

Beyond the Scope of the Deal: Configuration of Technology Alliance Portfolios and the Introduction of Management Innovation

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While firms invest in portfolios of technology alliances primarily seeking technological benefits (e.g. access to novel technological knowledge to develop product innovations), an adequate portfolio of technology alliances can also bring non-technological benefits, such as access to novel managerial knowledge, which can result in management innovation. However, it remains unclear under what conditions technology alliance portfolios yield such benefits. Drawing from the literature on knowledge utilization from alliance portfolios, we examine how the configuration of a firm's technology alliance portfolio affects the likelihood of the firm introducing management innovation. Our panel data analyses of Spanish manufacturing firms for 2008–2016 reveal that a firm is more likely to introduce management innovation when its alliance portfolio shows diversity of partner types; however, this positive effect of diversity becomes less pronounced as the alliance portfolio becomes more oriented towards exploration (i.e. relatively greater presence of research-focused partner types). Our study also provides recommendations for managers seeking to connect the technological and non-technological spheres of innovation: a technological alliance portfolio that brings together diverse partner types while avoiding excessive presence of research-focused partner types may offer greater opportunity for management innovation.

Introduction

Building an adequate technology alliance portfolio – a firm's set of concurrent technology

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alliances¹ (e.g. Faems, van Looy and Debackere, 2005; Garcia Martinez, Zouaghi and Sanchez Garcia, 2019) – is key to firm innovation, as such portfolios can provide access to external knowledge that enhances innovation opportunities and performance (e.g. Hagedoorn, Lokshin and Zobel, 2018; Subramanian and Soh, 2017; Vlaisavljevic, Cabello-Medina and Pérez-Luño, 2016). Thus, an important stream of research has focused on explaining firms' knowledge utilization

¹We define technology alliances as collaborative agreements between independent organizations for technological innovation activities, such as the development of product and process innovations (e.g. De Man and Duysters, 2005).

from alliance portfolios in the context of their innovation strategies (e.g. McGill and Santoro, 2009; Vasudeva and Anand, 2011).

Studies in the aforementioned stream view alliance portfolios as repositories from which the focal firm can source innovation-relevant knowledge that is not available in-house, helping alleviate internal resource constraints (Subramanian and Soh, 2017; Vasudeva and Anand, 2011). These studies further stress that, to understand when optimal knowledge utilization from alliance portfolios occurs, it is key to look at how these portfolios are configured, as this determines both the nature of knowledge a firm can source from its alliance partners (Garcia Martinez, Zouaghi and Sanchez Garcia, 2019; Hoffmann, 2007) and the firm's ability to effectively utilize such knowledge towards enhancing innovation performance (Vasudeva and Anand, 2011; Wassmer, 2010).

Despite contributing important insights, extant research has mostly focused on technological innovation outcomes (e.g. patent output or product innovation performance), paying little attention to the potential implications of technology alliance portfolios for non-technological innovation. In this study, we address this research limitation by examining the connections between technology alliance portfolios and a prominent kind of non-technological innovation known as management innovation (Birkinshaw, Hamel and Mol, 2008; Damanpour, Sanchez-Henriquez and Chiu, 2018) – that is, ‘the implementation of a new organisational method in the firm's business practices, workplace organisation or external relations [...] that has not been used before in the firm and is the result of strategic decisions taken by management’ (OECD/Eurostat, 2005: 51).

There are important theoretical and practical reasons why the implications of alliance portfolios for non-technological innovation – and management innovation in particular – deserve further attention. First, the limited attention span of extant alliance portfolio research – and its almost exclusive focus on technological outcomes – is surprising, as scholars in other streams highlight that technology alliances may provide outcomes beyond their formal goals, that is, non-technological outcomes (e.g. Ariño, 2003; Howard *et al.*, 2016; Sammarra and Biggiero, 2008). Howard *et al.* (2016), for example, report how several biotechnology firms utilize their R&D alliances with pharmaceutical company Lilly to enhance the col-

laborative routines of their own inventors through learning from Lilly's collaborative skills, as the firm is ‘recognized within the pharmaceutical industry for its expertise in collaborative innovation’ (Howard *et al.*, 2016: 2093). This evidence illustrates how in technology alliances partners usually exchange not only technological knowledge but also non-technological knowledge such as managerial knowledge, creating an opportunity for learning and innovation in non-technological domains (Sammarra and Biggiero, 2008). Therefore, achieving a more comprehensive understanding of the phenomenon of knowledge utilization from technology alliance portfolios requires redirecting research attention towards the non-technological implications of these portfolios, such as the introduction of management innovation.

Second, this is also a question of practical relevance, as firms face increasing pressure to embrace holistic strategies that connect the technological and non-technological spheres of innovation (Battisti and Stoneman, 2010; Damanpour, Sanchez-Henriquez and Chiu, 2018). In the alliance context, a clear indicator of such practical relevance is that tools used by firms to measure alliance success seem to explicitly account for ‘benefits outside the scope of the deal’ (Bamford and Ernst, 2002: 7). Therefore, if research is to provide useful recommendations for practice, the connections between technology alliance portfolios and non-technological innovation need to be clarified.

Furthermore, in doing so, a focus on management innovation seems particularly relevant, to the extent that management innovation plays a crucial role in a firm's long-term survival and performance (Birkinshaw, Hamel and Mol, 2008; Volberda, Van Den Bosch and Mihalache, 2014). Extant literature documents the key contributions of management innovation to, for example, firms' productivity (Mol and Birkinshaw, 2009), sales growth (Evangelista and Vezzani, 2012), reputation (Wang, 2010) and even ability to realize value from technological innovation (Camisón and Villar-López, 2014; Evangelista and Vezzani, 2010).

Overall, these reasons underlie the relevance of understanding how firms can utilize knowledge from their technology alliance portfolios towards the introduction of management innovation – but under what specific conditions can that occur? To answer this question, we draw from the literature on knowledge utilization from alliance portfolios (e.g. Garcia Martinez, Zouaghi and Sanchez

Garcia, 2019; Vasudeva and Anand, 2011) and examine how technology alliance portfolio configuration affects a firm's likelihood of introducing management innovation.

We theorize that portfolio diversity – operationalized as partner type diversity – is positively associated with an enhanced likelihood of introducing management innovation because it increases a firm's chances of finding innovation-relevant managerial knowledge within its technology alliance portfolio. We further propose that the effect of portfolio diversity is weakened as the portfolio becomes more oriented towards exploration – operationalized as greater relative presence of research-focused partner types (universities and other research organizations). We argue that firms may experience reduced ability to utilize knowledge from exploration-oriented portfolios owing to the higher levels of complexity and knowledge ambiguity they face in exploration alliances relative to exploitation alliances. Our findings from analysing panel data on a sample of Spanish manufacturing firms from the Technological Innovation Panel (PITEC) in the period 2008–2016 support our hypotheses.

Our study contributes to the literature on knowledge utilization from alliance portfolios by (i) redirecting attention from the technological towards the non-technological implications of technology alliance portfolios and broadening the spectrum of innovation outcomes studied by focusing on management innovation; and (ii) suggesting specific portfolio configuration conditions – diversity of partner types with greater emphasis on firm–firm collaboration (e.g. suppliers, clients) relative to collaboration with research-focused partner types–, under which technology alliance portfolios may be more likely to contribute to the introduction of management innovation.

Theoretical background and hypotheses

Research on knowledge utilization from alliance portfolios provides comprehensive evidence on a variety of technological outcomes of technology alliance portfolios (e.g. Faems, van Looy and Debackere, 2005; Oerlemans, Knobens and Pretorius, 2013; Subramanian and Soh, 2017; Van Beers and Zand, 2014), while paying little attention to the non-technological outcomes of these portfolios. To address this research limitation, we build on the

literature on knowledge utilization from alliance portfolios, as it also provides a clear theoretical logic to connect technology alliance portfolios with non-technological outcomes such as the introduction of management innovation.

Within the literature on knowledge utilization from alliance portfolios, a core theoretical framework is the knowledge search perspective on firm innovation (e.g. Katila and Ahuja, 2002; Laursen and Salter, 2006; Leiponen and Helfat, 2010). Proponents of the knowledge search perspective frame firms' innovation activities as problem-solving efforts through knowledge search (Katila and Ahuja, 2002; Leiponen and Helfat, 2010). Drawing from key premises of organizational learning theory, this search perspective stresses that both exploitation- and exploration-oriented search efforts are relevant to innovation (Katila and Ahuja, 2002; March, 1991), highlighting that finding suitable solutions to innovation problems often requires sourcing knowledge beyond the firm's boundaries (e.g. Laursen and Salter, 2006), where different external sources likely provide access to different knowledge and solutions (e.g. Köhler, Sofka and Grimpe, 2012).

In line with these ideas, the literature on knowledge utilization from alliance portfolios views alliance portfolios as repositories of external knowledge (Vasudeva and Anand, 2011; Wassmer, 2010) through which firms gain access to valuable technological knowledge that they can utilize to tackle innovation problems and opportunities (De Leeuw, Lokshin and Duysters, 2014; Parise and Casher, 2003; Subramanian and Soh, 2017). Thus, a key premise in these studies is that, because of such knowledge utilization, firms, to some extent, learn from their alliance portfolios, which may, in turn, yield important innovation outcomes.

Another central premise in these studies is that the nature and amount of knowledge available within an alliance portfolio differs across firms, depending on how they have configured their respective portfolios (Garcia Martinez, Zouaghi and Sanchez Garcia, 2019; Hoffmann, 2007). These studies also argue that alliance portfolio configuration is key to firms' abilities to utilize knowledge from their portfolios, as these abilities largely depend on attributes of the partners, their knowledge bases and how they combine with one another on a portfolio level (Vasudeva and Anand, 2011; Wassmer, 2010). Building on these premises, research on knowledge utilization from alliance

portfolios highlights the key role of technology alliance portfolios in firms' technological innovation.

In this study, we combine the basic premises of this literature with the assumption that technological innovation activities may also result in non-technological outcomes (e.g. Howard *et al.*, 2016; Sammarra and Biggiero, 2008), which allows us to conceptually articulate (i) why technology alliance portfolios can also contribute to non-technological innovation, and in particular, management innovation (i.e. portfolios as repositories of managerial knowledge); and (ii) under which conditions that may occur (i.e. the role of portfolio configuration).

Technology alliance portfolios as repositories of managerial knowledge

Interaction with technology alliance partners can generate benefits beyond the formal purpose and scope of the agreement (Ariño, 2003; Howard *et al.*, 2016). Research on technology and R&D alliances shows that partnering organizations – besides exchanging technological knowledge (e.g. Faems *et al.*, 2008; Lane and Lubatkin, 1998) – often share other types of knowledge, such as managerial knowledge (Lane, Salk and Lyles, 2001; Sammarra and Biggiero, 2008), which refers to 'competences and know-how necessary to efficiently and effectively coordinate and supervise organizational resources and processes' (Sammarra and Biggiero, 2008: 805). Managerial knowledge flows can occur deliberately, when contextual information is required to understand technological processes (Lane, Salk and Lyles, 2001), or unintentionally. Unintended knowledge spillovers may occur because partners need to interact closely, both formally and informally, in executing their joint technological project (Howard *et al.*, 2016; Oxley and Sampson, 2004). Therefore, a firm's portfolio of technology alliances generates a repository of external managerial knowledge, which, in turn, is relevant to management innovation.

Management innovation often requires access to managerial knowledge that is not available inside the firm (Birkinshaw, Hamel and Mol, 2008; Kimberly and Evanisko, 1981). By tapping into external sources, firms can gain insight on novel approaches to manage internal resources and external relationships, stimulating the adoption of new management practices (Damanpour,

Sanchez-Henriquez and Chiu, 2018; Mol and Birkinshaw, 2014). To the extent that firms can gain access to external managerial knowledge through their technology alliances, technology alliance portfolios can have implications for the introduction of management innovation. Two perspectives within the management innovation literature – rational and institutional – can be used to further underpin these ideas.

Scholars supporting the rational perspective argue that firms need management innovation to adapt and survive, just as they need technological innovation (e.g. Camisón and Villar-López, 2014; Evangelista and Vezzani, 2010). Firms introduce new practices to become more effective (Volberda, Van Den Bosch and Mihalache, 2014). Thus, a firm's technology alliance portfolio can be viewed as a source of external managerial knowledge that the firm can use to improve its organizational effectiveness (Mol and Birkinshaw, 2014). By observing the management practices of technology partners, firms gain a benchmark to evaluate their own practices, which allows them to replicate successful management practices and avoid unsuccessful ones (Denrell, 2003).

Scholars supporting the management fashion perspective (e.g. Abrahamson, 1991; Wang, 2010) offer a more institutional explanation (Birkinshaw, Hamel and Mol, 2008). Management innovation aims to accommodate exogenous pressures to comply with prevalent or emergent managerial rules (Abrahamson, 1991; Volberda, Van Den Bosch and Mihalache, 2014). The introduction of management innovation obeys legitimation purposes (Wang, 2010). Therefore, a firm's portfolio of technology alliances provides the firm with access to external managerial knowledge that can be used to enhance its institutional legitimacy (Mol and Birkinshaw, 2014). To gain legitimacy, the firm emulates the organizational practices of its partners as role models (Mol and Birkinshaw, 2009).

Research further highlights that the innovation performance implications of alliance portfolios largely depend on configuration attributes (e.g. De Leeuw, Lokshin and Duysters, 2014; Faems, van Looy and Debackere, 2005; Subramanian and Soh, 2017; Van Beers and Zand, 2014). A key implication for our study is that considering alliance portfolio configuration is crucial to determine the role of technology alliance portfolios in the introduction of management innovation. To theoretically understand this issue, we draw

from the literature on knowledge utilization from alliance portfolios.

Research hypotheses

Seeking to explain how firms utilize knowledge from their alliance portfolios, a number of studies emphasize the key role of alliance portfolio configuration (e.g. Garcia Martinez, Zouaghi and Sanchez Garcia, 2019; McGill and Santoro, 2009; Vasudeva and Anand, 2011). Drawing from different theoretical perspectives – importantly, the knowledge search perspective on innovation (e.g. Vasudeva and Anand, 2011) – these studies provide evidence on the links between different portfolio configuration attributes and firms' technological innovation performance.

For instance, studying the alliance portfolios of firms involved in fuel cell technology development, Vasudeva and Anand (2011) conclude that firms with portfolios characterized by medium levels of technological diversity can optimize their knowledge utilization outcome (i.e. citation-weighted patent count). Yet, the firm's ability to utilize knowledge from its portfolio reduces as the technological distance in the portfolio increases, as both technological diversity and technological distance impose a burden on a firm's absorptive capacity. In their study of alliance portfolios in biotechnology, McGill and Santoro (2009) examine the effects of alliance portfolio configurations on firms' patent output: firms with 'focus' portfolios (i.e. portfolios that focus on discovery and development in narrow technological areas and comprise partners with similar technological know-how) achieve the greatest patent output. These authors argue that a 'focus' configuration enables efficient knowledge exchange between the firm and its alliance partners. In a more recent study, Garcia Martinez, Zouaghi and Sanchez Garcia (2019) examine panel data from manufacturing firms in Spain and find an inverted U-shaped relationship between alliance portfolio diversity and firm innovation performance (i.e. share of total sales attributed to product innovations), emphasizing the interplay between a firm's internal capabilities (e.g. human capital), alliance portfolio configuration and effective knowledge sourcing from diverse alliance portfolios.

These studies demonstrate that alliance portfolio configuration is key to technological innovation performance because (i) it determines 'the qual-

ity, quantity, and diversity of information and resources to which the focal company has access' (Hoffmann, 2007: 834) and, hence, (ii) influences its competence to effectively leverage alliance portfolio resources – particularly, knowledge – towards achieving technological innovation (Wassmer, 2010).

We utilize these ideas by focusing on two portfolio configuration attributes: diversity and orientation to exploration. *Portfolio diversity* refers to heterogeneity of partners in the portfolio (e.g. Duysters and Lokshin, 2011; Garcia Martinez, Zouaghi and Sanchez Garcia, 2019; Subramanian and Soh, 2017). Heterogeneous partners tend to possess heterogeneous knowledge (Du, Leten and Vanhaverbeke, 2014; Vlasisavljevic, Cabello-Medina and Pérez-Luño, 2016). In particular, we focus on *partner type diversity*, which reflects the number of different partner types (e.g. clients, suppliers and universities) in a firm's technology alliance portfolio (Faems, van Looy and Debackere, 2005; Garcia Martinez, Zouaghi and Sanchez Garcia, 2019; Hagedoorn, Lokshin and Zobel, 2018). *Portfolio orientation* indicates whether a firm's technology alliance portfolio is primarily oriented towards exploitation or exploration (Faems, van Looy and Debackere, 2005). We define exploration-oriented portfolios as those in which research-focused organizations (e.g. universities and other research organizations, such as research institutes) are the predominant type of partner, and exploitation-oriented portfolios as those in which firms (e.g. suppliers and competitors) are the predominant type of partner. Our definition adapts the idea that certain organizational attributes of partners may increase the potential for exploration (Lavie and Rosenkopf, 2006) and, thus, different partner types may contribute differently to a firm's exploration and exploitation activities (e.g. Du, Leten and Vanhaverbeke, 2014; Köhler, Sofka and Grimpe, 2012).

Building on the premise that the configuration of a firm's alliance portfolio determines the nature of knowledge available through the portfolio (Garcia Martinez, Zouaghi and Sanchez Garcia, 2019; Hoffmann, 2007), we first argue that a diverse portfolio of technology alliances is more likely to contain innovation-relevant managerial knowledge. As the configuration of an alliance portfolio also conditions a firm's competence to utilize knowledge from its portfolio (Vasudeva and Anand, 2011; Wassmer, 2010), we further argue

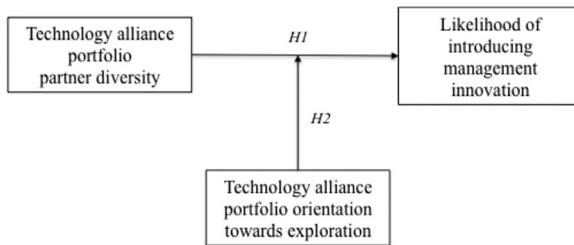


Figure 1. Technology alliance portfolio configuration and management innovation

that firms with portfolios that are more oriented towards exploration are less able to leverage the innovation benefits of diversity in the context of our framework (see Figure 1).

Portfolio diversity and management innovation. Research on knowledge utilization from alliance portfolios stresses that diversity, under the right conditions, can provide important advantages for technological innovation (e.g. Garcia Martinez, Zouaghi and Sanchez Garcia, 2019; Subramanian and Soh, 2017). A core idea of these studies is that having concurrent technology alliances with different types of partner generates a pool of diverse and complementary knowledge that the firm may draw on to boost its technological innovation performance (Hagedoorn, Lokshin and Zobel, 2018; Parise and Casher, 2003).

The logic underlying these arguments combines two ideas, which are well established in the search perspective on innovation: ‘breadth of knowledge search’ (e.g. Dahlander, O’Mahony and Gann, 2016) and ‘abundance of innovation-relevant external knowledge’ (Garriga, Von Krogh and Spaeth, 2013). According to this logic, partner type diversity usually means diversity of knowledge sources, which, in turn, increases the likelihood of finding innovation-relevant knowledge. More specifically, portfolio diversity enhances not only a firm’s opportunities for finding novel knowledge within its alliance portfolio, but also for creating novel (re)combinations of knowledge (e.g. Faems, van Looy and Debackere, 2005; Hagedoorn, Lokshin and Zobel, 2018; Parise and Casher, 2003). Both are crucial ways of achieving technological innovation (e.g. Grigoriou and Rothaermel, 2017; Zhou and Li, 2012).

Extending these arguments, we argue that firms with more diverse technology alliance portfolios enjoy greater opportunities to source and utilize portfolio knowledge towards realizing manage-

ment innovation. Different types of organization likely rely on different practices for their own internal organization, such as employee incentive and promotion systems (Ansari, Fiss and Zajac, 2010; Du, Leten and Vanhaverbeke, 2014), but also for managing external relationships with other organizations (Howard *et al.*, 2016). The characteristics of management practices are influenced by the attributes of the organizational context in which they are embedded (Datta, 1991): management practices vary across organizations owing to such factors as organizational mission or sector-specific regulations (e.g. Ansari, Fiss and Zajac, 2010). Consequently, different types of partner are likely to possess different knowledge of how to manage intra-organizational and inter-organizational issues (e.g. Howard *et al.*, 2016). Therefore, partner type diversity increases the chances that a firm acquires novel managerial knowledge – non-redundant knowledge that augments the firm’s managerial knowledge base – from its alliance portfolio. Extant literature views the novelty of knowledge as key to the development of innovations in general (e.g. Zhou and Li, 2012) and management innovations in particular (Damanpour, 2014; Mol and Birkinshaw, 2009). Further, partner type diversity can provide access to complementary insights from alliance partners on complex management problems, which can be combined among themselves and with a firm’s own knowledge (Parise and Casher, 2003) to articulate new management solutions (Mol and Birkinshaw, 2014).

In sum, partner type diversity increases the extent to which innovation-relevant managerial knowledge is available to a firm through its alliance portfolio by increasing the likelihood of finding managerial knowledge that is either novel *per se* relative to the firm’s knowledge base or can be recombined in novel ways with a firm’s existing knowledge, thus enhancing the opportunity to realize management innovation.

H1: The degree of partner type diversity in a firm’s portfolio of technology alliances is positively associated with the likelihood that the firm introduces management innovation.

Moderating role of portfolio orientation. In the previous section, we suggest that a diverse portfolio enhances a firm’s opportunity for sourcing innovation-relevant managerial knowledge. However, when the portfolio is not only diverse but also

highly oriented towards exploration, the firm may experience reduced ability to utilize such knowledge effectively. Thus, we propose a moderating role for this second configuration attribute owing to two key reasons.

First, exploration-oriented portfolios comprise alliances that are more complex on a technological level, relative to portfolios oriented towards exploitation. Hence, the amount of attention that firms' managers can allocate to understanding non-technological issues decreases as the technology alliance portfolio becomes more oriented towards exploration. Explorative projects are intricate and uncertain (March, 1991) and are likely to experience unexpected technical problems (Faems *et al.*, 2008; Yang, Lin and Peng, 2011), which may consume the attention of the firm's managers (Ocasio, 1997). When overseeing exploration-oriented portfolios, managers may be too busy dealing with technological issues and may 'constantly struggle to define responsibilities and benefits of partners' (Yang, Lin and Peng, 2011: 1072). Thus, the firm's managers may have limited chance to undertake actions beyond the technological scope of the project. In the context of our framework, these additional actions are required to sense and realize management innovation opportunities. Firms with exploration-oriented portfolios may be less able to perceive opportunities to access innovation-relevant managerial knowledge through the portfolio (Ocasio, 1997). Even if they become aware of such opportunities, they may still not be able to undertake the actions required to utilize such external knowledge towards the introduction of innovation (Foss, Lyngsie and Zahra, 2013).

Second, the extent of organizational dissimilarity between the focal firm and its alliance partners is likely to be more salient in exploration-oriented portfolios (collaboration mostly with research-focused organizations) than in exploitation-oriented portfolios (collaboration mostly with other firms). Firms and research-focused organizations are embedded in different institutional contexts and pursue different missions, implying fundamental organizational dissimilarities between them (e.g. Du, Leten and Vanhaverbeke, 2014; Estrada *et al.*, 2016). A key implication of such dissimilarity is knowledge ambiguity. Rooted in the notion of causal ambiguity (Reed and DeFillippi, 1990), knowledge ambiguity refers to a 'lack of understanding of the logical linkages between actions

and outcomes' that underlie the knowledge bases of alliance partners (Simonin, 1999: 597). Just as causal ambiguity protects a firm's core resources from imitation, knowledge ambiguity may inhibit a firm's ability to assimilate and utilize knowledge from alliance partners (Simonin, 1999, 2004). To the extent that knowledge ambiguity largely results from organizational dissimilarity between a firm and its partners (Lane and Lubatkin, 1998; Simonin, 1999), the difficulties a firm faces when attempting to utilize managerial knowledge from its portfolio of technology alliances increase with the portfolio's orientation towards exploration.

Taken together, these arguments suggest that portfolio orientation towards exploration undermines a firm's ability to capitalize on the innovation-relevant managerial knowledge present in diverse portfolios by (i) reducing the attention firms allocate to their partners' managerial knowledge; and (ii) exacerbating the knowledge ambiguity problem firms face when trying to absorb and utilize such knowledge.

H2: The orientation towards exploration in a firm's portfolio of technology alliances weakens the positive association between partner type diversity and the likelihood that the firm introduces management innovation.

Methods

Data and sample

We use data from PITEC, a panel database of the innovation activities of Spanish firms (e.g. Asimakopoulou, Revilla and Slavova, 2019; Garcia Martinez, Zouaghi and Sanchez Garcia, 2019; Trigo and Vence, 2012). PITEC builds upon the Spanish National Innovation Survey, which collects Spanish data for the European Community Innovation Survey (CIS). The survey has been conducted annually since 2004 by the Spanish National Statistics Institute (INE). CIS data have been widely used to analyse EU firms' innovation activities (e.g. Battisti and Stoneman, 2010; Faems, van Looy and Debackere, 2005; Mol and Birkinshaw, 2009). Damanpour (2014: 1269, 1273) refers to the CIS as 'the only longitudinal' and 'systematic data collection effort for management innovation'. Since we examine the links between technology alliance portfolios and management

innovation, PITEC is an adequate data source for our study.

We utilize nine PITEC waves (2008–2016) to construct a longitudinal firm-level dataset that includes the dependent variable in period t and lagged independent variables in $t-2$. Because of the temporal structure of the survey,² a 2-year lag structure helps mitigate potential endogeneity problems arising from the reverse causality between the dependent and core independent variable.³ Further, we restrict our sample to firms in manufacturing industries (and exclude service firms), as research suggests that manufacturing and service firms may display differences in their innovation patterns (e.g. Ettl and Rosenthal, 2011). These criteria restricted our sample to 24,505 observations. Because of the lag structure of our models and missing values on the focal variables, we computed our analyses based on a final sample of 5,327 observations (1,844 firms).

Measures

Management innovation. PITEC measures management innovation according to the Oslo Manual (organisational innovation, OECD/Eurostat, 2005) by asking respondents whether the firm has introduced one or more of the following innovation types in the last two years: (i) new business practices for the workplace's organization or the firm's procedures (e.g. knowledge management systems); (ii) new methods to improve division of responsibilities and decision-making in the firm's

workplace (e.g. decentralization, internal restructuring); and (iii) new methods of managing external relations with other firms or public institutions (e.g. outsourcing). We use this information to construct our dependent variable by aggregating the three items into a dummy variable, *management innovation*, which takes the value 1 if the firm has introduced one or more types of management innovation between t and $t-2$ (and 0 otherwise) (Ganter and Hecker, 2013a; Mol and Birkinshaw, 2009).

Partner type diversity. The survey asks whether firms have had cooperation activities for technological innovation with a number of organization types in the last two years (including external alliance partners and group subsidiaries). Focusing on external alliance partners, we consider six partner types in $t-2$: suppliers; clients; competitors (or other companies in the same sector); universities and higher-education institutions; consulting and private R&D labs/institutes; and research institutions and technology centres. Based on this information, we build a count variable (value varies from 1 to 6) indicating the number of different partner types present in a firm's technology alliance portfolio, an approach widely used in prior studies to operationalize partner type diversity (e.g. Faems, van Looy and Debackere, 2005; Hagedoorn, Lokshin and Zobel, 2018; Van Beers and Zand, 2014).

Portfolio orientation. We followed Faems, van Looy and Debackere (2005), who coded partner types into 'exploitation-oriented' vs. 'exploration-oriented' categories. We first counted the number of different partner types in the firm's portfolio under each category. While Faems, van Looy and Debackere (2005) rely on two separate count measures, we created an index to integrate both measures, as this approach better captures our definition of portfolio orientation (i.e. it reflects the relative magnitude of exploration-oriented partner types in the portfolio). We build on the idea that alliances with research-focused partners tend to be explorative, while firm-firm alliances are often exploitative, as organizational dissimilarity tends to be greater in the former than in the latter (e.g. Jiang, Tao and Santoro, 2010). Thus, we coded partner types as follows: (i) exploitation-oriented – clients, suppliers and competitors; and (ii) exploration-oriented – universities/higher-education institutions, consulting and private

²In each survey wave, firms are asked to provide information relative to the current year and past two years (e.g. in the 2015 survey, firms reported their R&D expenses in 2015, and the introduction of management innovation and technological cooperation activities in the period 2013–2015). By t we refer to the year in which the survey is conducted (e.g. $t = 2015$ in the previous example).

³We considered whether to use 1-, 2- or a 3-year lag (Belderbos *et al.*, 2006, 2014). We first ruled out the 1-year lag model, as we reasoned that a longer lag seemed necessary to mitigate reverse causality concerns. Moreover, the 2-year lag model showed better fit than the 3-year lag model (McFadden's R^2 : 0.230 vs. 0.128), while we did not observe decisive differences in results. Also, a 2-year lag model may better detect the effects of portfolio configuration variables, as these effects may fade over time. Therefore, we chose a 2-year lag model over a 3-year lag model (Belderbos *et al.*, 2006, 2014) because it seems to (i) show better fit; (ii) mitigate, to a fair extent, reverse causality concerns; and (iii) capture the effects of the core independent variables within a reasonable time frame.

R&D labs/institutes, research institutions and technology centres. Next, we calculated the difference between the number of exploration-oriented and exploitation-oriented partner types. *Portfolio orientation* ranges from -3 to 3 , with higher values indicating stronger orientation towards exploration.

Control variables. We control for several factors (in $t-2$) that the literature highlights as key predictors of management innovation. First, we control for firms' internal context factors (Ganter and Hecker, 2013a; Mol and Birkinshaw, 2009): *firm size* is the logarithm of the number of employees (PITEC provides anonymized data for this variable); *education of workforce* is the percentage of R&D employees with at least a university degree; and *market geographic scope* is an ordinal variable ranging from 1 to 4, corresponding to the markets the firm operates in (only in the local market; local and national markets; local, national and EU markets; local, national, EU and non-EU markets).

Second, we included dummy variables to control for firms' search factors (Ganter and Hecker, 2013a; Mol and Birkinshaw, 2009), capturing whether a firm has used knowledge from external sources to conduct its technological innovation activities: *internal sources* (within the firm or its group); *market sources* (suppliers, clients, competitors, consultants and commercial labs/R&D enterprises); and *professional sources* (conferences/meetings, trade associations, technical/press/computer database and fairs/exhibitions).

Third, we used binary indicators to control for *past management innovation*, *technological innovation* (i.e. introduction of new product and/or process) and *marketing innovation*. We did so to account, respectively, for a firm's potential persistence in introducing management innovation (Ganter and Hecker, 2013b) and the possibility that other types of innovation may trigger the introduction of management innovation (e.g. Battisti and Stoneman, 2010; Damanpour, 2014).

Last, we include another two dummy variables to control for other possibly relevant organizational attributes: whether the firm belongs to a *corporate group* (Ganter and Hecker, 2013b) and conducts *in-house R&D activity* (Cohen and Levinthal, 1990). *Industry* and *year* dummies are also included.

Estimation methods

Given the dichotomous nature of our dependent variable and the panel structure of our dataset, we apply random effects probit models. Random effects allow for variation across entities on the dependent variable (Baltagi, 2008), which fits our research objective. The Hausman test shows an insignificant result ($p > 0.10$), suggesting that the random effects specification is indeed suitable. We also correct for repeated observations (clustering) with robust estimation methods. The model equation is as follows:

$$\begin{aligned} \Pr(y_{i,t} = 1) = & \alpha + \beta_1 \text{Diversity}_{i,t-2} \\ & + \beta_2 \text{Orientation}_{i,t-2} + \beta_3 \text{Con}_{i,t-2} \\ & + \beta_4 \text{Ind}_{i,t-2} + \beta_5 \text{Years}_t \\ & + \varepsilon_{i,t-2} \end{aligned}$$

Here, y (for firm i and year t) denotes the probability of introducing *management innovation*. The probability of a positive outcome is assumed to be determined by the standard normal cumulative distribution function. We include 2-year lagged values of *Diversity* (partner type diversity), *Orientation* (orientation towards exploration), *Con* (control variables) and *Ind* (industry dummies). *Years* represents year dummies.

In limited dependent variable models such as probit, interpretation of results based on marginal effects – 'the effect of a unit change in an explanatory variable on the dependent variable' – tends to be preferred over coefficient-based interpretation (Wiersema and Bowen, 2009: 681, 682). Hence, we compute average marginal effects to test our hypotheses (e.g. Block *et al.*, 2015; Ganter and Hecker, 2013b).

Results

Main analysis

Table 1 displays descriptive statistics and the correlation matrix. Most of the correlation coefficients between the independent/control variables are below 0.5 and all variance inflation factor (VIF) values fall below the cutoff value of 5. Thus, multicollinearity does not seem problematic in our models (Hair *et al.*, 2006). As we use self-reported data, we checked for common method bias (CMB) using the Harman's one-factor method (Podsakoff *et al.*, 2003). We conducted a principle component

Table 1. Descriptive statistics and correlation matrix of independent variables (N = 5,327)

	Mean	S.D.	Min	Max	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
(1) Management innovation	0.53	0.50	0	1													
(2) Firm size (log)	4.14	1.25	0	9.12													
(3) Geographic scope	3.66	0.68	1	4	0.25*												
(4) Education workforce	37.90	32.30	0	100	0.17*	0.11*											
(5) Past technological innovation	0.93	0.26	0	1	0.08*	0.06*	0.06*										
(6) Past management innovation	0.59	0.49	0	1	0.15*	0.11*	0.15*	0.15*									
(7) Past marketing innovation	0.46	0.50	0	1	0.08*	0.11*	0.14*	0.15*	0.41*								
(8) Partner type diversity	2.09	1.27	1	6	0.14*	0.07*	0.15*	0.04*	0.20*	0.16*							
(9) Orientation towards exploration	0.28	1.19	-3	3	0.04*	0.03*	0.11*	-0.04*	-0.01	0.02	0.09*						
(10) Internal sources	0.96	0.19	0	1	0.10*	0.12*	0.15*	0.02	0.10*	0.09*	0.11*	-0.01					
(11) Market sources	0.95	0.21	0	1	0.10*	0.13*	0.15*	0.05*	0.13*	0.12*	0.13*	-0.04*	0.38*				
(12) Professional sources	0.82	0.38	0	1	0.09*	0.13*	0.20*	0.06*	0.21*	0.20*	0.21*	0.05*	0.29*	0.42*			
(13) Group	0.35	0.48	0	1	0.46*	0.13*	0.11*	0.01	0.01	0.00	-0.02	0.06*	0.01	0.00	-0.00		
(14) In-house R&D	0.80	0.40	0	1	0.18*	0.16*	0.55*	0.00	0.17*	0.16*	0.21*	0.07*	0.22*	0.23*	0.25*	0.08*	
VIF					1.49	1.14	1.56	1.07	1.30	1.28	1.15	1.06	1.23	1.37	1.35	1.32	1.57

Note: Except for the management innovation variable, all variables are lagged at t-2.
*Indicates significance at the 0.05 level (two-tailed).

analysis including the dependent, independent and control variables. The analysis resulted in four factors with eigenvalues greater than 1, with the first factor only accounting for 21.9% of the total variance. Thus, the CMB problem is unlikely to be an issue in our data (Garcia Martinez, Zouaghi and Sanchez Garcia, 2019).

Table 2 reports the results from the regression analysis.⁴ The results for Model 1 indicate that *partner type diversity* has a significant positive effect on the likelihood of introducing *management innovation* ($dy/dx = 0.019$, $p < 0.05$). Therefore, H1 is supported.

Model 2 includes portfolio orientation. *Orientation towards exploration* is negatively correlated with the likelihood of introducing *management innovation* ($dy/dx = -0.027$, $p < 0.001$). To examine H2, we plot the marginal effects of its interaction with portfolio diversity (Figure 2). As Figure 2 shows, *partner type diversity* is seemingly irrelevant to the introduction of management innovation for firms with alliance portfolios oriented towards exploration. On the contrary, *partner type diversity* is positively correlated to the introduction of management innovation for firms with alliance portfolios oriented towards exploitation. In this latter case, the more diverse the portfolio is, the more likely the firm is to introduce management innovation. Therefore, H2 is also supported.

Robustness checks

We crosschecked our results with two alternative measures for partner diversity. First, although we rely on a well-established approach to operationalize partner type diversity (e.g. Faems, van Looy and Debackere, 2005; Hagedoorn, Lokshin and Zobel, 2018), it may not reflect well the

⁴While the lag structure of our models helps mitigate reverse causality concerns, we checked for other potential endogeneity issues. We checked for a simultaneity issue between management and technological innovations (Damanpour, 2014) using a seemingly unrelated probit model. The correlations of the error terms of the two equations are insignificant and we found similar results to those reported in the main analysis. Further, we checked for a selection bias issue using the *heckprobit* model, based on the two-stage Heckman procedure (Van de Ven and Van Praag, 1981). After including the inverse Mills ratio, a selection parameter, in the main equation (Certo *et al.*, 2016) the results remained consistent. The results of these two tests help alleviate, to some extent, endogeneity concerns in our models.

Table 2. Marginal effects of partner diversity and orientation on management innovation

Dependent variable	Management innovation (random effects probit model)	
	Model 1	Model 2
Firm size	0.064(0.01)***	0.064(0.01)***
Market geographic scope	0.014(0.01)	0.015(0.01)
Education workforce	0.000(0.00)	0.000(0.00)
Past technological innovation	0.095(0.03)***	0.089(0.03)***
Past management innovation	0.309(0.02)***	0.308(0.02)***
Past marketing innovation	0.072(0.02)***	0.072(0.02)***
Internal sources	−0.029(0.05)	−0.028(0.05)
Market sources	−0.017(0.05)	−0.028(0.05)
Professional sources	0.067(0.03)***	0.071(0.03)***
Group	−0.004(0.02)	−0.002(0.02)
In-house R&D activity	0.088(0.03)***	0.089(0.03)***
Partner type diversity	0.019(0.01)**	0.021(0.01)***
Orientation towards exploration		−0.027(0.01)***
Industry dummies	Included	Included
Year dummies	Included	Included
Wald chi ²	603.01***	622.37***
Log pseudo-likelihood	−2,750.05	−2,742.35
No. observations (firms)	5,327(1,844)	5,327(1,844)

Notes: Average marginal effects (dy/dx) reported. dy/dx for factor levels is the discrete change from the base level. Delta-method standard errors reported in parentheses.

*Indicates significance at the 90% level.

**Indicates significance at the 95% level.

***Indicates significance at the 99% level.

‘accumulated diversity’ in the portfolio, which may, however, affect a firm’s learning opportunity. Thus, we created an alternative measure (adapted from Estrada and Dong, 2020), which aggregates the accumulated years of experience a firm has with each partner type. The results using this measure remained fairly consistent. Second, our main partner diversity measure is based on six partner types, which allowed for a reasonably clean aggregation of data across survey waves. A more conservative approach will be to code five partner types, combining the different research-focused partner types, other than universities, under a single label. We computed partner diversity in this way and re-ran the analysis, also obtaining fairly consistent results.

Moreover, management innovation can usher improved approaches within and outside a firm’s boundaries – respectively, to internally organize resources and processes and to manage external relationships with partners (Damanpour, Sanchez-Henriquez and Chiu, 2018). Although our main measure aggregates these two types of innovation (e.g. Ganter and Hecker, 2013a,b), differences may exist between them (Armbruster *et al.*, 2008). Thus, we crosschecked our results by creating two

separate dummy variables, based on the three items provided by PITEC (described earlier in *Measures*): *internal management innovation* [items (i) and (ii)] and *external management innovation* [item (iii)]. Using a seemingly unrelated probit model we found that, consistent with our main findings, partner diversity is positively correlated with internal (external) management innovation for firms with exploitation-oriented portfolios, but seemingly irrelevant for firms with exploration-oriented portfolios. Further details are available from the authors upon request.

Discussion and conclusion

In this study, we examined the connections between technology alliance portfolios and the introduction of management innovation through a knowledge utilization perspective. Based on panel data of a sample of Spanish manufacturing firms, our empirical findings suggest that technology alliance portfolios, under certain configuration conditions, may entail opportunities for management innovation. These findings have important implications, which we discuss below.

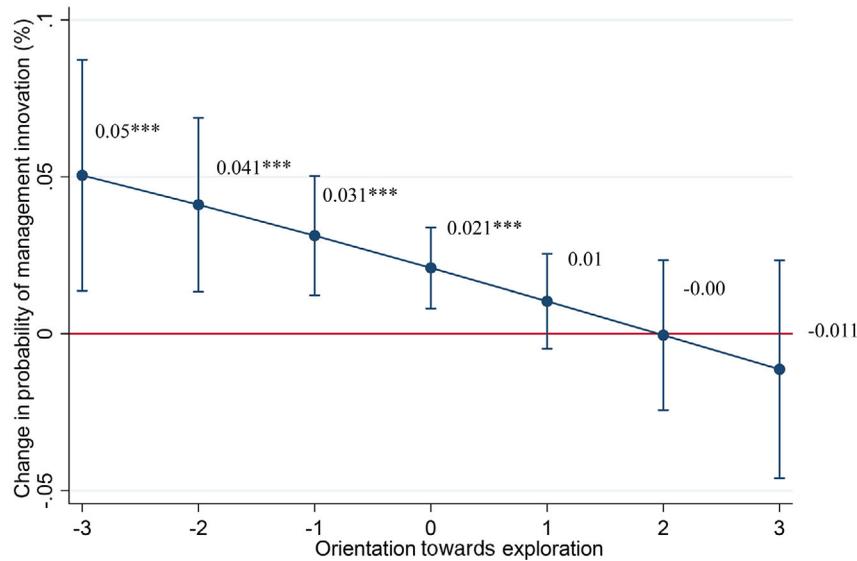


Figure 2. Marginal effects (95% CIs): interaction partner diversity and orientation towards exploration

Notes: Average marginal effects (dy/dx) reported. dy/dx for factor levels is the discrete change from the base level. Delta-method standard errors are computed.

** Indicates significance at the 95% level. *** Indicates significance at the 99% level.

[Colour figure can be viewed at wileyonlinelibrary.com]

Research implications

Our study contributes to the literature on knowledge utilization from alliance portfolios (e.g. Garcia Martinez, Zouaghi and Sanchez Garcia, 2019; McGill and Santoro, 2009; Vasudeva and Anand, 2011) in two fundamental ways.

First, it contributes to a more comprehensive picture of the range of innovation benefits that a firm can gain by sourcing knowledge from its portfolio of technology alliances. Recent research on the implications of technology alliance portfolios emphasizes an increasing array of innovation outcomes, from radical and incremental product innovation (Oerlemans, Knobens and Pretorius, 2013) to breadth of recombinant innovation (Subramanian and Soh, 2017). However, the focus of attention in these studies remains on the technological sphere of innovation. We complement recent efforts to develop a detailed view of the implications of technology alliance portfolios by highlighting their contributions to a prominent form of non-technological innovation: management innovation.

In doing so, our study highlights the flows of managerial knowledge that may occur within technology alliance portfolios. While extant research tends to under-emphasize the exchange of non-

technological knowledge in technology alliances (cf. Howard *et al.*, 2016; Sammarra and Biggiero, 2008), we broaden the view of alliance portfolios as sources of external knowledge (Hoffmann, 2007; Vasudeva and Anand, 2011) by accounting for their role as repositories of non-technological knowledge. The idea that a variety of knowledge flows (i.e. technological and non-technological) occur in the context of technological cooperation has important precedents in the literature. Some previous studies suggest that the exchange of non-technological knowledge enables learning in alliance-related domains: it may facilitate the performance of alliance tasks (e.g. Lane, Salk and Lyles, 2001; Sammarra and Biggiero, 2008) and, more broadly, enhance the abilities of the firms to manage technological cooperative relationships (e.g. Howard *et al.*, 2016). Overall, these insights from previous studies suggest that the non-technological knowledge a firm exchanges with technology partners primarily has consequences for the development of innovation activities beyond its organizational boundaries. The notion of alliance portfolios as repositories of managerial knowledge highlighted in this paper provides a nice complement to these insights, as we discuss below.

In an additional analysis (reported as a robustness check), we made an empirical distinction between innovations that concern the management of cross-boundary activities – which we operationalized as ‘external management innovation’ – and activities within the firm’s boundaries – which we operationalized as ‘internal management innovation’. From this additional analysis, we concluded that technology alliance portfolios might contribute to both types of innovation. A conceptual implication of this finding is that utilizing managerial knowledge from these portfolios may have implications above and beyond a firm’s inter-organizational activities, as it may also enhance processes at the core of the organization (e.g. internal knowledge management systems). Together, insights provided by our study advance the literature on knowledge utilization from alliance portfolios by redirecting attention from the technological to the non-technological knowledge search opportunities that technology alliance portfolios bring.

Our second major contribution resides in illuminating the key role of alliance portfolio configuration in enabling the non-technological implications of technology alliance portfolios. We identify specific configuration conditions under which a technology alliance portfolio may be more likely to help with the introduction of management innovation. We find that the degree of partner type diversity in a firm’s technology alliance portfolio positively affects the likelihood that the firm will introduce management innovation. Conceptually, we attribute this result to a firm’s greater chances of finding innovation-relevant managerial knowledge (Garriga, Von Krogh and Spaeth, 2013) within its portfolio. Furthermore, we report that portfolio orientation towards exploration (i.e. greater presence of research-focused partner types) weakens the positive association between diversity and management innovation and explain this result through the enhanced complexity (March, 1991) and knowledge ambiguity (Simonin, 1999) characterizing this type of portfolio. These ideas concur with Vasudeva and Anand’s (2011) argument that excessive complexity in the knowledge search opportunities offered by a technology alliance portfolio (e.g. the portfolio comprises diverse and distinct knowledge) may impose a serious burden on a firm’s learning ability, hampering technological innovation outcomes (e.g. patent output). Our findings add to this logic that such burden may also compromise a

firm’s competence to utilize portfolio knowledge towards introducing management innovation.

On a broader conceptual level, the implication is that the complexity of the technological knowledge present within an alliance portfolio may shape the potential of that portfolio to contribute to a firm’s non-technological outcomes. Assuming that portfolios where firm–firm collaboration is prevalent mainly convey opportunity for exploitative search, another implication of our findings is that when firms have the chance to refine their understanding of what they already know in technological domains (Katila and Ahuja, 2002), they may also be more able to revisit and improve how they deal with management challenges. Therefore, firms with more exploitative portfolios may be better equipped to reap the theorized benefits of diversity. With these insights, our study shifts the debate in alliance portfolio configuration research from ‘how can firms attenuate the detrimental effects of diversity to optimize their technological innovation performance’ (e.g. Garcia Martinez, Zouaghi and Sanchez Garcia, 2019; Hagedoorn, Lokshin and Zobel, 2018) towards ‘how can firms capitalize on the benefits of diversity to realize non-technological innovation’.

Managerial implications

The insights provided by our study might inform firms’ decision-making regarding technology alliance portfolio configuration. Our results seem relevant for firms seeking to capitalize on their technology alliance portfolios by connecting the technological and non-technological spheres of innovation. Based on our results, we would recommend collaboration with a broad range of different types of technology partner. However, managers should be aware that when managing the portfolio of technology alliances becomes too demanding, non-technological benefits may not be realized. A good strategy could be to build what we term an exploitation-oriented portfolio of technology alliances, placing emphasis on market-focused partner types while avoiding excessive presence of research-focused partner types. The firm can work, for example, with its clients and suppliers to capitalize on existing technologies while exploring new territories with the partner type that, in the firm’s technological field, is considered the key research provider (e.g. universities or specialized research centres).

Limitations and future research

Although CIS data are considered one of the best secondary datasets available for studying management innovation (Damanpour, 2014), they entail several limitations. We use a widely established approach of measuring portfolio diversity as partner diversity based on a count of partner types (e.g. Duysters and Lokshin, 2011; Faems, van Looy and Debackere, 2005; Van Beers and Zand, 2014). However, we acknowledge the limitations of this approach. Accounting for the actual number of partners would be relevant to capture different angles of portfolio diversity. Likewise, gathering data on specific alliance goals could be very useful to examine the configuration of the portfolio, as some studies suggest that firms may resort to vertical and horizontal collaboration for projects with diverse innovation orientation (e.g. Bouncken *et al.*, 2018; Köhler, Sofka and Grimpe, 2012). Thus, future studies could rely on more sophisticated measures to examine the effects of the two portfolio configuration attributes we studied on the introduction of management innovation. Similarly, although we control for several firm-level factors, we do not have detailed information on how the firm manages and governs its alliances (e.g. Choi and Contractor, 2017; Faems, Janssens and Neyens, 2012). Promising avenues for further research are to study how different alliance management and governance strategies shape the role of technology alliance portfolios as external sources of non-technological knowledge and innovation.

Although it was beyond the scope of this paper to compare different types of innovation, we distinguished between internal and external management innovation in an additional analysis. Results from this additional analysis suggest interesting research opportunities. We did not observe remarkable differences between internal and external management innovation regarding the hypothesized effects of the two configuration attributes we studied: utilizing knowledge from a diverse, exploitation-oriented portfolio might contribute to both types of innovation. However, we acknowledge that fundamental differences in scope and focus may exist between intra-organizational and inter-organizational management innovations (Armbruster *et al.*, 2008; Damanpour, Sanchez-Henriquez and Chiu, 2018). Therefore, differences could become appar-

ent when other portfolio configuration attributes are examined. For example, the alliance experience of portfolio partners (Howard *et al.*, 2016; Subramanian and Soh, 2017) might be more relevant for external than for internal management innovation. Thus, examining different portfolio configuration attributes and systematically comparing their effects on various types of management innovation is another promising way to further research on knowledge utilization from alliance portfolios.

Finally, although we strived to provide a sound analysis, we need to acknowledge some general limitations, which are largely present in management research (e.g. Belderbos *et al.*, 2018). Firstly, there is a limitation in making strong causal claims, which also applies to our empirical analysis. Secondly, while we sought to mitigate some endogeneity concerns, we cannot completely discard the presence of endogeneity in our models. We hope that future research will take steps towards tackling these issues and generate further insight on the non-technological implications of technology alliance portfolios.

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