Trans-specialization understanding in international technology alliances: The influence of cultural distance

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Abstract
In the information age, the firm's performance hinges on combining partners' specialist knowledge to achieve value co-creation. Combining knowledge from different specialties could be a costly process in the international technology alliances (ITAs) context. We argue that the combination of different specializations requires the development of "trans-specialization understanding" (TSU) instead of the internalization of partners' specialist knowledge. This article examines the extent to which inter-firm governance in ITAs shapes TSU, and whether the development of TSU is endangered by cultural distance. We hypothesize that relational governance, product modularity, and cultural distance influence TSU development, which in turn influences firm performance. We collected data from 110 non-equity ITAs between software and hardware firms participating in the mobile device sector. We analyzed the data using partial least squares path modeling. Our findings suggest that TSU largely depends on product modularity and relational governance in alliances. However, while cultural distance negatively moderates the path from relational governance to TSU, it has no effect on the relationship between product modularity and TSU. Based on this, we conclude that product modularity can substitute for relational governance when strong relational norms are not well-developed in international alliances. Thus cultural distance does not invariably amount to a liability in ITAs.
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INTRODUCTION

The emergence of international inter-firm innovation networks associated with cross-border innovation activities of firms has been one of the defining features of the global economy during the past several decades. Within the international business (IB) discipline, these developments are reflected in a new conceptualization of the multinational corporation (MNC), emphasizing the capability perspectives, and particularly highlighting the notion of cross-border value "co-creation" (Pitelis & Teece, 2010; Teece, 2014) and emerging MNC roles as "orchestrators" of the wider global value creation processes (Pitelis & Teece, 2010). One context for co-creation within the changing economic geography of international production is

that complementary specializations are frequently developed by firms or organizational units (e.g., subsidiaries or teams in MNCs) in different countries (Buckley & Ghauri, 2004; Doz & Hamel, 1997; Grant & Baden-Fuller, 2004; Lew & Sinkovics, 2013), opening up opportunities for value creation through knowledge combination. However, the extant literature has not addressed the question of how different specializations can be combined effectively in a cross-border setting or, in particular, whether cultural distance may undermine the effectiveness of knowledge combination in such contexts.

This article focuses on the above question in the context of international technology alliances (ITAs), wherein performance hinges on partners combining their highly specialist knowledge[1] for a specific and jointly valued purpose. Our study examines how partners with complementary specializations may be enabled to combine their specialist knowledge and hence "co-create", without fully internalizing each other's specialist capabilities. The combination of different specializations requires the development of "trans-specialization understanding" (TSU). TSU has been conceptualized as a limited degree of knowledge sharing, as *islands of shared knowledge in a sea of mutual ignorance* (Postrel, 2002), the development of which is underpinned by a level of managerial "meta-knowledge" that is akin to the concept of "combinative capability" (Kogut & Zander, 1992), which itself has proved highly influential in IB thinking (Tallman, 2003).

To our knowledge, previous research has not empirically investigated the antecedents and performance consequences of mutual understanding in a cross-border setting. In this article we investigate the role of TSU as a mediator of the relationship between relational capabilities and firm performance in cross-border alliances in the mobile devices sector, where ITAs between software and hardware specialists are a rapidly growing organizational form (Lew & Sinkovics, 2013).

We view an ITA as a relational and technological governance structure that handles partner diversities. We focus on two core diversities that are typical in ITAs in the mobile devices sector. One element of diversity is the heterogeneous specialization of potential partners. An important question is how the development of TSU is affected by the character of the required interface connecting the specializations. As we shall see in the section below, extant literature supports the inference that a high level of modularity helps partners to combine their specialized knowledge.

More critically, given the cross-border setting of our study, the other core diversity corresponds to cultural and institutional differences between the partners. While the development of TSU requires a level of inter-partner cooperation, in an international technology venture cultural distance can potentially have a negative impact on the working relationships necessary for generating TSU. Thus cultural differences can increase the cost of inter-firm cooperation (White, 2005) and hinder flexibility due to the cross-border nature of collaborations. Research suggests that cultural differences impact upon the implementation of IT systems practices across nations (Sheu, Chae, & Yang, 2004; Yamin & Sinkovics, 2007; Yamin & Sinkovics, 2010). This challenge arises due to communication, coordination, and control-related problems in cross-border collaborations (Lyles & Salk, 1996; Shenkar, 2001). It has also been noted that cultural differences between countries make it difficult for home-based strategies to be implemented in host markets (Ambos & Håkanson, 2014; Gaston-Breton & Martín Martín, 2011). Recent work, however, also suggests a potential enabling role of cultural differences due to the advantage of cultural diversity (Leung & Morris, 2015; Reus & Lamont, 2009; Stahl & Tung, 2015; Vaara, Sarala, Stahl, & Björkman, 2012). Against this backdrop, product modularity may facilitate the development of TSU by making it less sensitive to relational harmony between partners, and hence mitigate the potentially negative impact of high cultural distance (Tihanyi, Griffith, & Russell, 2005).

We investigate these relationships in depth in the mobile devices sector, employing relevant data for 110 ITAs. Our findings indicate the existence of a path from TSU to firm performance, highlighting the importance of the co-creation interface in ITAs for performance outcomes. Relational governance and modularity have a direct positive impact on TSU development. With respect to cultural distance, while it does not affect TSU directly, it does negatively moderate the relationship between relational governance and TSU. However, cultural distance does not have a significant impact on the positive relationship between modularity and TSU. Thus while product modularity helps to bridge partner diversity *vis-à-vis* their knowledge heterogeneity, cultural distance has a somewhat detrimental effect on the development of TSU and hence firm performance in mobile device ITAs.

Our article contributes to the IB literature in two ways. The key findings revolve around the role of

cultural distance. While there is a negative moderating effect of cultural distance on relational governance's influence on TSU, cultural distance does not moderate product modularity's influence on TSU. These contrasting findings with respect to relational governance and modularity suggest that the effect of cultural distance is contingent on the degree to which relational harmony is critical to effective knowledge sharing. Furthermore, the absence of a direct effect of cultural distance on TSU is explicable in terms of the specific context and type of knowledge sharing – involving technical and scientific information and hence not necessarily liable to misinterpretation on grounds of cultural distance. Our findings thus add to recent arguments that cultural distance does not necessarily represent a liability in cross-border interactions (Stahl & Tung, 2015) and suggest a more nuanced understanding of eco-system co-creation (Pitelis & Teece, 2010) in cross-border contexts. Second, the findings indicate that product modularity renders TSU development less dependent on overcoming firm-level diversities. Thus product modularity has the potential to function as a governance mechanism in ITAs, which can substitute for relational governance when strong relational norms are not well-developed, especially in international alliances.

THEORY AND HYPOTHESIS DEVELOPMENT

Specialization, TSU, and Knowledge Combination
The high-tech software and hardware sectors are characterized by highly specialized knowledge-based products and resources. This specialist type of knowledge places these firms in different cognitive domains, and most of the cross-domain knowledge constitutes sticky information (Song, 2014; von Hippel, 1994). Specialization defines knowledge boundaries within which communication and knowledge sharing are relatively easy. This is due to shared cognition, technical "language", and sense-making frames (Buckley & Carter, 2004). By the same token, communication across knowledge boundaries is likely to be relatively difficult (Dougherty, 1992; Haas & Cummings, 2014).

The critical function of TSU is to enable or facilitate the solving of the problems that are likely to occur when different specializations need to be combined. Without TSU, each specialist may inadvertently pose unsolvable problems to the other, resulting in "glitches", defined as "costly mistakes that could have been avoided if some of the parties involved understood things that were *known by other participants*" (our emphasis) (Hoopes & Postrel, 1999:

838). As such, TSU is not *per se* the outcome of (inter)-organizational learning (where *new* knowledge, currently unknown to all the parties, is created) but rather of accessing knowledge that is already available. Accessing another organization's knowledge is generally less demanding in terms of (relative) absorptive capacity (Lane & Lubatkin, 1998) than acquiring it (Grant & Baden-Fuller, 2004). The "stickiness" of knowledge in the TSU generation process is more a consequence of ineffective communication than of the inherent characteristics of the knowledge rendering it "unshareable". Compared with transferring knowledge in a process of (inter)-organizational learning, TSU generation involves knowledge that is more likely to be "teachable" than "non-teachable" (Kogut & Zander, 1993).

However, even though TSU entails a limited scope of knowledge sharing and eschews acquiring an intimate knowledge of partners' expertise, it can nevertheless be very expensive to generate as it requires the work of a number of specialists who must sacrifice some specialist expertise (Forsgren, 2008). The intentional generation of TSU requires the sort of "combinative capabilities" emphasized by Kogut and Zander (1992). In particular, it is necessary to foster "social identity" (Kogut & Zander, 1996) and hence develop cognitive norms between specialists to motivate them to develop shared knowledge *despite* different specializations and the high cost/effort involved in cross-border alliances. In essence, the coordination of tasks can proceed informally and tacitly rather than according to formal procedures and guidelines (Bechky, 2003; Chwe, 2001).

Relational Governance and TSU in ITAs
Relational governance mechanisms in alliances are premised on an appropriate socialization process, social interactions, and ties that help generate mutual trust and the demonstration of credible commitment to the relationships (Hansen, 1999; Hansen, 2002; Heiman & Nickerson, 2004). Social exchange theory suggests that relational governance be conceptualized as a degree of trust and commitment developed between partners (Dyer & Singh, 1998; Kollock, 1994). Kollock (1994: 327) notes, "trust and commitment are likely to mutually reinforce each other". Further, trust and commitment are interrelated and these two are the key elements of relational governance (Morgan & Hunt, 1999; Zhou & Xu, 2012). Overall, it can be expected that partnerships relying on relational/cooperative norms as the major mechanism for governing mutual interdependencies

provide a more motivating (or less arduous) basis for knowledge sharing and joint problem solving than partnerships in which relational norms are weak or absent (Heiman & Nickerson, 2004).

Extant research also suggests that relational norms are easier to create and sustain in alliances intent on knowledge combination than in those engaged in organizational learning (Grant & Baden-Fuller, 2004; Grunwald & Kieser, 2007). The reason for this is, in part, that in the former type of alliance, partners are likely to display a lower priority placed on knowledge protectiveness (Simonin, 1999). Thus in knowledge-combining alliances, long-term cooperation is perceived as less risky; partners are not in a "race" to learn faster than each other (Hamel, 1991) and hence will be less anxious that their specialist capabilities may be captured or internalized by their partners. We can reasonably infer that, in knowledge-combining alliances, relational governance can support a degree of inter-firm "combinative capability" to enable joint problem solving critical to product development (Eisenhardt & Martin, 2000).

It can therefore be expected that managers in partnerships focused on co-creating will be cognizant of the need to encourage the development of relational norms that support a cooperative context with the ability to motivate knowledge sharing, in particular that by their specialist scientists and engineers, whose collaboration is critical to TSU development. As long as knowledge sharing is perceived to generate net benefits for the partners, they will provide resources and support the nurturing of the relational norms and socialization necessary for knowledge sharing. Hence:

Hypothesis 1: There is a positive relationship between relational governance and TSU development in ITAs.

Product Modularity's Influences on TSU in ITAs

There are various definitions of modularity in the literature, but it is widely accepted that it is a collective set of loosely coupled interdependent and complementary sub-modules (Baldwin & Clark, 2000). In this article, we follow Campagnolo and Camuffo's (2010: 259) definition that it is "an attribute of a complex system that advocates designing structures based on minimizing interdependence between modules and maximizing interdependence within them that can be mixed and matched in order to obtain new configurations without loss of the system's functionality or performance". Therefore a modular system has separable and recombinable attributes

(Baldwin & Clark, 1997; Salvador, 2007; Schilling, 2000).

IB academics have investigated modularity mostly in the context of global sourcing (Griffith, Harmancioglu, & Dröge, 2009; Kenny, Massini, & Murtha, 2009) and the governance of the global production network (Argyres & Bigelow, 2010). In this study we seek to examine the impact of modularity in the context of ITAs and focus specifically on product-level modularity. In the inter-firm context, product modularity contributes to value co-creation through its separable and recombinable characteristics (Salvador, 2007; Schilling, 2000). Recombination and reconfiguration of modular components increases the visibility of the product development process and hence enhances collaboration within the product development team (Jacobides, Knudsen, & Augier, 2006; Schilling, 2000). In addition, by reducing design complexity, modularity helps a firm to speed up product development while decreasing new product development costs (Ethiraj, Levinthal, & Roy, 2008; Galunic & Eisenhardt, 2001). Seen through the lens of reconfiguration and recombination, an important advantage of modular product design is that it facilitates product development through a loosely coupled development group, combining the capabilities of "an extensive group of component developers" (Sanchez & Mahoney, 1996: 70).

Loose coupling, enabled by product modularity, can be particularly advantageous in a cross-border setting, enabling partners in an ITA to achieve both product design efficiency (e.g., cost and time savings) and learning effectiveness (e.g., passing on an understanding of technological knowledge between modules). Benefiting from the modular design, focal firms can easily access and understand the necessary trans-specialized knowledge without assimilating the entire set of specialized knowledge of a partner. Thus technological partners working with a modular product design will find it easier to develop shared knowledge such as standardized platforms, including interfacing knowledge that both partners can mutually understand. Therefore:

Hypothesis 2: The higher the degree of product modularity, the easier it is for ITA partners to develop TSU.

Cultural Distance, Cooperation Costs, and TSU in ITAs

In ITAs, partner diversity has a national culture dimension. A number of prior studies on international alliances have indicated that cultural distance

complicates the process of organizational learning, inter-partner knowledge transfer, and value creation (Barkema, Bell, & Pennings, 1996; Beamish & Kachra, 2004; Meschi & Riccio, 2008; Simonin, 1999; Sirmon & Lane, 2004). However, other studies have noted both positive and negative impacts of cultural distance on international acquisition performance, calling it a double-edged sword (Reus & Lamont, 2009). The notion of the psychic/cultural-distance paradox (Brouthers & Brouthers, 2001; O'Grady & Lane, 1996) also suggests a not necessarily positive impact of cultural similarity on performance. Consistent with this, some studies note a positive impact of cultural distance on cross-border alliance performance, including knowledge acquisition, more learning opportunities, creativity, and shared values (Barkema & Vermeulen, 1998; Larsson & Finkelstein, 1999; Reus & Lamont, 2009; Stahl & Tung, 2015; Vaara et al., 2012). Stahl and Tung (2015) note that evidence from several meta studies indicates that "the size and direction of effect sizes for the relationship between cultural differences and IB outcomes are contingent on situational factors" (Stahl & Tung, 2015: 407). In a similar vein, Leung, Bhagat, Buchan, Erez, and Gibson (2005: 368) note, "instead of addressing whether or not national culture makes a difference, it is more useful to address the issue of how and when it makes a difference". In short, there is now an emerging consensus that, in considering the impact of cultural difference, context matters.

In our study, we attempt to trace the influence of cultural distance through its impact on the cost of inter-firm cooperation, that is costs "arising from the need to collaborate with a partner" (White, 2005: 1383).[2] As noted by White, cooperation costs have two components: those arising from task-related coordination needs (see also, Gulati & Singh, 1998) and those arising from inter-firm diversity. In the case of TSU, task-related cooperation costs are those incurred when individuals with different specializations (e.g., hardware and software engineers) need to undertake joint problem solving to enable the effective combination of partners' specialization. Additionally, cooperation costs can arise from partners' differences in terms of specific operational procedures, and managerial practices that are to varying degrees complex and tacit (Koza & Lewin, 1998). Seen through the lens of the costs of cooperation, cultural distance can negatively impact the development of TSU both directly and indirectly.

The direct influence would be through increasing the cost of task-related cooperation, hence limiting or even preventing beneficial knowledge sharing between specialists working on TSU development. Relational norms and thus socialization among the interacting specialists tasked with developing a shared understanding may be negatively affected by the cultural distance between them. A consequence can be that differences in national culture reduce the propensity of individual specialists to seek knowledge from each other (Haas & Cummings, 2014). Reluctance to seek knowledge from someone with a different culture can render knowledge sharing more cumbersome and hence complicate the development of TSU. It has also been argued that cultural traits, such as individualist vs collectivist and high vs low power distance, affect an individual's acceptance of or resistance to team work, such as that involving joint problem solving and TSU development (Kirkman & Shapiro, 1997). These arguments support a negative relationship between cultural distance and TSU generation. Hence:

Hypothesis 3a: Cultural distance negatively affects the development of TSU in ITAs.

Cultural distance can also affect TSU development indirectly, through an impact on the cost of cooperation arising from partners' diversities. Differences in national culture and institutions may pose complications that harm alliance working relationships and adversely affect the development of relational norms of trust and commitment between the partners. In this way, cultural distance may (negatively) moderate the relationship between relational governance and TSU development.

High cultural distance may make it harder for supportive relational norms to develop (Buckley & Carter, 2004: 372). A study by Luo (2005), showing the importance of shared perceptions of procedural justice to cooperative relationships, is particularly relevant. This study shows that, when cultural distance is high, a shared perception of procedural justice is even more important for alliance profitability; the reasoning is that, in the presence of cultural distance, managerial efforts to instill a shared sense of justice are crucial for reducing inter-partner frictions and hence avoiding or resolving inter-partner conflicts. Thus at high levels of cultural distance, the maintenance of a cooperative inter-partner relationship may be more resource-intensive, in turn rendering the generation of TSU more costly. Hence:

Hypothesis 3b: Cultural distance negatively moderates the relationship between relational governance and TSU.

We expect cultural distance to have no moderating impact on the relationship between modularity and TSU development. A few studies on technological integration and cultural distance note that adopting auxiliary technological solutions helps to reduce communication and cooperation costs in international buyer-supplier or headquarters-subsidiary relationships (Sheu et al., 2004; Sinkovics, Jean, Roath, & Cavusgil, 2011). In such contexts, cultural differences increase the cost of cooperation, such that firms may have to devise expensive control mechanisms. However, modular product design can reduce technology transaction-related hazards and costs through the integration of knowledge within modules (Furlan, Cabigiosu, & Camuffo, 2014; Langlois, 2002; Sanchez & Mahoney, 1996). Further, it reduces intensive and rather intrusive control/ monitoring mechanisms between the alliance partners (Baldwin & Clark, 2000). Therefore modular product design in ITAs between specialists from heterogeneous knowledge domains will facilitate the achievement of mutually agreed goals for the alliance. As noted in the previous section, product modularity facilitates knowledge combination through loose coupling and, in cross-border alliance contexts, reduces the need for intensive interaction between the partnering firms (Sanchez & Mahoney, 1996). Thus inter-partner diversity, including cultural distance between partners, will not significantly impair the development of the necessary level of TSU. Hence:

Hypothesis 3c: The relationship between product modularity and TSU is not affected by cultural distance.

Firm Performance

Lavie (2006: 641) states, "resources of alliance partners transferred via direct inter-firm interactions have a considerable impact on firm performance". In the context of our study, relational governance and product modularity underpin a firm's capabilities for TSU, helping to overcome complications in complex project and product development processes (Powell, Koput, & Smith-Doerr, 1996). In the ITA, TSU allows each partner to build up their own innovative products. Furthermore, a focal firm has a heterogeneity-creating mechanism based on its own internal technological resources and capabilities. In this vein, having capabilities for TSU, a focal firm will quickly respond to new technological demands and changes so as to become more accomplished in the market. Because TSU creates knowledge that is mutually cognitive and specific only to the partners themselves, it will be difficult for competitors to imitate. Hence:

Hypothesis 4: There is a positive relationship between the level of TSU and each partner's firm performance (Figure 1).

RESEARCH METHODS

Research Setting

We deliberately chose ITAs between software and hardware firms in the mobile computing industry as our research context. This context is unique in that the technological change in the industry happens quickly, and involves numerous international firms with a multitude of specialized knowledge attributes. In this fast-paced industry, partnering firms need an
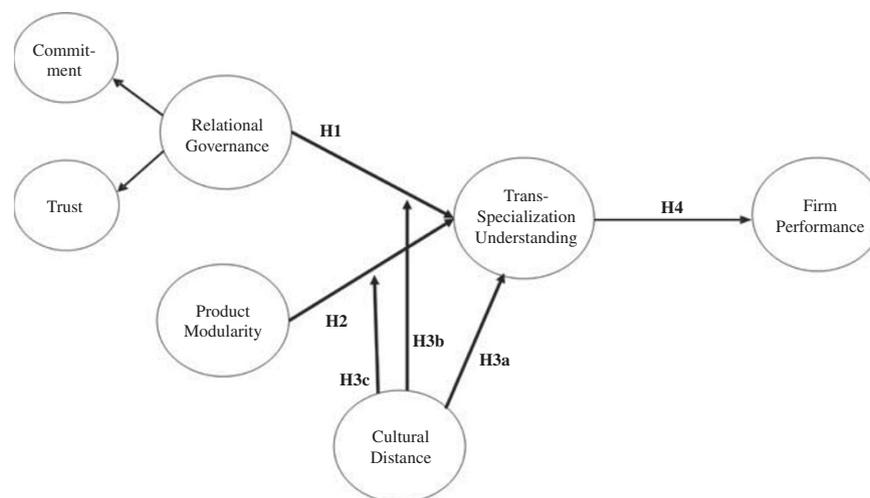

Figure 1 Conceptual model.

overlapping design protocol and mutual understanding to achieve technological innovation (Brusoni, Prencipe, & Pavitt, 2001). Through the ITAs, software and hardware firms contribute towards the development of the fundamental architectures of highly innovative products such as smartphones and tablet devices. More interestingly, software and hardware firms' core competences come from very different islands of specialized knowledge and product resources. For instance, software products consist of logical binary codes, which are intangible resources, whereas tangible hardware products such as semiconductor chipsets are composed of physical parts and components. In other words, at the product level (i.e., physical hardware and logical software), innovative smart devices consist of modularized subsystems such as physical components and logical stacks. The knowledge characters of these products are highly specialized, thus necessitating TSU in such alliances. As argued above, product modularity could facilitate such understanding in these alliances.

Sampling Frame and Data Collection

We developed a survey questionnaire and sampling frame. In the mobile device industries, value chain activities between the software and hardware firms are closely interrelated and complementary (Pisano & Teece, 2007). The extant databases (e.g., FAME and Thomson) and industry code classification systems (e.g., NACE REV and US SIC) did not provide us with an appropriate sampling frame because of the duplication and inappropriateness of the case firms derived from the industry code classifications. For this reason, we developed our sampling frame using publicly available global partnership pools of large hardware MNCs such as Intel, Qualcomm, ARM, Texas Instrument, and MIPS. From these pools, we obtained 768 software and hardware firms. We then complemented this list by adding lists of hardware and software firms that had participated in global IT exhibitions in 2011, such as the Mobile Word Congress and COMPUTEX. Our final sampling frame was composed of 879 firms from both the hardware and software industries (350 and 529 firms, respectively). This focused method of sampling helped us to exclude firms irrelevant to the research context. After this, we collected data via three rounds of web-based surveys, followed by a fourth round consisting of a field survey. To increase the response rate, we actively used social networking sites, sending them emails to introduce the purpose of our research and ask them to complete the web survey.

The managers were also promised that research summaries would be shared with them. Through these initiatives, the response rate was increased. In the end, we collected 110 usable, completed questionnaires from top managers at the headquarters of firms.

Table 1 shows our sample characteristics. The sample firms are based in 15 diverse countries. 52 software firms have developed non-equity-based ITAs with hardware firms, while 58 hardware firms are engaged in alliance relationships with software firms. The case firms have developed various modes of international alliances, such as co-development (37%), technology licensing (23%), joint R&D (15%), and knowledge sharing (13%); others or no agreement make up the final 11%. Regarding the distribution of ITAs (see Table 2), the alliance partners come from various countries and regions. From a geographical perspective, the most frequent alliances are ITAs between Taiwanese and US firms (21%), followed by Chinese–Taiwanese (11%) and Korean–US alliances (7%). Although a few of the alliances are formed within the same macro region, a majority of the ITAs are geographically dispersed. It is important to highlight that we have captured the geographical reality of this industry as well. For instance, the US, Taiwan, China, and Korea are core nodal players in the global value chain of the mobile computing sector (Chen, 2002; Sturgeon & Kawakami, 2011), collaborating with each other intensively. Notably, the most frequent alliances are between the US, Taiwan, China, and Korea.

Common Method Bias Test

We examined early–late response bias and common method variance in the data. For the response bias test, we followed the procedure suggested by Armstrong and Overton (1977) and found that there were no significant differences between the early and late groups' constructs ($p < 0.05$). We then proceeded to examine common method bias. Due to single key informants responding regarding both independent and dependent variables in our questionnaire (Chang, van Witteloostuijn, & Eden, 2010), this warranted investigation. Following Podsakoff, MacKenzie, and Lee's (2003) approach, we undertook a number of measures to limit common method bias. First, we assured the respondents of anonymity and randomized questions and statements throughout the questionnaire. Second, items of the study constructs were connected with specific topics in the questionnaire, for example, a new product, technology exchange, or relationship.

Table 1 Sample characteristics

	Number of respondents[a]	%
HW industry		
System-on-chips	19	33
Chip design/IP	13	22
Communications	10	17
Microcontroller	7	12
Graphics/Video	1	2
Others	8	14
Total	58	100
SW industry		
OS and system	16	31
Application SW	12	23
Application platform	10	19
Development SW	4	5
User interface/Browser	2	4
Others	8	15
Total	52	100
Alliance form		
Joint R&D	20	15
Co-development	51	37
Mutual knowledge sharing	18	13
Technology licensing	32	23
Other types	10	7
No agreement	6	4
Total	137[b]	100
Country		
Taiwan	42	38
United States	23	21
Republic of Korea	12	11
United Kingdom	6	5
India	5	5
China	4	4
Japan	4	4
Finland	3	3
France	3	3
Canada	2	2
Ireland	2	2
Israel	1	1
Morocco	1	1
Norway	1	1
Sweden	1	1
Total	110	100

[a]Total number of respondents: 110.
[b]Twenty-seven firms formed two types of technology alliances.

Third, in the survey, we asked firms to report their 2011 sales revenue. Subsequent to the survey stage, we collected secondary and objective sales data for 32 of the firms in our sample. This allowed us to investigate the correlation between these primary and secondary data sources. The correlation was 98.02%. Next, we statistically checked the highest correlation among the constructs. The highest value was 0.447, which is lower than Bagozzi, Yi, and Phillips' (1991) cutoff of 0.8, as shown in Table 4. Lastly, we examined common method variance by conducting Harman's one-factor analysis, as outlined by Podsakoff and Organ (1986). The results show the five factors extracted with eigenvalues above 1.0 (62% of the total variance) to be explained by the first factor, which accounts for only 20.12%. The above results reduce concerns regarding the presence of common method variance in this research.

Measures
Regarding relational governance, we developed a second-order construct with two reflective indicators, that is, trust and commitment. The measure of relational governance was adapted from Gundlach, Achrol, and Mentzer's (1995) five commitment items, and Aulakh, Kotabe, and Sahay's (1996) three trust items were used. Product modularity was defined as the extent to which a focal firm's product resource is decomposed into separable components that can be recombined with other components (Baldwin & Clark, 1997; Salvador, 2007). The measure of the construct was adapted from Lau, Yam, and Tang (2010). Considering technological knowledge involved in an alliance, the measure of TSU was adapted from Zhou and Wu's (2009) three items for the construct. We assessed firm performance using non-financial items adapted from Venkatraman and Ramanujam (1986), focusing on overall effectiveness (i.e., increased reputation and overall performance) and innovative market performance (i.e., increased number of new products and customers, and enhanced product quality). Regarding cultural distance, we adopted Hofstede's (2001) power distance, uncertainty avoidance, individualism, and masculinity indices and Kogut and Singh's (1988) approach to measuring cultural distance.

When testing the hypotheses related to performance, we controlled for firm size because firm and partnership performance may differ depending on the size of a firm. For instance, the size of a firm may affect firm performance as a large firm such as a large MNC may be in a better position, or have stronger capabilities for accessing and understanding external knowledge so as to achieve superior performance, than a smaller firm. We measured firm size using the natural logarithm of sales (in millions of dollars) as of the fiscal year 2010 (Hitt, Hoskisson, & Kim, 1997). Also, we controlled for industry type as the presence of software or hardware firms in a

Table 2 Country distributions of ITA partners in this research

Focal firm country	Partner country	Frequency	Focal firm country	Partner country	Frequency
Taiwan	USA	23	Japan	Taiwan	1
China	Taiwan	12	Japan	USA	1
Korea	USA	8	Korea	Canada	1
UK	USA	5	Norway	USA	1
USA	UK	5	Sweden	USA	1
Taiwan	India	4	Taiwan	Germany	1
France	USA	2	USA	Netherlands	1
Japan	Taiwan	2	USA	Japan	1
Korea	Taiwan	2	USA	Canada	1
Taiwan	UK	2	USA	Taiwan	1
Taiwan	USA	2	China	USA	1
USA	Korea	2	Korea	China	1
Ireland	USA	2	Morocco	USA	1
USA	China	2	Taiwan	Malaysia	1
Canada	USA	1	Taiwan	Russia	1
Canada	Taiwan	1	UK	China	1
China	Hong Kong	1	USA	Bulgaria	1
Finland	USA	1	USA	Vietnam	1
Finland	Korea	1	USA	Russia	1
France	Taiwan	1	USA	no answer	5
India	Japan	1	Finland	no answer	1
India	Netherlands	1	India	no answer	1
India	USA	1	Korea	no answer	1
Israel	Korea	1	Total		110

partnership may affect the relationships in the model. Software firms ($n = 52$) were coded as 1 and hardware ($n = 58$) as 0.

RESULTS

Given the paucity of research on inter-firm governance and TSU in IB, we engaged in an exploratory process of theoretical development using variance-based partial least squares (PLS) soft modeling rather than covariance-based theory confirmation (Henseler, Ringle, & Sinkovics, 2009; Lohmöller, 1989). PLS is suitable for exploratory research because it is a less restricted and prediction-oriented method (Henseler et al., 2014), and its iterative algorithm helps resolve "the blocks of the measurement model and then, in a second step, estimates the path coefficients in the structural model" (Vinzi, Trinchera, & Amao, 2010: 48). In addition, considering the small sample size ($n = 110$) and the complexity of the model, PLS structural equation modeling was appropriate for testing the model in an exploratory sense (Hair, Sarstedt, Pieper, & Ringle, 2012). We used a bootstrapping method to construct randomized and standardized errors, which provided us with t-statistics with which to test the hypotheses

(Henseler et al., 2009; Tenenhaus, Vinzi, Chatelin, & Lauro, 2005).

The Measurement Model

The quality of the measurement model is needed to ensure that we can conduct the subsequent structural model (Hulland, 1999; Lee, Yang, & Graham, 2006; Schotter & Beamish, 2013). Thus we first investigated the quality of the measurement model in terms of reliability and validity. Construct reliability was tested using composite reliability and Cronbach's alpha values for each construct. All composite reliability and alpha values were higher than 0.70, except for that for the product modularity (alpha = 0.693). However, the outer-loading values of the indicators related to product modularity were all higher than 0.50, suggesting indicator reliability (Chin, 1988). Thus we decided to keep the construct. Following Fornell and Larcker (1981), we assessed convergence validity with average variance extracted values. The values of all constructs showed satisfactory values of 0.5 and above (see Table 3).

We assessed the discriminant validity of our measurement model. First, we compared the average variance extracted value of each construct with the

Table 3 Measurement model

Construct measures	Mean	SD	Outer loading
Trust (alpha = 0.796, CR = 0.881, AVE = 0.714)			
(strongly disagree = 1, strongly agree = 7)			
The relationship with this partner is characterized by a high level of trust	5.25	1.267	0.913
My company and this partner generally trust that each will stay within the terms of the contract	5.54	1.194	0.885
My company and this partner are generally skeptical of the information we receive from each other *(R)*	5.16	1.260	0.725
Commitment (alpha = 0.763, CR = 0.840, AVE = 0.516)			
(strongly disagree = 1, strongly agree = 7)			
Willing to make further investment in supporting this partner	4.71	1.336	0.577
Willing to share industry trends and information with this partner	5.26	1.072	0.769
Willing to provide our proprietary information to this partner	4.75	1.443	0.639
Make an honest effort to deliver on our promises to this partner	5.46	1.209	0.764
Wish to cooperate technologically with this partner for a long time	5.67	1.126	0.815
Second-order construct – Relational governance (alpha = 0.849, CR = 0.885, AVE = 0.500)			
Commitment	—	—	0.932
Trust	—	—	0.902
Product modularity (alpha = 0.693, CR = 0.813, AVE = 0.601)			
(strongly disagree = 1, strongly agree = 7)			
We are able to make changes in the key component of this product without redesigning others	4.57	1.639	0.569
Product components can be reused in other products of my company	5.60	1.383	0.790
This product has a high degree of component carry-over	5.28	1.190	0.925
Trans-specialization understanding (alpha = 0.745, CR = 0.854, AVE = 0.661)			
(strongly disagree = 1, strongly agree = 7)			
My company is able to monitor technological knowledge/resources in the market	5.61	1.134	0.788
My company is able to understand new technological knowledge of partners	5.55	0.982	0.834
My company is responsive to technology changes	5.74	0.905	0.819
Firm performance (alpha = 0.758, CR = 0.832, AVE = 0.502)			
(not achieved very well = 1, achieved very well = 7)			
Increased number of new products officially launched	4.94	1.152	0.570
Increased number of new customers	5.15	1.068	0.706
Enhanced product quality	5.25	1.035	0.673
Increased reputation	5.52	1.064	0.801
Increased overall performance	5.45	1.028	0.767

Note: SD: standard deviation, CR: composite reliability, AVE: average variance extracted, R: reverse item(s). The unit of analysis of the current research is "the firm" (either a hardware or software firm) with questions focusing on the alliance partner. We asked the respondents to "think about the most important strategic partnership with a foreign [HW/SW] partner in the mobile computing industry" when responding to the questionnaire items.

variances among the constructs in the model. As shown in Table 4, the highest correlation (i.e., the square root of the highest variance) between constructs in each column was lower than the square root of the average variance extracted. This suggests that there is discriminant validity in the measurement model (Bagozzi et al., 1991; Hair et al., 2012). In addition, we compared the loading values of every single indicator with the cross-loadings with other indicators (Chin, 1988). The results show that each indicator loading was higher than the respective cross-loadings, which again indicates the existence of discriminant validity. In addition, based on Stone–Geisser's Q^2 (Geisser, 1975; Stone, 1974), we assessed the predictive relevance of the latent constructs by adopting the cross-validated redundancy Q^2 and the cross-validated communality Q^2 (Fornell & Cha, 1994). The results show that there is predictive relevance in the measurement model, as both the cross-validated redundancy and communality are above zero.

Table 4   Discriminant validity

Constructs	1	2	3	4	5
1. Product modularity	*0.775*				
2. Relational governance	0.205	*0.707*			
3. Trans-specialization understanding	0.299	0.447	*0.813*		
4. Firm performance	0.272	0.217	0.237	*0.708*	
5. Cultural distance	−0.089	0.102	−0.001	0.096	—

Note: Italic values are the square root of the average variance extracted and off-diagonal values are the correlations between the constructs.
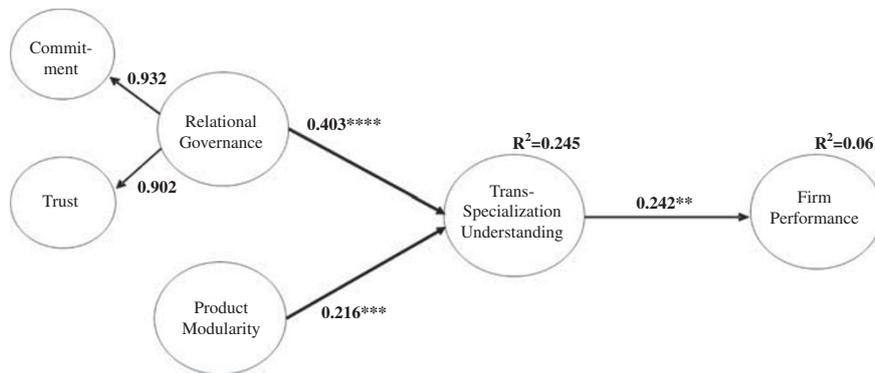
Figure 2   Result of hypothesis test.

The Structural Model

First, the impact of relational governance on TSU was significant ($b=0.403$, $t=3.706$, $p<0.001$), supporting Hypothesis 1. The path from product modularity impacted positively on trans-specialized knowledge ($b=0.216$, $t=2.592$, $p<0.01$), which supports Hypothesis 2. The support for Hypotheses 1 and 2 suggests that relational governance and product modularity for TSU between international partners from different knowledge domains help to co-create value between them. Otherwise, it would be difficult to understand the context-specific knowledge of the international partner. The path from TSU to firm performance was significant ($b=0.242$, $t=2.158$, $p<0.05$). Thus Hypothesis 4 is supported. When we controlled for firm size and industry type, we found that the control variables did not have significant effects on the performance dimension at a 0.05 level of significance. Figure 2 illustrates the results of the structural model.

Then, we tested the moderating effect of cultural distance, with a specific interest in examining how cultural distance as a moderator would change the nature or the strength of the relationship between the dependent and outcome variables (Andersson, Cuervo-Cazurra, & Nielsen, 2014; Baron & Kenny, 1986). Cultural distance does not have a direct effect

on TSU ($b=-0.030$, $t=0.495$), hence Hypothesis 3a is rejected. The moderating effect of cultural distance on the path from relational governance to TSU was negatively significant ($b=-0.245$, $t=1.829$, $p<0.1$), which supports Hypothesis 3b. As we expected, cultural distance did not significantly moderate the relationship between product modularity and TSU ($b=-0.062$, $t=0.433$), which supports Hypothesis 3c. At the same time, the association between product modularity and TSU was still significant ($b=0.224$, $t=2.577$, $p<0.01$). This indicates that relational governance and product modularity can serve as substitutive governance mechanisms in ITAs when cultural distance is considered. As shown in Figure 3, the R^2 value of TSU is increased to 0.311 compared with when the moderating variable of cultural distance is included, and cultural distance only negatively moderates the association between relational governance and TSU. This suggests that relational governance is a useful governance solution for improving TSU between international alliance partners, particularly when culturally close international partners collaborate with each other.

As discussed earlier, we tested the culture-related hypotheses (Hypotheses 3a, 3b, and 3c) using interaction terms (Andersson et al., 2014). Additionally, in order to further explore the mechanism underlying
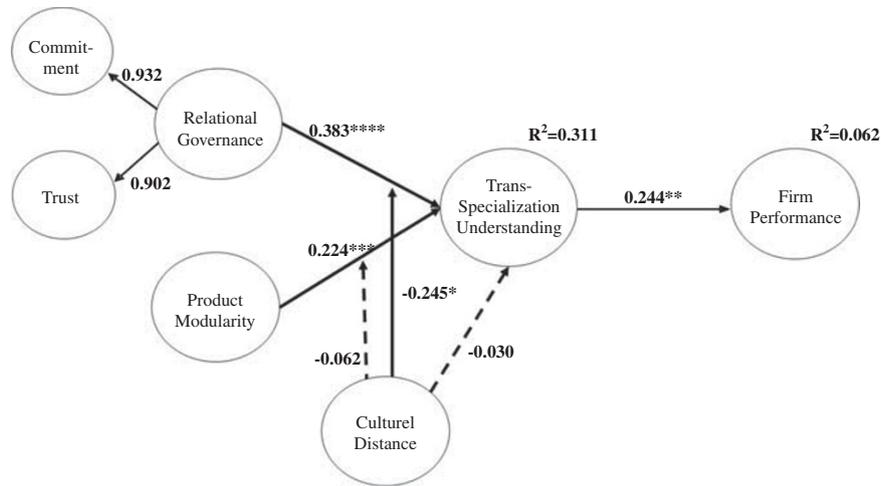
Figure 3   Effect of cultural distance.

the moderating effect of cultural distance, we performed an *ex post* analysis and divided the sample into pairs of low- and high-cultural-distance partnerships ($n_{high} = 49$ and $n_{low} = 53$), that is, lower and higher than the median value of cultural distance. Excluding eight missing pairs (see Table 2), this allowed us to identify structural differences between high and low cultural differences among partners in the mobile devices sector. For the subsample of high cultural distance, the relationship between relational governance and TSU ($b = 0.614$, $p < 0.001$) and that between product modularity and TSU ($b = 0.203$ $p < 0.1$) were significant, and the path from TSU to performance was significant ($b = 0.435$, $p < 0.001$). This indicates that, for the high-distance group, cultural distance does not impair the effect of TSU as a mediator between relational governance, product modularity, and firm performance. For the low-cultural-distance subsample, the association between relational governance and TSU ($b = 0.359$, $p < 0.05$) and that between product modularity and TSU ($b = 0.333$, $p < 0.05$) were significant, but the relationship between TSU and performance was insignificant at the 0.1 level.

Due to the low number of observations from the split-sample (dichotomous) subgroup analysis (*cf.* the continuous moderation effect that we performed earlier) (Hair, Hult, Ringle, & Sarstedt, 2013), we have to interpret the findings cautiously and point the way towards future research efforts. The results of the subgroup analysis may also have been affected by other distance-related factors, such as cultural, administrative, geographic, and economic (CAGE) distances. Additionally, the small sample size of the

subsampling groups and the types of ITAs in the subgroups may have affected our results. Notwithstanding these considerations, our approach points to the importance of "situational and contextual factors" regarding enigmatic cultural research in IB (Stahl & Tung, 2015). Thus we interpret our (*ex post*) findings as reinforcing the notion that cultural distance does not invariably amount to a liability in cross-border interactions, and our specific context of ITA in the mobile devices sector appears to be a case in point.

Lastly, we investigated the relationship between product modularity and relational governance. The relationship was not significant ($b = 0.209$, $t = 1.623$), indicating that there is no mediation possibility among product modularity, relational governance, and TSU. Then, we included cultural distance as a moderator in the relationship between product modularity and relational governance. There was no significant association between them ($b = 0.022$, $t = 0.139$). The moderating effect of cultural distance on the relationship between product modularity and relational governance was weaker than its effect on relational governance alone. These results support our theory and empirical results.

DISCUSSION AND CONCLUSIONS

Our study was motivated by the desire to understand the antecedents and performance consequences of mutual understanding in a cross-border alliance context. Our analysis of TSU has been framed within a broad capability perspective on IB (Pitelis & Teece, 2010; Teece, 2014). Hitherto, however, the capability framing in IB has not been extensively employed

to explain knowledge sharing. The MNC literature has been far more interested in knowledge transfer,[3] than in knowledge sharing (Forsgren, 2008). Our study addresses this gap in the IB literature by focusing on the antecedents and performance consequences of TSU in the context of international alliances. Our analytical approach is based on the recognition that generating TSU requires the nurturing of a collaborative interface to motivate knowledge exchange despite differing specializations.

Our empirical study has confirmed this through support for Hypotheses 1 and 4. Support for Hypothesis 1 indicates that partnering firms appreciate the importance of relational norms of trust and commitment as enablers of knowledge sharing across partner specializations. We found support for Hypothesis 4 – a positive relationship between TSU and firm performance. While managers provide resources underpinning the development of a workable relational interface for the partnership, the performance of their own firm is also enhanced.

With respect to modularity, we found a direct positive relationship between product modularity and TSU. Hence Hypothesis 2 is supported. This implies that product modularity reduces the technical and managerial challenges found in the knowledge combinations used in product design and development.

As regards cultural distance, we found no support for a direct influence of cultural distance on TSU development (Hypothesis 3a). This suggests that communication among specialists is not affected by differences in cultural norms.

The negative moderating effect of cultural distance on the relationship between relational governance and TSU (Hypothesis 3b) indicates that cultural distance indirectly discourages the development of TSU. We surmise that this is due to cultural distance increasing the costs of cooperation between alliance partners, even though these partners develop relational governance in the alliance. This finding suggests that it may be important to develop both relational (e.g., trust and commitment) and further structural capital (e.g., relationship tie and interaction frequency) in international alliances (Tsai & Ghoshal, 1998).

Our findings indicate that cultural distance does not negatively moderate the positive relationship between product modularity and TSU (Hypothesis 3c). We interpret this finding in the following way: Modular interfaces reduce the extent of inter-partner interaction by facilitating loose coupling. Thus the influence of cultural difference is not necessarily strong.

Theoretical Contribution and Implications

In our view, the most theoretically important findings of our study demonstrate the influence of cultural distance: the lack of direct influence on TSU development, the absence of a moderating effect on the relationship between product modularity and TSU and, by contrast, the strong negative moderation of the relationship between relational governance and TSU. We interpret these findings as supporting the view of Shenkar, Luo, and Yeheskel (2008) that "friction" can be a more appropriate metaphor than "distance" when considering culture in cross-border interactions.

A related implication is that product modularity has the potential to function as a governance mechanism in international alliances. In effect, in the presence of high modularity, the process of generating TSU may "outflank" partner diversities, including cultural distance. It can substitute for relational governance when strong relational norms are not well-developed, especially in international alliances.[4] On the other hand, cultural distance has a negative moderating effect on the relationship between relational governance and TSU generation. The contrasting finding with respect to the effects of cultural distance is in line with what we perceive to be an emerging consensus in the literature, suggesting that, in considering the impact of cultural difference, context matters.

Accordingly, in order to draw a broader theoretical inference from the finding of a negative moderating effect of cultural distance, it is important to be reminded of the non-equity nature of the alliances we studied. Much of the interaction between the partners is, presumably, virtual (Internet enabled). The literature on relational governance, to our knowledge, has not specifically considered how the development of relational norms of trust and commitment may be affected when the interface between partners is primarily virtual or how resilient these norms may prove to be when cultural distance is high. Previous literature on online internationalization has highlighted the possibility of a virtuality trap (Sinkovics, Sinkovics, & Jean, 2013; Yamin & Sinkovics, 2006), implying the possibility of negative performance consequences from over-reliance on virtual communication. Yamin and Sinkovics (2006) highlight that, while online interaction may engender a perception of a reduction in cultural or psychic distance, this perception may turn out to be illusory. Such effects are probably not present, or at least are considerably weaker, in the interaction between scientists and engineers combining their specializations. As we have already noted, the content of knowledge exchange is

usually highly codified, scientific and engineering information, unaffected by culture. In fact, much of their knowledge is embodied in electronically enabled engineering components and software. Lew and Sinkovics (2013) provide an interesting picture of how scientists and engineers work across a cluster of industry and application boundaries, and how they combine their know-how in the production of mobile devices. Their working world is largely an Internet-enabled and virtual "eco-system". However, the work of partners' managers does not necessarily match up to this description. Their working world entails dealing with context-specific managerial tasks and is likely to be shaped by their cultural and institutional environments. While the alliance is virtual, the individual partners are embedded and separated geographically. Their (virtual) interactions are thus not buttressed by the benefits flowing from "situated learning" (Tyre & von Hippel, 1997).[5] This, we suggest, explains why relational governance generated through virtual interactions may become fragile (suffer from "friction") in the presence of high cultural distance (Shenkar et al., 2008).

Taken together, these findings suggest a more nuanced understanding of eco-system co-creation (Pitelis & Teece, 2010) in cross-border contexts. Specifically, the notion of eco-systems may apply more readily to the work of specialists (e.g., software and hardware scientists and engineering experts), whose working relationship does not appear to be impeded by cultural differences, than to the interactions between the firms that employ them, for which cultural difference does seem to remain a complicating influence.

Limitations and Recommendations
This research is not free from limitations. First, we focused on hardware and software industries to explore the application of our theoretical reasoning. The effectiveness of TSU as an enabler of knowledge sharing requires a moderate rather than highly dynamic industry environment. Second, although our approach was successful in terms of finding significant interrelationships between the constructs, the issue of the extension of the empirical context remains. For this reason, we recommend that future researchers empirically investigate our model in a different industry context (e.g., automotive manufacturing or aerospace engineering). Third, there may be different associations between modularity and control-based governance mechanisms such as process and outcome controls (e.g., Tiwana, 2008). Further studies could expand on cultural

distance to include a broader conceptualization, for instance the CAGE framework of Ghemawat (2001) or the institutional approach of Berry, Guillen, and Zhou (2010) to cross-national distance, to develop a better understanding of the role cultural distance plays for the trans-specialized knowledge in international alliances between heterogeneous partners.

Related to the conceptualization, we suggest that future research add a control mechanism to the governance mechanism dimension in our model, so as to develop a more comprehensive model. Next, we did not consider interfacing protocols between partners' modular products in the model. Thus it would be interesting to investigate how modular firms initiate the interface protocols when they form exchange arrangements on an international level. Also, firm age may represent a firm's experience, thus being related to a firm's capabilities for understanding external knowledge, although our empirical settings are technologically fast-moving and turbulent industries. Finally, we looked at focal firms' perceptions of governance mechanisms through a (one-sided) questionnaire. An investigation of the dyadic context (e.g., bilateral perceptions of partners) may not be practically feasible for reasons of access and confidentiality, but would be a meritorious aspiration.

NOTES
[1]In this article we use the specialist knowledge, specialized knowledge, and knowledge specialization of the firm interchangeably.

[2]Inter-firm alliances also entail "control" costs, that is, the costs arising from the need to check partners' opportunism (Koza & Lewin, 1998; White, 2005). While both control and cooperation cost considerations are present in any alliance and influence its governance and evolution (Koza & Lewin, 1998), their relative weight is related in part to the purpose of the alliance. Alliances intent on the combination of the existing knowledge bases of the partners will be less vulnerable to opportunism (Grant & Baden-Fuller, 2004; Grunwald &

Kieser, 2007); alliance performance is largely a function of the costs of cooperation.

[3]Knowledge transfer is conceptualized (Teece, 1977) as a process whereby technical and managerial staff from the transferring and receiving organizations engage in explaining and understanding know-how and utilizing it in the production process of the receiving organization. Knowledge transfer is thus an overwhelmingly unidirectional flow of information and know-how from the sender to the recipient. Knowledge exchange or sharing is a relatively minor aspect of knowledge transfer.

[4]Arguably, this conclusion is reinforced by the *ex post* analysis, showing a positive effect of product modularity on TSU for the high-cultural-distance subsample.

[5]Tyre and von Hippel (1997) argue that adaptive learning has a "situated" dimension – meaning that intimate knowledge of the physical context of a partner's value-adding activity is a critical part of the process of problem solving.

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