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Disentangling the role of knowledge similarity on the choice of alliance structure

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ABSTRACT

This paper examines the effect of knowledge similarity on the choice of alliance structure in the biotechnology industry. Knowledge similarity between two alliance partners has implications for both integrating and protecting knowledge. Alliance partners have incentives to select the alliance structure that maximizes efficiency in integrating knowledge. Likewise, alliance partners have incentives to select the alliance structure that protects appropriable knowledge. We draw upon the arguments of the knowledge accessing theory and causal ambiguity perspectives as well as the transaction cost economics perspective to predict the role of knowledge similarity on the choice of alliance structure. We empirically test the role of technological overlap and technological component on alliance structures-equity based versus non-equity based. The empirical results show that as technological overlap increases and technological component exists, the probability of equity based alliance structure increases.

Introduction

Given its frequency and importance to firms, alliances have received significant research interest among strategy scholars. A key issue within this research stream has been what factors impact the choice of the alliance structure. With the increasing importance of knowledge, a few studies (Colombo,

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2003; Sampson, 2004) have examined the role of knowledge similarity (i.e., similar versus dissimilar) between two partners on the choice of alliance structure (i.e., non-equity based versus equity based). Drawing on the knowledge-based view and transaction cost economics, these studies suggest that the transfer of knowledge and protection of knowledge play a key role in the structure of alliances. These studies are consistent with much of the prior literature that emphasizes acquisition of knowledge or organizational learning as the main motivation for alliances.[2] However, Grant and Baden-Fuller (2004) and Hennart (2005) propose that the prior literature has been limited by focusing mainly on *acquisition* of knowledge and largely ignoring a firm's desire to *access* knowledge as a motivation for alliances. Furthermore, the extant alliance literature has not fully explored the concept of casual ambiguity (King, 2007; Cording et al., 2008) and its role on knowledge integration on alliance structures.

In this paper, we investigate further the role of knowledge similarity between two partners on the choice of alliance structure. Prior research has focused on the role of knowledge similarity in the context of transferring and protecting knowledge (or acquiring knowledge) and its effects on alliance structures (Colombo, 2003; Sampson, 2004). However, we know less about the role of knowledge similarity in the context of accessing knowledge (or integrating knowledge) and its effects on alliance structures (Grant and Baden-Fuller, 2004; Hennart, 2005). In doing so, we hope to sort out the complex role of knowledge similarity and to add to the literature by focusing on the concept of knowledge integration on the choice of alliance structure. We begin by reviewing the literature that has mainly employed the knowledge based view and transaction cost economics perspectives to prescribe how best to structure the alliance to achieve knowledge transfer and knowledge protection. We next draw on the knowledge accessing theory (Grant and Baden-Fuller, 2004; Hennart, 2005) and the literature on casual ambiguity (King, 2007; Lippman and Rumelt, 1982; Rumelt, 1984) to present differing arguments and predictions on the role of knowledge integration on the choice of alliance structure. We also briefly revisit the transaction cost economics perspectives on knowledge protection. The subsequent section describes the data and methodology to empirically test our predictions. We then summarize the empirical findings and offer some concluding remarks.

Knowledge transfer and knowledge protection: knowledge based view and transaction cost economics perspectives

Many studies (e.g., Gulati and Singh, 1998; Kogut and Zander, 1992; Mowery et al., 1998; Kale and Singh, 2007; Tiwana and Keil, 2007; Mesquita et al., 2008) have examined the role of knowledge in alliances. However, we limit our review to the studies that focus on knowledge type (i.e., *similar*, *dissimilar*, or *very dissimilar*) between two alliance partners and its implications for the choice of alliance structure since that is the focus of our study. While there are many variations of alliance structures, we focus on two distinct types of identified in prior research (Colombo, 2003; Sampson, 2004; Kale and Singh, 2009): (1) equity based, which involve equity investments or share purchases, and (2) non-equity, which involve contractual arrangements such as joint research and development or distribution agreements without the terms of equity. There exist clear tradeoffs between the two types of alliance structures. Equity relative to non-equity alliance generally confers more control, which leads to better transfer and integration of knowledge through close coordination between two partners and better protection of proprietary knowledge against a potentially opportunistic partner. However, equity relative to non-equity alliance generally requires more investment and risk. We speak to these arguments further in subsequent discussions (see Table 1).

To date, there exist two prominent studies (Colombo, 2003; Sampson, 2004) that examine the role of knowledge similarity on alliance structure by drawing upon the knowledge based view (KBV) and transaction cost economic (TCE) perspectives. Using these theoretical arguments, they offer similar and inconsistent prescriptions on how best to structure the alliance to achieve knowledge transfer and

[2] While economic motivations are often given for alliances, there may exist non-economic motivations such as dependence, control, and uncertainty (Pfeffer and Salancik, 1978) for alliances. In addition, organizational learning can occur not only in acquisition of knowledge but also in accessing knowledge (Zahra and George, 2002).

Table 1
Theoretical arguments and predictions for the role of knowledge similarity on alliance structure.

Knowledge between alliance partners	Knowledge based view perspective	Transaction cost economics perspective	Knowledge accessing theory & knowledge ambiguity perspectives	Alliance structure
Similar	Knowledge transfer: Familiar knowledge so easier and less knowledge to transfer, coordinate and control	Knowledge protection: Familiar knowledge so less risk of opportunism and leakage of knowledge		Non-equity
		Knowledge protection: Familiar knowledge so greater risk of knowledge leakage or appropriability	Knowledge integration: Familiar knowledge so easier and less cost and less ambiguity to combine similar types of knowledge	Equity
Dissimilar			Knowledge integration: Unique knowledge so harder and greater costs and greater ambiguity to combine dissimilar types of knowledge	Non-equity
	Knowledge transfer: Unique knowledge so harder and more knowledge to transfer, coordinate and control	Knowledge protection: Unique knowledge so greater risk of opportunism and leakage of knowledge		Equity
Very dissimilar		Knowledge protection: Greater unique knowledge so less risk of opportunismand leakage of knowledge	Knowledge integration: Unique knowledge so harder and greater costs and greater ambiguity to combine dissimilar types of knowledge	Non-equity
	Knowledge transfer: Greater unique knowledge so harder and more knowledge to transfer, coordinate and control			Equity

knowledge protection. Colombo (2003)[3] and Sampson (2004) suggest that both theories offer the same prediction when two firms have *dissimilar* knowledge. From a KBV perspective, Colombo proposes that the equity based alliance structure facilitates knowledge transfer by reducing coordination costs, supporting relation-specific investments, and overcoming the lack of absorptive capacity (Cohen and Levinthal, 1990). Similarly, Sampson proposes that the equity based alliance structure facilitates knowledge transfer by increasing the efficiency of coordination and learning better than the non-equity based alliance structure. From a TCE perspective, both Colombo and Sampson propose that the equity based alliance structure safeguards against leakage of knowledge better than the non-equity based alliance structure. Thus, under the condition of dissimilar knowledge between alliance partners, both theories prescribe an equity based structure.

Interestingly, Colombo (2003) and Sampson (2004) suggest the two separate theories differ in their predictions under different conditions when knowledge is *similar* or *very dissimilar*. First, when knowledge is *similar* between two alliance partners, Colombo (2003) proposes that the KBV perspective recommends the non-equity based alliance structure because knowledge transfer is easier

[3] Colombo's (2003) study uses similar arguments associated with the KBV perspective but refers to them as the competence perspective.

and sufficient absorptive capacity is present. But Colombo proposes that the TCE perspective is inconsistent in its prediction as it recommends the equity based alliance structure because of greater risk of unintended leakage of knowledge but also recommends the non-equity based alliance structure because of risk of holdup or opportunism is reduced. When knowledge is *very dissimilar* between two alliance partners, Sampson (2004) proposes that the KBV perspective recommends the equity based structure as the need to facilitate knowledge transfer remains. However, the TCE perspective recommends the non-equity based structure as the threat of opportunism is reduced because of the lack of absorptive capacity – a firm's ability to "identify, assimilate and exploit knowledge" (Cohen and Levinthal, 1990: 569).

Both Colombo (2003) and Sampson's (2004) studies find empirical support for the KBV as firms use equity based alliance structures as knowledge dissimilarity increases to ease the transfer of knowledge between two partners. Both studies also find empirical support for the TCE perspective that firms use equity based alliance structures to safeguard against leakage of knowledge. Colombo (2003) finds as knowledge dissimilarity increases firms use equity based alliance structures only when the alliance has a technological component. Moreover, Sampson (2004) finds that firms use non-equity based alliance structures at very high levels of knowledge dissimilarity (i.e., a curvilinear relationship). Since the concern for opportunism dominates the concern for knowledge transfer, Sampson (2004) concludes that TCE perspective provides a better explanation at least in the context of R&D alliance structures.

Table 1 summarizes the theoretical arguments and predictions of the KBV and TCE used in prior studies to explain the effect of knowledge similarity on the choice of alliance structure. We also present the theoretical arguments and predictions of knowledge accessing theory and knowledge ambiguity used in this study. We discuss in more detail these concepts in the following section.

Knowledge integration: knowledge accessing theory and knowledge ambiguity perspectives

Grant and Baden-Fuller (2004) and Hennart (2005) suggest that the literature has mainly viewed alliances as a "quest for resources" or a "learning race." Consequently, many studies (e.g., Hamel, 1991; Kogut, 1988; Thorgren et al., 2009) have presumed acquiring knowledge or organizational learning as the primary objective of alliances. Naturally, this focus on knowledge transfer raises the importance of knowledge protection in alliances (Heiman and Nickerson, 2004; Kale et al., 2000). Thus, prior studies have drawn on both KBV and TCE to explain the role of knowledge transfer and protection on alliance structure (Colombo, 2003; Sampson, 2004).

While recognizing some firms pursue alliances to *acquire* knowledge, Grant and Baden-Fuller (2004) and Hennart (2005) suggest that many firms pursue alliances primarily for *accessing* knowledge – referred to as the knowledge accessing theory (KAT). Hennart (2005) also states that the prior literature on alliances has focused more on internalizing knowledge than accessing knowledge and suggests that "scholars pay greater attention" to the latter issue (p. 106). Acquiring knowledge focuses on knowledge transfer, while accessing knowledge focuses on the efficiency of knowledge integration (Kleinsmann et al., 2010). Grant and Baden-Fuller (2004: p. 67) define knowledge integration as "combining multiple types of knowledge into goods and services." Hennart (2005: p. 106) refers to knowledge integration as cooperative specialization, which is defined as the "pool[ing] of competencies with those of their partner" and "specializ[ing] in what they do best." Although Grant and Baden-Fuller (2004) speak to the role of knowledge integration at a broader level of firm governance (i.e., market versus alliance versus hierarchy), we propose that these ideas can be used to explain the role of knowledge integration at a more precise level of alliance structure (i.e., non-equity based versus equity based). As Grant and Baden-Fuller (2004: 68) note, the "efficiency of integration tends to decline as the firm's knowledge domain expands" and efficiency of integration is maximized through markets when multiple types of knowledge are present.

From the KAT perspective, combining multiple types of knowledge increases the costs of integrating the knowledge in the alliance. In other words, the non-equity based has an advantage over the equity based alliance structure when two partners have *dissimilar* knowledge because of the high costs and difficulty in integrating multiple types of knowledge. Conversely, the equity based has an advantage over the non-equity based alliance structure when two partners have *similar* knowledge because of the lower costs and ease in integrating fewer or common types of knowledge.

We next explore knowledge integration from a causal ambiguity perspective. Causal ambiguity is defined as ''a basic ambiguity concerning the nature of the causal connections between actions and results'' (Lippman and Rumelt, 1982: 418). Most studies have emphasized the role of causal ambiguity as a source of sustainable advantage or inimitability among separate, competing firms. However, some studies have suggested that casual ambiguity exists within a firm to affect performance. Rumelt (1984) states that ''there is ambiguity as to what the factors of production actually are and as to how they interact'' (p. 562) and refers to this as ''*uncertain postentry efficiencies*'' (p. 565, italics in original). Reed and DeFillippi (1990: 90) describe that ''at the extreme, ambiguity maybe so great that not even managers within the firm understand the relationship between actions and outcomes.'' Empirical studies that examine casual ambiguity within a firm and within alliances are rare. One noted exception is King and Zeithaml's (2001) study that found different types of causal ambiguity affect firm performance in different ways. Another is Simonin's (1999) study that focused on casual ambiguity and its impact on knowledge transfer or learning – not knowledge integration – within alliances. In a more recent study, King (2007) reviewed various concepts and measures for causal ambiguity that affect a firm's competitive advantage.

If we acknowledge that casual ambiguity exists within a firm (or intrafirm casual ambiguity), then knowledge ambiguity exists in alliances and can impact their structure and performance. Drawing from Lippman and Rumelt (1982), we define *knowledge ambiguity* as the basic ambiguity concerning the nature of the causal connections between knowledge and results. As we noted earlier, Grant and Baden-Fuller (2004: 67) defined efficiency of *knowledge integration* as ''combining multiple types of knowledge into goods and services.'' In the context of alliances, we propose that knowledge ambiguity: (1) appears from the fact that two alliance partners cannot fully figure out the complex cause-effect relationships between their respective knowledge and performance and (2) affects the efficiency and effectiveness of the process during which knowledge is integrated. Clearly, when two alliance partners have *dissimilar* knowledge, the two partners are more unfamiliar with each other's knowledge. This results in increasing knowledge ambiguity, which, in turn, makes knowledge integration more difficult because it will be harder and more costly to combine multiple types of knowledge.

As we discussed earlier, Grant and Baden-Fuller (2004) suggest that the efficiency of knowledge integration tends to decline as a firm's knowledge domain expands and the efficiency of integration is maximized through markets when multiple types of knowledge are present. Drawing on these arguments of the knowledge accessing theory and knowledge ambiguity, we propose that the non-equity based has an advantage over the equity based alliance structure when two partners have *dissimilar* knowledge because knowledge ambiguity and knowledge integration costs are increased. Conversely, the equity based has an advantage over the non-equity based alliance structure when two partners have *similar* knowledge because of knowledge ambiguity and knowledge integration costs are decreased. (See Table 1 for a complete summary of the arguments and predictions of the different theoretical perspectives to explain the role of knowledge on alliance structures.) Thus, we offer the following hypothesis:

Hypothesis 1. As the similarity of knowledge increases between two partners, the probability of equity based alliance structure increases.

Revisiting knowledge protection: transaction cost economics perspective

Since the concept of knowledge protection in alliances has been widely studied and transaction cost economics (TCE) has been widely used to explain governance structure, we only provide a brief discussion here. Simply put, TCE suggests that hierarchy has an advantage over market because hierarchy reduces the threat of opportunism (Coase, 1937; Williamson, 1975, 1985). As such, firms will pursue alliance structures to reduce the possible opportunistic behavior of partners (Williamson, 1991; Oxley, 1999; Hoetker and Mellewigt, 2009). The threat of opportunism is escalated when alliances have a technological component because it intensifies the learning race in alliances (Colombo, 2003). Furthermore, technology has been considered as a highly appropriable asset (Coff, 2003; Oxley, 1999; Kim, 2009) and technological leakage has been of interest in designing alliance structure (Gulati and Singh, 1998; Monteverde, 1995; Pisano, 1990; Robertson and Gatignon, 1998; Teece, 1986; Li et al., 2008; Mayer, 2006). For example, Pisano (1990) observed high transaction costs when the presence of technological component existed in alliances. In sum, TCE argues that hierarchy can safeguard against knowledge leakage or appropriability of knowledge. Thus, we offer the following hypothesis:

Hypothesis 2. When an alliance has a greater risk of appropriability, the probability of equity based alliance structure increases.

Method and analysis

Sample

The biotechnology industry provides an ideal context to study the role of knowledge integration and protection on alliance structures. First, the industry is driven by a number of knowledge intensive activities that are critical for this study (Dunne et al., 2009; Schweizer, 2005). To a great extent, the industry's knowledge can be measured through the patent activities of the firms. We thus operationalize similarity and dissimilarity of knowledge between two alliance partners by the patent activities of the alliance partners. That is, high patent overlap signifies similarity of knowledge, while low patent overlap signifies dissimilarity of knowledge. Second, many biotechnology firms rely on large pharmaceutical or chemical firms to fund their development, commercialization, and distribution activities. Thus, there are many types of alliances transactions involving equity and technological components, which allow us to test our hypotheses.

In addition, by focusing on a single industry, we remove the contextual variance that may exist in alliance transactions across different industries. For example, Oxley (1999) and Gulati and Singh (1998) showed that industries may have different levels of appropriation regime. As a result, firms in some industries may prefer more equity participation than firms in other industries. Moreover, firms may use patents more intensively in some industries than in other industries because the effect of patent protection may be different across industries (Mansfield, 1985, 1986). Therefore, patent data may not be a suitable source to examine similarity or dissimilarity of knowledge in other contexts.

We collected the alliance transactions from the North Carolina Biotechnology *Actions* database, which contains information on over 13,000 transactions and other types of events (IPOs, facility establishments, etc.) among biotechnology firms during 1982–1996. We collected the patent data from *Micropatent* 1979–1996 abstract CDs.

We adopt a unique way to identify technological components in this study. While other studies used cross-sectional data to see the relationship between relation-specific factors and governance choices, which are determined at the same time (e.g., Gatignon and Anderson, 1988; Meyer, 2001), we used longitudinal data to see the effect of previous transaction's characteristics on the following transaction's alliance structure. The reason that we adopted this method is to get more valid results in TCE (Gulati, 1995). In other words, the current alliance structure transaction may be affected by the characteristics of previous transactions. Some studies have found that the earlier alliance transaction affects the nature of later alliance transactions (Hayward, 2002; Harzing, 2000; Gulati, 1995), and TCE has been criticized that the theory considers every transaction independently and ignores possible relationships between transactions (Ring and Van de Ven, 1992).

While our approach overcomes this criticism of TCE, it greatly reduces the sample size from 13,000 to 5200 because only firms that have multiple transactions remained in the sample. We further reduced the sample by eliminating any alliance that began with the equity based structure. Therefore, the final sample includes 399 sets of alliance transactions between the same two partners. 137 alliances were equity based and 262 alliances were non-equity based. These non-equity transactions included research arrangements, license agreements, co-marketing, etc.

After finalizing the sample, patent data was collected for the alliance partners from the *Micropatent* database. The number of patents and citations were counted during 7 years before the second transaction is made. This study assumes that patent citations that are older than 7 years are not strategically important (e.g., Miller, 2006). The number of patents ranged from 0 to 4134, and the number of patent citations ranged from 0 to 33,213. While some scholars have been critical of the use of patent data because the use of patents varies across industries and the number of patents may not represent a firm's innovation abilities, we avoid these concerns by using a single industry and analyzing that uses patents to protect their intellectual property (Lee et al., 2001). In addition, as a requirement of the patent application process, an inventor must submit a list of citations to all relevant patents acknowledging the existing inventions that are nearest in technical component to the proposed invention. Patent citations, therefore, show how close any two patents are in terms of technological or knowledge similarity, which is focus of this study.

Dependent variable

The dependent variable for this study is the *alliance structure*. We use equity based alliances since the existence of equity can be an important component for hierarchical governance (Hennart, 1988; Pisano, 1989). Equity based alliances were identified by the terms of equity investments, share purchases, and so on.[4] Non-equity based alliances were identified by the terms of only contracts and agreements without the terms of equity.[5] We coded alliance transactions that are equity based as "1" and non-equity based as "0."

Independent variables

Technological overlap

To test Hypothesis 1 on the role of knowledge similarity and dissimilarity, we measured the degree of technological overlap between firms (Mowery et al., 1998). When two firms share similar technological capabilities, they will experience fewer difficulties in integrating their capabilities to explore new technology (Cohen and Levinthal, 1990). The similarity between alliance partners is often measured by "shared capabilities" that may affect alliance partner selection and transaction scope (Mowery et al., 1998). We measure technological overlap by counting the number of common patent citations that alliance partners share and divided it by total number of citations. As discussed above, patent citations show a list of references to previous patents, known as "prior art." Sharing many patent citations means that two patents come from similar prior art or the same technological branch. In other words, high common citation rates imply that two firms have similar knowledge or technologies.

Technological component

When alliance partners possess appropriable assets, they are likely to have incentives to protect the asset from each other because highly appropriable assets may be opportunistically used by transaction partners (Oxley, 1999; Klein et al., 1978). As we noted earlier, technology has been considered as a highly appropriable asset and technological leakage has been of interest in designing governance structure (Gulati and Singh, 1998; Robertson and Gatignon, 1998; Monteverde, 1995; Pisano, 1990; Teece, 1986). The *Actions* database describes summaries of transactions allowing us to identify transaction types. We follow Gulati and Singh's (1998) study that used technological component in an alliance to determine the degree of appropriability. Alliances that include such expressions as joint research, joint development and research collaboration were regarded as having a technological component (coded as 1). Alliances that include only licensing, marketing, production, and supply agreements were considered as not having a technological component (coded as 0). This variable was used to test Hypothesis 2.

[4] For example, *Actions* recorded: "Ophidian Pharmaceuticals and Eli Lilly and Co. announce that they will jointly develop a new type of pharmaceutical for the treatment of gastrointestinal infections. Under the agreement, Ophidian could receive up to $12.4 million in *equity* investments, milestone and other precommercial payments, and will manufacture the compound for Lilly. Lilly will conduct clinical testing, register and market the drug worldwide" (italics added).

[5] For example, *Actions* recorded: "Celltech to *supply* Ortho w/bulk anti-D MABs. Ortho to market the MABs w/w in its new blood typing reagent, Anti-D Bioclone, for use in hospitals/transfusion ctrs" (italics added).

Table 2
Description of variables and model.

Variable	Definition	Model prediction
Alliance structure	Dummy variable: 1 = equity based; 0 = non-equity based	Dependent
Technological overlap	Ratio of common patent citations over total citations between partners	Hypothesis 1 (+)
Technological component	Dummy variable: 1 = presence of technological component; 0 = otherwise	Hypothesis 2 (+)
Patent size	Sum of the number of patents of partners	Control
Alliance experience	Number of prior alliances between partners during 1982–1996	Control
Nationality of partners	Dummy variable: 1 = partners are from different countries; 0 = partners are from the same country	Control

Control variables

We control for *patent size* since other size measurements such as sales or number of employees may not properly characterize the size of the alliance partners and since our sample consists of biotech firms where patents are an essential resource. We also control for *alliance experience* of partners by counting the number of alliances during the target period (1982–1996). Alliance experience may be important in predicting alliance structure because if partners have prior alliance experience with each other, they are likely to develop greater trust and be more familiar with each other's knowledge base. Finally, we control for *nationality of alliance partners* as prior studies suggest it can affect alliance structure (Gulati and Singh, 1998; Oxley, 1999). For example, Oxley (1999) shows that international alliances are more equity based than domestic alliances because the cost of monitoring will be higher in international alliances (Table 2).

Model

We employed the binary logit regression model to test the effects of the independent variables on the likelihood of adopting an equity alliance.[6] The specification of the model is as follows:

$$\log \frac{P(Mi = 1)}{1 - P(Mi = 1)} = A_0 + Bi\,(Xi)$$

where $P(Mi = 1)$ is the probability that alliance i is equity based and Xi is the vector of independent variables.

Results

Table 3 presents descriptive statistics and correlations for all variables used in our regression models. The sample includes 333 alliances, among which 26% were equity-based and 66% had a technological component such as technology development, research collaboration, etc. The average number of patents was 462 for the partners during the seven years prior to the alliance. The number of patents ranged from a minimum of zero to a maximum of 4328.[7] The average number of common citations for each alliance was 2.56 and the average number of total citations for each alliance was 2749, and the average overlap ratio was around 0.001.

Table 4 shows the results of our binary logit regression models. The first column or Model 1 reports the base model including only the constant and control variables. P value of Model 1 is 0.013 (10.741 LR statistics with 3 degree of freedom), which is significant at $\alpha = 0.05$. All other models are significant

[6] The probit model produces essentially the same results.
[7] Similar to prior studies that have used patent data (e.g., Frost, 2001; Lee et al., 2001), we report high standard deviations for the number of patents (size) and the number of common citations (technological overlap).

Table 3
Descriptive statistics and correlations.

	Variable	Frequency								
		0 = non-equity	1 = equity	Mean	s.d.	1	2	3	4	5
	Alliance structure	245	88	0.26	0.4424					
1	Patent size			462	678.55	1.0				
2	Alliance experience			2.34	0.75	0.17***	1.0			
3	Nationality of partners	172	161	0.48	0.51	−0.031	0.046	1.0		
4	Technological overlap			0.001	0.003	−0.005	−0.028	−0.098	1.0	
5	Technological component	113	220	0.66	0.47	0.037	0.093	−0.080	0.008	1.0

* $p < 0.10$.
* $p < 0.05$.
*** $p < 0.01$.

Table 4
Results of binary logistic regression models.

Variable	Model 1	Model 2	Model 3	Model 4
Constant	−1.879**	−1.971***	−2.396***	−2.495***
	(0.402)	(0.407)	(0.458)	(0.464)
Patent size	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Alliance experience	0.437***	0.449***	0.402***	0.414***
	(0.157)	(0.158)	(0.159)	(0.159)
Nationality of partners	−0.440	−0.402	−0.392	−0.350
	(0.253)	(0.256)	(0.258)	(0.260)
Technological overlap		58.158*		59.506*
		(34.827)		(35.222)
Technological component			0.820**	0.828**
			(0.299)	(0.301)
N	333	333	333	333
Log likelihood	−186.927	−185.518	−182.850	−181.411
-2 {LL-LL(0)}	10.741**	13.559***	18.896***	21.775***
Increments (from 1)		2.818**	8.155**	11.034**
(from 2)				8.216**
(from 3)				2.879*
(from 4)				
Correctly classified	74.8%	75.1%	74.8%	73.6%

Standard errors are in parentheses.
* $p < 0.10$.
** $p < 0.05$.
*** $p < 0.01$.

at $\alpha = 0.01$.[8] The second column or Model 2 includes the technological overlap variable, while the third column or Model 3 includes the technological component variable. The fourth column or Model 4 includes both variables and shows the highest significance (the Chi-squared test statistics is 21.775 with 5 degrees of freedom, which is significant at $\alpha = 0.01$ level). Thus, these results suggest that the main effect of the two variables jointly determine alliance structure.[9]

The results of Model 2 support Hypothesis 1. That is, alliances between partners who share patent citations or have higher levels of technological overlap are more likely to be equity based. This result is consistent with the arguments of the knowledge accessing theory and knowledge ambiguity perspectives that knowledge similarity reduces ambiguity and costs of combining knowledge,

[8] McFadden R^2, which represents the amount of total variation explained, ranges from 0.046 to 0.064 in our models.

[9] The log-likelihood ratio increases from 10.741 to 21.775 when we added technological overlap and technological component to our model ($p < 0.005$). We also tested for a curvilinear relationship for technological overlap and for an interaction effect between technological overlap and technological component variables. Both tests were not significant.

influencing the choice of alliance structure. The results of Model 3 also support Hypothesis 2. That is, alliances involving technological component are more likely to be equity based. This finding is consistent with the arguments and prediction of transaction cost economics perspective, even after controlling the effect of previous alliance experience.[10]

Conclusions and implications

With the increasing importance of knowledge, firms pursuing alliances must manage the challenges of not only transferring and protecting knowledge but also accessing and integrating knowledge. Drawing on the knowledge-based view and transaction cost economics, prior studies (Colombo, 2003; Sampson, 2004) have examined the role of knowledge similarity on alliance structure but emphasized the aspects of knowledge transfer and knowledge protection. We also draw on the well-established transaction cost economics perspective and argue that the presence of technological component in an alliance requires firms to emphasize knowledge protection and to prefer equity based alliance structures. We find support for this perspective proposed in Hypothesis 2, and our result is consistent with prior studies.

Apart from knowledge protection, firms may also have an incentive to access and integrate knowledge in alliances. Hence, in this paper we examine the role of knowledge similarity on alliance structure but emphasize the aspects of accessing and integrating knowledge, which have been largely ignored. Drawing on the knowledge accessing theory and casual ambiguity perspectives, we argue that knowledge similarity may in fact lead to different predictions on the choice of alliance structure. That is, firms prefer equity based alliance structure as knowledge similarity or technological overlap increases between two partners because of lower ambiguity and costs of combining similar knowledge. Conversely, firms prefer non-equity based alliance structure as knowledge similarity or technological overlap decreases between two partners because of the higher ambiguity and costs in combining dissimilar knowledge. Our finding confirms these arguments proposed in Hypothesis 1.

While our finding is inconsistent with prior studies, which have found and argued that firms prefer equity based alliance structure when knowledge dissimilarity increases (Colombo, 2003; Sampson, 2004), it suggests that knowledge similarity plays a more complex role on the choice of alliance structure than previously suggested. Most importantly, if firms are motivated to access and integrate knowledge, then firms may prefer to choose an equity-based alliance structure as knowledge similarity increases between the two partners. Moreover, we posit that the relationship between knowledge similarity and alliance structure may indeed be industry specific. Sampson's study (2004) examined alliances only in the telecommunications equipment industry. Similarly, Colombo's study (2003) examined alliances in the telecommunications industry, but also included other information technology industries such as semiconductors and data processing. Likewise, our study examined alliances only in the biotechnology industry. While the industries examined in our study and past studies possess some similarities (e.g., knowledge-intensive, patent protection, importance of complementary assets, etc.), we speculate on some notable differences that may affect the relationship between knowledge similarity and alliance structure. For instance, Stuart et al. (2007) noted that firms in the biotechnology industry rely much more on vertical alliances with large pharmaceutical firms and on alliance relationships that are "more iterative and interactive" (p. 478). On the other hand, firms in information technology industries (e.g., telecommunications and semiconductors) tend to depend on both vertical and horizontal alliances and on alliance relationships that promote the development of a dominant standard or technology, which often determines who wins and losses in competition (Hill, 1997). The advantage of examining a single industry or similar industries removes the contextual variance that may exist in alliance transactions across different industries, but our inconsistent results suggest that future studies should examine other industries,

[10] Table 4 reports the ratio of "correctly classified" for each of the models. The ratios suggest that all five models perform better than a random proportion chance model of 0.615, which is derived from $p^2+(1-p)^2$, where p equals 0.26 and is the probability of an equity-based alliance. Our results show a significant increase in the log-likelihood ratio when the independent variables are added to the model but no significant impact on the correctly classified ratios. We also report small variances similar to other studies (e.g., Gulati, 1995) that have used 'correctly classified' ratio.

which may disentangle the complex role between knowledge similarity and alliance structure and shed further insights on the effects of industry context on this relationship. In sum, researchers should be circumspect in applying arguments related to knowledge access and acquisition to explain alliance structures.

Our results also proffer some managerial implications. Managers need to consider carefully the motivations for engaging in a strategic alliance, which, in return, will affect the choice of alliance structure (i.e., non-equity based versus equity based). That is, if managers are pursuing alliances to *access or integrate* knowledge, then equity based relative to non-equity based structure may be preferred when knowledge is similar between the two partners because knowledge ambiguity and integration costs will be decreased. On the other hand, if managers are pursuing alliances to *transfer or acquire* knowledge, then non-equity based relative to equity-based structure may be preferred when knowledge is similar between two partners because familiar knowledge will be easier to coordinate and control. Not surprisingly, as with many strategic decisions, our study suggests that the context – in our case the motivation for the alliance – may determine the ideal strategic choices.

Lastly, we offer some suggestions for future research. First, future studies can advance our understanding by examining different types of knowledge – for example, functional knowledge such as human resource management routines, accounting routines, and/or marketing procedures – and their effect on alliance structure. Also, the nature of managerial routines as well as industry-specific effects may further explain the complex role of knowledge similarity on the choice of alliance structure. Moreover, future studies can shed further insights by examining the effect of complementary activities between partners on the choice of alliance structure. Researchers have argued that even when two partners possess very dissimilar knowledge, they may prefer more hierarchical governance mode or equity based alliance structures if their knowledge bases are closely complementary (Richardson, 1972; Steinle and Schiele, 2002; Araujo et al., 2003; Wang and Zajac, 2007; Parmigiani and Mitchell, 2009).

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