Strategic Management Journal
Strat. Mgmt. J., **28**: 623–634 (2007)
Published online 16 March 2007 in Wiley InterScience (www.interscience.wiley.com) DOI: 10.1002/smj.623
Received 1 March 2005; Final revision received 6 December 2006

DOES PERIPHERAL KNOWLEDGE COMPLEMENT CONTROL? AN EMPIRICAL TEST IN TECHNOLOGY OUTSOURCING ALLIANCES

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While the normative logic for forming technology outsourcing alliances is that such alliances allow outsourcing firms to specialize deeper in their domain of core competence without being distracted by noncore activities, recent empirical studies have reported the puzzling phenomenon of some firms continuing to invest in R&D in domains that are fully outsourced to specialized alliance partners. An underlying—and widely made—assertion that can potentially reconcile this contradiction is that 'peripheral' knowledge (specialized knowledge in the domain of outsourced activities) complements control in technology outsourcing alliances. However, this assertion is untested; and empirically testing it is the objective of this research study. Using data from 59 software services outsourcing alliances, we show that such peripheral knowledge and alliance control are imperfect complements: peripheral knowledge complements outcomes-based formal control but not process-based control. Thus, outsourcing firms might sometimes need knowledge outside their core domain because *such knowledge facilitates effective alliance governance. Our theoretical elaboration and empirical testing of the assumed complementarities between peripheral knowledge and control in technology outsourcing alliances has significant implications for strategy theory and practice, which are also discussed.*

INTRODUCTION

Technological outsourcing alliances allow firms ('outsourcers') to specialize deeper in their domain of core competence while relying on outside specialist firms ('outsourcees') for complementary expertise and skills (Grant and Baden-Fuller, 2004). The normative logic is that such arrangements allow outsourcing firms to focus on activities that are core to their business and outsource noncore activities. As such relatively peripheral activities move outside the firm boundary, there is lesser motivation to actively maintain a skillset in activities that are no longer done in-house. A related motivation for forming outsourcing alliances is to access specialized knowledge that is so removed from the outsourcer's core activities that it might simply not exist in the outsourcing firm. The growing prevalence of outsourcing relationships encompassing a wide variety of knowledge-intensive domains such as automotive design (Takeishi, 2001), R&D (Oxley and Sampson, 2004), contract manufacturing, and software services (Ethiraj *et al.*, 2005) underscores this trend. Generally, it is costly and impractical for the outsourcer to maintain in-depth specialized knowledge in the outsourced activity's knowledge domain.

Paradoxically, recent empirical studies in the knowledge-based view of the firm have observed that firms sometimes continue to maintain knowledge in the domain of completely outsourced activities. For example, Toyota maintains in-depth

Keywords: outsourcing; alliances; software; control; IT; governance; knowledge management
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technical knowledge of specialized auto parts whose design and manufacturing are fully outsourced (Takeishi, 2002). Similarly, Brusoni, Prencipe, and Pavitt (2001) observed that the three leading manufacturers in the aircraft jet engine industry continue to invest internally in research and development for digital control electronics even though their development is fully outsourced to outside firms. This is puzzling because maintaining internal technical knowledge about activities that are fully outsourced contradicts the normative specialization-driven motivations underlying outsourcing. Whether and why an outsourcing firm requires such 'peripheral' knowledge in technological outsourcing alliances remains unclear.

Peripheral knowledge is defined as the outsourcing firm's knowledge in the domain of the activity that is outsourced to another outside firm (Brusoni *et al*., 2001; Takeishi, 2002). The objective of this research is to explore the unexamined tension that the lack of peripheral knowledge creates for the outsourcer's capacity to govern alliance activities, a key facet of which is formal control (Inkpen and Currall, 2004). The question of whether peripheral knowledge is necessary for controlling outsourcing alliance activities becomes especially important because the lack of formal authority over the outsourcee and divergent organizational objectives create a legitimate fear of opportunism for the outsourcing firm (Leiblein, Reuer, and Dalsace, 2002).

The idea that control and what we conceptualize as peripheral knowledge are complements surfaces implicitly in theories of organizational control (Kirsch, 1996; Ouchi, 1979), most notably in Jensen and Meckling's (1992: 259) assertion that 'knowledge and control are complements.' Jensen and Meckling argue that it is difficult to control specialized activities *within* the firm without in-depth knowledge about them. This idea becomes troublesome when extrapolated to interfirm boundaries. After all, maintaining in-depth knowledge of activities that are no longer carried out in-house contradicts the premise of outsourcing as a means to achieving greater focus on the core competencies of the outsourcing firm rather than having to simultaneously focus on peripheral activities as well. Therefore, knowledge-based and core competence-based perspectives offer somewhat conflicting perspectives on whether (and why) outsourcing firms need peripheral knowledge. Neither the alliances nor organizational control literature has directly examined this assertion that control and peripheral knowledge are complements. Prior research on control has focused almost exclusively on predicting the structure of control portfolios (e.g., Goold and Quinn, 1990; Kirsch, 1996; Kumar and Seth, 1998), with little direct attention to the relationships between control, peripheral knowledge, and alliance performance. We focus on knowledge that can be viewed as peripheral from the core-competence perspective, while recognizing that other types of knowledge such as that of managing alliances and partner-specific knowledge are outside the theoretical scope of our research questions. Thus, the question of whether peripheral knowledge is necessary in order for the outsourcer to exercise adequate control over the outsourcee is one that has significant theoretical implications.

The intent of this research is to empirically test whether the outsourcer's peripheral knowledge complements formal control in interfirm technological outsourcing alliances. Data from 59 interfirm software services outsourcing alliances show that they are imperfect complements: peripheral knowledge is necessary to effectively deploy outcomes-based formal control but detrimental to deploying process-based control. The theoretical elaboration and empirical testing of the implied complementarities between peripheral knowledge and control in interfirm outsourcing alliances form our central contribution.

The remainder of this paper is organized as follows. The hypotheses are developed in the next section. The subsequent sections describe the study methodology, followed by analyses and results. We conclude the paper with a discussion of the contribution and implications of the study.

THEORY AND HYPOTHESES

Control in interfirm alliances

Control in outsourcing alliances refers to the process and rules governing actions by the outsourcee firm in a manner that promotes desirable outsourcee behaviors (Choudhury and Sabherwal, 2003; Jensen and Meckling, 1992). Control is implemented by the *outsourcer* firm (the controller) through a variety of *control mechanisms* that attempt to influence *outsourcee* (the controllee) behavior to ensure that the outsourcee acts in a manner that is consistent with achieving the outsourcer's alliance objectives (Domberger, 1998). We focus on formal control mechanisms, which rely on performance-based rewards or adherence to prescribed processes (Kirsch, 1996; Ouchi, 1979). Two forms of formal control can be used: (1) *outcome controls*, which refer to the prespecification of the desired interim and final outputs without regard to the process by which the outputs are achieved; and (2) *process (or behavior) controls*, which refer to explicitly prescribing the methods and procedures to be adopted by the outsourcee in undertaking project activities. Outcome controls therefore prespecify *what* the outsourcee should accomplish while process controls prescribe *how* it should achieve that outcome (Henderson and Lee, 1992; Kirsch *et al*., 2002). To be effective, controls must be precisely specified *and* enforced. Enforcing outcome controls requires evaluation of the outsourcee outputs (e.g., judging whether the outsourcee has achieved specified levels of software functionality and reliability, and delivered the software on schedule and within budget). Enforcing process controls requires evaluation of whether the outsourcee followed prescribed methods and procedures (e.g., for requirements elicitation, technical design, development, and testing).

Peripheral knowledge and formal control in outsourcing alliances

Following Takeishi (2002) and Brusoni *et al.* (2001) we define peripheral knowledge as the outsourcing firm's knowledge in the domain of the activity that is outsourced. Such knowledge therefore refers to the content of the activity that has been outsourced. Such knowledge is core to the outsourcee (typically a specialist in the outsourced activity) but peripheral to the outsourcer. For example, knowledge of digital electronic circuits is peripheral to the design of jet aircraft engines (Brusoni *et al*., 2001) and the design of satellite navigation systems and geographic topological data are peripheral to a major car manufacturer (Takeishi, 2002). This definition can be applied to software services alliances, the context of our study. Peripheral knowledge in software services alliances refers to the outsourcer's technical knowledge specific to the outsourced project. Technical knowledge is defined as knowledge about design (e.g., software architecture, design patterns, heuristics, and estimation models), programming (e.g., programming languages and tools), and software development processes (e.g., systems analysis, detailed design, and testing and debugging procedures) (Rus and Lindvall, 2002). The complementarities between peripheral knowledge and formal controls can be theoretically predicted by considering (a) the *informational intensity* and (b) the *temporality* of deployment of each type of control. Informational intensity is defined as the degree to which deploying a given form of control requires *ex ante* knowledge of the activity over which the control is deployed (Ouchi, 1979). The higher the informational intensity, the higher is the need for project-related peripheral knowledge in the outsourcing firm. Temporality refers to the stage of the outsourcing process at which the control is deployed. While the primary locus at which control specification decisions are made is the outsourcing firm, the primary locus at which such controls must be enforced is the outsourcee firm. *Peripheral knowledge will complement control when it facilitates precisely specifying and enforcing a given type of control.* When peripheral knowledge helps specify a given type of control but it cannot readily be enforced, we theorize that the control will not enhance outsourcing alliance performance. This logic is discussed in detail for both outcome and process control next.

Peripheral knowledge and outcome control

Outcome control, which is a form of market-based control, is the most informationally intense type of control because its deployment requires the outsourcing firm to prespecify how the performance of the outsourcee in the alliance activities will be judged (Ouchi, 1979). Such specifications include project milestones, deliverables, cost, and schedule for the outsourced project (Choudhury and Sabherwal, 2003; Ethiraj *et al*., 2005). Realistically estimating and accurately specifying such details and targets for the outsourcee requires that the outsourcer possess in-depth project-related technical knowledge. Without precise specification of the expected outcomes, outcome controls are subjective and ineffective (Cardinal, 2001). Once specified, outcome controls establish accountability by specifying output goals and standards, and an agreement on project objectives. Outcome control thus provides a market-like alignment in objectives such that outcomes that help achieve project goals

DOI: 10.1002/smj

are the same ones that help achieve the outsourcing alliance objectives. Therefore, the theoretical rationale for the value of greater peripheral knowledge in the outsourcing firm is that it facilitates specifying and enforcing outcome controls. Therefore, higher peripheral knowledge in the outsourcing firm increases the effectiveness of outcome control in enhancing alliance performance, leading to the first hypothesis.

> *Hypothesis 1: Higher peripheral knowledge in the outsourcing firm enhances the effectiveness of outcome control mechanisms in interfirm technological outsourcing alliances.*

Peripheral knowledge and process control

Process control—which requires prescribing the methods and procedures that the outsourcee is expected to follow—is less informationally intense than outcome control (Ouchi, 1979). Peripheral knowledge is a dual-edge sword because it facilitates implementing process control but process control is difficult to enforce irrespective of such knowledge, as discussed next.

Technical knowledge of the outsourced project helps the outsourcer prescribe at the outset the exact methods and procedures that the outsourcee should follow; a tendency that has also been observed in practice (Lacity, 2002). The tendency to impose additional process control would be consistent with agency theoretic thinking, which would suggest that the outsourcer (the principal) would act in ways that fit its own best interests (Baiman, 1990). However, the organizational separation of the two firms makes compliance with the prescribed processes difficult to monitor, and the weaker formal authority over outsourcee firm employees *vis-à-vis* internal employees makes it difficult to *enforce* process control (Baiman, 1990; Conlon and Parks, 1990; Jensen and Meckling, 1976). An outsourcer with high peripheral knowledge is more likely to use that knowledge to impose detailed process control (Levina and Ross, 2003), which can inadvertently decrease outsourcee autonomy in ways that can potentially generate dysfunctional behavior, thus *lowering* alliance performance. For example, imposition of prescribed processes can potentially be disruptive or incompatible with the established work practices, idiosyncratic routines, and internalized performance norms of the outsourcee firm (McAfee, 2003). Imposing rigid process guidelines can also potentially impede technically skilled outsourcee employees from applying their own resourcefulness or idiosyncratic technical skills to the project for fear of being penalized for deviating from the prescribed process. Once the processes to be followed are predefined by the outsourcer, the outsourcee has lower discretion in interpreting and adjusting standardized development methods in the specific context of the outsourced project. The peripheral knowledge of the outsourcer is also likely to be relatively generic, failing to distinguish processes at the macro level (depicting general approaches to develop software) from the micro level (detailing the specific methods that are appropriate for developing software in a particular outsourcee organizational context) (McAfee, 2003). Excessive use of detailed process controls can further signal a lack of trust, which can motivate the outsourcee to behave in ways that comply with the prescribed processes even if they are dysfunctional to the project objectives (Sundaramurthy and Lewis, 2003). Therefore, peripheral knowledge helps specify but not enforce process controls. Instead, it raises the risk of replacing outsourcee discretion with procedural mandates that might be incompatible with the idiosyncratic norms and practices in the outsourcee firm. An outsourcer with higher peripheral knowledge is therefore potentially more likely to attempt greater process control, which nevertheless remains difficult to effectively enforce irrespective of the level of outsourcer peripheral knowledge. This leads to the second hypothesis.

> *Hypothesis 2: Higher peripheral knowledge in the outsourcing firm lowers the effectiveness of process control mechanisms in interfirm outsourcing alliances.*

METHODOLOGY

Data collection

The hypotheses were tested in a field study of software services outsourcing alliances (i.e., settings in which a specialized software services firm custom develops a software application to solve a specific business problem in the outsourcing firm). This is an increasingly popular form of interfirm alliance through which firms access specialized technical capabilities in software design, development, and execution (Ethiraj *et al*., 2005). To increase the robustness of our findings, two informants were collected: (1) the primary project liaison (typically a mid-level IT manager who headed the outsourcer's IT department); and (2) the manager of the business unit or department for which the software was primarily developed. All projects in the study were custom software application development projects wherein the outsourcee custom developed a software-based system to solve a specific business problem in the outsourcing firm.

Data from 59 IT managers in 59 U.S. firms that had formed outsourcing alliances with specialized U.S. software services firms (19.6% response rate) and a matched-pair second respondent from 42 of these (71.1% response rate) were used to test the hypotheses. A random sample of IT function managers in 500 U.S. firms from *Dun & Bradstreet's Million Dollar Executive Directory* (2002) was contacted to identify firms that had existing or previous alliances of this nature. Of these, 131 were not eligible because of lack of prior experience with software services outsourcing; 68 were unreachable. Of the remaining 301 firms, 59 responded for a conservative 19.6 percent response rate that compares favorably to other studies of mid-level managers. Following this phase, alliance performance assessments from a second respondent in the 59 firms were requested. Forty-two responses were obtained, representing a 71.1 percent response rate. The firms in the sample represented a variety of industries including manufacturing, medical services, pharmaceuticals, engineering, construction, retail, and communications. These types of industries are representative of the firms that extensively outsource IT services. Note that none of the outsourcing firms were software firms, increasing the likelihood that software development technical expertise was indeed peripheral knowledge from their perspective.

Alliance performance assessments of both respondents were cross-validated using the interclass coefficient (ICC) (McGraw and Wong, 1996). We found high interrater agreement, as indicated by ICC values of 0.783. We also conducted the Harmon one-factor test (Podsakoff *et al*., 2003) to mitigate the threat of common methods bias, in addition to using multiple informants. Harmon's one-factor test was conducted by entering all independent variables and dependent variables in an exploratory factor analysis. The data would have a common methods bias problem if a single factor emerged that accounted for a large percentage of the variance in the resulting factors. However, a single factor did not emerge in our analyses and the first factor accounted for 17.2 percent of the total variance. All items retained in the factor analyses accounted for 77.9 percent of the total variance. This provides additional assurance that our results are not due to common methods variance. Given considerable interrater agreement between the two respondents for which matched pair data were obtained, we used data from the primary respondents (IT managers, $N = 59$) for the hypotheses tests. The matched pairs therefore served the sole purpose of assessing the threat of methods bias. *Post hoc* tests comparing the early (first 20) and late (last 20) respondents on all key independent variables provided assurance against nonresponse bias.

Construct measures

Existing scales were adapted to the study context, most of which were multi-item, seven-point Likert scales. The items in each scale are shown in the Appendix. The unit of analysis was the outsourced project. Kirsch *et al*.'s (2002) scales for *outcome control* and *process control* were used. *Alliance performance* was measured using a nine-item performance scale developed by Faraj and Sproull (2000) in the software project context. The items provided an assessment of the outsourcee's work by the outsourcing firm using items such as adherence to budgets and schedules, work quality, meeting alliance goals and objectives, and overall efficiency and effectiveness of the delivered software application. *Peripheral knowledge* was measured as the outsourcer's technical knowledge specific to the outsourced project. Following Tiwana (2003, 2004) and Rus and Lindvall (2002), seven items were used to assess outsourcer technical knowledge about the programming language, detailed technical design, design constraints, software code testing and debugging procedures, development tools, software development practices, and the software development process. The measures and sources of the seven control variables are shown in the Appendix. The construct measures exhibited discriminant validity (verified through factor analysis) as well as convergent validity (verified by scale alphas of 0.71 and higher). The interconstruct correlations, means, standard deviations, and reliability coefficients for the constructs in the model are summarized in Table 1.

Control variables

To account for alternative rival explanations of alliance performance in software services outsourcing alliances, seven control variables were included in the model. Five of these controls were project *alliance characteristics* (technological complexity, scope, goal codifiability, goal instability, and duration) and two were *alliance process characteristics* (relational governance and process formalization) that can potentially explain alliance performance independent of our main model (Ethiraj *et al*., 2005; Zollo, Reuer, and Singh, 2002). No industry- or firm-level controls were included because the unit of analysis is projects. Projects involving higher *alliance technological complexity* and larger *alliance scope* are more difficult to manage, potentially lowering alliance performance (Ethiraj *et al*., 2005). Both were specified relative to what was typical for the outsourcing firm rather than in absolute terms such as function-points or person-months of effort (see Ethiraj *et al*., 2005). Software services alliances require the outsourcer to communicate the goals of the alliance to the outsourcee, and some of this knowledge is tacit, firm-specific, complex, and difficult to communicate readily (Nidumolu, 1995). However, it is difficult to successfully translate imprecise business needs into precise technical deliverables that satisfy them (Sengupta and Abdel-Hamid, 1996). Thus, *alliance goal codifiability* was included as a control variable. *Alliance goal instability*, defined as the degree to which the outsourcer's project requirements fluctuated over the course of the alliance, can also impede alliance performance (Banker and Slaughter, 2000; Nidumolu, 1995). Use of *relational governance*—defined as the extent to which the outsourcer relied on social or clan-like approaches for influencing alliance activities—can enhance alliance performance; this is a relational form of control that complements formal control mechanisms (Poppo and Zenger, 2002). Finally, we controlled *process formalization*, which refers to whether the outsourcee used a formal software development methodology for the project (Faraj and Sproull, 2000). *Project duration* was also controlled (Ethiraj *et al*., 2005).

Descriptive statistics

The primary respondents in the study were highly experienced, as suggested by their average IT experience of 17.6 years (S.D. 8.6) and prior experience with 21 (S.D. 27) outsourced software projects. The average duration of the outsourced project was 9.1 months (S.D. 9.3) and the number of individuals assigned full time to the project by the outsourcee averaged 6.1 (S.D. 7.7).

ANALYSIS AND RESULTS

The analyses were conducted using a three-step hierarchical regression model. First, the control variables were introduced in the model (Step 1), followed by the main effect variables (Step 2). The hypotheses were tested in the third step, where residual-centered interaction terms between both formal control mechanisms and peripheral knowledge were added to the model. The simultaneous analysis of main effects variables and interaction terms in the model distorts the partial coefficients for the main effects variables because they tend to be highly correlated with the interaction terms. We used Lance's (1988) residual centering technique to correct this problem. In this two-stage procedure, we first regressed the interaction term (outcome control $\times$ peripheral knowledge) on its component parts (outcome control and peripheral knowledge). We then used the resulting residual instead of the interaction term in the regression equation. This approach reduces multicollinearity between the interaction terms and main effects variables, yielding a regression coefficient for the cross-product term that can be directly interpreted as the effect of the interaction term on the dependent variable. The results are summarized in Table 2.

The control variables introduced in Step 1 were in the expected direction and accounted for 25.2 percent of the variance in alliance performance. Several of the control variables were nonsignificant, plausibly because they have rarely been used in studies of software services alliances and never together in prior work. Of the main effects in Step 2, outsourcer peripheral knowledge was significant and positive, suggesting that higher levels of such knowledge enhances alliance performance. The main effects of outcome controls

DOI: 10.1002/smj

Table 1. Construct correlation matrix and descriptive statistics

Construct	Mean	S.D.	α	Construct correlations									
				1	2	3	4	5	6	7	8	9	10
1. Alliance tech complexity	4.19	1.25	0.80	—									
2. Alliance scope	4.69	1.28	0.91	0.324**									
3. Alliance goal codifiability	4.85	1.10	0.71	−0.113	−0.367**								
4. Alliance goal instability	3.64	1.30	0.72	0.065	0.310*	−0.130							
5. Relational governance	5.76	1.01	0.87	0.080	0.097	0.279*	0.153						
6. Process formalization+	—	—	—	−0.217	0.006	0.106	0.036	0.074					
7. Project duration	9.1	9.36	—	0.040	0.280*	0.118	0.081	0.229*	0.142				
8. Outcome control	5.97	0.83	0.82	0.016	0.022	0.303*	0.078	0.393**	−0.088	0.105			
9. Process control	5.47	0.97	0.89	0.179	0.107	0.319**	0.346**	0.473**	−0.118	0.054	0.199		
10. Peripheral knowledge	4.42	1.34	0.92	−0.188	−0.122	0.365**	0.087	0.200	0.176	−0.167	0.057	0.078	
11. Alliance performance	4.98	1.44	0.90	−0.060	−0.376**	0.536**	−0.175	0.212	−0.030	−0.066	0.180	0.147	0.336**

** $p > 0.01$; * $p > 0.05$ one-tailed test; + dummy variable

DOI: 10.1002/smj

Table 2. Effects of peripheral knowledge and formal control on alliance performance

	Step 1 Control variables			Step 2 Main effects			Step 3 Interaction with peripheral knowledge		
	β	T-value	S.E.	β	T-value	S.E.	β	T-value	S.E.
(Constant)		1.545			1.181			1.283	
Alliance technological complexity	0.085	0.644	0.150	0.190	1.421	0.151	0.171	1.351	0.144
Alliance scope	−0.213	−1.403	0.168	−0.236	−1.602	0.164	−0.146	−1.011	0.161
Alliance goal codifiability	0.429	3.034**	0.184	0.368	2.318*	0.206	0.310	2.038*	0.198
Alliance goal instability	−0.061	−0.471	0.145	−0.041	−0.308	0.148	−0.118	−0.915	0.144
Relational governance	0.146	1.100	0.182	0.166	1.093	0.209	0.192	1.327	0.199
Process formalization	−0.019	−0.149	0.365	−0.051	−0.407	0.357	−0.003	−0.021	0.344
Project duration	−0.097	−0.728	0.020	−0.036	−0.264	0.020	−0.052	−0.398	0.020
Outcome control mechanisms				0.019	0.145	0.225	0.087	0.678	0.217
Process control mechanisms				−0.187	−1.197	0.248	−0.304	−1.940*	0.248
Peripheral knowledge				0.315	2.307*	0.148	0.394	2.938**	0.145
Peripheral knowledge × Outcome control							0.303	2.323*	0.189
Peripheral knowledge × Process control							−0.344	−2.263*	0.258
R^2 (Model F)	35.5%*** (3.456)			44.6%** (3.302)			53%*** (3.668)		
$R^2_{\text{Adj.}}$	25.2%			31.1%			38.6%		
ΔR^2 (F-change)	—			5.9% (2.26*)			7.5% (3.49***)		

*** $p > 0.001$; ** $p > 0.01$; * $p > 0.05$ one-tailed test

($\beta = 0.019$, T-value 0.145, n.s.) and process control ($\beta = -0.187$, T-value -1.19, n.s.) were nonsignificant, suggesting that the mere use of formal controls in alliances does not directly influence alliance performance. This suggests that peripheral knowledge enhances performance but formal control by itself does not enhance performance; instead, as the larger betas in Step 3 show, control influences alliance performance only when it is used to exploit the outsourcer's peripheral knowledge. (Note that the main effect coefficients cannot be interpreted in the presence of interaction terms in Step 3 because those represent the conditionalized main effects rather than the simple main effects (Jaccard and Turrisi, 2003)). The main effects accounted for an additional 5.9 percent of the explained variance in alliance performance. The addition of the interaction terms between outcome and process control with peripheral knowledge tests whether such knowledge complements control (Step 3). The positive and significant interaction term between peripheral knowledge and outcome control ($\beta = 0.303$, T-value 2.32, $p < 0.05$) supports Hypothesis 1, which proposed that the two are complements. Thus peripheral knowledge significantly influences alliance performance when it is used to implement formal outcome control. The significant but negative interaction term between process control and peripheral knowledge in the outsourcing firm ($\beta = -0.344$, T-value -2.26, $p < 0.05$) supports Hypothesis 2, which proposed that peripheral knowledge facilitates utilizing process control, but this benefit would be outweighed by the interference that excessive process control would cause, lowering alliance performance. The interaction terms accounted for an additional 7.5 percent of the explained variance in alliance performance. The increase in explained variance in each step was statistically significant, suggesting that the complementarities between formal control and peripheral knowledge contribute significant additional explanatory power to the model. The increase in explained variance from Step 2 to 3 further suggests that peripheral knowledge enhances alliance performance when it is used to specify and exercise formal control over alliance activities.

In our *post hoc* regression tests, we also explored the possibility that greater peripheral knowledge by itself might influence the extent to which clients attempt to use outcome and process controls, independent of second-stage alliance performance effects. However, a nonsignificant relationship between peripheral knowledge and outcome control ($\beta = 0.043$, T-value $= 0.304$, n.s.) and process control ($\beta = 0.07$, T-value $= 0.493$, n.s.) provides no evidence to support this possibility.

Limitations

The results discussed in the next section should be interpreted with four caveats in mind. The cross-sectional study design limits the ability to test temporal causality between control and performance over the outsourced project life cycle. The study did not control for prior history of collaboration between the alliance partners or for contract structure (time-and-materials vs. fixed-fee), and industry effects, which might influence alliance performance. It is also possible that other types of knowledge besides peripheral knowledge (thus outside the theoretical scope of this study) such as partner-specific business knowledge specific to a given client domain in the outsourcee firm (Hoang and Rothaermel, 2005) and knowledge about managing interfirm partnerships (Simonin, 1997) that were not controlled might also affect alliance performance. Future work should also incorporate additional controls for client industry effects and firm-level variables in a *multilevel* model. (These were not included in the study because the unit of analysis was projects.) Finally, software services outsourcing has peculiar characteristics that might not generalize to traditional manufacturing outsourcing, although it has considerable similarities to knowledge-intensive services that are widely outsourced (such as technical support, drug development, R&D, medical diagnostics, and financial services) and technology manufacturing (notably such as Quanta building iMac computers and iPod music players for Apple Computer).

DISCUSSION AND IMPLICATIONS

The central theoretical assertion explored in this paper is whether the lack of deep knowledge about an outsourced technological activity constrains the outsourcing firm's capacity to govern outsourcing alliance activities. Such knowledge is ordinarily peripheral to the outsourcing firm's core domain and thus can be costly to maintain internally. While the need for such knowledge is implied in theories of *intra*firm control, the assumption has neither been developed in outsourcing alliances nor empirically tested.

We sought to test whether peripheral knowledge complements one key facet of alliance governance *vis-à-vis* control. We examined both forms of formal control: outcome control, which specifies *what* the outsourcee should achieve and process control, which specifies *how* it should achieve those objectives. Analyses of data from 59 software services outsourcing alliances show that peripheral knowledge and control are imperfect complements: it complements formal control that is based on specifying outcomes but not the other form that is based on prescribing work processes to the outsourcee. These insights into the interplay between peripheral knowledge, control, and alliance performance have two important theoretical implications for organizing interfirm outsourcing alliances.

First, the results show that peripheral knowledge complements formal outcome control, presumably because it aids in both the specification and enforcement of such controls. Contrary to popular belief, effectively controlling outsourcing alliances using outcome-based controls appears to actually require peripheral knowledge of outsourced activities. It is therefore necessary for firms that outsource technological activities to internally maintain deep knowledge in the outsourced domain simply to be able to effectively deploy and enforce formal outcome controls. This finding directly contributes to the empirically observed phenomenon of outsourcers maintaining knowledge in the domain of fully-outsourced activities (e.g., through mechanisms such as internal R&D for fully outsourced activities) (Brusoni *et al.*, 2001; Takeishi, 2002) that has hitherto lacked an explanation for *why* such knowledge matters. Our findings highlight that sometimes firms 'need to know more than they make' (Brusoni *et al.*, 2001) because it can facilitate more effective governance of interfirm technological alliances. This result also emphasizes the need for internally maintaining peripheral knowledge, such as by retaining a small internal software development operation even when the majority of such work is outsourced. This perspective reinforces the relatively underdeveloped theory of plural governance, which has advocated redundantly and actively engaging internally in fully outsourced activities simply to be able to understand them better (Bradach, 1997). Thus, the most novel contribution of this study is in

DOI: 10.1002/smj

empirically showing how and why the knowledge boundaries must sometimes stretch beyond the production boundaries of outsourcing firms for them to be able to effectively outsource technology development.

Second, the results show that peripheral knowledge is a two-edged sword with respect to process controls; while it can facilitate specifying process controls, they nevertheless remain difficult to enforce across organizational boundaries, which can heighten the risk of imposing inflexible processes on the outsourcee. Since prior research has shown that outsourcers with higher technical expertise have a propensity to implement detailed process control, this has important implications. Moreover, imposition of rigid process control can potentially decrease outsourcee discretion and discourage utilization of idiosyncratic technical expertise to avoid the risk of noncompliance with process-based controls. Thus the net benefits of peripheral knowledge in specifying process controls appear to be outweighed by the dysfunctional outsourcee behaviors that it can invoke, effectively lowering alliance performance. This result suggests that outsourcing firms with high peripheral knowledge might be better off allowing outsourcees to use their own local knowledge to decide on the processes and adaptations that they believe will work best in their organizational contexts to meet the alliance objectives. It is also noteworthy that outcome and process control have a nonsignificant correlation, which casts doubt on the extrapolability of the assertion in the *intra*firm controls literature that these two forms are mutual complements (Kirsch *et al*., 2002) to technological outsourcing alliances. It is plausible that process control and outcome control are substitutes, with the former becoming necessary only where the latter cannot be readily used (i.e., when ideal outcomes cannot easily be prespecified).

The overarching theoretical implication is that outsourcing firms must internally maintain enough peripheral knowledge to effectively specify outcome controls but be cautious about using it to *overspecify* process control that they cannot readily enforce. The potential knowledge-use disincentives, perception of mistrust, and decrease in outsourcee autonomy far outweigh the potential benefits of the latter. Thus, a more implicit sense of direction provided by clearly specified outcome controls works better than inadvertently micromanaging outsourcee responsibilities through process controls. Paradoxically, this implies that specialized knowledge that is peripheral to the outsourcing firm, and that it seeks to access through an interfirm alliance, might itself be necessary for it to effectively govern outsourcing alliance activities. More broadly, the study advocates a shift in the debate about whether firms should maintain peripheral knowledge to *how* peripheral knowledge matters in technological outsourcing alliances.

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APPENDIX: CONSTRUCT MEASUREMENT SCALES

Peripheral knowledge was measured as the extent to which the outsourcing firm understood the following specific to the outsourced project (Anchors: Not at all—Somewhat—To a great extent): (1) the programming language; (2) detailed technical design; (3) technical design constraints; (4) code testing and debugging procedures; (5) development tools and coding environment; (6) effective vs. ineffective development practices; and (7) the systems development process.

Outcome control was measured using four items that assessed the extent to which the outsourcing firm, in assessing the outsourcee firm: (1) placed

DOI: 10.1002/smj

significant weight on timely project completion; (2) placed significant weight on completion within budget; (3) placed significant weight on meeting requirements; and (4) placed significant weight on accomplishing project goals.

Process control was measured using three items that assessed the extent to which the outsourcing firm expected the outsourcee firm to follow an understandable written sequence of steps specified by the outsourcing firm during the development process: (1) toward accomplishing project goals; (2) to ensure this system met the outsourcing firm's requirements; and (3) to ensure the success of this project.

Alliance performance was measured using nine items on which the outsourcing firm assessed the outsourcee firm's performance on the outsourced project relative to other IT projects (Anchors: Much worse—Much better): (1) adherence to schedules; (2) adherence to budgets; (3) work quality; (4) meeting project goals; (5) meeting design objectives; (6) team operations; (7) work excellence; (8) overall effectiveness; and (9) overall efficiency.

Alliance technological complexity was measured as the extent to which, relative to other IT projects in the outsourcing firm, this project (Anchors: Strongly disagree—Strongly agree): (1) was technically complex to develop; (2) used a complex development process; (3) required pioneering innovations; and (4) was relatively complex. Adapted from Sarin and Mahajan (2001).

Alliance scope: the outsourcing firm was asked to assess the following aspects of the outsourced project relative to other IT projects in the company (Anchors: Much lower—Much higher): (1) person-months of development work; (2) project duration; (3) budget; and (4) project size. Adapted from Barki, Rivard, and Talbot (2001).

Alliance goal codifiability was measured using four items that assessed the outsourcing firm's agreement on the extent to which (Anchors: Strongly disagree—Strongly agree): (1) there was a clearly known way to convert the outsourcing firm's needs to requirements specifications (dropped); (2) available knowledge was of great help in converting the outsourcing firm's needs to requirements specifications; (3) established procedures and practices could be relied upon to generate requirements specifications; and (4) an understandable sequence of steps could be followed for converting the outsourcing firm's needs to requirements specifications. Adapted from Nidumolu (1995).

Alliance goal instability was measured using three items that measured the extent to which (Anchors: Strongly disagree—Strongly agree): (1) the requirements for the outsourced project fluctuated quite a bit in earlier phases; (2) the requirements for the outsourced project fluctuated quite a bit in later phases; and (3) the requirements identified at the beginning of the project were quite different from those existing at the end. Adapted from Nidumolu (1995).

Relational governance was measured using four items that assessed the extent to which members of the outsourcing firm: (1) attempted to be 'regular' members of the *project team*; (2) attempted to understand the *project team's* goals, values, and norms; (3) placed a significant weight on understanding the *project team's* goals, values, and norms; and (4) actively participated in project meetings to understand the *project team's* goals, values, and norms. Adapted from Kirsch *et al.* (2002).

Process formalization was measured as a dummy variable. The name of the development methodology used in the outsourced project was asked and the variable was scored 1 if a known methodology was named, following Faraj and Sproull (2000).