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The link between technical knowledge transfer in alliances and resource efficiency: ambidexterity in development of R&D and appropriation capabilities

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Abstract
This study investigates how learning from alliances leads to more efficient use of resources in developing firm capabilities. To do so, we investigate how knowledge transfer in technological and non-technological alliances affects firms' efficiency to develop R&D and appropriation capabilities, respectively. Further, we examine the impact of alliances on firms' ambidexterity. lastly, we examine the contingencies that can influence the direct effect of alliances on firm ambidexterity. This longitudinal study uses a sample of 3,045 U.S. firms that formed alliances in 2006. The findings suggest that the firms' capabilities improve as a result of forming technical alliances but the same cannot be said about non-technical alliances. Nevertheless, establishing either form of alliance improves firms' efficiency in the use of resources to achieve ambidexterity. However, this effect is contingent on the disparity in the size of alliance partners and industry munificence.

Keywords Alliances · Ambidexterity · Organizational learning · Firm

JEL Classification O32

1 Introduction

Advancements in information technologies and the knowledge economy, fueled by globalization trends, offer a myriad of opportunities for firms to innovate collaboratively by forming interorganizational relationships (Parmigiani & Rivera-Santos, 2011). These relationships help develop valuable assets (Barringer & Harrison, 2000; Trahms et al., 2013; Villalonga & McGahan, 2005) and create resources in organizations (Newbert, 2007). Establishing and managing relationships with other organizations can foster the continuous revitalization of critical organizational capabilities. In this context, capabilities emerge

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from the coordination and integration of interorganizational knowledge (Phelps, 2010; Phelps et al., 2012).

While the existing literature suggests that interorganizational relationships are imperative to the development of valuable assets and accessing and creating resources in organizations (Newbert, 2007), findings on firm-level outcomes of alliances suggest varying levels of support (David & Han, 2004; Geyskens et al., 2006). For instance, research on alliances lacks consensus on whether these strategies are indeed cost-effective (David & Han, 2004). However, empirical support for the conducive effect of alliances on accessing resources have been more robust (Newbert, 2007). Similarly, empirical findings support the positive effect of these strategies on other intangible firm-level outcome such as legitimacy, and reputation, survival, and adaptation (Alter & Hage, 1993).

In this study, we argue that the reason for these inconsistencies is twofold. First, prior research has largely failed to consider the heterogeneity of alliances. Alliances are created for a variety of reasons (Parmigiani & Rivera-Santos, 2011) and firms hope to gain different benefits from them. We believe that this failure to consider the heterogeneity of alliances could explain why alliances have been shown to have an inconsistent effect on firm outcomes. To overcome this limitation, this study considers two types of alliance which provide different potential benefits to alliance partners (namely, technology and non-technology-based alliances) and examines the effect of these two types of alliances on firms' outcomes.

Second, we argue that these inconsistent results may be in part due to the fact that prior research has often failed to consider important alliance- and environmental- level contingencies (namely, the relative difference in the size of alliance partners, and the munificence of the industry) which affect the extent to which firms may benefit from alliances (Ferrigno et al., 2021; Terjesen et al., 2011). At the alliance level, we believe that since firms of different sizes often possess different resources, assets, and capabilities, joining an alliance with a partner of a significantly different size provides firms access to not only different sets of resources, assets, and capabilities than they currently possess, but also different from those they might have access to when joining an alliance with a partner of a similar size. Thus, the potential benefit from an alliance may be increased as the relative difference in partner size increases. At the industry level, we believe that differences in the relative munificence of the industry effects the potential benefits firms may gain from any alliance. Specifically, we believe that in less munificent environments, where resources are seriously constrained, alliance partners are more likely to gain access to beneficial resources, assets and capabilities available from their partner. Conversely, in munificent environments, where firms generally have relatively easy access to resources, assets, and capabilities, the potential benefit of an alliance is diminished as the alliance partner is less likely to provide a key resource, asset, or capability to their partner. As a result, the potential benefit of joining an alliance is lower as the munificence of the firm's industry increases.

In short, alliances are commonly viewed as resourcing strategies pursued by two or more organizations to share various forms of capital and create value (Rothaermel & Deeds, 2006; Zhao et al., 2017). However, the mere act of resource sharing does not necessarily guarantee positive outcomes from alliances. Rather, we argue that the form of knowledge gained from alliances influence firms' capabilities to use existing resources to create and capture value. Conversely, to develop the desired capabilities, firms must pursue the proper type of alliance that allows the transfer of required knowledge. We draw on the literature in organizational learning (March, 1991), alliances (Parmigiani & Rivera-Santos, 2011), and capabilities (Barney, 1991) to propose and empirically examine the link between forming: (1) technology, or (2) non-technology based alliances on developing firm R&D and appropriation capabilities, respectively. Further, we argue that these firm-level outcomes gained from alliances may be influenced by the characteristics of partnering firms and the environment. Thus, we examine the moderating effect of an alliance-level (i.e., the disparity in the size of alliance partners) and an environmental contingency (i.e., industry munificence) that can influence the nature of the direct relationship between alliances and firms' capabilities (Edelman & Yli-Renko, 2010).

In sum, to address and explain some of the inconsistencies across the body of literature on the effect of alliances on firm-level outcomes (David & Han, 2004; Geyskens et al., 2006), this study aims to investigate two research questions. First, this study aims to investigate the dissimilar impacts of two forms of alliances on developing firm capabilities. Specifically, we aim to investigate how technological and non-technological alliances affect firms' R&D and appropriation capabilities differently. Second, this study aims to examine how the impact of alliances on firm capabilities can vary in different environments and firms. Specifically, we examine how characteristics of partnering firms (i.e., size) and the environment (i.e., munificence) can change the impact of alliances on firm capabilities.

This study offers three key contributions to the literature on the structure of interorganizational alliances, firm capabilities, and ambidexterity. First, by dissecting the effect associated with the type of alliances on corresponding firm capabilities, this study extends our understanding of how alliances can contribute to different firm-level outcomes, such as innovation and financial performance. Second, we enrich the literature on firm ambidexterity by stressing the role of forming alliances to achieve firm exploration and exploitation objectives. Third, we shed new light on the role of environmental and firm-level contingencies that influence the effect of alliances on firm performance. Ultimately, the findings in this study advance our understanding of the factors that contribute to the success of alliances (Ritala, 2012).

This study is structured in five sections. A brief literature review synthesizes the literature on organizational learning, capabilities. Hypotheses are developed next. Then, the methods section, which explains the operationalization of constructs and the testing of the hypotheses, is presented, followed by a section that discusses the empirical findings, implications for theory, and directions for future research.

2 Literature review

As noted earlier, this study aims to investigates research questions positioned at the intersection of three areas of literature on: (a) organizational learning; (b) capabilities, and; (c) alliances. Thus, in this section we synthesize these areas of literature to first discuss the role of exploration and exploitation in alliances and next explore the implications of firm capabilities in improving ambidexterity.

2.1 Exploration and exploitation in alliances

Alliances are defined as a common form of interorganizational relationships where assets can be shared by and acquired from partners. Literature on alliances tends to use a typology by drawing on March's (1991) exploration and exploitation model. In his seminal piece, March (1991) defines exploration as "search, variation, risk-taking, experimentation, play, flexibility, discovery, and innovation," and exploitation as "refinement, choice, production, efficiency, selection, implementation, and execution" (p. 71). March's (1991) original conceptualization views exploration and exploitation processes as incompatible since (a) each competes for the same scarce resources; (b) each requires different mindsets, as exploration requires openness to new knowledge, while exploitation stresses commitment to existing knowledge; and (c) each are self-reinforcing, meaning exploration often leads to failure, which triggers more exploration (i.e., the failure trap), and exploitation often leads to success which triggers more exploitation (i.e., the success trap).

In context of alliances, Yang et al. (2011) differentiate between learning in exploration alliances versus exploitation alliances. Exploration alliances are usually related to seeking opportunities and intrinsic value from new, tacit knowledge, while exploitation alliances generally focus on short-term benefits from existing, codified knowledge. Further, these two types of alliances differ in the advantages they offer. Exploration alliances, in comparison to exploitation alliances, provide an opportunity to better understand the nature and the value of resources of the partnering firm. Additionally, exploration alliances tend to be more dynamic and thus create more opportunities for each partner (Yang et al., 2011). Similarly, Parmigiani and Rivera-Santos (2011) assert that exploration-oriented relationships are intended to build on reciprocal, interpersonal, and ongoing interactions that focus on learning, innovation, and tacit knowledge, under conditions of relative certainty. In contrast, co-exploitation relationships are intended for sequential, routinized, and formal interactions that focus on expansion, efficiency, and explicit knowledge, under conditions of relative uncertainty.

In this study, we focus on two specific forms of alliances, characterized based on the nature of knowledge transfer. As such, we define *Technology Alliances* as alliances that are formed mainly for the purpose of transferring technological knowledge between partners. Conversely, we define *Non-technology Alliances* as alliances that are formed primarily for the purpose of transfer of knowledge that is not necessarily technological in nature (Belderbos et al., 2018; Steensma et al., 2000).

2.2 Ambidexterity and firm capabilities

The logic for balancing exploration and exploitation has long been a point of contention (Gupta et al., 2006). Although one camp of scholars argues that exploration and exploitation should be conceptualized as two ends of a continuum (e.g., Auh & Menguc, 2005; Smith & Tushman, 2005), another group advocates that the relationship is orthogonal and propose that exploration and exploitation are complementary (e.g., Beckman, 2006; Lavie & Rosenkopf, 2006; Lubatkin et al., 2006). The continuity perspective is rooted in March's (1991) original conceptualization of exploration and exploitation as incompatible. However, this continuity view has been contested in recent years. This shift is associated with the merits of the orthogonal logic in explaining how exploration and exploitation can be indeed complementary as organizations can operate in multiple domains and across different levels (e.g., networks) (Lazer & Friedman, 2007). Thus, the scholarly debate on the two logics of exploration and exploitation has arrived at the conjunction that although in a single domain scarcity of resources increases the likelihood of mutual exclusivity of exploration and exploitation; across different loosely coupled domains, exploration and exploitation are indeed orthogonal.

The orthogonal argument allows for "the synchronous pursuit of both exploration and exploitation via loosely coupled and differentiated subunits or individuals, each of which specializes in either exploration or exploitation" (Gupta et al., 2006). This synchronous pursuit of exploration and exploitation is referred to as ambidexterity. Ambidexterity can be achieved through both context and structure (Benner & Tushman, 2003, 2015) by making the decision on whether exploration and exploitation will be pursued in the same context, or will be allocated across separate structures. Despite the theoretical advancements and refinements, the review by Gupta et al. (2006) points out the scarcity of empirical studies that investigate the validity of these assertions. Because ambidexterity requires the simultaneous allocation of organizational resources to both exploration and exploitation activities, its pursuit can be impeded by the resource constraints faced by the firm. Nevertheless, some resources can be shared and developed across firm boundaries without a depreciation of their value (Kraaijenbrink et al., 2010). Thus, firms can utilize the resources of others shared through interorganizational relationships to develop capabilities, and subsequently, satisfy the resource requirements of ambidexterity (Faridian & Neubaum, 2021).

However, the resource-based view (RBV) argues that above-average rents can be gained from developing, acquiring, and leveraging firm-specific resources (Hoskisson, Hitt, & Wan, 1999). Conversely, according to RBV, competitive advantage heavily relies on acquiring and managing difficult-to-imitate internal resources. For instance, while the literature on competitive forces (e.g., Porter, 1980) overlooks the significance of acquiring assets, RBV argues for the heterogeneous nature of resources and their stickiness, making it difficult for firms to develop new capabilities and competencies quickly. Many capabilities, such as tacit know-how, are commonly viewed as non-tradable. The seminal work of Teece et al. (1997) highlights the importance of developing dynamic capabilities to help sustain competitive advantages in rapidly changing environments. In this perspective, competencies and capabilities were conceptualized as the collection of a firm's processes, positions, and paths (Teece et al., 1997). In a more recent piece, Teece (2007) extends the focus of the dynamic capability perspective beyond the dynamism dimension by arguing that firms use three organizational processes to explore and exploit opportunities in their environment. These three processes aim to: (a) better understand the environment in terms of the opportunities and threats; (b) make strategic choices among possible opportunities, and (c) realize opportunities through organizational reconfiguration. These three processes, respectively, represent the *sensing-seizing-transforming* typology that has been likened to the *processes-positions-paths* in Teece et al.,'s 1997 piece (Schilke et al., 2018).

In sum, the literature on capabilities was founded on the underlying assumption of firm-specific assets, which limits the efficacy of inter-organizational relationships as a means to acquire knowledge from partners and build capabilities (Provan et al., 2007). However, in recent years, this view has evolved to recognize the importance of opportunities available in the environment that can be seized and utilized by firms (Schilke et al., 2018). Forming relationships with other firms, which are conducive to the development of capabilities to create and capture value, are an important vehicle to leveraging such opportunities (Ketchen et al., 2004). More recent literature extends exploration and exploitation focus to capabilities research. For instance, Sarkees et al. (2014) view a firm's exploration capability as "the efficiency with which the firm is able to create value through investments in experimentation and innovation" that ultimately leads to new products. Conversely, the exploration capability is defined as "the efficiency with which the firm is able to appropriate value from its existing markets" (p. 8) through marketing and advertising processes that directly affect outputs such as sales (Dutta et al., 1999; Mizik & Jacobson, 2003).

In this study, we focus on the use of internal inputs only.

This approach enables us to capture the effect of transferring and applying the knowledge gained from alliances to improving firm-specific capabilities to create and capture value. Thus, we dimensionalized capabilities along two specific types, namely *R&D* capabilities and *Appropriation* capabilities. Thus, we define *R&D capabilities* as firm efficiency in use of firm-specific research and development resources to create knowledge assets. Conversely, we define *Appropriation capabilities* as firm efficiency in the use of firm-specific production resources to monetize products and services. Capabilities associated with research and development (R&D) are commonly deemed vital to creating value. Conversely, appropriation capabilities are aimed at monetization and appropriation of technology.

3 Hypotheses development

The importance of interorganizational relationships has grown considerably as globalization and the advancements of the digital economy have blurred firm and industry boundaries (Barringer & Harrison, 2000). These relationships can be conducive to developing and renewing organizational capabilities as interactions aimed at establishing and managing relationships with other organizations can foster the continuous revitalization of critical organizational capabilities. Capabilities can emerge from the coordination and integration of interorganizational knowledge, which can subsequently lead to value creation and capture (Phelps, 2010; Phelps et al., 2012). Interorganizational relationships are imperative to the development of valuable organizational assets (Barringer & Harrison, 2000; Trahms et al., 2013; Villalonga & McGahan, 2005). Specifically, the implications of alliances for developing capabilities are immense (Buckley & Prashantham, 2016). However, evidence suggests a high degree of failure associated with alliances and their outcomes (Parmigiani & Rivera-Santos, 2011).

In this study, we provide a clearer understanding of the impact of alliances by dissecting the effects associated with two forms of alliances, namely technology and non-technology alliances, on ambidexterity and firm R&D and appropriation capabilities, respectively. Further, we examine the moderating impact of industry munificence, and size disparity

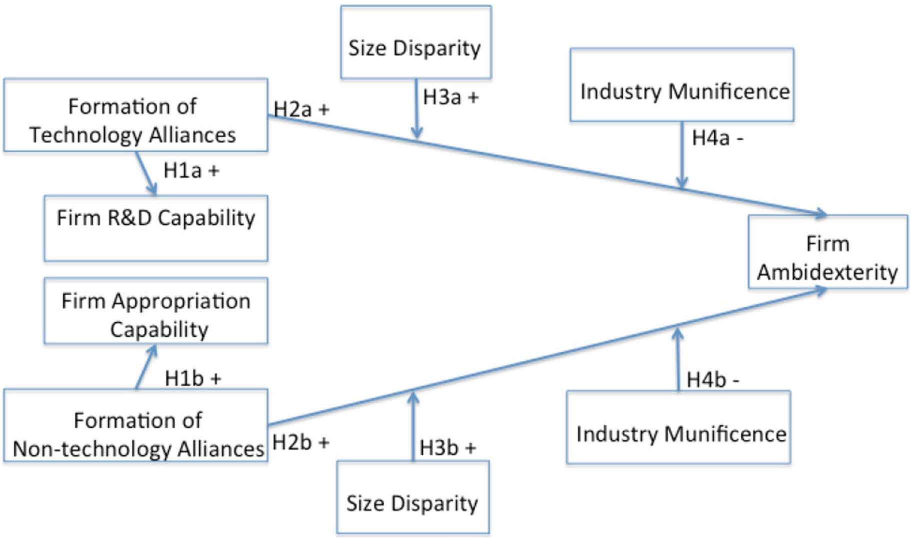

Fig. 1 Model

between alliance partners as contingencies that influence the effect of alliances on ambidexterity. The resulting model is depicted in Fig. 1.

3.1 Effect of alliances on capabilities

As discussed earlier, the alliances literature suggests that organizations absorb knowledge from their alliance partners in order to extend and improve their competencies (Kogut, 1988; Barringer & Harrison, 2000; Camisón & Villar-López, 2012). In other words, firms leverage partnerships to develop the ability to recognize the value of new knowledge, assimilate it, and apply it to their processes and practices (Cohen & Levinthal, 1990; Lane & Lubatkin, 1998). In short, by integrating the literature on types of alliances and capabilities, it can be argued that the development of R&D and appropriation capabilities can be strengthened by learning and knowledge gained from forming alliances that directly correspond to each type of capability.

Thus, while alliances can improve firm capabilities, in general, the new tacit knowledge gained from forming a technology alliance can carry a direct positive effect on improving the firm's efficiency to create knowledge-assets through investments in innovation and experimentation, namely R&D capabilities. In that light, as the firm acquires knowledge through forming technology alliances, it can also learn new and efficient ways to experiment and innovate. Assimilating, transferring, and integrating this type of tacit technological knowledge can help firms improve their capability to create knowledge assets through efficient use of resources such as patents. In short, forming technology alliances can positively affect firms' R&D capabilities.

Conversely, a similar logic can be applied to non-technology alliances. In that sense, the codified knowledge commonly acquired from forming non-technology alliances is expected to help develop firm capabilities to capture value from its products and services. In other words, as firms acquire codified knowledge through non-technology alliances, they also learn new ways to appropriate value from existing knowledge and innovations (Pisano, 2006). Thus, by assimilating, transferring, and integrating this form of learning into their processes, firms can improve their capability to appropriate through efficient use of resources such as sales and marketing expenditures, in order to increase firm-level output. In short, forming non-technology alliances positively affects firms' appropriation capabilities.

Hypothesis 1a *Forming technology alliances is positively associated with improved R&D capabilities.*

Hypothesis 1b *Forming non-technology alliances is positively associated with improved appropriation capabilities.*

A central argument proposed in previous research for explaining firms' intent in forming alliances suggests that firms tend to develop alliances that are conducive to addressing their objectives in terms of acquiring needed resources or improving desired activities, skills, and processes. Following this logic, it can be argued that firms tend to form technology and non-technology alliances in order to acquire and improve their R&D and appropriation capabilities as needed. In doing so, and by improving each area, forming alliances can subsequently result in improved firm ambidexterity. In that light, technology alliances, formed in response to firms' need for improving R&D capabilities, can improve firm ambidexterity. Likewise, non-technology alliances, likely formed in response to firms' need for improving appropriation capabilities, will also likely result in improved firm ambidexterity.

Because firms can access shared resources in alliances, improving one type of capability is not contingent upon sacrificing or neglecting the other type. In other words, as firms improve their R&D capability as a result of forming technology alliances, their appropriation capabilities should not suffer in return, and vice versa. Thus, because there is no trade-off between the two types of capabilities improved through alliances, the ambidexterity achieved by each firm follows the orthogonality logic, suggesting a complementary effect between R&D and appropriation. In short, forming either type of alliance can positively affect firm ambidexterity.

Hypothesis 2a *Forming technology alliances is positively associated with improved ambidexterity.*

Hypothesis 2b *Forming non-technology alliances is positively associated with improved ambidexterity.*

3.1.1 Moderating effects of size disparity and industry munificence

As discussed earlier, inconsistencies in research findings on the effects of alliances on firm-level outcomes (Parmigiani & Rivera-Santos, 2011) suggests the possibility of contingencies that moderate the direct effect of alliances. In that sense, the link between technology and non-technology alliances and ambidexterity, as postulated earlier, may be moderated by factors that govern the efficacy of alliances in terms of learning outcomes addressing firms' needs for a particular capability. In this section, we discuss the effects of two types of contingencies on the link between technology and non-technology alliances and ambidexterity. First, we discuss the positive moderating effect associated with the disparity in the size of alliance partners, as a type of alliance-level contingency. Second, we propose a negative moderating effect of industry munificence as a type of environment contingency.

Size disparity. Because we focus on the effect of learning gained through alliances, it is essential to consider that alliance partners with dissimilar characteristics are more likely to possess stocks of knowledge that are distinctly different. On the other hand, partners with similar characteristics are more likely to own considerably similar stocks of knowledge. For example, larger firms are more likely to possess codified knowledge, while smaller firms are more likely to possess tacit knowledge. In that sense, the disparity in size, defined as the difference in the number of employees of the partnering firms in alliances, can improve the likelihood of achieving learning outcomes that are radically different from firms' existing stock of knowledge. This effect is due to the fact that firms that are distinctly larger or smaller than their partner can offer stock of new R&D and appropriation forms of knowledge that their alliance partner is lacking. For example, when a relatively small firm enters an alliance with a distinctly larger firm, the learning outcomes for both firms are radically different than their existing stock of knowledge. However, this mutual benefit is less likely to occur when the partner firms are the same relative size. This type of learning that directly addresses the firms' knowledge gaps can strengthen the positive effect of technology and non-technology alliances on improving the form of capabilities that firms are in need of, and subsequently, improve ambidexterity. In short, size disparity positively moderates the impact of technology and non-technology alliances on ambidexterity.

Hypothesis 3a *The size disparity between alliance partners positively moderates the effect of technology alliances on ambidexterity.*

Hypothesis 3b *The size disparity between alliance partners positively moderates the effect of non-technology alliances on ambidexterity.*

Industry munificence. In addition to the partnering firms' dissimilarities, environmental contingencies, such as industry factors (i.e., industry munificence), may also moderate the link between technology and non-technology alliances and ambidexterity. This effect is attributed to the fact that environmental contingencies can influence the necessity of a firm to develop a particular type of capability based on knowledge gained from their alliance partner. Although scholars suggest that organizations can absorb knowledge from their alliance partners (Barringer & Harrison, 2000; Kogut, 1988), the extent to which firms rely on alliances, as opposed to other possible sources of learning in their environment to develop competencies and capture value, is not clear.

Thus, we suggest that in highly munificent environments, firms can easily access resources (Castrogiovanni, 1991), so there is less need to learn how to access them, and thus the firm is less likely to benefit from alliances as a source of learning. In that sense, in munificent environments, resources are more likely to be widely spread across industry participants, thus the marginal benefit of a particular alliance is lower. In a low-resource environment, the stocks of resources possessed by firms are likely to be unique, since resources are not as equally distributed across firms, thus an alliance will be a greater benefit to each partner.

Conversely, a low degree of environmental munificence suggests a decline in the likelihood of firms' access to a diverse stock of resources, and consequently, increases firms' benefit from alliances as a source of learning. In short, environmental munificence can weaken the positive effect of technology and non-technology alliances to address their need for improving R&D and appropriation capabilities, and subsequently improve ambidexterity. In short, environmental munificence can negatively moderate the link between technology and non-technology alliances and ambidexterity.

Hypothesis 4a *Industry munificence negatively moderates the effect of technology alliances on ambidexterity, such that the positive relationship between technology alliances and ambidexterity grows less positive as industry munificence increases.*

Hypothesis 4b *Industry munificence negatively moderates the effect of non-technology alliances on ambidexterity, such that the positive relationship between technology alliances and ambidexterity grows less positive as industry munificence increases.*

4 Methods

4.1 Sample

To test the hypotheses proposed in this study, we compiled a sample by merging three databases: Securities Data Company (SDC) Platinum database, COMPUSTAT, and the United States Patent and Trademark Office (USPTO). First, we used SDC Platinum database to identify firms that formed at least one alliance in 2006. Based on this search, we collected a list of 3,045 U.S. firms that fit the sampling criteria. Second, we collected data on the alliances formed by these firms from SDC Platinum database. Third, we used COMPUSTAT to collect data on performance and other general characteristics of these firms. Lastly, to collect data related to innovation and knowledge asset creation (e.g., patent registration) we used the United States Patent and Trademark Office (USPTO). In order to mitigate the threat of common source bias (Spector, 2006), we collected the dependent variables and independent variables from different sources. Specifically, we collected alliance data from the SDC Platinum database, while we used COMPUSTAT and the USPTO databases to obtain firms' financial and patent data. Further, to establish causality (Cook & Campbell, 1979) and determine the direction of relationships, we used a four-year time lag to separate independent and dependent variables.

Our sample includes 3,045 U.S. firms that formed alliances in 2006, as identified in the SDC Platinum database. We collected the independent variables (e.g., technology- and non-technology alliances) from the 2006 SDC Platinum database. The time lag between independent and dependent variables was determined based on the average life cycle duration of alliances. The literature typically assumes alliance length to be three to five years (Kogut, 1988; Lavie & Rosenkopf, 2006; Stuart, 2000), thus we drew dependent variables for each firm using the 2010 data in the COMPUSTAT and USPTO databases. Appendix Table 3 demonstrates the relevant summary statistics data of the firms in the sample.

We test the hypotheses with hierarchical linear regression in order to separate the effects associated with control variables, independent variables, and interaction terms. The treatment of missing values uses the pairwise exclusion of cases in the SPSS software package. In pairwise exclusion, correlation coefficients for each pair of variables were created based on all the cases with valid data for that pair.

4.2 Measures

Dependent variables To operationalize the two dependent variables representing *R&D Capability* and *Appropriation Capability,* we drew on prior operationalizations of these variables as efficiency measures (Sarkees et al., 2014). Thus, the two capability measures were calculated as a ratio of inputs and outputs. As discussed earlier, a firm's *R&D Capability* represents the ability of the firm to efficiently create value through experimentation and innovation. We conceptualize the intended output of value creation in terms of developing new knowledge assets (Rothaermel & Deeds, 2004). Conversely, the input required to support experimentation and innovation is conceptualized as a firm's investment in research and development. As a result, a firm's *R&D Capability* in this paper reflect the efficiency with which investment in research and development is converted into new knowledge assets. To measure knowledge assets, this study uses the number of patents granted to each firm in 2010. Patent registration marks the initial stage of transforming ideas generated through research into potential products and services to be developed by firms (Rothaermel & Deeds, 2004). Consequently, patents are appropriate outputs representing firm's experimentation and innovation. This data was extracted from the USPTO database. To measure investment in research and development, this study utilizes a firm's total expenditure on research and development in 2010, drawn from the COMPUSTAT database. To resolve division by zero, we incremented the denominator by one. In short, we used the below formula to measure R&D capability:

A firm's *Appropriation Capability*, on the other hand, represents how efficiently a firm leverages resources, such as manufacturing and production, to successfully appropriate value from its existing products and markets (Sarkees et al., 2014). We conceptualize the intended output of value appropriation in terms of monetization of products and services, which subsequently translates into increased profit. Conversely, the input required to support manufacturing is conceptualized as a firm's investment in infrastructure, such as production equipment. These investments can lead to economies of scale, which in turn improve efficiency in appropriating value from the market. As a result, a firm's *Appropriation Capability,* in this paper reflects the efficiency with which investment in production improves profit. The ultimate goal of appropriation is to maximize profit. Thus, following Sarkees et al. (2014) approach, we used a firm's total sales in 2010 to represent the output of the appropriation capability variable. This data was drawn from COMPUSTAT. To measure investment in production, we used the total cost of goods sold, which represents the cost of manufacturing a good. The total cost of goods spent by each firm in 2010 was drawn from COMPUSTAT. To resolve division by zero, we incremented the denominator by one. Subsequently, the below formula was used to measure appropriation capability:

In accordance with the two logics of continuity and orthogonality, the two terminologies of *balanced* and *combined* ambidexterity, respectively, are commonly used to measure ambidexterity. The balanced form of ambidexterity suggests a trade-off between exploration and exploitation, and thus is associated with the continuity logic, while the combined form of ambidexterity suggests a complementary effect between exploration and exploitation. Because ambidexterity requires an allocation of organizational resources to exploration and exploitation activities, its pursuit can be impeded by the resource constraints of firms. In this study combined ambidexterity is used as the theoretical arguments are based on the logic of orthogonality where firms can utilize the resources of others shared through alliances to avoid the potential trade-off between exploration and exploitation. Thus, in this study, *Ambidexterity* was measured by multiplying *R&D Capability* and *Appropriation Capability* (Cao et al., 2009).

Independent and moderating variables. Since this study is focused on technology transfer, we distinguished between technology and non-technology based alliances. Thus, *Technology Alliance* was operationalized as the total number of firm alliances that involved the transfer of technology. Conversely, *Non-technology Alliance* was operationalized as the total number of firm alliances that did not involve the transfer of technology. We operationalized *Size Disparity* as the absolute value of the average difference in firm sizes, based on the (number of employees of each alliance partner. *Industry Munificence* was calculated as a time-varying industrial factor (Carpenter & Fredrickson, 2001) by creating a five-year (2001 to 2005) rolling window for net sales at the four-digit SIC code level to measure munificence for the sixth year (2006). To do so, we followed the common approach (Carpenter & Fredrickson, 2001) to calculate environmental indicators using $yt = b0 + b1 \times t + et$ equation, where yt is industry sales, t is year, and e is the residual. In this approach, *Industry Munificence* is calculated by dividing the regression coefficient of time (b1) with the mean value of industry sales. Appendix Table 4 shows the relevant data on industries in sample of firms used in this study.

Control variables. We controlled for four variables in this study. At the firm level, we controlled for *Firm Age* and *Firm Size*. *Firm Age* is the firm's date of incorporation subtracted from 2006 and *Firm Size* is the total number of employees- neither is log-transformed. We also controlled for two variables that can affect exploration, exploitation, and ambidexterity, and thus can explain variances in the model beyond the effect of independent variables. Following approaches used in previous alliance research (e.g., Lavie & Rosekopf, 2006; Lavie et al., 2011), we controlled for firm-level effects such as firms' past financial performance: *Firm Profitability* and *Firm Solvency,* which can lead to exploitation trap, and thus, prevent exploration (Levinthal & March, 1993). *Firm Profitability* is the ratio of firm net income to its total assets in the year preceding the formation of alliances (i.e., 2005), and *Firm Solvency* is the log-transformed ratio of firm cash to long-term debt. Both are calculated from COMPUSTAT data.

5 Results

Table 1 contains descriptive statistics and bivariate correlation analysis for relevant variables. Table 2 presents the results of hierarchical regression analyses that examine the effect of technology and non-technology alliances on R&D and appropriation capabilities as well as ambidexterity. The average of total alliances per firm is 1.34. The average number of non-technology alliances (0.91) is almost twice the average number of technology alliances (0.43). The average firm age is around 22 years old, while the average firm size is approximately 19 employees. The average gross profit of firms in the sample is approximately $4,450,000, and the average market value is estimated at $14,120,000. Table 1 demonstrates a positive and significant ($p < 0.01$) correlation between technology alliances and R&D capability. The correlation between non-technology alliances and appropriation capability is also positive and significant ($p < 0.05$). Lastly, correlations between both technology and non-technology alliances and ambidexterity are positive and significant ($p < 0.01$).

We tested Hypotheses 1a and b, suggesting positive relationships between technology and non-technology alliances and R&D and appropriation capabilities, respectively, in Models 1–4 in Table 2. Model 2 tests Hypothesis 1a predicting a positive relationship between technology alliances and R&D capabilities. This relationship is positive and significant ($p < 0.01$), supporting Hypothesis 1a. Hypothesis 1b predicting a positive relationship between non-technology alliances and appropriation capability, is tested using Model 4. Unlike the relationship postulated in Hypothesis 1a, this relationship is not significant. Overall, the regression results for Hypotheses 1a and b suggest partial support due to the lack of significant findings for Hypothesis 1b. Thus, while we found strong support for the effect of technology alliances on firms' R&D capabilities, the same cannot be said about the effect of non-technology alliances on firms' appropriation capability.

We tested Hypotheses 2a and b, predicting positive effects of forming technology and non-technology alliances on ambidexterity, in Models 5–10 in Table 2. Firm age is not included as a control variable in these models due to model specification process. The relationship between technology alliances and ambidexterity is positive and significant ($p < 0.01$), supporting Hypothesis 2a. Similarly, the relationship between non-technology alliances and ambidexterity, proposed in Hypothesis 2b, is also positive and significant ($p < 0.01$). These results indicate full support for hypotheses 2a and b, suggesting that forming either technology or non-technology alliances improve firm ambidexterity.

We tested hypotheses 3a and b, proposing positive moderation effects of disparity in the size of partnering firms on the link between technology and non-technology alliances and ambidexterity, in Models 7 and 10 of Table 2. Testing for the moderation effect of size disparity on the link between technology alliances and ambidexterity resulted in a positive and significant ($p < 0.01$) interaction term. However, the direct effect of size disparity on ambidexterity is not significant. Thus, we conducted supplemental analysis to examine the significance of the F change in order to confer the potential for moderation effect. After entering the interaction term, the F change is indeed significant ($p < 0.000$). Further R-square

Table 1 The results of bivariate correlation analysis

	N	M	SD	Correlations											
Firm size	457	19.06	106.51	–	.196**	.047	−.090	.172*	−.019	.109	.069	.096*	.933**	−.050	.082
Firm age	213	22.78	7.06	.196**	–	.142*	−.150*	.235*	.069	.202*	.005	.127*	.058	.106	.084*
Firm profitability	431	–.35	2.15	.047	.142*	–	.136**	.122	.057	.055	.062	.073	.048	−.145**	.051
Firm solvency	340	−.17	1.17	−.090	−.150*	.136**	–	−.068	−.044	−.058	.123*	−.035	−.062	−.030	.313**
R&D capability	163	119.31	479.51	.172*	.235*	.122	−.068	–	−.020	.861**	.643**	.483**	.125*	−.085	−.158*
Appropriation capability	345	3.67	17.99	−.019	.069	.057	−.044	−.020	–	.092	.023	.113*	−.013	.069	−.158*
Ambidexterity	167	383.00	1671.61	.109	.202*	.055	−.058	.861**	.092	–	.714**	.607**	.085	−.082	.563**
Technology alliances	3045	.43	.70	.069	.005	.062	.123*	.643**	.023	.714**	–	−.120**	.040	−.102*	.753**
Non-technology alliances	3045	.91	.88	.096*	.127*	.073	−.035	.483**	.113*	.607**	−.120**	–	.030	−.008	−.359**
Size disparity	942	22.54	88.53	.933**	.058	.048	−.062	.125*	−.013	.085	.040	.030	–	.083	1.000
Industry munificence	473	.12	.33	−.050	.106	−.145**	−.030	−.085	.069	−.082	−.102*	−.008	.083	–	.082

Note: Standardized regression coefficients are reported

* $p<0.05$ | ** $p<0.01$

Table 2 Results of hierarchical regression on the effect to alliance orientation on capabilities and ambidexterity

	R&D capability $_t$		Appropriation capability $_t$		Ambidexterity $_t$					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Control variables										
Firm age $_{t-4}$	.190	.133*	.062	.05	–	–	–	–	–	–
Firm size $_{t-4}$	.127	.032	−.038	−.049	.101	.070	.063	.101	−.108	−.744**
Firm profitability $_{t-4}$	.095	.034	.057	.049	.058	.028	.037	.058	.002	.013
Firm solvency $_{t-4}$	−.041	−.119*	−.046	−.049	−.056	−.148*	−.135*	−.056	−.038	−.031
Independent variables										
Technology alliance $_{t-4}$	–	.718**	–	.042	–	.727**	.610**	–	–	–
Non-technology alliance $_{t-4}$	–	.542**	–	.111	–	–	–	–	.610**	.443**
Size disparity $_{t-4}$	–	–	–	–	–	.033	−.085	–	.162	.037
Industry munificence $_{t-4}$	–	–	–	–	–	−.006	.018	–	−.077	.267*
Interaction variables										
Technology alliance * Size disparity	–	–	–	–	–	–	.350**	–	–	–
Technology alliance * Industry munificence	–	–	–	–	–	–	−.169*	–	–	–
Non-technology alliance * Size disparity	–	–	–	–	–	–	–	–	–	.961**
Non-technology alliance * Industry munificence	–	–	–	–	–	–	–	–	–	−.390**
R^2	.081	.772	.01	.023	.018	.534	.650	.018	.381	.679
Adjusted R2	.041	.757	−.02	−.023	−.01	.507	.623	−.01	.346	.665
R^2 change	.081	.691	.01	.013	.018	.516	.116	.018	.363	.298

Note: Standardized regression coefficients are reported

$^*p < 0.05$ | $^{**}p < 0.01$

change suggests an improvement of over 9.4 percent in the effect size. These results suggest the potential for the moderation effect postulated in hypothesis 3a. To further confirm the moderation effect, we used PROCESS in SPSS. The model generated using this process reports significant values ($p < 0.000$) for all direct and moderation effects. Further, the graph generated using this process, as demonstrated in Appendix Fig. 2 suggests that at high levels of the size disparity, technology alliances result in higher values of ambidexterity. Together, these analyses confirm the moderation effect of size disparity on the link between technology alliances and ambidexterity, and thus, support Hypothesis 3a.

Testing the moderation effect of size disparity on the link between non-technology alliances and ambidexterity, as postulated in Hypothesis 3b results in a positive and significant ($p < 0.01$) interaction term, as shown in Model 10. However, the direct effect of size disparity on ambidexterity is not significant. Supplementary analysis suggests that the F change is indeed significant ($p < 0.000$) after entering the interaction term. Moreover, the R-square change shows an improvement of over 26 percent in the effect size after entering the interaction term in the model. These results suggest the potential for the moderation effect postulated in Hypothesis 3b. The PROCESS model reports significant values ($p < 0.000$) for all direct and interaction effects, which further confirms moderation. The graph generated using this process, Appendix Fig. 3 shows that at average and high levels of non-technology alliances, the moderation effect is stronger, confirming Hypothesis 3b. However, as the value of exploitation alliances decreases to low levels, this effect becomes slightly weaker. These analyses confirm the significant moderation effect of size disparity on the link between non-technology alliances and ambidexterity, in support of hypothesis 3b. Thus, Hypotheses 3a and 3b are supported.

We tested Hypotheses 4a and 4b, which proposed negative moderation effects of industry munificence on the link between technology and non-technology alliances and ambidexterity, in Models 7 and 10 of Table 2. Testing this moderation effect on the link between technology alliances and ambidexterity, as postulated in hypothesis 4a, resulted in a negative and significant ($p < 0.05$) interaction term. However, the direct effect of size disparity on ambidexterity was not significant. In the supplementary analysis, the F change is indeed significant after entering the interaction term ($p < 0.05$). Further, R-square change suggests a slight improvement of over 3 percent in the effect size. These results suggest the potential for the moderation effect postulated in hypothesis 4a. The PROCESS model confirms a negative and significant ($p < 0.05$) interaction term. However, the direct effect associated with industry munificence remains non-significant. Further, the graph generated using this process, presented in Appendix Fig. 4 confirms the moderation effect being stronger at average and high levels of technology alliances. Together, these analyses confirm the significant and negative moderation effect of industry munificence on the link between technology alliances and ambidexterity, supporting Hypothesis 4a.

Testing this moderation effect on the link between non-technology alliances and ambidexterity, as postulated in Hypothesis 4b, results in a negative and significant ($p < 0.01$) interaction term, as shown in Model 10. The direct effect of industry munificence on ambidexterity is also significant ($p < 0.05$). Moreover, based on supplemental analysis, the F change is significant ($p < 0.01$) after entering the interaction term. However, R-square change suggests only a slight improvement of over 4 percent in the effect size after entering the interaction term in the model. These results suggest a potential moderation effect. Further analysis of the model generated using PROCESS reports a significant value ($p < 0.05$) for the direct effect of industry munificence as well as a negative and significant ($p < 0.000$) interaction effect. The graph generated using this process, presented in Fig. 5 in the Appendix, confirms the moderation effect of size disparity on the link between non-technology alliances and ambidexterity, suggesting a pattern similar to Hypothesis 4a. At average and high levels of non-technology alliances, the moderation effect is stronger. Together, these analyses confirm the significant and negative moderation effect of industry munificence on the link between non-technology alliances and ambidexterity, supporting Hypothesis 4b. In short, both hypotheses 4a and b are supported. Overall, from four sets of hypotheses proposed in this study, three (Hypotheses 2a/b, 3a/b, and 4a/b) are fully supported, and one (Hypotheses 1a/b) is partially supported.

6 Discussion

The support for hypotheses proposed in this study can help explain some of the inconsistent findings across the body of literature on alliances, capabilities, and ambidexterity (David & Han, 2004; Geyskens et al., 2006). By examining the effect of alliances through dissecting the outcome associated with each type of technology and non-technology alliances, we enrich the current state of knowledge about the firm-level outcomes of forming alliances. Specifically, we find that technology alliances can improve firm R&D capability. However, we do not find a significant effect associated with non-technology alliances on firm appropriation capabilities. In that sense, whether firms' capabilities benefit from forming alliances may indeed depend on the type of alliances they join. Further, because the benefit from alliances may relate only to a specific type of capability, studies that do not examine such capabilities may not find significant firm-level outcomes associated. As such, this study offers a better understanding of factors that influence the success of alliances.

Further, the inconsistent results for the effect of technology and non-technology alliances can offer insights on research that emphasizes the distinctions between alliance types. For instance, technology alliances, in comparison to non-technology alliances, provide an opportunity to better understand the nature and the value of resources of the partnering firm, which subsequently results in better learning outcomes, as found in this study. Additionally, technology alliances tend to be more dynamic and thus create more opportunities (Yang et al., 2011). Lastly, the effect of learning tacit knowledge associated with technology alliances tends to be long-term, while codified knowledge gained through non-technology alliances carries a more immediate effect. Codified knowledge is easy to articulate, transfer, teach, and learn. However, because this type of knowledge is usually externalized and has a fixed content that may not be effective or relevant after a certain period, the effect of codified knowledge can dissipate more quickly or become obsolete, (Polanyi, 1960; Nonaka & Takeuchi, 1995). In contrast, tacit knowledge, while more difficult to capture and share in the short run, becomes embedded and internalized for future use in the long run, and thus, its effect can last longer. Because we used four-year outcomes to measure the effect, the short-term effect of non-technology alliances may not have been captured. Future research should use panel data to better understand the temporal effect impacting the link between technology and non-technology alliances and capabilities.

Our results suggest that although forming alliances may not lead to significant improvement in appropriation capabilities, firm ambidexterity will improve from either type of alliance. These findings challenge the conventional assumptions of capabilities literature (Barney, 1991; Teece et al., 1997), which overlooks interorganizational relationships as a means to learn, improve capabilities, and gain competitive advantage (Provan et al., 2007). Conversely, our findings on the effect of alliances on firm ambidexterity reaffirm the current direction of research on capabilities, recognizing the importance of opportunities available in the environment to access non-firm-specific resources (Ketchen et al., 2004; Schilke et al., 2018). The positive effect of alliances on ambidexterity, specifically, suggests that because firms can access resources shared in an alliance, improving one type of capability is not contingent upon sacrificing and neglecting the other type. Thus, because there is not a trade-off between the two types of capabilities improved through alliances, the ambidexterity outcome achieved represents the combined, as opposed to the balanced form of ambidexterity. These findings are aligned with the orthogonality logic, which in contrast to the traditional continuity logic, has gained more support in recent years.

The findings on the moderating effects of alliance and environment characteristics can further explain inconsistencies in research on alliances, as it governs the efficacy of alliances with regards to learning outcomes that address firms' desire for specific capabilities. The positive moderating effect of partners' size disparity on the link between alliances and ambidexterity suggests that the difference in the size of the partnering firms in alliances can improve the likelihood of achieving learning outcomes that are radically different from firms' existing stock of knowledge. This effect is due to the fact that distinctly larger or smaller partners can offer stocks of new knowledge that the firm is lacking. These findings suggest the importance of considering partners' characteristics, in terms of differences, rather than similarities, during the selection process and before alliance formation. Additionally, we found that industry munificence can also moderate the link between alliances and ambidexterity, as it weakens the potential benefits which may accrue from alliance praters. Thus, the degree to which firms rely on, and benefit from, alliances as a source of learning (Barringer & Harrison, 2000; Kogut, 1988) can depend on the availability of other knowledge resources in their environment. In that sense, a high degree of environmental munificence increases the likelihood of firms' access to a diverse stock of resources in the environment, and consequently, decreases the efficacy of alliances as a source of learning. These findings can offer some explanation for the popularity of alliances in some industries in comparison to others.

Further, the industry-level moderation effects found in this study can help explain discrepancies in research on the impact of alliances that use industry-specific samples. Thus, while utilizing samples from industries, such as computer software, is a popular practice, due to the prevalence of alliances, future research should use samples that contain different industries, or a greater cross section of industries, in order to ensure the generalizability of findings. Lastly, future research should examine the effect of other environmental contingencies which may affect the potential benefits of alliances, such as rate of technological change, on the link between alliances and ambidexterity. Including such environmental contingencies can help researchers better understanding the conditions under which alliances may help improve firm outcomes and their competitive position.

Our findings imply the possibility that the learning outcomes gained from the formation of alliances may be subject to a temporal effect. In that light, the effects of forming alliances may be revealed only after enough time is allowed for newly acquired knowledge to be absorbed, transferred, integrated, and applied to firms' own processes (Cohen & Levinthal, 1990; Lane & Lubatkin, 1998). Thus, future research should use longitudinal approaches that examine the effect of alliances on firms' processes and capabilities across various stages of alliance development and even after termination. Lastly, to better understand the role of firms' intentions in forming alliances in achieving firm-level outcomes, future research should further examine such assumptions through the use of surveys, interviews, and qualitative methodologies.

7 Conclusions

While improving firm performance is commonly considered the ultimate goal of alliances (Parmigiani & Rivera-Santos, 2011), findings on firm-level outcomes suggest varying levels of support for whether alliances are indeed effective (David & Han, 2004; Geyskens et al., 2006). In this study, we investigated how learning from alliances leads to more efficient use of resources in developing firm capabilities. Drawing on organizational learning, alliances, and capability literature, we explore how technological and non-technological knowledge transfers in alliances, affect firms' efficiency to develop R&D and appropriation capabilities, respectively. Further, we examined the effect of forming alliances on firms' efficiency in using resources to achieve ambidexterity. Moreover, we examined the moderation effect of an alliance-level and an environmental level contingency that can influence the direct effect of alliances on firm ambidexterity.

The findings suggest that whether firms' capabilities benefit from forming alliances may indeed depend on the forms of knowledge transferred in the alliance. Nevertheless, either form of alliance helps improve firms' efficiency in the use of resources to achieve ambidexterity. However, this effect is contingent on the disparity in the size of alliance partners and industry munificence. In short, this study contributes to the existing literature by delineating the effect of alliances on firm capabilities and ambidexterity and highlighting contingencies that govern these effects to explain inconsistent findings in this area of research.

Table 3 Summary statistics on firms included in the sample

	Mean	Std. Deviation
Total current assets $_{t-4}$	2281.79	6289.00
Cost of goods sold $_{t-4}$	4442.42	19,194.68
Total long-term debt $_{t-4}$	3643.54	24,906.85
Net income (loss) $_{t-4}$	524.99	1981.043
R&D expense $_{t-4}$	– 14.89	186.59
Number of patents $_{t-4}$	77.53	300.88
Net Sales/Turnover $_{t-4}$	7123.80	26,534.81
Sale of common and preferred stock $_{t-4}$	149.07	674.90
Total stockholders equity $_{t-4}$	5401.27	15,181.45
Total current assets $_{t}$	3389.65	8673.06
Cost of goods sold $_{t}$	5713.52	22,284.49
Total long-term debt $_{t}$	12,021.55	159,993.68
Net income (loss) $_{t}$	719.76	2754.04
R&D expense $_{t}$	– 2.17	20.56
Number of patents $_{t}$	116.70	456.04
Sales/Turnover (net) $_{t}$	9386.12	31,794.90
Sale of common and preferred stock $_{t}$	179.64	1543.09
Total stockholders equity $_{t}$	5259.89	17,457.10
Total market value $_{t}$	12,673.89	34,985.00
Gross profit (loss) $_{t}$	3672.60	12,534.24

All values except Number of Patents are in millions

Table 4 Summary statistics on industrial sectors included in the sample

Industries (based on the 2-digit Sic codes)	% Cases in each industry	Sales* $_{t-6}$		Sales $_{t-5}$		Sales $_{t-4}$		Sales $_{t-3}$		Sales $_{t-2}$		Sales $_{t-1}$	
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Agriculture, forestry, and fishing	1.1%	3850.50	6912.56	3684.72	6593.71	3447.68	6068.03	3861.90	6705.49	4237.73	7454.62	4740.03	8257.90
Construction	1.6%	13,513.05	18,100.78	15,309.18	20,031.52	17,242.01	24,683.45	19,249.48	29,776.81	23,433.91	37,466.80	29,522.73	47,495.97
Finance, insurance, and real estate	8.9%	50,926.23	79,114.71	49,382.04	73,257.17	46,462.63	66,560.05	49,789.41	71,617.37	52,521.25	77,404.80	58,123.00	85,653.38
Manufacturing	49.4%	19,505.27	52,390.92	18,675.35	47,124.04	18,250.02	45,623.10	19,481.14	48,949.41	22,372.70	58,180.93	24,082.94	64,579.00
Mining	2.5%	26,440.68	61,622.81	26,303.16	58,803.20	23,168.10	48,386.40	31,747.72	72,288.20	38,539.59	89,362.94	49,252.47	115,381.00
Public administration	0.5%	104,897.00	118,718.53	104,782.54	122,402.43	106,673.45	128,356.07	118,758.13	147,080.61	134,561.03	170,216.92	137,855.67	175,321.07
Retail trade	6.6%	41,803.20	62,417.64	45,598.11	69,360.76	48,337.21	74,190.44	50,836.90	78,605.36	57,609.20	89,882.50	61,921.93	95,774.02
Services	14.1%	6720.10	14,981.33	6414.59	14,247.02	6107.27	13,556.65	6503.17	14,923.73	7141.92	16,239.86	7302.27	15,696.80
Transportation, communications, electric, gas, and sanitary services	7.7%	65,104.85	99,323.25	78,202.39	130,969.45	59,363.37	87,161.33	63,207.63	89,664.73	66,481.19	90,534.52	71,485.21	96,890.32

Table 4 (continued)

Industries (based on the 2-digit Sic codes)	% Cases in each industry	Sales* $_{t-6}$		Sales $_{t-5}$		Sales $_{t-4}$		Sales $_{t-3}$		Sales $_{t-2}$		Sales $_{t-1}$	
		M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
Wholesale trade	7.5%	18,277.40	27,269.12	17,907.29	27,999.24	18,555.92	34,131.70	20,308.16	38,756.29	22,952.33	43,405.90	24,092.10	46,410.92

*Values are reported in millions

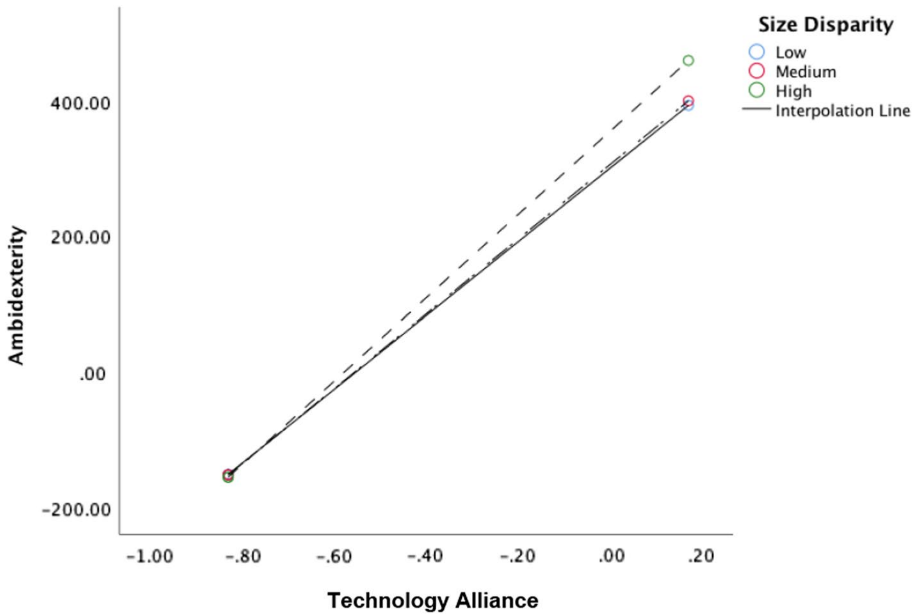

Fig. 2 Visualization of the moderation effect of size disparity on the link between Technology alliances and ambidexterity

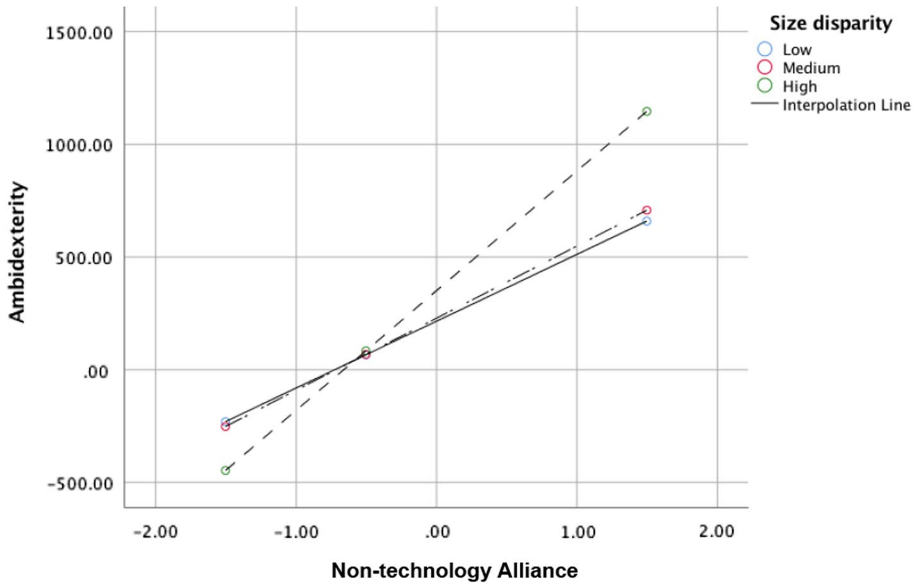

Fig. 3 Visualization of the moderation effect of size disparity on the link between Non-technology alliances and ambidexterity

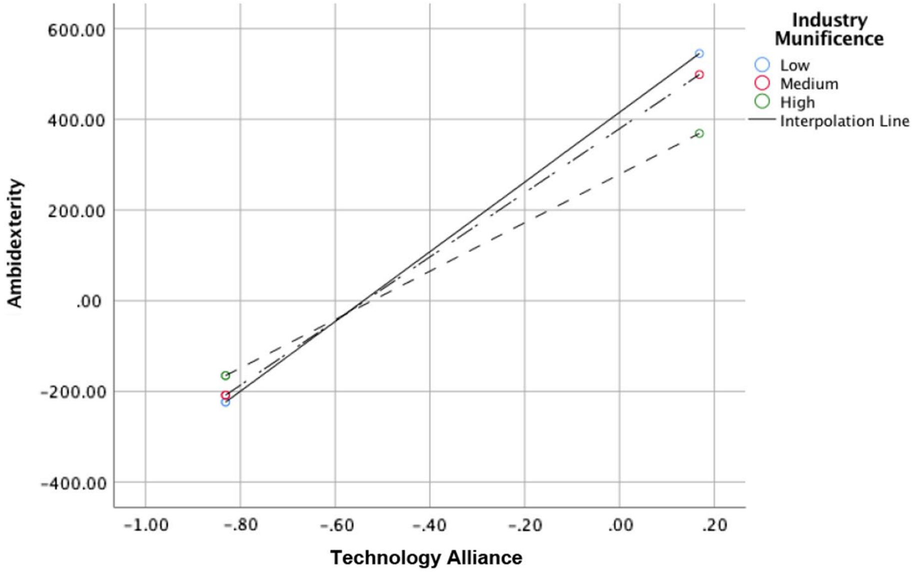

Fig. 4 Visualization of the moderation effect of industry munificence on the link between technology alliances and ambidexterity

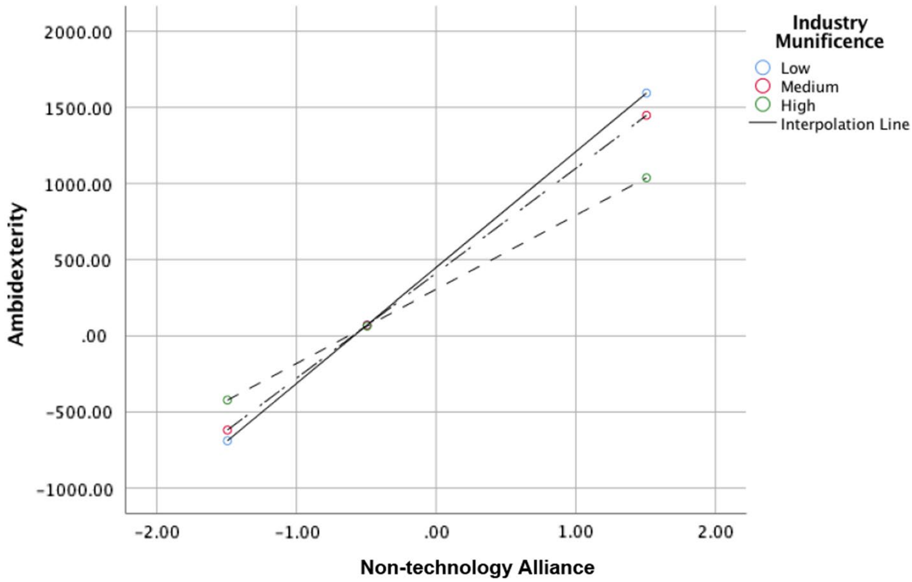

Fig. 5 Visualization of the moderation effect of industry munificence on the link between Non-technology alliances and ambidexterity

Appendix

See Tables 3, 4 and Figs. 2, 3, 4, 5.

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