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Choose Your Friends Wisely: Complementarity and Suplementarity of IT Capabilities in IT Alliance Formation

Short Paper

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Abstract

While IT capabilities are an important concept in IS research, past studies often focus on the internal impacts of firms' IT capabilities. Less is known about how firms' IT capabilities drive their alliance formation with IT partners. This question is particularly pertinent to firms in non-IT industries as these firms often lack these important capabilities to succeed in the digital era. In this study, we combine the alliance literature and the organization-stakeholder fit theory to hypothesize a U-shaped relationship between the IT capabilities of non-IT firms and their alliance formation with IT partners. We further theorize a complex moderating role of environmental dynamism in this relationship. A panel data set of 8808 non-IT firms in 2012-2020 provides partial support to our theory. This study potentially contributes to the business value of IT literature as well as the alliance literature.

Keywords: IT capabilities, alliance formation, IT partners, complementarity, suplementarity

Introduction

The IS literature emphasizes the role of IT capabilities — the organizational capabilities of mobilizing IT resources in combination with other resources, in driving strategic outcomes for firms in both IT and non-IT industries. Empirical evidence has demonstrated that IT capabilities are beneficial for firm performance through reinforcing business capabilities (e.g., marketing, innovation, operation) and enhancing organizational agility (Chen et al. 2014; Kim et al. 2011; Lu and Ramamurthy 2011; Pavlou and El Sawy 2010). Therefore, IT capabilities remain on the agenda of IS researchers, especially in the field of IS strategy and the business value of IT.

With the pervasiveness and ubiquity of IT, IT capabilities have become increasingly important, especially for firms in non-IT industries. This pertains to the fact that these firms often fall short of their ability to effectively use and transform IT to generate business value (Fitzgerald et al. 2014). As a result, they seek to expand their IT knowledge through internal investments or through collaborations with partners who excel at information technologies (Park et al. 2020; Ravichandran and Giura 2019). Internal investments in IT can be challenging for these firms, however, as they reside in non-IT industries and thus, have limited opportunities to learn about IT from industry peers. To overcome such shortfalls, non-IT firms likely form collaborations with IT partners in order to enhance their IT capabilities. Despite the prevalence of this type of collaboration, the IS literature shows limited understanding of the role of IT capabilities in influencing focal firms' formation of IT alliances. More specifically, it remains unclear how non-IT firms leverage their IT capabilities (or the lack thereof) to form collaborations with potential IT partners.

Our study seeks to illuminate this important research question using the organization-stakeholder fit theory, which proposes that firms select partners following two resource-based motivations:

complementary and supplementary fit (Bundy et al. 2018). Complementarity represents situations when the focal firms seek partners to strengthen the aspects, they underperform with the aim to improve these aspects (Mitsuhashi and Greve 2009). Following this logic, the focal firms expect to learn from their partners and synergize this new external knowledge with their current internal knowledge for super-additive value. In contrast, supplementarity refers to circumstances in which the focal firms choose partners based on their similarities (Mitsuhashi and Greve 2009). The underlying rationale for seeking similarities is based on a belief that when two organizations are similar, they often share the same principles and strive to achieve the same objectives. Moreover, similar organizations are more likely to be familiar with each other's resources (Reuer and Lahiri 2014). Consequently, coordination efforts can be reduced, and the focal collaboration is more likely to create benefits for both organizations involved. These two mechanisms have been viewed as being independent when explaining the antecedents of strategic alliance formation. In other words, whether complementarity or supplementarity prevails as the motivation for focal firms to form alliances depends on the type of resources and capabilities. Moreover, past research has shown mixed results in both complementary and supplementary effects (e.g., Furlotti and Soda 2018; Lin et al. 2009; Mitsuhashi and Greve 2009; Yayavaram et al. 2018). Overall, these two mechanisms, when being considered independently, might not be sufficient to shed light on whether IT capabilities have complementary or supplementary effects on focal firms' alliance formation with IT partners.

In this study, we draw on the organization-stakeholder fit theory and propose that complementarity and supplementarity may simultaneously exist and depend on the level of IT capabilities the focal firms possess. At a low to moderate level of IT capabilities, firms likely seek to bridge the IT knowledge gap, and thus, the complementarity effect is expected. At a higher level of IT capabilities, firms rely on supplementary fit to facilitate collaboration. Put differently, there is a U-shaped relationship between IT capabilities and IT alliance formation such that IT capabilities first negatively relates to IT alliance formation, indicating a complementary effect. After a tipping point at which IT capabilities become high, IT capabilities are positively associated with IT alliance formation, suggesting a supplementary effect. Further, we draw broadly from the organization-stakeholder fit theory to propose that environmental dynamism can reduce firms' collaboration tendency due to the escalating integration challenges, uncertainty, and risks (Bundy et al. 2018). Yet, when firms are required to collaborate in a highly dynamic environment, we leverage firm capabilities research and the alliance literature to theorize a shift in the preferences of focal firms toward alliance formation. Using panel data of 8808 non-IT firms, we find partial support for our model. Our study primarily contributes to the business value of IT literature, particularly the role of IT capabilities in driving strategic alliance formation. We also contribute to the alliance literature by showing new conditions under which firms seek complementary and supplementary fit with their partners.

Theory and hypotheses

Complementarity and supplementarity in alliance formation

Extant alliance literature has explored why firms form alliances with partners, and they proposed two main motivations to form alliances: complementarity and supplementarity. Complementarity refers to situations in which focal firms select partners based on differences in order to fill areas that the focal firms are missing (Bundy et al. 2018; Mitsuhashi and Greve 2009). On the other hand, supplementarity exists when focal firms choose partners through similarities in order to promote trust and coordination (Bundy et al. 2018; Mitsuhashi and Greve 2009). Prior studies have shown that which of these mechanisms prevails depends on the resources and capabilities being possessed and considered by the focal firms.

First, complementarity has been shown to drive alliance formation between the focal firms and their partners. Specifically, resource complementarity allows partners to access each other's resource base and potentially fill each other's resource gap (Chung et al. 2000; Furlotti and Soda 2018; Mitsuhashi and Greve 2009; Rothaermel and Boeker 2008). In other words, resource complementarity potentially provides both the focal firms and their partners the opportunity to utilize each other's strengths to compensate for each other's weaknesses. Moreover, complementarity, or non-overlap, in capabilities also enhances value creation as each partner has its specialization and can contribute its unique experience to the alliance activities (Diestre and Rajagopalan 2012). Lastly, when the focal firms and their partners possess complementary knowledge, such a complementarity fosters mutual learning opportunities (Meuleman et al. 2010; Yayavaram et al. 2018). Specifically, each partner can experiment with combining distinct

elements from different technological areas or different markets in order to generate super-additive value (Mitsuhashi and Greve 2009; Yayavaram et al. 2018). In the context of non-IT firms forming alliances with IT partners, they seek to leverage IT resources and capabilities that they might lack otherwise. Whereas the IT partners can contribute to the alliance with their IT knowledge, the non-IT firms can provide their industrial knowledge to assist the IT partners in the implementation and application of IT. In addition, such alliances allow the non-IT firms to implement the IT capabilities that they obtain from their IT partners into their operations, subsequently creating additional values to the focal firms through enhancing efficiency or spurring innovation (Xue et al. 2012). Further, through the alliances, focal firms can directly learn from the experts, absorb the IT knowledge and improve their own IT capabilities (Ravichandran and Giura 2019).

Second, prior studies have suggested that supplimentarity between focal firms and their partners also increases the likelihood of alliance formation between them. Particularly, allying with partners having similar resources allows the focal firms to pool resources together with those of the partners to achieve economies of scale (Yayavaram et al. 2018). Also, since their costs, processes, and outputs are homogeneous, the value created from pooling resources within these alliances can be consistent in terms of quality (Mitsuhashi and Greve 2009). Furthermore, when technologies are supplementary, the focal firms and their partners can easily identify and evaluate each other's knowledge base, as well as absorb and assimilate each other's technological components, subsequently enhancing value creation (Diestre and Rajagopalan 2012; Reuer and Lahiri 2014; Yayavaram et al. 2018). Supplimentarity in technologies additionally assures the focal firms that the alliances will entail efficient communication and coordination with the partners due to their similarities, thus further increasing the likelihood of alliance formation (Rothaermel and Boeker 2008). Lastly, supplimentarity, such as when the focal firms and partners operate in overlapping product markets, increases their familiarity with each other's resources and capabilities as well as decreases their risks of opportunism (Reuer and Lahiri 2014; Ryu et al. 2020). Following this argument, non-IT partners with high IT capabilities will be more likely to form alliances with IT partners to take advantage of supplimentarity. The success rates of these alliances are higher because the partners are familiar with each other's resources and capabilities and thus, can easily pool resources and enhance value creation. Further, the focal non-IT firms' familiarity with IT eases the collaboration with IT partners as they have a mutual understanding of IT and can absorb each other's IT components without having to make significant changes to their operational routines. Lastly, the IT knowledge possessed by both focal firms and IT partners can serve as a safeguard against opportunism, such that behaviors like hiding important knowledge or free-riding can be prevented (Dong and Yang 2015).

As each of these mechanisms has been argued by extant alliance literature to be independently important in determining focal firms' motivations for alliance formation, it remains unclear under which conditions complementarity or supplimentarity fit is preferred by the focal firms. This lack of clarity exists in our context, such that past research has not shed light on whether non-IT firms form alliances based on complementarity or supplimentarity. In this study, we posit that the type of fit depends on different levels of focal firms' IT capabilities. Incorporating both of these motivations within the mechanism is theoretically meaningful because the decisions to form alliances might depend not only on the type of resources and capabilities being considered, as suggested by prior research, but also on the level of these resources and capabilities that the focal firms possess.

IT capabilities and alliance with IT partners

Drawing from the organization-stakeholder fit theory and the alliance literature, we propose that the IT capabilities of the focal non-IT firms play a key role in driving alliance formation with IT partners. Particularly, we argue that when the focal non-IT firm have low IT capabilities, they tend to seek complementary fit with their partners, such that they collaborate more with IT partners. As IT capabilities of the focal firm increase, they will form alliances with IT partners to leverage supplementary fit.

At a low to moderate level of IT capabilities, focal firms seek to enhance their IT knowledge stock through collaboration with IT partners. The key reasoning here is that firms, via collaboration, aim to solve resource acquisition problems as the resource of interest is challenging to develop internally (Mitsuhashi and Greve 2009). Strategic alliances with partners who possess complementary resources have been shown as an effective strategy for the focal firms not only to obtain these missing resources but also to combine their own resources with those of their partners (Furlotti and Soda 2018; Mitsuhashi and Greve 2009).

Therefore, complementarity remains a strong extrinsic motivation for alliance formation (Bundy et al. 2018). Further, an extension of this reasoning is the assumption that firms in different industries excel in a certain area while underperforming in others (Diestre and Rajagopalan 2012; Rothaermel and Boeker 2008). Collaboration is among the best approaches for learning from partners' expertise and experience, subsequently helping the focal firms improve the areas in which they underperform.

These arguments hold for firms with low IT capabilities because IT capabilities require more than the adoption and implementation of IT (Chen et al. 2014; Pavlou and El Sawy 2010). More specifically, IT capabilities also engender the ability to integrate sophisticated IT into the organizations and facilitate alignment between IT and business functions (Rai and Tang 2010). Therefore, firms with low levels of IT capabilities aim to combine their firm-specific knowledge with IT knowledge from partners in the IT industries. For instance, firms can initiate IT projects for business development that they otherwise could not have done alone (Saldanha et al. 2013). Moreover, obtaining IT knowledge from relevant experts is considered a reliable strategy (Ravichandran and Giura 2019), allowing the focal firms to rely on IT experts to overcome their shortfalls in IT capabilities.

Remarkably, we argue that complementarity is replaced by supplementarity when the focal firms possess higher IT capabilities. Firms with supplementary resources can easily communicate and coordinate due to a mutual understanding and familiarity with each other's resources (Reuer and Lahiri 2014; Rothaermel and Boeker 2008). Further, as both the focal firms and their partners possess similar resources, such supplementarity assures the involved parties that the risk of opportunism and misappropriation is low, subsequently resulting in a higher level of trust (Ryu et al. 2020). Moreover, focal firms can easily evaluate as well as absorb partners' knowledge if there is supplementarity between the two knowledge bases (Diestre and Rajagopalan 2012; Yayavaram et al. 2018).

Extending these arguments to firms with high IT capabilities, we suggest that IT-capable firms look for different ways to apply and enhance their IT capabilities through allying with partners who share similar IT capabilities, i.e., partners operating in IT industries, for several reasons. In particular, focal firms will not have to concern about the possibility that the partners might misappropriate their IT capabilities, given that these partners also possess high IT capabilities themselves. Additionally, as both the focal firms and the partners have sufficient IT knowledge, they can easily share their routines, communicate, as well as coordinate over the course of the alliance, thus creating the initial perception of potentially successful collaboration (Rothaermel and Boeker 2008). Relatedly, the focal IT-capable firms and IT partners are also able to absorb and assimilate each other's knowledge, given that their knowledge bases share IT as the common component (Yayavaram et al. 2018).

Hypothesis 1: There is a U-shaped relationship between a firm's IT capabilities and its alliance formation with IT partners.

Boundary conditions: Environmental dynamism

Environment dynamism is defined as the frequency of changes and the uncertainty in the environment the firms operate (Sirmon et al. 2007; Zahra et al. 2006). Environmental dynamism is an important boundary condition in strategy research (Schilke 2014), especially in the context of alliance formation. Two parallel lines of research on environmental dynamism exist. First, research on organizational routines proposes that effective strategic behaviors require path-dependent accumulation to be fully integrated into firms (Eisenhardt and Martin 2000; Schilke 2014). A dynamic environment thus disturbs such accumulation and prevents the effective deployment of strategic behaviors. In contrast, studies on firm capabilities indicate that resource-consuming strategic behaviors are effective only in a dynamic environment (Helfat and Peteraf 2009; Zahra et al. 2006). This is because a dynamic environment creates opportunities for firms to exercise valuable capabilities. These opportunities are otherwise lacking in a stable environment where firms aim to achieve efficiency and maximize profits.

In this study, we contextualize the first argument and propose that environmental dynamism exacerbates alliance formation with IT partners. To successfully generate business value from IT knowledge, firms are required to integrate IT knowledge through path-dependent accumulation (Grewal and Tansuhaj 2001; Pavlou and El Sawy 2010). As environment dynamism introduces constant changes to the focal firms, it challenges this integration process of IT knowledge, especially when external knowledge outside of the focal firms' boundary is involved (Chakravarty et al. 2013; Levinthal and Rerup 2006).

Further, alliance formation with IT partners can be costly (Caner et al. 2018) while environment dynamism requires firms to carefully plan and allocate their resources to maintain and function, prompting firms to resort to less costly options (Girod and Whittington 2017; Wilhelm et al. 2015). Moreover, a dynamic environment increases the salience of risk which affect managerial decision toward inherently risky investments such as forming alliances with IT partners. Therefore, when firms face frequent and unpredictable changes in the environment, they will reconsider forming alliances with IT partners either for complementarity- or supplimentarity-purpose. Put differently, environmental dynamism weakens the effect of IT capabilities on alliance formation with IT partners because, under high uncertainty, firms will opt for safer, more controllable strategies such as developing IT knowledge through internal research and development (Kulatilaka and Perotti 1998).

Hypothesis 2: Environmental dynamism flattens the U-shaped relationship between a firm's IT capabilities and its alliance formation with IT partners.

In addition, we rely on the second argument and the alliance literature to argue that under extreme environmental dynamism, strategic alliances with IT partners might be imperative to survive and gain competitive advantages (Beckman et al. 2004). In such a circumstance, however, we propose that firms' collaborative preference switches. Because environmental dynamism represents a risky situation, firms with low IT capabilities will rely on similarity and mutual understanding as a basis of trust and hence, collaborate with similar partners to reduce risks and enhance collaboration effectiveness (Bierly III and Gallagher 2007; Rothaermel and Boeker 2008). As a result, under high environmental dynamism, firms with a low level of IT capabilities are more inclined to form alliances with IT partners as this capability increases. When firms possess a high level of IT capabilities, they may seek complementarity, thus likely collaborating with partners having an asymmetric level of IT capabilities (Terjesen et al. 2011). A high level of IT capabilities facilitates the absorption and integration of external knowledge (Dong and Yang 2015; Ravichandran and Giura 2019). Further, IT capabilities enable firms to critically evaluate partners (Lioukas et al. 2016), making the alliance with a dissimilar partner less risky and more worthwhile. In other words, as environmental dynamism is high, firms with a high level of IT capabilities presumably seek resource and knowledge complementarity from partners with a different knowledge base. They consequently refrain from allying with IT partners to free scarce resources much needed for this risky environment. Using the above discussion, we hypothesize a flipping mechanism at a high level of environmental dynamism, such that the U-shaped effect of IT capabilities on alliance formation turns into an inverted U-shaped relationship.

Hypothesis 3: The relationship between a firm's IT capabilities and its alliance formation with IT partners flips from U-shape under low environmental dynamism to inverted U-shape under high environmental dynamism.

Methods

We test our model in the context of U.S. public firms in non-IT industries forming alliances with partners in IT industries over the period from 2012 to 2020. As we focus on non-IT firms' collaboration behaviors, we start with the list of firms in the S&P 500 in the period and we exclude firms that belong to the IT industries. We classify IT industries using Kim et al. (2016)'s classification of 4-digit SIC codes. Subsequently, we construct our dataset by merging the following main sources: Thomson Reuters' SDC for alliance data, WRDS U.S. Patents extended with USPTO's PatentsView for patent data, and Compustat for firm financial data. We follow firms' operational and patenting activities one year before the alliance formation (t-1). Because our main sample consists of non-IT firms, they are theoretically operating outside the IT industries. After removing observations with missing financial information in Compustat, we arrive at a final sample of 52,908 firm-year observations from 8,808 firms.

To measure our dependent variable—a non-IT firm's alliance formation with IT partners, we count the number of alliances that each sampled firm forms in a year with partners who operate in at least one of the IT industries (Rahmati et al. 2022). We then take the natural logarithm of this number plus 1 to account for the skewness of our data. To proxy for a firm's IT capabilities, we count the number of granted IT patents that a firm applies for in a single year (Levitas and McFadyen 2009; Singh and Fleming 2010). A patent is classified as IT-related if it belongs to at least one IT class identified by prior research (Firk et al. 2021). We then divide the number of IT patents by a firm's patent portfolio size to adjust for the firm's patenting

tendency. To operationalize environmental dynamism, we regress industry sales over a three-year period, and then divide the standard errors of the regression slope by the mean of industry sales (Schilke 2014). Following prior research on alliance formation, we control for firm-level and industry-level factors: return on assets, Tobin's Q, firm size, R&D intensity, slack resources, alliance portfolio size, and industry competition (Beckman et al. 2014; Caner et al. 2018; Furlotti and Soda 2018; Mitsunashi and Greve 2009). Finally, we include year dummies to control for macro-level effects.

Due to the panel nature of our data, we employ firm fixed-effects models to test our hypotheses. Further, Hausman's test is significant, suggesting that a fixed-effects model should be preferred.

Preliminary results

According to Haans et al. (2016), hypothesis 1 is supported if (1) the first-order and squared terms of IT capabilities are significant and in line with the direction of the U-shaped relationship, (2) the slopes are significantly steep at the lower and higher end, and (3) the turning point lies within the data range. Model 2 in Table 1 shows that IT capabilities have a negative and significant effect and IT capabilities squared have a positive and significant effect on alliance formation with IT partners. Further, using the u-test command (Lind and Mehlum 2010), we find that the slope is significantly steep at both sides ($b = -0.158, p < 0.01$ and $b = 0.158, p > 0.01$) and the turning point (0.499) is within the data range from 0 to 1. We also check the shape of the curve by including the cubic term in model 3 and find an insignificant effect of this term. Thus, the result supports H1.

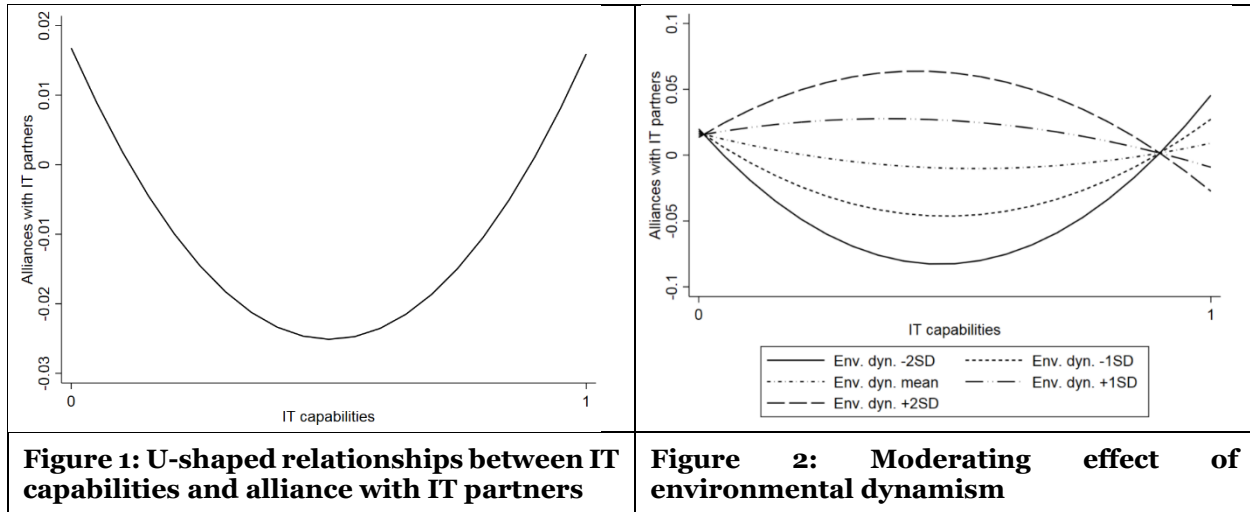
We find a significant positive interaction between IT capabilities squared and environmental dynamism. This indicates that as environmental dynamism increases, the U-shaped relation flattens (Haans et al. 2016). Figure 2 demonstrates the relationship between IT capabilities and alliance formation with IT partners at different levels of environmental dynamism. In general, we find support for H2.

	Model 1	Model 2	Model 3	Model 4
<i>Main effects</i>				
IT capabilities	-0.028 *** (0.008)	-0.167*** (0.026)	-0.226*** (0.059)	-0.221*** (0.030)
IT capabilities squared		0.166*** (0.029)	0.390* (0.202)	0.226*** (0.035)
IT capabilities cubic			-0.167 (0.149)	
<i>Moderating effects</i>				
IT capabilities x environmental dynamism				0.016*** (0.004)
IT capabilities squared x environmental dynamism				-0.017*** (0.005)
Control variables	Included	Included	Included	Included
Year fixed effects	Included	Included	Included	Included
R-Square (within)	0.0388	0.0395	0.0395	0.0398
Observations (firms)	52908 (8808)	52908 (8808)	52908 (8808)	52908 (8808)
Notes: * $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$. Standard errors in parentheses.				
Table 1: GLS fixed-effect results				

Remarkably, we also find that the interaction of IT capabilities and environmental dynamism is positive and significant, indicating that the turning point of the U-shaped relation might shift. We follow Haans et al. (2016) and calculate the direction and the significance of the turning point shift. To this end, we first derive the regression function with regard to IT capabilities and then further derive it with regard to environmental dynamism (Haans et al., 2016). We observe insignificant shifts from the low and high levels

of environmental dynamism ($p > 0.1$). This finding is in line with figure 2, demonstrating that the curve flips from U-shape to inverted U-shape at high levels of environmental dynamism and thus prevent a continuous turning point shift (Taeuscher and Rothe 2021). The empirical evidence does not support a significant turning point shift in our data range.

Finally, our graphical illustration shows that at a higher level of environmental dynamism, the relationship between IT capabilities and alliance formation with IT partners flips from a U-shaped to an inverted U-shaped relation. Following Haans et al. (2016), we calculate the value of environmental dynamism at which the curve flips. We find that the curve flips when the value of environmental dynamism is equal to 12.167, which is well within our data range. However, we do not identify a significant inverted U-shaped relationship at a high level of environmental dynamism (+1 SD and +2 SD). Thus, we do not find strong support for H3.



Conclusion and future direction

This study contributes to the IS literature by demonstrating the importance of the IT capabilities of the focal firms in influencing their future collaborations with IT partners, thereby preparing them to face the challenges in the digital age. We also contextualize the alliance literature and theorize that whether non-IT firms seek complementarity and supplementarity in future alliances depends on their level of IT capabilities. We further join the IT capabilities literature by showing the contingency of environmental dynamism. Our initial results show that a dynamic environment hinders alliance formation with IT partners as it poses integration challenges and increases the salience of risks. Further, under high environmental dynamism, alliance formation is imperative for competitive advantages. Under such circumstances, however, firms' preferences for partners shift. From these results, our study thus enriches the IT capabilities and business value of IT literature. Finally, we contribute to the alliance literature by synthesizing the complementary-supplementary effect of the focal firm's resources on alliance formation. We introduce the level of focal firms' resources and capabilities as the condition to determine whether focal firms collaborate with complementary partners to learn from and expand their knowledge, or with similar partners to facilitate collaboration.

In the future, we aim to improve the current study in two aspects. First, we plan to further investigate our shape-flipping hypothesis (H3) by examining the shape of the curves at different levels of environmental dynamism. Second, we seek to increase the robustness of our results by, for example, introducing different measures for IT capabilities and IT alliance formation. For examples, we plan to measure IT capabilities using the power of IT department (Feng et al. 2015) and the orientation toward IT in firms' strategy (Kindermann et al. 2021). Moreover, while the firm fixed-effect model enables us to limit endogeneity, we also plan to identify a theoretically meaningful instrument to increase the reliability of our results and corroborate our hypotheses.

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