)	(1.010)
GOVERNANCE = EJV	0.632**		0.848***		0.413	
	(0.285)		(0.301)		(0.288)	
SCOPE		0.613**				
		(0.263)				
MANUFACTURING				0.940***		
				(0.318)		
MARKETING						0.397
						(0.272)
TELECOMMUNICATIONS		0.162*		0.572*		1.130
		−(0.092)		(0.330)		(0.884)
MICROELECTRONICS		0.024		0.150		0.492
		−(0.074)		(0.305)		(0.718)
JUDICIAL SYSTEM		−0.053		−0.032		−0.455
		−(0.037)		(0.166)		(0.425)
NON-TARIFF BARRIERS		−0.053**		−0.221*		−0.163
		−(0.025)		(0.119)		(0.204)
INTERCEPT	0.352	0.797*	−2.109***	0.964	−1.503**	5.691
	−(0.224)	−(0.449)	(0.684)	(1.705)	(0.750)	(5.170)
n		169		169		169
Log-likelihood		−99.26		−72.28		−92.39
d.o.f.	8	10	8	10	8	10

Significant at * 10%, ** 5%, and *** 1% level for 2-tailed tests.
Standard errors in parentheses.

aspects of alliance scope and governance further and, in particular, allows us to test Hypotheses 4a and 4b, that broad scope increases the likelihood that firms select an equity joint venture and, conversely, firms selecting an equity joint venture are more willing to undertake broad alliance activities. Here we estimate non-recursive simultaneous equation models that allow us to fully endogenize scope and governance, including scope in the governance equation and vice versa.[19]

[19] Recursive models that omit governance from the scope equations, similar to the bivariate probit, yield results that are materially identical to those in Table 4.

Notice first that the results of these analyses are quite consistent with those of the bivariate probit estimation, with some slight changes in significance for some of the variables. Furthermore, the results in columns A1 and A2 suggest that scope and governance do indeed act as substitutes: GOVERNANCE = EJV is positive and significant in the scope equation *and* the coefficient on scope is positive and significant in the governance equation. Thus, when alliance scope is narrowed the need to embed the alliance activities in a protective governance structure, such as the equity joint venture, is reduced. Conversely, when the alliance is organized as an equity joint venture, the partners are more willing to engage in activities of broad scope. These results thus support Hypotheses 4a and 4b. Estimation of the models with modifications to the scope equation once again adds nuance to this interpretation of the relationship between scope and governance and reinforces the earlier results. The substitution effect between scope and governance is very clear in the model in columns B1–B2, where we see that the adoption of an equity joint venture structure significantly increases the probability of joint manufacturing, and vice versa. In contrast, there is no significant link between joint marketing activities and governance choice, but the effect of market and geographic competition, reducing partner firms' willingness to engage in joint marketing, is still readily apparent.

Before we turn to a broader discussion of the implications of these findings, it is worth noting one remaining issue regarding the robustness of the empirical results. In this study we have taken a significant step beyond the focus on a single alliance decision common to previous research, and have analyzed the joint determination of alliance scope and governance decisions. We nonetheless were forced to ignore other potentially endogenous decisions in order to render the problem analytically and empirically tractable. In particular, it is quite possible that partner selection decisions are based, at least in part, on some of the same considerations that we have identified as affecting the scope and governance of alliance activities. If firms select partners that are most compatible in terms of technological overlap and competitive position and presence, for example, then ignoring this selection process may introduce bias into our analysis of subsequent alliance decisions (Shaver, 1998). Furthermore, the characteristics of our alliance sample do point towards the possibility of such selection bias—for example, we see that relatively few alliances in our sample involve leading firms, or partners with their primary activities in the same industry, or partners with very high levels of technological overlap—all conditions that might be expected to raise the hazards of cooperation, according to our arguments. Fully incorporating the partner choice decision into our analysis clearly goes beyond the scope of this paper, but endogenizing this decision represents an interesting avenue for future research.

In the meantime, as a robustness check to test whether partner selection issues significantly bias our current findings we generated a sample of 'non-allying' firm pairs, randomly drawn from the pool of firms in our sample and then filtering for the condition that the pair did not have any joint alliances reported in the SDC database. We then added this non-allying sample to our sample of alliances and estimated a probit model that predicted alliance formation based on partner characteristics. The results of this analysis suggest that MARKET OVERLAP and LAGGARD are indeed significant predictors of alliance pairings. Then, to explore the extent of any self-selection bias in our results, we estimated a two-stage model of alliance scope, with the partner selection decision as a first stage. Our results on the choice of alliance scope are robust even with this correction.[20]

DISCUSSION AND CONCLUSION

The findings reported above provide support for our contention that the alliance scope decision is an important aspect of alliance management. Our results also provide support for the argument that decisions to restrict alliance scope are made, at least in part, as a response to the elevated leakage concerns associated with knowledge sharing in particular competitive contexts, and that restrictions to alliance scope may substitute for protective governance structures in such circumstances. However, we also showed that protecting technological capabilities is not the complete story, as issues of absorptive capacity and feasibility are implicated in the alliance scope decision, particularly with respect to joint manufacturing. Below, we

[20] These results are available on request from the authors.

discuss the possibility of an alternative explanation for these results, and explore the implications of our findings for alliance research and for studies of firm boundaries and governance more broadly. We also speculate on some useful directions for future research.

One potential concern about our findings is the possibility of alternative explanations. In particular, it is possible that the scope and governance decisions may be driven more by antitrust issues than by the private risks of collaboration highlighted in our theoretical arguments. Firms headquartered in the United States and/or operating in the same 4-digit SIC code may be subjected to greater scrutiny from antitrust authorities when they expand collaboration beyond pure R&D activities and this could explain why we observe a negative effect of product and geographic market overlap on alliance scope. However, there are two reasons to believe that antitrust concerns are not the primary driver here. First, our domain of study—R&D alliances—mitigates this concern: The National Cooperative Research Act (NCRA) of 1984, along with its 1993 extension, the National Cooperative Research and Production Act (NCRPA), encourages (or at least does not discourage) the formation of consortia and joint ventures for R&D, both alone and in combination with production, by members of the same industry.[21] Second, given that equity joint ventures in general tend to come under closer scrutiny from antitrust authorities than non-equity alliances, we would expect to see the effects of product and/or geographic market overlap showing up in the governance equation consistently more strongly than in the alliance scope equation if antitrust concerns were a significant issue. In general, this is not what we observe.

The analysis presented in this paper suggests that alliance managers can and do pay attention to the competitive implications of potential loss of control of technological assets that comes with cooperation in R&D, and that these considerations play a role in the design of the content and governance of R&D alliances. As such, the study reaffirms some of the main conclusions of previous studies of alliance organization undertaken within the transaction cost economics tradition. The study also highlights limitations of the exclusive focus on alliance governance in much of this previous research, however. Although the point has long been made that transaction cost economizing involves joint determination of the content and governance of transactions (Riordan and Williamson, 1985; Oxley, 1999), it has rarely been implemented in prior empirical work; instead, the most common empirical approach has been to 'take the transaction as given' and to test TCE predictions regarding the effect of transaction characteristics on governance. As suggested earlier, this reduced-form approach has simplified analysis and has yielded important insights, but it has also led to criticisms that the transaction cost approach pays insufficient attention to 'value creation' in alliances (Zajac and Olsen, 1993) and to the social and/or competitive context in which a transaction is embedded (Granovetter, 1985; Day and Klein, 1987). By focusing explicitly on decisions regarding the scope of alliance activities, and on the influence of the competitive context on the scope decision, we are able to confront these criticisms here. And indeed our results suggest that the reduced-form analysis of alliance governance employed in prior TCE studies may have overstated the role of governance in alliance management. When the scope and governance equations for our sample of R&D alliances are estimated jointly, we find that some of the factors previously associated with differences in alliance governance appear to operate more directly on the scope of alliance activities, particularly when the hazards of cooperation are related to joint marketing activities as opposed to joint manufacturing. Of course our analysis is far from definitive in this regard, but it suggests an important avenue for further research on alliance management (and in the study of governance more generally); i.e., to further explore the joint determinants of the content and governance of these relationships.

Our study also points to important complementarities between theoretical approaches that emphasize hazard mitigation in alliances (such as TCE) and those that place more emphasis on crafting

[21] The NCRA altered antitrust treatment of research consortia in two significant ways: first, it ensured that cooperative research ventures were subjected to rule of reason analysis rather than *per se* rules (i.e., their pro-competitive effects must be weighed against potential anti-competitive concerns). Second, it limited the liability of registered consortia participants to single rather than treble damages. These safeguards were extended to joint ventures involving both production and R&D with the 1993 NCRPA. See Jorde and Teece (1993) for a more thorough analysis of the NCRA and the NCRPA.

inter-firm alliances to promote effective knowledge sharing, such as the information-processing perspective (Sobrero and Roberts, 2001) or knowledge management perspective (Inkpen, 2000). While research in this latter tradition tends to take more of an organizational process approach, it does direct attention to the role of cognitive limitations in restricting the objectives achievable within a particular alliance. Our study suggests that these cognitive limitations (as manifested in the importance of adequate absorptive capacity to support broad-scope alliances involving joint manufacturing) are an important consideration, in addition to—though not to the exclusion of—concerns with mitigating the hazards of potential opportunism. In particular, our results suggest that the decision to bring manufacturing within the scope of the alliance is driven largely by feasibility issues related to overlapping capabilities and absorptive capacity; in situations where such joint manufacturing raises the fear of leakage and other competitive concerns (such as when multiple partners are involved and so monitoring of alliance activities and delineation of property rights is more complex) partners choose to embed their activities in a protective alliance structure such as an equity joint venture. The relationship between these issues of feasibility and hazard mitigation deserves further attention in future work. Extension of our own study in this direction is hampered by the crudeness of our measures (for both our dependent and independent variables), highlighting an important limitation of the analysis. Future work would benefit from more fine-grained and multidimensional measures, particularly of alliance scope, partner capabilities, and competitive and social context. This is a challenging proposition for large-scale analysis and would undoubtedly require access to primary data sources (for example, through a survey of alliance participants), but it is an area ripe for research.

In sum, the analysis presented here indicates that when firms design R&D alliances with an eye to acquiring, protecting, and leveraging technological resources, the choice of an appropriate governance structure is not the only critical decision to be made; delineating the scope of alliance activities is also an important and complementary decision. Although preliminary, our analysis suggests that this is a line of enquiry with potentially important implications for the theory and management of inter-firm alliances. In addition, the work contributes to an emergent research stream aimed at understanding the relationship between firm strategy and efficient economic organization. In common with other recent work in this area (e.g., Nickerson, Hamilton, and Wada, 2001) our research suggests that a complete understanding of firm boundary decisions requires the adoption of a combined positioning–economizing perspective (Nickerson, 1997) that takes into account the interdependence of market position, firm resources, and governance.

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REFERENCES

Barney JB. 1986. Strategic factor markets: expectations, luck, and business strategy. *Management Science* **32**(10): 1231–1241.

Basberg BL. 1982. Technological change in the Norwegian whaling industry: a case study in the use of patent statistics as a technology indicator, *Research Policy* **11**: 163–171.

Branstetter LG., Sakakibara M. 2002. When do research consortia work well and why? Evidence from Japanese panel data. *American Economic Review* **92**(1): 143–159.

Clark KB, Fujimoto T. 1991. *Product Development Performance: Strategy, Organization and Management in the World Auto Industry.* Harvard Business School Press: Boston, MA.

Cohen WM, Levinthal DA. 1990. Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly* **35**: 128–152.

Comanor WS, Scherer FM. 1969. Patent statistics as a measure of technical change, *Journal of Political Economy* **77**: 329–398.

Cusumano MA, Selby RW. 1995. *Microsoft Secrets: How the World's Most Powerful Software Company Creates Technology, Shapes Markets, and Manages People*. Free Press: New York.

Day GS, Klein S. 1987. Cooperative behavior in vertical markets: the influence of transaction costs and competitive strategies. In *Review of Marketing*, Houston MJ (ed). American Marketing Association: Chicago, IL; 39–66.

Dierickx I, Cool K. 1989. Asset stock accumulation and sustainability of competitive advantage. *Management Science* **35**(12): 1504–1514.

Doz YL, Hamel G. 1998. *Alliance Advantage.* Harvard Business School Press: Boston, MA.

Dussauge P, Garrette B, Mitchell W. 2000. Learning from competing partners: outcomes and durations of scale and link alliances in Europe, North America and Asia. *Strategic Management Journal* **21**(2): 99–126.

Duysters G, Hagedoorn J. 1996. Internationalization of corporate technology through strategic partnering: an empirical investigation. *Research Policy* **25**: 1–12.

Eisenhardt KM, Schoonhoven CB. 1996. Resource-based view of strategic alliance formation: strategic and social effects in entrepreneurial firms. *Organization Science* **7**(2): 136–150.

Eisenhardt KM, Tabrizi BN. 1995. Accelerating adaptive processes: product innovation in the global computer industry. *Administrative Science Quarterly* **40**(1): 84–110.

Gomes-Casseres B. 1996. *The Alliance Revolution.* Harvard University Press: Cambridge, MA.

Granovetter M. 1985. Economic action and social structure: the problem of embeddedness. *American Journal of Sociology* **91**(November): 481–501.

Greene WH. 1997. *Econometric Analysis* (3rd edn). Prentice-Hall: Upper Saddle River, NJ.

Gulati R. 1995a. Social structure and alliance formation patterns: a longitudinal analysis. *Administrative Science Quarterly* **40**: 619–652.

Gulati R. 1995b. Does familiarity breed trust? The implications of repeated ties for contractual choice in alliances. *Academy of Management Journal* **38**(1): 85–112.

Gulati R, Singh H. 1998. The architecture of cooperation: managing coordination costs and appropriation concerns in strategic alliances. *Administrative Science Quarterly* **43**: 781–814.

Hagedoorn J. 1993. Understanding the rationale of strategic technology partnering: interorganizational modes of cooperation and sectoral differences. *Strategic Management Journal* **14**(5): 371–385.

Hamel G, Doz YL, Prahalad CK. 1989. Collaborate with your competitors—and win. *Harvard Business Review* **67**(1): 133–139.

Henderson RM, Clark KB. 1990. Architectural innovation: the reconfiguration of existing product technologies and the failure of established firms. *Administrative Science Quarterly* **35**(March): 9–30.

Hergert M, Morris D. 1988. Trends in international collaborative arrangements. In *Cooperative Strategies in International Business*, Contractor FJ, Lorange P (eds). Lexington Books: Lexington, MA; 99–109.

Imai K, Nonaka I, Takeuchi H. 1985. Managing the new product development process: how the Japanese companies learn and unlearn. In *The Uneasy Alliance*, Clark KB, Hayes RH, Lorenz C (eds). Harvard Business School Press: Boston, MA; 337–377.

Inkpen AC. 2000. Learning through joint ventures: a framework of knowledge acquisition. *Journal of Management Studies* **37**(7): 1019–1045.

Jaffe AB. 1986. Technological opportunity and spillovers of R&D: evidence from firms' patents, profits and market value. *American Economic Review* **76**: 984–1001.

Jorde TM, Teece DJ. 1993. Rule of reason analysis of horizontal arrangements: agreements designed to advance innovation and commercialize technology. *Antitrust Law Journal* **61**: 579–619.

Kale P, Singh H, Perlmutter H. 2000. Learning and protection of proprietary assets in strategic alliances: building relational capital. *Strategic Management Journal* **21**(3): 217–237.

Khanna T. 1998. The scope of alliances. *Organization Science* **9**(3): 340–355.

Khanna T, Gulati R, Nohria N. 1998. The dynamics of learning alliances: competition, cooperation and relative scope. *Strategic Management Journal* **19**(3): 193–210.

Klavans R. 1993. Technology strategy and competitive intelligence. In *Global Perspectives on Competitive Intelligence*, Prescott JE, Gibbons PT (eds). Society of Competitive Intelligence Professionals: Alexandria, VA; 129–136.

Kogut B. 1988. Joint ventures: theoretical and empirical perspectives. *Strategic Management Journal* **9**(4): 319–332.

Kogut B, Zander U. 1992. Knowledge of the firm, combinative capabilities and the replication of technology. *Organization Science* **3**: 383–397.

Koka BR, Prescott JE. 2002. Strategic alliances as social capital: a multidimensional view. *Strategic Management Journal* **23**(9): 795–816.

Krishnan V, Eppinger SD, Whitney DE. 1997. A model-based framework to overlap product development activities. *Management Science* **43**(4): 437–451.

Lane PJ, Lubatkin M. 1998. Relative absorptive capacity and interorganizational learning. *Strategic Management Journal* **19**(5): 461–477.

Levin RC, Klevorick AK, Nelson RR, Winter SG. 1987. Appropriating the returns from industrial research and development. *Brookings Papers on Economic Activity* **3**: 783–833.

Loch CH, Terwiesch C. 2000. Product development and concurrent engineering. In *Innovations in Competitive Manufacturing*, Swamidass PM (ed). Kluwer: Dordrecht; 263–274.

Mitchell W, Singh K. 1996. Survival of businesses using collaborative relationships to commercialize complex goods. *Strategic Management Journal* **17**(3): 169–195.

Mowery DC, Oxley JE, Silverman BS. 1996. Strategic alliances and inter-firm knowledge transfer. *Strategic Management Journal*, Winter Special Issue **17**: 77–91.

Mowery DC, Oxley JE, Silverman BS. 1998. Technological overlap and inter-firm cooperation: implications for the resource-based view of the firm. *Research Policy* **27**: 507–523.

Nakamura M, Shaver JM, Yeung B. 1996. An empirical investigation of joint venture dynamics: evidence from US–Japan joint ventures. *International Journal of Industrial Organization* **14**: 521–541.

Narula R, Hagedoorn J. 1999. Innovating through strategic alliances: moving towards international partnerships and contractual agreements. *Technovation* **19**(5): 283–294.

Nickerson JA. 1997. Toward an economizing theory of strategy: The choice of strategic position, assets, and organizational form. Doctoral dissertation, University of California, Berkeley.

Nickerson JA, Hamilton BH, Wada T. 2001. Market position, resource profile, and governance: linking Porter and Williamson in the context of international courier and small package services in Japan. *Strategic Management Journal* **22**(3): 251–274.

OECD (Organization for Economic Cooperation and Development). 2000. *OECD Information Technology Outlook 2000: ICTs, E-Commerce and the Information Economy*. OECD: Paris.

Oxley JE. 1997. Appropriability hazards and governance in strategic alliances: a transaction cost approach. *Journal of Law, Economics and Organization*, **13**(2): 387–409.

Oxley JE. 1999. Institutional environment and the mechanisms of governance: the impact of intellectual property protection on the structure of inter-firm alliances. *Journal of Economic Behavior and Organization* **38**(3): 283–309.

Park SH, Ungson GR. 1997. The effect of national culture, organizational complementarity and economic motivation on joint venture dissolution. *Academy of Management Journal* **40**(2): 279–307.

Patel P, Pavitt K. 1997. The technological complexities of the world's largest firms: complex and path-dependent, but not much variety. *Research Policy* **26**: 141–156.

Pisano G. 1989. Using equity participation to support exchange: evidence from the biotechnology industry. *Journal of Law, Economics and Organization* **5**(1): 109–126.

Pisano G, Russo M, Teece D. 1988. Joint ventures and collaborative arrangements in the telecommunications equipment industry. In *International Collaborative Ventures in U.S. Manufacturing*, Mowery D (ed). Ballinger: Cambridge, MA; 23–70.

Prescott JE. 2001. Competitive intelligence: lessons from the trenches. In *Proven Strategies in Competitive Intelligence*, Prescott JE, Miller SH (eds). Wiley: New York; 1–22.

Red Herring. 1997. The Herring 100: The best private and public technology companies of 1997. *Red Herring* 1 September.

Reich RB, Mankin ED. 1986. Joint ventures with Japan give away our future. *Harvard Business Review* **64**(2): 78–86.

Reuer JR, Zollo M, Singh H. 2002. Post-formation dynamics in strategic alliances. *Strategic Management Journal* **23**(2): 135–151.

Riordan MH, Williamson OE. 1985. Asset specificity and economic organization. *Industrial Journal of Industrial Organization* **3**: 365–378.

Sabbagh K. 1996. *Twenty-First Century Jet*. Scribner: New York.

Sampson RC. 2004. The cost of misaligned governance in R&D alliances. *Journal of Law Economics and Organization* (forthcoming).

Sanchez R, Mahoney JT. 1996. Modularity, flexibility, and knowledge management in product and organization design. *Strategic Management Journal*, Winter Special Issue **17**: 63–76.

Shaver JM. 1998. Accounting for endogeneity when assessing strategy performance: does entry mode choice affect FDI survival? *Management Science* **44**(4): 571–585.

Shaver JM, Flyer F. 2000. Agglomeration economies, firm heterogeneity and foreign direct investment in the United States. *Strategic Management Journal* **21**(12): 1175–1193.

Sobrero M, Roberts EB. 2001. The trade-off between efficiency and learning in interorganizational relationships for product development. *Management Science* **47**(4): 493–511.

Stuart T. 2000. Interorganizational alliances and the performance of firms: a study of growth and innovation rates in a high-technology industry. *Strategic Management Journal* **21**(8): 791–812.

Takeuchi H, Nonaka I. 1986. The new product development game. *Harvard Business Review* **64**(1): 1–11.

Terwiesch C, Loch CH. 1999. Measuring the effectiveness of overlapping development activities. *Management Science* **45**(4): 455–465.

Teece DJ. 1992. Competition, cooperation, and innovation: organizational arrangements for regimes of rapid technological-progress. *Journal of Economic Behavior and Organization* **18**(1): 1–25.

Wacziarg R. 2001. Measuring the dynamic gains from trade. *World Bank Economic Review* **15**(3): 393–429.

Zajac EJ, Olsen CP. 1993. From transaction cost to transaction value analysis: implications for the study of interorganizational strategies. *Journal of Management Studies* **30**(1): 131–145.

