Technological knowledge and governance in alliances among competitors

Joseph P. McGill

Department of Management
College of Business
Kean University
1000 Morris Ave.
Union, N.J. 07083, USA
Fax: (908)737 4165
E-mail: jmccgill@kean.edu

Abstract: This study examines how the governance form of an alliance enables partners to develop, transfer and protect knowledge in alliances. More integrative forms of control are expected when collaborations are exploratory in nature, when partners are moderately similar in technological knowledge and when industry rivalry increases. An empirical analysis of alliances, patent cross-citation rates and industry structure for 109 firms in the communications equipment industry over ten years offers support for the hypothesised effects. Support was found for a curvilinear relationship between the technological similarity of partners and the form of alliance governance. Results confirm that similarity in technology knowledge and industry rivalry influence alliance partners’ choice of governance.

Keywords: knowledge management; strategic alliances; technology alliances; industry rivalry; patents; communications industry; knowledge based view; Transaction Cost Economics (TCE).


Biographical notes: Joseph P. McGill is Associate Professor of Management at Kean University in New Jersey. He has been a member of the faculty at Kean since 2003, teaching courses in Strategic Management and Global Business. Dr. McGill’s research interests are in alliance formation and governance in high-technology industries, with a particular focus on the role of governance in integrating cooperative and competitive activities between alliance partners.

1 Introduction

The dramatic and worldwide growth of strategic alliances in the last 20 years indicates the value firms place on opportunities to combine and create new capabilities (Hagedoorn, 1996). Not surprisingly, the structures used by firms to combine and protect resources in alliances have been an important focus of knowledge-based (Kogut and Zander, 1992), Transaction Cost Economics (TCE) (Williamson, 1985) and real options theories (Folta, 1998). Although the ability to learn through collaboration is critical to the development of new capabilities, learning may also create vulnerabilities (Hamel, 1991).
This is especially true of high-technology industries where rapid shifts in markets and technologies increase the likelihood that collaborations will develop among partners who are also competitors. Partnering under these conditions involves significant uncertainty regarding the form of collaborative structure needed to transfer and integrate resources on one hand, and to protect resources from unintended transfer on the other. As a result, attention continues to be drawn to alliance governance as a means to create and protect valuable resources.

The setting for this study is the global communications equipment manufacturing industry. Over the past two decades, a tremendous amount of acquisition, merger and alliance activity has occurred in this industry from the combination of local market deregulation and convergence between information and communications technologies (Oh, 1996; Chan-Olmsted and Jamison, 2001). While service providers (carriers) have been the most directly affected by regulatory shifts, firms that design and deliver technology to service providers have also increased their level of alliance activity, driven largely by the need to achieve technology dominance across global markets in order to amortise large R&D investments. Although the liberalisation of local markets allowed the entry of new carriers, and in some cases provided market opportunities for the equipment divisions of vertically integrated carriers, most local markets had already been opened to equipment suppliers prior to the deregulation of carriers in the 1990s. In addition to the large number of suppliers that had been competing globally, newer suppliers such as Cisco had never been ‘captive’ suppliers to carriers in home markets, competing instead with newer technologies in unregulated markets. In general, the global communications equipment industry has generated a large number of intra-industry technology alliances, providing a useful setting for the study of alliances among competitors.

This study examines how alliance purpose, technological similarity and industry dynamics (competitive rivalry) affect the choice of governance form. Although research on technological similarity and collaboration has grown (e.g., Mowery et al., 1996; Colombo, 2003), most studies have examined vertical interfirm relationships across numerous industries. This paper’s first contribution is the examination of horizontal collaborations, i.e., alliances among competitors within one industry, and the way partners choose to govern these alliances. Alliances must be structured to manage multiple, conflicting demands imposed by the need to explore new opportunities, to respond to competitive dynamics and to manage the flow of technological knowledge in alliances. Especially given the increasing frequency of alliances among competitors in short-cycle, high-technology industries, a study of alliances among competitors is an important step towards understanding how partners structure their collaborations to develop and simultaneously protect knowledge. The second contribution of this study lies in its examination of industry dynamics as a contextual factor influencing the way partners choose to govern an alliance. Researchers have recently noted how empirical work on alliances fails to address how collaborative activity and environments ‘co-evolve’ (Koza and Lewin, 1998; Park et al., 2002), thus providing a critique of studies examining governance as a narrowly tailored solution to the problems arising from a specific alliance’s goals. In response, this paper examines how an alliance’s industry and competitive contexts also influence the way partners structure their collaboration. Third, this paper contributes to our understanding of how the degree of similarity between partners regarding technological knowledge may affect their need for knowledge integration and therefore their choice of alliance governance.
The remainder of the paper is organised as follows: the next section addresses implications for governance from alliance purpose, followed by discussions of the effects of technological knowledge and industry rivalry. Following the data analysis and results section, the paper concludes with implications for research and practice.

2 Theory and hypotheses

Alliances are voluntary and ongoing interfirm agreements to exchange or combine resources, wherein the partnering firms agree to remain independent. Alliance governance has been studied extensively from transaction cost economics (Williamson, 1991) and, more recently, from knowledge-based perspectives (Kogut and Zander, 1992; Zollo et al., 2002). The transaction cost view focuses on co-specialised investments made between partners to increase the value of the collaboration. For example, in an effort to improve outcomes, partners may co-locate research personnel or create joint research teams to integrate partners’ know-how, and co-develop and test new or hybrid applications or technologies. However, once agreements to co-specialise are made, partners’ self-interests may derail joint efforts when, for example, one partner underinvests in the quantity or quality of needed resources, or haggles over the terms of the agreement. This potential for opportunism is minimised as governance forms shift along a continuum from least integrative (e.g., one-way licensing) through moderately integrative (e.g., bilateral arrangements such as cross-licensing or shared R&D) to most integrative (e.g., equity joint venture) (Williamson, 1985; Oxley, 1997; Grossman and Hart, 1986; Pisano, 1989). The choice of more integrative governance reduces the difficulty of specifying and enforcing property rights for know-how, and reduces incentives to misappropriate knowledge (Oxley, 1997). While the knowledge-based view predicts many of the same uncertainty-governance relationships as TCE, the knowledge-based view differs by its focus on knowledge as a source of value. In the knowledge-based view, the governance mode is important not for controlling vulnerabilities, but for the organisational and social integration it can provide to facilitate interaction, and thus knowledge creation and transfer, among participants (Kogut and Zander, 1992).

2.1 Exploration and exploitation alliances

Broadly speaking, the purpose of any alliance is to employ resources (whether owned or not) to improve a firm’s competitive position. More narrowly, the focus of alliance activity can be seen as either exploration or exploitation related (March, 1991; Koza and Lewin, 1998). Exploration alliances span organisational boundaries and provide exposure to new technologies or markets (Rosenkopf and Nerkar, 2001), while exploitation alliances attempt to increase the economic returns to current resources. Consider the communications technology industry, where, for example, the commercial feasibility of nanotechnology has created the possibility of manufacturing process innovations for optical transmission, switching and storage products. Exploration activities have begun at the intersection of nano- and current technologies and involve applications such as holographic storage and nano-based chip production, resulting in alliances involving a number of competitors including NEC and Mitsubishi (Lenatti, 2004).
Firms engaging in exploration alliances confront unfamiliar terrain, requiring learning about and developing new technology areas that are usually substantially different from either partner’s current technology (Koza and Lewin, 1998). Exploration activities often involve the use of integrated structures, such as joint ventures, to improve the speed and accuracy of knowledge transfer, both within the focal project (Mowery et al., 1996; Kogut and Zander, 1992) and upstream to parent organisations (Gopalakrishnan et al., 1999). To encourage knowledge transfer, partners rely on supporting structures such as research or project teams and encourage social and interpersonal contact among team members. However, because of the imprecision with which tacit know-how is transferred, joint structures designed to improve the integration and transfer of complex and tacit knowledge may actually lead to the unintended transfer of valuable know-how (Heiman and Nickerson, 2002). Consequently, from the TCE view, the use of integrated governance structures such as joint ventures protects firms from misappropriation of know-how, through governance structures that align incentives and thereby limit opportunism (Oxley, 1997). Bilateral and joint governance modes are also more useful than contractual approaches in enabling partners to adapt to changing circumstances without having to continuously bargain and renegotiate alliance terms (Gulati and Singh, 1998).

In contrast to exploration alliances, exploitative alliances increase returns to existing resources by commercialising or improving the productivity of existing technologies or products (Harrigan, 1988; Das and Teng, 2000). In the case of technological knowledge, alliances may focus on exploiting knowledge that is substantially common to both partners, using cost sharing R&D arrangements (Sakakibara, 1997). Because exploitation alliances leverage current resources (rather than create new resources), codified rather than tacit knowledge is transferred, which requires fewer integration and coordination investments than do exploration alliances. Accordingly:

\[ H1a \quad \text{Exploration alliances are more likely than exploitation alliances to use more integrative governance.} \]

Despite both knowledge-based and TCE rationales for the use of more integrative governance in exploration, empirical support for a link between exploration/exploitation and governance structure is mixed. Supporting the TCE view, for example, Mitchell et al. (2002) found that alliances among competitors were likely to use more integrative governance, especially for alliances involving R&D. Mowery et al. (1996) also found that equity governance arrangements increased partners’ ability to internalise new technologies, lending support to the knowledge-based view. In contrast, however, Rowley et al. (2000) found that alliance outcomes were poorer when integrative governance was used in exploration alliances, suggesting a negative relationship between exploration intent and the use of hierarchical governance. Similarly, McGrath’s (2001) study of firms engaged in business development activities demonstrated that the exploration of new markets, products and technologies was less effective when activities were governed under more formal organisational structures. Many studies that examine exploration and governance do not account for the process by which firms ‘bridge’ current knowledge to targeted areas of new knowledge, a process that is facilitated when alliance partners share some degree of cumulative experience with a given technology (Zander and Kogut, 1995; Cohen and Levinthal, 1990). Exploration intent is a necessary condition for learning, but may not be sufficient because firms can alternatively acquire
the rights to ‘encapsulated’ knowledge through licensing or acquisition. Exploration alliances as learning modes are more accurately defined by the degree of similarity between partners’ current and prospective knowledge. Formally:

**H1b** The positive relationship between exploration alliances and the use of more integrative governance is stronger when alliance partners have overlapping technological knowledge.

### 2.2 Technological similarity

The development of technological know-how is a path-dependent process in which technological and organisational knowledge co-evolve. The ability of alliance partners to transfer knowledge depends in part upon absorptive capacity (Cohen and Levinthal, 1990), because shared knowledge enables partners to recognise and integrate related knowledge from external sources. Firms are more likely to generate successful technological innovations when they build on existing knowledge (Teece, 1986), and technological similarity positively influences the choice of partners in alliance formation (Stuart, 1998). However, building on existing knowledge alone does not guarantee learning, since firms differ in their abilities to transfer and integrate external know-how (Bierly and Chakrabarti, 1996; Khanna et al., 1998). The literature is unclear about whether similarity in partners’ technological knowledge is simply a precondition for knowledge transfer or is instead a substitute for more integrated governance that simplifies knowledge transfer. For example, while Mowery et al. (1996) showed that technological similarity between firms resulted in improved knowledge transfer only when more integrative (equity) governance was used, Colombo (2003) concluded that alliances between technologically similar firms were more likely to use less integrative (non-equity) governance.

While more empirical work is needed in this area, knowledge-based, transaction costs, and real options perspectives offer insights into the presumed relationship between partners’ technological knowledge similarity and governance form. First, from the knowledge-based view technologically similar partners are more favourably positioned to engage in learning alliances because overlapping areas of technological knowledge can serve as ‘bridges’ in the exchange of know-how. Because technological development is path dependent, partners with related technological knowledge may be more capable of learning and internalising know-how (Cohen and Levinthal, 1990). Because firms seek opportunities to deploy their current knowledge resources productively (Penrose, 1959), they are likely to seek alliance partners who are technologically similar so that excessive search and knowledge acquisition costs can be avoided (Stuart and Podolny, 1996). Alliances between technologically similar partners involve the exchange and creation of knowledge, requiring social learning processes and close cooperation (Hitt et al., 2004). Because these alliances can generate relational routines that are partner specific (Dyer and Singh, 1998), these routines are not easily transferred to other uses or partners in the event one partner decides to renegotiate or withdraw from alliance commitments. From the TCE view therefore, as partners recognise this potential for hold-up or haggling (Williamson, 1991), integrative governance (e.g., equity joint ventures) more effectively aligns partners’ incentives. Because the focus of this study is on alliances among competitors within an industry, greater weight is given to the risk of appropriation;
technological similarity between partners indicates that each is more capable of identifying the competitive potential of the shared technological knowledge, requiring more integrative governance to align incentives.

Based on the preceding discussion, alliances between technologically similar partners can be expected to require more integrative governance because of the need to organise around knowledge transfer and to align partners’ incentives to avoid appropriation risks. Thus:

\[ H2a \quad \text{Technological similarity between firms will be positively related to the use of more integrative governance.} \]

Following the discussion of technological similarity and governance above, more extreme cases of technological similarity and dissimilarity may have different effects on governance than the general positive relationship hypothesised. For example, from the knowledge-based view, partners with high levels of technological similarity may find themselves redundant in terms of their ability to acquire new knowledge through the alliance. Resources are usefully combined only when partners “bring non-redundant, distinctive competencies to the partnership” (Hill and Hellriegel, 1994, p.595). Consequently, partners with high levels of technological similarity have less to learn from each other, implying a decreasing need for integrative organisational structures to facilitate knowledge transfer. From the TCE view, partners’ technological similarity may reach the point where the setup and administrative costs of integrative governance outweigh the corresponding decrease in appropriation risk. Therefore at high levels of technological similarity, behavioural uncertainty and appropriation risks decline to the point where less integrative governance becomes a more efficient organisational solution (Williamson, 1991).

In contrast, consider the case of very low or nonexistent levels of technological relatedness between alliance partners. From the knowledge-based view, partners with little or no familiarity with a prospective technology must commit resources to developing and internalising new knowledge, leading to uncertainty and time-compression diseconomies (Dierickx and Cool, 1989). Technologically dissimilar partners are disadvantaged when compared with technologically similar partners, because they face significant uncertainties and costs when exchanging and internalising knowledge. In such cases, technologically dissimilar partners may prefer to transfer and receive knowledge in ‘encapsulated’ or codified forms, using licensing or other less tightly coupled arrangements that will nonetheless allow the technology to be included in a process or product (Demsetz, 1988).

The Real Options (RO) view (Myers, 1977) highlights how the uncertainty of internalising ‘distant’ technological knowledge leads to less integrative governance. RO stresses that governance should provide flexibility under uncertainty, providing partners with the ability to make discretionary future investments while at the same time deferring the setup, administrative and dissolution costs associated with more integrative governance forms (Kogut, 1991; Folta, 1998). A real option’s value increases when partners can defer investments that would otherwise lead to sunk costs. Equity Joint Ventures (EJVs), for example, specify rights to make future investments and to claim returns, but they incur high setup, control and dissolution costs. Less hierarchical forms (e.g., licensing) also create options value because they may function as transitional governance arrangements that enable partners to shift to more integrative governance.
forms at a later time (Steenbsma and Corley, 2001). Although numerous option types can exist under limited conditions (Kulatilaka and Perotti, 1998), the option to abandon or to defer investment under uncertainty is central to RO (Adner and Levinthal, 2004). To avoid the opportunity cost of forming, managing and potentially dissolving (for example) an equity joint venture, an organisation can seek less integrated governance (e.g., licensing). Less integrative governance can be seen as a transitional arrangement that enables partners to gain information about prospective technological knowledge at a lower cost, while deferring the choice of more integrative forms to the future (Steenbsma and Corley, 2001). As an example, consider the 1997 strategic alliance (non-equity) between Cisco and Alcatel to co-integrate ATM and IP technologies. While the basic technologies involved were not easily integrated because of fundamental differences in switching and routing protocols, the alliance provided Cisco and Alcatel with the capability to develop future integrated designs to improve interoperability, and to pursue a number of related acquisitions as options on future technology development.

In combination, the effects of high, low and moderate levels of technological similarity suggest an inverted ‘U-shaped’ relationship between integrative governance and technological similarity. Based on the arguments from knowledge-based, TCE and real options views, alliances involving moderate levels of technological similarity are more likely to use more integrative governance, while partners who are either substantially similar or dissimilar in technological knowledge will be less likely to use integrative governance. Consequently:

\[ H2b \quad \text{The positive relationship between technological similarity and more integrative governance will be highest when technological similarity between firms is at moderate rather than high or low values, suggesting an inverted ‘U’ shaped relationship.} \]

2.3 Rivalry

Rivalry differs from competition, which refers to the presence of other firms in similar product markets. Rivalry refers to incompatible competitive positions that drive performance below a level predicted by the number or concentration of firms in the industry. However, not all firms within an industry face the same level of rivalry. Research from strategic group theory (Caves and Porter, 1977; Cool and Dierickx, 1993; Peteraf, 1993) suggests that as market differences among firms increase, it is more difficult for firms to detect, interpret and react to competitors’ behaviour, leading to market actions and responses that stimulate rivalry. While a negative effect of rivalry on collaboration has been shown in a number of studies (e.g., Park and Russo, 1996; Gomes-Casseres, 1996; Park et al., 2002), no research has addressed how rivalry and technological knowledge interact to affect the governance form. From the previous discussion on behavioural uncertainty due to the risk of appropriation, hold-up, and recontracting, we can expect that rivalry is most likely to affect alliances between technologically similar partners. It follows that all things being equal, technologically similar partners will be more likely to use integrative governance when faced with higher levels of rivalry. As suggested by the multi-market competition perspective (Chen, 1996; Gimeno and Woo, 1996), rivalry arises from a combination of market and resource factors. Because firms with similar resources and markets tend to recognise their mutual interdependence, they are more likely to forego competitive attacks because they
anticipate a credible threat of retaliation in shared markets. However, when market and resource similarity between firms is asymmetrical (e.g., high resource similarity and low market overlap), these firms appear more likely to intensify competitive actions (Gimeno and Woo, 1996). Therefore, alliances formed between partners under conditions of asymmetrical resource and market overlap (intensified industry competition) are more likely to require integrative governance in order to manage the behavioural uncertainty arising from increased incentives for partners to act opportunistically. Conversely, as partners’ technological and market similarity increase together, increased interdependence is likely to forestall opportunistic behaviour within alliances, reducing the need for more integrative governance. Formally:

\[ H3 \quad \text{Higher levels of market similarity will weaken the relationship between technological similarity and the use of integrative governance (i.e., } H2a \text{ } H2b). \]

3 Methods

3.1 Data

The data for alliances and firms covered in this study included 109 firms over the period 1988–1997 in the global communications equipment industry. Communications equipment manufacturers were defined as firms designing and supplying technology to ‘downstream’ service providers such as AT&T, BT and Verizon, and to other end customers. Downstream customer firms and upstream supplier firms (e.g., Broadcom in chips and processors) were similarly excluded. Based on a grouping of SIC codes representing communications equipment manufacturers, information for each year was collected from the EXTEL database for Europe and Asia, and from COMPUSTAT for North America. While this is not an exhaustive account of every firm of every size in this industry (since data on small, privately held firms are typically unavailable through secondary sources), most of the industry is accounted for in this sample, including all publicly traded firms. The study window was limited by the availability of alliance data for the ten-year period from 1988–1997; however the substantial shifts in technologies and markets (addressed earlier in this paper) generated significant intra-industry alliance activity during this period, suited to this paper’s focus on alliances among competitors. The study period included a substantial number of technology alliances, reflecting the convergence of previously separate communications technologies (e.g., voice, data, video and wireless) and transformation across a number of related technologies including communications software (e.g., CRM and unified messaging) and data switching (e.g., ADSL, ATM and SONET).

3.1.1 Alliances

For these 109 firms, information on publicly announced alliances from 1988–1997 was obtained from the Securities Database Company (SDC), resulting in 230 alliances and 306 alliance dyads (the difference reflecting alliances with more than two partners). Information was collected for each alliance, including the date formed, governance structure, functional purpose and descriptive information about the scope and rationale for the alliance. Only horizontal alliances between the 109 firms in the sample were included. Any alliances between the sample firms and firms outside the sample (i.e., vertical alliances) were excluded.
3.1.2 Patents

Patent information was used to construct a patent history for each firm over the study period (Source: MicroPatent Database). Patents must be filed to protect property rights protection, and the US patent system is the most comprehensive for purposes of analysing patterns in technology development. In the structure of US patent data, prior citations are used to indicate related patents, or ‘prior art’, providing the ability to trace common bases of technological knowledge among firms (Stuart, 1998). Based on a review of communications equipment technologies, 11 relevant patent classes were selected for this study: communications, coded data generation, optic systems, data processing systems, information storage and retrieval, multiplex communications, error detection/correction, pulse/digital/telephonic communications, audio signal processing systems/devices, optical waveguides, and information processing systems. For the 109 firms during 1988–1997, 136 124 new patents were created in these classes, and of these new patents, 14 378 contained prior patent citations cited by two or more firms in the sample.

3.2 Variables and measures

3.2.1 Governance

Following TCE logic, alliance governance modes were defined along a market-hierarchy continuum. For example, licensing involves arms-length transactions and is closest to the market end of the continuum, while non-equity governance involves more partner-specific contracting and more bilateral activity than standard licensing arrangements (Oxley, 1997; Williamson, 1985). Equity ventures provide control through joint investment, management and independent organisational structures (Gulati and Singh, 1998). Ordered values indicated the degree of integrative governance. One-way arrangements were coded with a ‘1’, and included licensing, and supply, distribution and other vertical agreements. Bilateral forms were coded with a ‘2’, and included cross-licensing, joint R&D activities, shared design or manufacturing agreements, co-marketing agreements and other activities involving shared activities. Equity agreements were coded ‘3’.

3.2.2 Technological similarity

Each patent assigned to the 109 firms between 1988 and 1997 in one of the 11 patent classes was examined to determine if it contained previous patent citations. The cross-citation rate for each alliance dyad was calculated based on common patent citations as a proportion of all current patents between dyad members. Following Mowery et al. (1996), the technological similarity measure was defined as:

\[
\text{Cross-citation rate (Firm}_1, \text{ Firm}_2) = \frac{\text{Citations to Firm}_1 \text{ patents in Firm}_2\text{'s patents}}{\text{Total citations in Firm}_2\text{'s patents}}
\]
3.2.3 Exploratory/exploitative alliances

Each alliance’s description was reviewed to determine if the purpose of the alliance was exploration or exploitation. Following Koza and Lewin (1998), an alliance was coded as exploratory (‘1’) if the intent was to create technology substantially different from either partner’s current product lines, or if the intent was to combine existing partner technologies into substantially new products or designs; otherwise the alliance was considered as exploitative (‘0’).

3.2.4 Market similarity

Market similarity was based upon distances between alliance partners within the strategic group structure of the communications equipment industry. Market similarity based on strategic group structure was chosen over a more direct measure of firm similarity because strategic group structures incorporate interdependence among firms (e.g., Nath and Gruca, 1997; Reger and Huff, 1993). To develop a measure of market similarity based on strategic groups, industry-specific variables underlying the strategic group structure were identified, validated by three industry experts and gathered from SEC 10Ks, COMPSTAT (for US firms) and EXTEL (for non-US firms) (Cool and Schendel, 1988). Variables included customer segments, global presence, product scope (voice communications, data communications, communications applications, and/or value-added systems integration), diversification, and functional focus (manufacturing versus R&D). Strategic groups were identified using Ward’s method for clustering, following the stopping rule that an additional cluster fails to provide $\Delta R^2$ of $>5\%$ and all clusters explain 60% of the variance ($R^2 > 0.60$) (Fiegenbaum and Thomas, 1990). Stable strategic time periods were identified through year-to-year changes in the variance-covariance matrices of the strategic group variables and panel input about significant breakpoints in competitive markets during 1988–1997 (Fiegenbaum and Thomas, 1990). The distance between each pair of firms was then calculated based on each firm’s strategic group membership, and Market Similarity was calculated as the reverse value of this distance. This measure was derived by using canonical discriminant analysis (SAS CANDIS procedure), which reduced the model to two dimensions, allowing distance measures between the centres of each strategic group-pair to be calculated.

3.2.5 Rivalry

Rivalry was measured in two ways. The first measure captured the degree of similarity between partners in both markets and technological knowledge (the interaction variable Market Similarity x Technological Similarity). For each alliance, the measure of strategic similarity reflects the conditions for rivalry under the multi-market competition discussed previously (Gimeno and Woo, 1996). Higher levels of this variable indicate greater overlap between partners in both market and resource terms, and thus a lower level of rivalry. Data limitations prevented a more fine-grained measure of market overlap using market segment shares; however, the Market Similarity measure captures the degree to which alliance partners are present in the same market and technology areas.
The second measure of rivalry, *Competitive Asymmetry*, captured the differences in market rivalry faced by each partner. *Competitive Asymmetry* reflected the notion that large gaps between partners in the competitive pressure they face could require more integrative governance to limit opportunistic behaviour in the alliance (Williamson, 1991). First, a rivalry index was established for each firm by subtracting the squared market share of each firm from the industry Herfindahl (Cool and Dierickx, 1993) and then determining the absolute value of the difference in rivalry measures for the two firms in each dyad. *Competitive asymmetry* was measured as the absolute difference in the levels of rivalry faced by alliance partners. The significance of these last two measures is that partners facing substantially different competitive environments are likely to have asymmetric interests in and reactions to the collaboration, leading to the use of more integrative governance to control uncertainty.

### 3.2.6 Control variables

Previous studies have suggested control variables that influence the choice of governance. First, *prior ties* between partners may influence the choice of governance in subsequent alliances because partners may develop trust through repeated ties, and trust may act as a substitute for formal governance structures (Gulati, 1995). For each alliance formed during the study period, the count of prior alliances from the preceding two years was included. A measure for cross-border alliance activity, *international*, was introduced to control for the complexity expected in alliances spanning multiple regions (Europe, North America, Asia).

### 3.2.7 Data analysis

Since the dependent variable *Governance* is an ordinal variable and independent variables are a mix of categorical, ordinal and continuous measures, I used ordinal logistic regression (ordered logit model) to test the hypotheses. The logistic regression model is specified as:

$$
\ln[P(1-P_i)] = \alpha + \beta \chi_i
$$

where $\alpha$ is the intercept parameter, $\beta$ is the vector of slope parameters, and $\chi_i$ is a vector of explanatory variables. The logistic regression model is suited for noncontinuous dependent variables that can nonetheless be ordered, and tests the probability that the data fit the specified model using the method of maximum likelihood (Agresti, 2002). Results were obtained using the logistic regression procedure from SAS V8.

### 4 Results

Table 1 shows firms within the communications equipment manufacturing industry for the period 1992–1996, the longest period of stable strategic group membership during the study period.
Table 1
Strategic groups and business firms in the communications equipment industry (1992–1996)

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2,7 (i)</th>
<th>Group 3</th>
<th>Group 4</th>
<th>Group 5</th>
<th>Group 6</th>
<th>Group 8</th>
<th>Group 9</th>
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<tr>
<td>Global voice and data</td>
<td>Applications – end customers</td>
<td>Multi-media segment focus</td>
<td>Data transport</td>
<td>Applications – service providers</td>
<td>Global voice</td>
<td>Multi-segment voice and data</td>
<td>New voice/data-service providers</td>
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</table>

(i) Strategic groups and business firms in the telecommunications equipment industry (1992–1996)
<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2,7 (1)</th>
<th>Group 3</th>
<th>Group 4</th>
<th>Group 5</th>
<th>Group 6</th>
<th>Group 8</th>
<th>Group 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global voice and date</td>
<td>Applications – end customers</td>
<td>Multi-media segment focus</td>
<td>Data transport</td>
<td>Applications – service providers</td>
<td>Global voice</td>
<td>Multi-segment voice and data</td>
<td>New voice/data-service providers</td>
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<tr>
<td>Scientific Atlanta</td>
<td>Polycom Inc</td>
<td>Intellect Commnctn</td>
<td>Tekon Corporation</td>
<td>Excel Switching Corp</td>
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<tr>
<td>Tadiran Ltd</td>
<td>Pulspoint Comm</td>
<td>Inter-Tel Inc</td>
<td>General Datacomm Inds</td>
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<td></td>
<td>Synellect Inc</td>
<td>IPC Info Sys</td>
<td>Newbridge Networks</td>
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<td></td>
<td>Veramark Tech</td>
<td>JWE Telecom</td>
<td>Pairgain Technologies</td>
<td></td>
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<td></td>
<td>Vocalis Group Plc</td>
<td>Oneworld Systems</td>
<td>Premisys Comm Inc</td>
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<td>Summa Four</td>
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<td>Tellabs Inc</td>
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<td>Tekspec Plc</td>
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<td></td>
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<td>Westell</td>
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<td></td>
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<td>World Access</td>
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</tbody>
</table>
Table 2 contains the means, standard deviations and Pearson correlations for variables used to test the hypotheses about the choice of governance.

Table 2  
Descriptive statistics and correlations

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>S.D.</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Governance</td>
<td>1.87</td>
<td>0.86</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Prior Ties</td>
<td>1.18</td>
<td>2.14</td>
<td>0.13</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>3. International</td>
<td>0.78</td>
<td>0.41</td>
<td>0.26</td>
<td>0.13</td>
<td>&lt; 0.0001</td>
<td>0.02</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Exploration</td>
<td>0.38</td>
<td>0.49</td>
<td>0.37</td>
<td>0.09</td>
<td>0.05</td>
<td>&lt; 0.0001</td>
<td>0.13</td>
<td>0.31</td>
<td></td>
</tr>
<tr>
<td>5. Technological similarity</td>
<td>0.02</td>
<td>0.03</td>
<td>0.17</td>
<td>0.37</td>
<td>0.11</td>
<td>-0.02</td>
<td>&lt; 0.01</td>
<td>0.05</td>
<td>0.79</td>
</tr>
<tr>
<td>6. Tech similarity squared</td>
<td>0.001</td>
<td>0.001</td>
<td>-0.01</td>
<td>0.19</td>
<td>-0.01</td>
<td>0.02</td>
<td>0.78</td>
<td>&lt; 0.0001</td>
<td>0.05</td>
</tr>
<tr>
<td>7. Market similarity</td>
<td>4.16</td>
<td>2.38</td>
<td>0.10</td>
<td>0.13</td>
<td>0.05</td>
<td>-0.07</td>
<td>0.24</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>8. Competitive asymmetry</td>
<td>0.62</td>
<td>0.80</td>
<td>0.14</td>
<td>-0.04</td>
<td>0.05</td>
<td>0.01</td>
<td>0.06</td>
<td>-0.01</td>
<td>-0.04</td>
</tr>
</tbody>
</table>

Note:  
a N = 306 (alliances). Correlations above |0.11| are significant at the 5% level, those above |0.15| are significant at the 1% level.

4.1 Hypothesis testing

Table 3 contains ordinal logistic regression results for the hypotheses. Main effect and interaction variables were examined for their variance inflation factors and all variables had VIF values well below 2. The scores for the models’ proportional odds assumptions were nonsignificant.

Model 1 shows the control variables and the independent variables for Hypothesis 1a (exploration) and Hypothesis 2a (technological similarity). Model 1 was significant overall at p < 0.0001, Wald $\chi^2 = 60.3$. The control variable international was significant in the expected direction, while prior ties was not significant, although the sign was as expected. The finding for prior ties is not entirely surprising given the tentative nature of empirical support for this prediction. The results for Model 1 support Hypotheses 1a and 2a, which proposed that exploration alliances and alliances between technologically similar partners would use more integrative governance forms. Model 2 tests Hypothesis 2b, which proposed that moderate levels of technological similarity would increase the likelihood that more integrative governance would be used. To test this hypothesis, technological similarity squared is introduced into the model together with technological similarity. Although the introduction of a squared term with the term itself can introduce a multi-collinearity problem, this can be resolved by normalising (or centering) the term in its mean deviation form before squaring it (Agresti, 2002, p.167). By introducing orthogonality between the term and its square, multi-collinearity is reduced. Model 2 was
improved from Model 1 with Wald $\chi^2 = 73.9$ and $R^2 = 0.26$. Both technological similarity and its square were significant at $p < 0.0001$, and the negative coefficient value for the squared term indicates that the relationship between technological similarity and governance is curvilinear with an inverted ‘U’ shape as hypothesised, providing support for Hypothesis 2b. Model 3 introduced the interaction term exploration x technological similarity to test Hypothesis 1b, which proposed that technological similarity between partners would strengthen the use of integrative governance in exploration alliances. The interaction term was significant at $p < 0.05$, providing support for Hypothesis 1b. Models 4 and 5 test the alternative measures of rivalry under Hypothesis 3, which proposed that higher levels of rivalry would increase the use of integrative governance in alliances. Model 4 tests the negative interaction of technological and market similarity, providing limited support ($p < 0.08$) for an inverse relationship between integrative governance and the overlap between partners in technological and market domains. Model 5 provides support ($p < 0.05$) for an increased use of integrative governance as partners become more divergent in the level of rivalry they confront. Models 4 and 5 are each improved over prior models with increases in Wald $\chi^2$ and in $R^2$.

To illustrate the relationships between technological similarity, market similarity and the governance form, Figure 1 provides a surface plot for these three variables (SAS G3D procedure using spline interpolation). The curvilinear relationship between technological similarity and governance can be seen through the Technological_Similarity plane, and the shift towards less integrative governance can be seen as Technological_Similarity and Market_Similarity increase together.

Although the primary focus of this study is governance form, supplementary analyses were performed to explore possible implications for firm performance. Because no alliance-level performance data were available in this study, firm-level measures of ROA and ROS were used with a one-period (i.e., one SSTP) lag. Model specification and assumptions about cross-level effects are problematic since many factors other than alliance activity affect performance; however, this supplementary analysis was exploratory in nature. It could also be noted also that for many firms, alliance activity is key to competitiveness and systematically related to a firm’s overall strategy. Various combinations of independent variables including technological similarity, rivalry and integrative governance were regressed on ROA and ROS. Results showed a significant effect on ROS from the interaction of integrative governance, rivalry differences between partners, and technological similarity ($p < 0.05$, $F = 3.07$). ROA was not significant in any model. One interpretation of this finding is that higher performance was accrued to firms that (in combination) used more integrative governance and chose partners who were similar technologically and in terms of the level of rivalry they were confronting.
Table 3: Ordinal logistic regression results for governance

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior ties</td>
<td>-0.02 (0.06)</td>
<td>-0.02 (0.06)</td>
<td>-0.04 (0.06)</td>
<td>-0.04 (0.06)</td>
<td>-0.03 (0.06)</td>
</tr>
<tr>
<td>International</td>
<td>**1.20 (0.30)</td>
<td>**1.10 (0.31)</td>
<td>**1.12 (0.31)</td>
<td>**1.13 (0.31)</td>
<td>**1.10 (0.31)</td>
</tr>
<tr>
<td>Exploration</td>
<td>**1.52 (0.24)</td>
<td>**1.72 (0.25)</td>
<td>**1.23 (0.30)</td>
<td>**1.33 (0.30)</td>
<td>**1.22 (0.30)</td>
</tr>
<tr>
<td>Technical similarity</td>
<td>**12.6 (4.6)</td>
<td>**38.7 (7.8)</td>
<td>**30.3 (8.4)</td>
<td>**79.1 (30.1)</td>
<td>**28.5 (8.5)</td>
</tr>
<tr>
<td>Technical similarity squared</td>
<td>**-594 (143)</td>
<td>**-702 (169)</td>
<td>**-691 (168)</td>
<td>**-680 (170)</td>
<td></td>
</tr>
<tr>
<td>Exploration × technical similarity</td>
<td>**29.5 (10.2)</td>
<td>*25.6 (10.2)</td>
<td>**29.8 (10.2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market similarity</td>
<td>+0.01 (0.005)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Market similarity × technological similarity</td>
<td>+0.42 (0.23)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Competitive asymmetry</td>
<td>*0.30 (0.15)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercept 3</td>
<td>**-2.78 (0.33)</td>
<td>**-2.89 (0.34)</td>
<td>**-2.65 (0.34)</td>
<td>**-3.71 (0.66)</td>
<td>**-2.82 (0.36)</td>
</tr>
<tr>
<td>Intercept 2</td>
<td>**-1.52 (0.30)</td>
<td>**-1.56 (0.31)</td>
<td>**-1.29 (0.32)</td>
<td>**-2.32 (0.63)</td>
<td>**-1.44 (0.32)</td>
</tr>
<tr>
<td>-2 log-likelihood</td>
<td>582</td>
<td>563</td>
<td>554</td>
<td>549</td>
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</tr>
<tr>
<td>$R^2$</td>
<td>0.21</td>
<td>0.26</td>
<td>0.28</td>
<td>0.29</td>
<td>0.29</td>
</tr>
<tr>
<td>Z</td>
<td>***60.3</td>
<td>***73.9</td>
<td>***74.1</td>
<td>***79.0</td>
<td>***77.3</td>
</tr>
</tbody>
</table>

Notes:
- Standard errors in parenthesis
- Ordered dependent variable: unilateral = 1, bilateral = 2, equity = 3
- $+p < 0.08, *p < 0.05, **p < 0.01, ***p < 0.001$
5 Discussion

The key finding of this paper is that the purpose of the alliance, the technological knowledge, and competitive dynamics interactively affect how partners chose to govern their collaborations. More integrative governance forms are used when partners are moderately similar in their bases of technological knowledge, rather than extremely similar or extremely dissimilar. This curvilinear relationship between knowledge and governance is also influenced by the competitive rivalry that partners face.

This study contributes to our understanding of how partner-specific factors, such as technological knowledge, combine with industry-level factors to influence alliance activities. The finding that technological similarity between partners increased the likelihood that integrative governance would be used supports the argument that alliance partners structure their exploration and knowledge-‘bridging’ activities in a patterned way. It is apparently not exploration per se but the need to internalise external knowledge quickly that affects the choice of governance form. This alliance behaviour is consistent with the idea that technologically similar partners forge more highly integrated linkages to complement and capitalise on absorptive capacity (Cohen and Levinthal, 1990). The finding of a nonlinear relationship between partners’ technological knowledge and the governance form they chose indicates that alliance activities have multi-theoretic foundations, including those grounded in the knowledge-based view, transaction cost economics, and real options reasoning. While higher levels of either technological similarity or dissimilarity involve less integrative governance, moderate levels of
technological similarity increase the likelihood that more integrative governance will be used. These results suggest that partners select governance forms that efficiently manage the uncertainties arising from partners’ similarity.

Although the choice of interfim linkage has been viewed as an outcome of the relational characteristics of partners and the alliance’s purpose (Gulati, 1995), the results of this study suggest that industry effects are also an important part of how collaborations with competitors are structured. Rivalry was found to have a significant effect on the choice of governance, indicating that rivalry intensifies the uncertainty associated with allying with a competitor. Partners apparently increase the use of integrative governance when facing either higher or dissimilar levels of rivalry. It is interesting to note that alliance governance as well as alliance formation can be seen as adaptive processes – partners choose governance at least in partial response to competitive dynamics in an industry.

This study complements previous research on alliance governance by examining how technological knowledge can be both cultivated and protected through governance. This study also adds to our knowledge of collaborative activities among competitors, which has only recently begun to be explored (e.g., Park and Russo, 1996), showing that governance decisions may differ in important ways between vertical and horizontal alliances.

Although the results of this study provided support for the hypotheses, a number of limitations should be noted. The ability to generalise findings from the communications equipment industry to other industries may be problematic, because the focal industry experienced significant shifts in technologies and market structure during the study period. Less turbulent industries may confront different competitive dynamics with potentially different effects on knowledge transfer and governance decisions. Additionally, while this industry also grew at a significant rate during the study period, industries that have matured or are declining may exhibit different alliance patterns (Cool and Dierickx, 1993). Future research might consider, for example, the effects of competitive dynamics on alliances across multiple industries. A second limitation in this study arises from relying exclusively on patent-citation relationships to indicate similarity in technological know-how. Although patents are frequently used in alliance research to indicate knowledge relationships among firms, patents alone may not capture important dimensions of technology-specific knowledge such as tacitness and complexity (McEvily and Chakravarthy, 2002). Future studies might consider multi-method approaches using primary research to examine important dimensions of technological knowledge that would complement patent-based measures. Nevertheless, the findings of this study suggest that governance decisions are a response to partners’ technological knowledge and competitive positions, and so are likely to be relevant to many industries. Although each industry will have distinctive knowledge and competitive factors, these factors will significantly influence alliance governance decisions.
References


Technological knowledge and governance in alliances among competitors  


