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DON'T GET CAUGHT ON THE WRONG FOOT: A RESOURCE-BASED PERSPECTIVE ON IMITATION THREATS IN INNOVATION PARTNERSHIPS

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Innovation partnerships can be a double-edged sword. While they are important vehicles for learning and value creation, such partnerships also increase a firm's vulnerability to unintended knowledge leakage and imitation by others. In this study, we go beyond previous research by studying the imitation threats induced by innovation partnership portfolios rather than individual alliances. Drawing on the resource-based view, we develop and test a model that links salient structural attributes of partnership portfolios and distinct forms of imitation. Results from our analysis of 803 German manufacturing firms support our prediction that a firm's probability of being imitated increases with the partnership variety of its portfolio. We also find that firms can mitigate this threat by carefully selecting innovation partners and using appropriation mechanisms.

Keywords: Imitation; innovation partnership; partnership portfolios; open innovation; resource-based view.

Introduction

Especially firms operating in technology-driven industries see themselves confronted with increasing technological complexity, shorter product life cycles, and rapidly changing customer demands. As part of their strategic response, many firms have sought to establish collaborative relationships with a wide array of innovation

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partners (Hoffmann, 2007; Lavie, 2006, 2007; Parmigiani and Rivera-Santos, 2011; Wassmer, 2010; Wind and Mahajan, 1997). Given the prevalence of this phenomenon today, the literature has gradually moved from its traditional focus on single dyadic alliances towards a more holistic analysis of a firm's partnership portfolio (Sivakumar *et al.*, 2011; Wuyts *et al.*, 2004). Drawing on partly diverging conceptual foundations and terminologies, research on strategic alliances (Jiang *et al.*, 2010; Lavie and Miller, 2008), and open innovation (Chesbrough, 2003; Laursen and Salter, 2006) has begun to shed light on the emergence, configuration, management, and performance implications of such partnership portfolios.

There is now mounting evidence that maintaining broad partnership portfolios composed of diverse members (e.g., suppliers, customers, research institutions) can indeed boost a focal firm's, i.e., the portfolio holder's, innovative performance, as it not only broadens access to technology and market knowledge, but also enables risk and cost sharing among partners (Hooley *et al.*, 2005; Jiang *et al.*, 2010; Laursen and Salter, 2006; Leiponen and Helfat, 2010). That said, managing diverse alliances simultaneously is costly and challenging in many ways. Value appropriation concerns are a particularly critical issue that arises from innovation partnerships (Giarratana and Mariani, 2014; Laursen and Salter, 2006; Lavie, 2007; Manzini and Lazzarotti, 2016). It is precisely by opening up the innovation process, i.e., by rendering organisational boundaries permeable, that the focal firm risks exposing otherwise secret knowledge to its innovation partners or third parties (Dahlander and Gann, 2010; Martinez-Noya *et al.*, 2013). Although some attention has been devoted to the issue of knowledge leakage and interorganisational imitation in dyadic alliances (Kale *et al.*, 2002; McEvily *et al.*, 2004; Oxley and Sampson, 2004), studies examining the specific, presumably more pronounced imitation threats emanating from multifaceted, geographically dispersed innovation partnership portfolios are still missing.

In the present study, we therefore draw on the resource-based view (RBV) of the firm to develop a model that specifies the relationship between the partnership variety of a focal firm's innovation partnership portfolio and its risk of being affected by imitation, defined as the unsolicited use of technical inventions, products and business models, brand names, and designs by others. We test our model using comprehensive data from 803 German manufacturing firms, thereby contributing to the literatures on innovation partnerships and value appropriation in three important ways.

First, we shed new theoretical and empirical light on the conditions under which a collaborative approach to innovation is associated with detrimental effects stemming from imitation. Extending previous research on the imitation risks associated with dyadic alliances, we specifically elucidate the potential downside of maintaining a broad portfolio of functionally, geographically, and temporally

diverse innovation partnerships. As most firms tend to be involved in multiple collaborative arrangements at the same time, focusing on the partnership portfolio as the unit of analysis is likely to provide a more realistic appreciation of the imitation threats firms are exposed to. Indeed, for various reasons (e.g., difficulties to identify opportunistic behaviour due to a higher degree of complexity), the imitation threat emanating from a portfolio of multiple, diverse partnerships is expected to be greater than the sum of the risks of individual alliances (Li *et al.*, 2012).

Second and related, we provide new insights into how the focal firm's decisions concerning the configuration and governance of its partnership portfolio affect its risk of being imitated. Research on the contingency factors that enable firms to manage the trade-off between capturing the benefits, yet avoiding the costs of multiple innovation partnerships is still scant (Hsieh and Tidd, 2012). Against this backdrop, we explore the role of partner type (e.g., customer or supplier), partner location (e.g., domestic or international), and innovation phase the partnership is focusing upon (e.g., R&D or commercialisation stage). We also examine the moderating role of firms' intellectual property (IP) protection strategy and internal R&D activities as two potentially important isolating mechanisms safeguarding the focal firm from partnership-induced imitation. Knowing with whom, where, and when to collaborate in order to minimise imitation threats and avoid getting caught on the wrong foot is not only theoretically meaningful, but also of great practical importance.

Finally, our study provides a test of key assumptions of the RBV of the firm as an increasingly prevalent conceptual platform for research on technology and innovation management. RBV theorising, however, has remained ambiguous regarding whether innovation partnerships facilitate resource imitation given the greater permeability of organisational boundaries or, conversely, impede imitation attempts by means of greater causal ambiguity induced by collaborative innovation processes (Ketchen *et al.*, 2007; Kozlenkova *et al.*, 2013). Our study helps elucidate this persisting tension by identifying those factors that shape the direction and intensity of the link between innovation partnerships and the threat of imitation.

Theory and Hypotheses

A resource-based perspective on innovation partnership portfolios

According to the RBV, firms can be conceptualised as bundles of productive resources, that is, tangible and intangible assets (e.g., machinery, human capital, organisational structures), which are semi-permanently tied to the firm (Wernerfelt, 1984). Assuming that resources are heterogeneously distributed across firms

and imperfectly mobile, proponents of the RBV have emphasised that valuable, rare and inimitable resources are the major source of interfirm performance differences (Barney, 1991; Peteraf, 1993). Possessing a favourable resource endowment, however, does not guarantee that a firm achieves a competitive advantage, much less that this advantage can be sustained over time (Newbert, 2007; Sirmon *et al.*, 2007). Importantly, organisations need to possess the ability to effectively exploit their resources and protect them from imitation in order to generate and appropriate value (Barney and Hesterly, 2012). In line with this reasoning, resource-based theorising suggests that a firm's ability to manage interorganisational collaborations is contingent on its knowledge, processes, and supporting structures (Dyer and Nobeoka, 2002; Kale *et al.*, 2002). In particular, the ability to harvest the benefits of innovation partnership is seen as a function of the firm's absorptive capacity (Lavie and Miller, 2008; Vasudeva and Anand, 2011), that is, "the ability of a firm to recognise the value of new, external information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal, 1990, p. 128).

Innovation partnerships and interfirm relationships more generally can both act as a valuable, rare, and hard to imitate resource *per se* (Barney, 2014; Dyer and Singh, 1998) and fuel the continuous renewal of the organisational resource base (Hoffmann, 2007; Lavie, 2007). Yet at the same time, collaborating firms also face value appropriation challenges (Alexy *et al.*, 2013; Giarratana and Mariani, 2014; Katila *et al.*, 2008; Lawson *et al.*, 2012). In this context, Alvarez and Barney (2004, p. 625) argue that the "twin tasks of gaining access to those resources to generate rents associated with a market opportunity, and doing so in a way that enables this economic actor to appropriate at least some of the rents that were generated can become quite complicated". As innovation partnerships entail a risk of involuntary knowledge spillovers, collaborating firms need to consider how to prevent the imitation of technologies, products, and business models by their partners and their partners' partners (Kozlenkova *et al.*, 2013; Martinez-Noya *et al.*, 2013; Ritala and Hurmelinna-Laukkanen, 2013). Within resource-based theorising, inimitability is seen as a critical attribute of resources, without which a firm cannot sustain a competitive advantage stemming from innovation (Liebeskind, 1996; Polidoro and Toh, 2011). Given the theoretical and practical importance of this issue, scholars have devoted considerable attention to identifying the factors that make resources inimitable (McEvily and Chakravarthy, 2002; Reed and DeFillippi, 1990), or what Rumelt (1984) refers to as isolating mechanisms. These isolating mechanisms include legal property rights (e.g., patents and registered designs), secrecy, causal ambiguity, and first-mover or lead time advantages (Barney, 1991; Dierickx and Cool, 1989; Mahoney and Pandian, 1992; Peteraf, 1993).

Innovation partnerships and imitation threats

A collaborative approach to innovation enhances the potential for problem solving and helps to identify and assimilate essential knowledge to innovate on domestic and global markets (Chesbrough *et al.*, 2006; Lewin *et al.*, 2009; Sivakumar *et al.*, 2011). For a number of reasons, though, innovation partnerships are also likely to increase a focal firm's vulnerability to violations of its IP (Almirall and Casadesus-Masanell, 2010; Dahlander and Gann, 2010; Schmiele, 2013). First, jointly generated IP is not only known to, but also often claimed by the involved parties, causing legal conflicts over property rights especially in absence of a clear IP strategy among partners (Bercovitz and Feldman, 2007; Grimpe and Kaiser, 2010). This can be particularly harmful, if the focal firm operates on international markets, where litigations can be costly, lengthy, and uncertain with regard to their outcome (Schmiele, 2013). Second, collaborative innovation provides partners with insights into a focal firm's innovation capabilities (Wuyts *et al.*, 2004), thereby enabling them to replicate superior innovative performance (Ketchen *et al.*, 2007; Martinez-Noya *et al.*, 2013). De Rond and Bouchikhi (2004), for instance, report how a previously collaborative innovation partnership between a pharmaceutical giant and a small biotech company turned competitive, when the smaller partner decided to market and sell to third parties chemical structures similar to those jointly developed as part of the partnership. When collaborating with a broad portfolio of partners, firms face the dilemma of being required to share their knowledge with these partners in order to maximise value creation, while protecting its knowledge from undesirable spillovers to maximise value appropriation (Grimpe and Kaiser, 2010; Li *et al.*, 2012; Martinez-Noya *et al.*, 2013). Innovation collaboration may also indirectly increase imitation threats, when innovation partners do not act opportunistically themselves, but function as a channel for third parties to obtain and infringe critical knowledge. As a case in point, competitors may gain access to valuable technological knowledge of the focal firm by collaborating with its suppliers or associated scientific institutions rather than with the focal firm itself (Dyer and Nobeoka, 2002).

The risk of imitation becomes particularly evident when viewing innovation partnerships through the theoretical lens of the RBV. Accordingly, it can be expected that the extent to which a firm's resources and capabilities are readily observable decreases the causal ambiguity surrounding their relationship with performance, and thus the challenges and costs of imitation (Liebeskind, 1996; Reed and DeFillippi, 1990). As stated by Barney (2014, p. 26), "It is in the self-interest of firms to keep information about the emergence of many of their resources and capabilities in-house, to reduce the threat of imitation." Empirical evidence corroborates this argument. For example, Ethiraj and Zhu (2008) findings

suggest that the amount of available information determines whether competitors can effectively (e.g., at lower cost and risk) imitate innovations. In this regard, Kogut and Zander (1992, p. 394) use the "*poker hand*" metaphor, according to which imitation will rapidly ensue, once a firm has revealed its cards — i.e., its knowledge. Being provided voluntarily with information by the focal firm and obtaining insights into its operations, opportunistic partners are well positioned to understand the value of the focal firm's resources and how they are best used (Li *et al.*, 2008; Martinez-Noya *et al.*, 2013). This may trigger the desire among partners to imitate in the first place. In particular, intense innovation partnerships can provide imitators with the rare opportunity to observe a firm's competencies in use. This is highly problematic, as the inability to do so is widely regarded as deterring imitation (Barney, 2014), because outside actors cannot fully understand how and why certain resources contribute to firm performance without considering the idiosyncratic context in which they are put to use (King, 2007; Polidoro and Toh, 2011). Collaboration enhances an imitator's ability to capture the focal firm's tacit, sticky knowledge embedded in its operating routines and managerial practices, because the transmission of this kind of knowledge requires social interaction (Li *et al.*, 2008). From this perspective, keeping innovation partners at arm's length and reducing interaction appears necessary in order to protect IP (Roy and Sivakumar, 2011).

While the arguments provided thus far similarly apply to dyadic alliances, simultaneously engaging in collaborative arrangements with various domestic and international innovation partners has specific implications for understanding imitation threats. We expect the focal firm to become more vulnerable to imitation the greater the variety of its partnership portfolio (i.e., the number of the different partner types with which the firm collaborates in different phases of the innovation process), if nothing else because more potential imitators have more opportunities to get access to the firm's proprietary knowledge. In particular, a greater number and diversity of innovation partners amplify the degree of managerial complexity and impede the monitoring of potentially opportunistic partners (De Leeuw *et al.*, 2014; Li *et al.*, 2012; Oxley and Sampson, 2004). Managing a partnership portfolio composed of multiple partner types such as suppliers, customers, and research institutions involves different exchange relationships and requires specific contractual rules as well as IP protection mechanisms (Laursen and Salter, 2006). This is especially the case when simultaneously engaging in collaboration during various phases (e.g., idea generation, R&D, commercialization) of the innovation process, each of which poses specific challenges regarding the protection of IP (Manzini and Lazzarotti, 2016). Moreover, there might be a trade-off between collaboration breadth and depth in that firms collaborating with a fewer number of different partners will be more likely to be able to build trusting relationships with

their partners than those with multiple partners (Meuleman *et al.*, 2010). This is consequential, as trust is widely considered an effective safeguard against opportunism in alliances (Dyer and Singh, 1998). In light of these arguments, we propose:

H1. *The greater the variety of a focal firm's innovation partnership portfolio, the greater will be its risk of being affected by imitation.*

Partner type, partner location, and innovation phase as contingency factors

To shed further light on how the structural configuration of a partnership portfolio influences imitation threats, we go beyond the aggregate effect of partnership variety and explore the specific effects of *partner type*, *partner location*, and *innovation phase* on imitation.

Partner type

Any innovation partnership with competitors, suppliers, customers, and research institutions entails a certain risk of opportunistic behaviour and knowledge leakage (Bercovitz and Feldman, 2007; Hernandez *et al.*, 2015). Nevertheless, a focal firm's risk of being imitated is likely to vary based on the specific types of innovation partners being included into its portfolio (Diestre and Rajagopalan, 2012; Nieto and Santamaría, 2007). In particular, we expect that, given their strategic position towards the focal firm, certain partners will be more inclined than others to misuse these relationships for accessing and exploiting the focal firm's proprietary knowledge for their own advantage (Emden *et al.*, 2006; Ritala and Hurmelinna-Laukkanen, 2013; Sivakumar *et al.*, 2011).

According to this reasoning, scientific innovation partnerships, that is, collaborative arrangements with universities and research institutes, are likely to be the partner type of choice for firms seeking to minimise appropriability concerns. Scientific institutions tend to have fewer incentives to act opportunistically and also typically lack complementary assets required to commercialise IP generated as an outcome of joint research themselves (Bercovitz and Feldman, 2007; Martinez-Noya *et al.*, 2013). That said, scientists and practitioners might still have conflicting interests with regards to IP. While managers are interested to keep IP proprietary and secret in an attempt to ensure value appropriation, publishing technological advancements is critical for academics to enhance their scientific reputation (Bercovitz and Feldman, 2007).

Collaborative research endeavours with customers and suppliers, or what has been referred to as vertical partnerships, are deemed less hazardous for unintended

knowledge leakage and imitation than horizontal partnerships with competitors, which are widely regarded as particularly risky (Bercovitz and Feldman, 2007; Miotti and Sachwald, 2003; Nieto and Santamaría, 2007; Oxley and Sampson, 2004; Sivakumar *et al.*, 2011). It should be noted, however, that collaborative arrangements with suppliers are by no means immune to imitation. In particular, a supplier might turn into a future competitor through forward integration or serve as a conduit through which technological knowledge of the focal firm leaks to third parties that are not only customers of the supplier, but also competitors of the focal firm (Martinez-Noya *et al.*, 2013). Indeed, the same may be assumed for corporate customers and, to a lesser extent, research institutions.

However, current competitors engaged in innovation partnerships with the focal firm do not only have the strongest incentives and complementary assets to exploit proprietary knowledge of the focal firm, but are also likely to possess the absorptive capacity necessary to identify, assimilate, and utilise this knowledge. This assumption can be made as competitors serve similar markets and hence tend to possess comparable knowledge bases, which enable imitating firms to understand the value and applicability of their partner's technological competencies (Diestre and Rajagopalan, 2012; Ritala and Hurmelinna-Laukkanen, 2013; Yang *et al.*, 2010). A high degree of knowledge overlap between innovation partners increases the partner-specific absorptive capacity (Dyer and Singh, 1998), which facilitates interfirm knowledge transfer regardless of occurring voluntarily or involuntarily (Emden *et al.*, 2006). Based on the arguments presented, we expect that:

H2. *Horizontal innovation partnerships will be associated with a greater risk of being affected by imitation for the focal firm than vertical and scientific innovation partnerships.*

Partner location

The issue of geographic location has received considerable attention in various fields such as research on strategic alliances (Phene and Tallman, 2014; Sivakumar *et al.*, 2011), innovative search (Ahuja and Katila, 2004), and headquarter-subsidiary relationships (Goerzen and Beamish, 2003). Conceptualising distance in multidimensional terms (e.g., geographical, cultural, and institutional distance), this body of work highlights both the potential benefits (e.g., access to complementary knowledge) and challenges (e.g., coordination, control, and knowledge transfer) associated with distal exchange relationships (Lavie and Miller, 2008; Zaheer and Hernandez, 2011). In an effort to extend these studies mainly concerned with the general performance implications of distance, in the present research, we explore how the location of innovation partners in a focal firm's partnership portfolio affects its imitation threat. We do so by comparing the risks

of collaborating with domestic (i.e., located in Germany), continental (i.e., located in Europe), and international (i.e., located elsewhere) innovation partners.

There are, however, conflicting arguments concerning the relationship between partner distance and the threat of imitation. On the one hand, it is argued that proximity to an innovation partner fosters not only intended, but also unintended knowledge spillover (Giarratana and Mariani, 2014; Schmiele, 2013). In particular, proximity in terms of geography, culture, language, institutional conditions, and organisational knowledge has been associated with improved interaction and knowledge sharing in innovation partnerships by facilitating face-to-face communication between actors and the development of trusting relationships (Boschma, 2005; Ben Letaifa and Rabeau, 2013). Although, good interorganisational and interpersonal relationships are often regarded as an effective safeguard against opportunistic behaviour (Dyer and Singh, 1998; Lavie and Miller, 2008), other scholars have argued that familiarity increases the focal firm's vulnerability to unintended knowledge leakage (Boschma, 2005; Li *et al.*, 2008). In line with resource-based theorising, frequent personal interaction can be seen as a prerequisite for understanding and exploiting tacit, causally ambiguous knowledge (Kogut and Zander, 1992; Oxley and Sampson, 2004; Wuyts *et al.*, 2004; Zaheer and Hernandez, 2011). As such, proximal innovation partners are best equipped to imitate even complex technical inventions, products, and business models that would otherwise be very difficult to replicate (Li *et al.*, 2008). This is especially true, as firms may underestimate the risk of opportunism in alliances with seemingly well-known partners (Boschma, 2005), and thus miss the opportunity to employ adequate protection mechanisms. The ability of proximal innovation partners — especially domestic ones — to assimilate and exploit the focal firm's IP can also be traced back to their greater absorptive capacity compared to foreign partners, which stems from having a similar cultural, institutional, and cognitive background (Giarratana and Mariani, 2014; Lavie and Miller, 2008). Finally, proximity makes it easier for opportunistic partners to hire away key employees of the focal firm who may provide access to otherwise secret knowledge.

On the other hand, despite distance-induced difficulties to obtain insight into the focal firm's operations and lower levels of absorptive capacity (Lavie and Miller, 2008), there are reasons to suggest that distal innovation partnerships can be risky in their own right. First, foreign innovation partners might have stronger incentives to imitate the focal firm. Indeed, imitation is a prevalent strategy used by foreign firms to mitigate the liabilities of foreignness, that is, the costs associated with the international expansion of operations (Salomon and Wu, 2012; Zaheer, 1995). Second, research suggests that geographic, cultural, institutional, economic, and linguistic distance between collaboration partners can lead to conflicts, mistrust,

and lack of commitment. Such interorganisational tensions provide a fertile ground for the misappropriation of the focal firm's IP (Katsikeas *et al.*, 2009; Robson *et al.*, 2008). Finally, the difficulty of monitoring violations of property rights and protecting them is likely to increase with distance. In particular, formal governance mechanisms tend to be less effective in preventing imitative behaviour by foreign as opposed to domestic partners. Litigations in a foreign country can be costly, time consuming, and uncertain in terms of their expected outcomes due to oftentimes weaker appropriability regimes abroad (James *et al.*, 2013; Schmiele, 2013; Zaheer, 1995). Especially emerging countries often lack legal mechanisms to prosecute and penalise imitators, rendering the enforcement of IP rights challenging at best (Keupp *et al.*, 2010). This governance vacuum in global partnerships is also likely to increase the chances of co-created IP being contested and commercially exploited or shared with third parties in particular in international markets given the ambiguities of delineating, evaluating and enforcing boundary-crossing ownership claims (Hernandez *et al.*, 2015). Initial evidence supports these arguments in that offshoring R&D to distant countries increases the risk of infringement of valuable IP by host country competitors (Schmiele, 2013).

Bridging the two positions outlined above, we argue that both too much and too little distance to its innovation partners increases a focal firm's risk of being affected by imitation. This implies that domestic and international innovation partnerships are associated with a particularly high imitation threat. Continental partnerships characterised by a moderate degree of geographic, cultural, and institutional distance, in contrast, are expected to be less risky. Our reasoning is broadly consistent with Lavie and Miller (2008) finding that a moderate degree of alliance portfolio internationalisation yields the highest level of firm performance. Since differences to continental, in this case European, innovation partners are noticeable but not excessive, the focal firm can establish high quality exchange relationships with geography keeping its partners at arm's length. At the same time, chances are high that any unauthorised exploitation of IP by firms operating on the same continent will be detected and sanctioned legally or socially, thereby further discouraging imitative behaviour. Taken together, we expect:

H3. *Continental innovation partnerships will be associated with a lower risk of being affected by imitation for the focal firm than domestic and international innovation partnerships.*

Innovation phase

Finally, differences in the structural characteristics of collaborative activities carried out in early stages (e.g., idea generation, R&D), mid stages (e.g., design, prototyping), and later stages (e.g., commercialisation) of the innovation process

may hold implications for the resulting risk of imitation (Hussinger, 2006; Paasi *et al.*, 2010). Only few empirical studies have explicitly examined this issue in previous research, with Manzini and Lazzarotti's (2016) case study being a notable exception. They shed light on the specific imitation risks and IP management challenges that firms are facing in different phases of the innovation process. In particular, their study suggests that imitation risks are most pronounced in early stages of innovation processes. In line with this observation and supported by a number of theoretical reasons, we expect that a partnership portfolio featuring a high proportion of early-stage innovation partnerships relative to those in mid and late stages of the innovation process will expose the focal firm to particularly high imitation risks.

Early-stage partnerships pertaining to joint ideation and R&D activities have been characterised as involving close interaction and extensive exchange of core technological knowledge between partners in order to develop new ideas and getting them to work (Laursen and Salter, 2006; Li *et al.*, 2008). While intensive interaction, for example, between engineers of innovation partners allows for the transfer of tacit knowledge and may foster creative problem-solving, it also increases the likelihood of unintended knowledge leakage (Li *et al.*, 2012; Roy and Sivakumar, 2011). It is hence through close collaboration that front-end intangible resources become vulnerable to outside imitation (Kozlenkova *et al.*, 2013).

In contrast, the interaction in later stages of the innovation process can be expected to be less intense and restricted to solving highly specific problems related to prototyping or commercialising already existing products or services. In these stages, firms often engage in innovation partnerships to gain access to complementary assets such as distribution and marketing capabilities (Harhoff *et al.*, 2003; Kozlenkova *et al.*, 2013). As such, the focal firm can pursue selective revealing strategies more effectively by providing partners with information relevant to solve the specific problem at hand rather than with the core technological knowledge (Alexy *et al.*, 2013; Harhoff *et al.*, 2003). Without this knowledge about the technological principles underpinning a new product, service, or business model, imitating firms will find it difficult to succeed in their replication efforts, for example, trough reverse engineering (McEvily *et al.*, 2004). Moreover, the pre-existence of a product or process technology in later stages of the innovation process enables the focal firm to delineate its IP rights more clearly from the outset (Pisano, 1989).

Such delineation attempts are likely to be notably more difficult in early-stage partnerships involving joint idea generation and concept development activities (Li *et al.*, 2008). These innovation activities are characterised by a higher degree of ambiguity given the lack of information and the considerable uncertainty about available courses of action and possible innovation outcomes (Carson *et al.*, 2006;

Manzini and Lazzarotti, 2016). It will then be most difficult — if not practically impossible — to disentangle the respective contributions of each partner and allocate IP rights accordingly (Bercovitz and Feldman, 2007). This might well provide a fertile breeding ground for future IP disputes. Such ambiguity also increases the likelihood of opportunistic behaviour by partners, as acts of opportunism are less likely to be detected when perceptions of partner behaviour are ambiguous (Carson *et al.*, 2006; Oxley and Sampson, 2004). In line with the arguments presented above, Katila *et al.* (2008) found that entrepreneurial firms are more likely to take the risk of engaging in corporate investment relationships in later stages of technology ventures, as it is easier to protect more mature technologies. In light of these arguments, we hypothesise:

H4. *Early-stage innovation partnerships will be associated with a greater risk of being affected by imitation for the focal firm than mid-stage and late-stage innovation partnerships.*

IP protection and internal R&D as isolating mechanisms

Resource-based theory suggests that the strength of isolating mechanisms protecting resources from imitation is critical for appropriating the rents of collaborative innovation activities (Lawson *et al.*, 2012; Wang *et al.*, 2009). This is even more important for firms with a broad and diverse portfolio of innovation partnerships. As the risk of knowledge leakage is likely to increase with the number of innovation partners, firms engaged in multilateral alliances have been found to devote particular attention to knowledge protection by means of governance structures (Li *et al.*, 2012). In the present study, we explore whether both legal and strategic isolating mechanisms, as represented by a focal firm's formal IP protection strategy and its internal R&D activities, can mitigate partnership-induced imitation threats. As previous evidence on this issue is limited to dyadic alliances, it remains to be seen whether these protection mechanisms are also effective in governing partnership portfolios featuring heterogeneous actors and exchange relationships.

IP protection

First, formal IP protection mechanisms such as patents, trademarks, and copyrights have long been acknowledged as important imitation barriers within resource-based theorising (Mahoney and Pandian, 1992; Peteraf, 1993; Rumelt, 1984). By establishing property rights, firms can, at least temporarily, protect knowledge residing in new products or processes from imitation and preserve their rent streams (Lawson *et al.*, 2012; Teece, 1986; Thomä and Bizer, 2013). For example, empirical evidence suggests that obtaining a patent increases the returns of an

innovation by around 47%, since it provides a temporary monopoly over the knowledge contained within the innovation (Jensen *et al.*, 2011). In the context of innovation partnerships, formal IP protection is not only assumed to prevent collaboration partners from using a focal firm's core knowledge in their own operations, but also to facilitate controlled knowledge transfer between firms by defining clear property rights (Chesbrough *et al.*, 2006; Huang *et al.*, 2013; Ritala and Hurmelinna-Laukkanen, 2013). Yet, at the same time, it has been argued that patents and other property rights are often narrowly defined, costly and time-consuming to enforce, and provide only limited protection, especially in countries with weak appropriability regimes (Somaya, 2012). It is even possible that legal property rights foster imitation instead of preventing it as, for example, patents require the codification and formal disclosure of some of a focal firm's knowledge (Hurmelinna *et al.*, 2007).

However, we expect that the safeguarding effect of formal IP protection mechanisms will outweigh the potential disadvantages stemming from disclosure. Infringing a focal firm's IP rights or legally inventing around them by creating substitute technologies can be costly, time consuming, and risky (Polidoro and Toh, 2011; Reitzig *et al.*, 2007). Alleged infringers often face substantial litigation costs and may also suffer reputational damage that restrains other firms from collaborating with them in the future. Taken together, we argue that imitation barriers raised by patents and other IP rights will lower the occurrence of partnership-induced imitation, as others will perceive imitation as a less promising strategic alternative (Polidoro and Toh, 2011). Thus:

H5. *A focal firm's IP protection strategy will moderate the positive association between the variety of its innovation partnership portfolio and its risk of being affected by imitation, in such a way that this relationship will be weaker the stronger the IP protection.*

R&D intensity

Internal R&D activities constitute the second, at first sight less obvious, isolating mechanism deterring imitation of firms pursuing a portfolio approach to innovation partnerships examined in this study. In the innovation literature, in-house R&D is mainly viewed as a complementary activity to external knowledge sourcing (Cassiman and Veugelers, 2006; Ritala and Hurmelinna-Laukkanen, 2013). In line with the notion of absorptive capacity, firms need to develop prior related knowledge to be able to identify, assimilate, and exploit knowledge from external sources (Cohen and Levinthal, 1990). Yet, by engaging in R&D activities, firms can also create effective barriers to imitation (Cassiman and Veugelers, 2002; James *et al.*, 2013). Knowledge generated through extensive in-house R&D is

often firm-specific, complex, and tacit in nature, and thus causally ambiguous (i.e., it is unclear how and why certain knowledge resources contribute to competitive advantage) and difficult to imitate (Helfat, 1994; Kozlenkova *et al.*, 2013; Reed and DeFillippi, 1990).

Firms that seek to imitate innovations based on knowledge with these characteristics must not only gain access to the knowledge itself, but also need to understand and replicate the organisational routines through which such knowledge has been generated and can be exploited (Wang *et al.*, 2009; Yang *et al.*, 2010). It is especially, the context-dependent nature of the R&D process and the important tacit element it involves that act as potentially powerful barriers to imitation (Helfat, 1994). This is consistent with the argument that the ease with which innovation partners can imitate a focal firm's resource stock is related to the characteristics of the process through which this resource stock has been accumulated (Dierickx and Cool, 1989). Particularly, strong imitation barriers can be

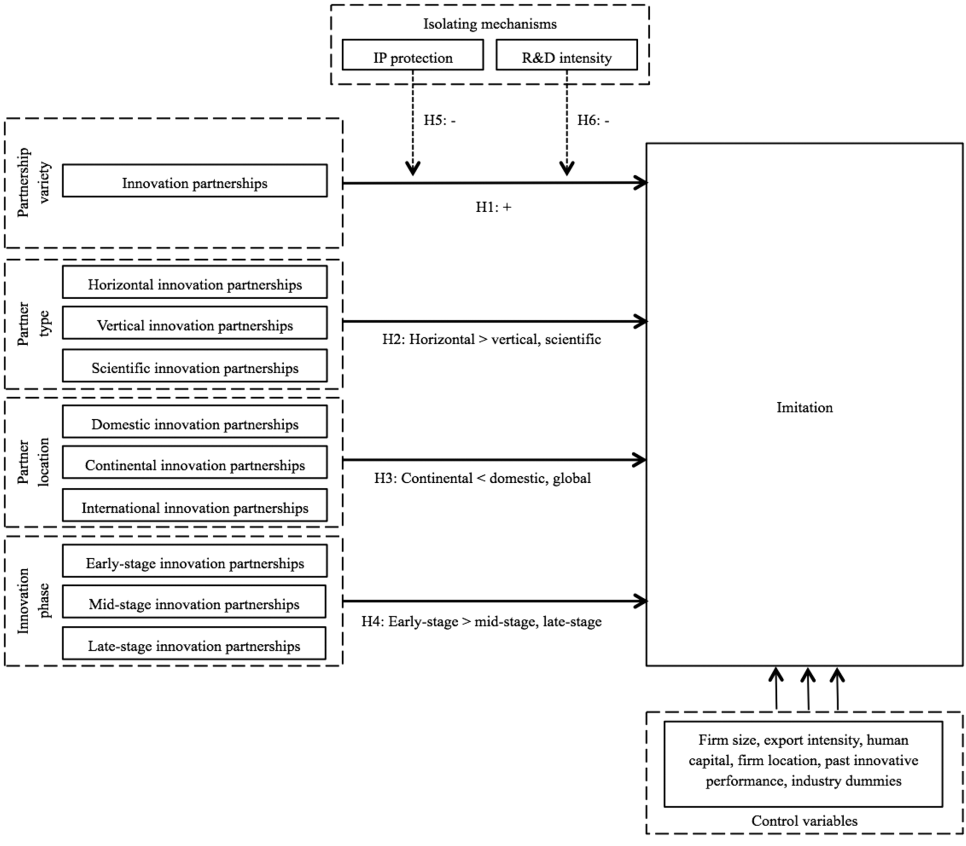

Fig. 1. Conceptual model on innovation partnerships and imitation.

expected to arise from combining internal and external knowledge resources during the innovation process (Grimpe and Kaiser, 2010; Sirmon *et al.*, 2007). The causal mechanisms underlying the emergence of such new knowledge combinations are highly complex and causally ambiguous (Ketchen *et al.*, 2007). Amongst others, it has been argued that such R&D-induced complexity and ambiguity overwhelm managerial cognitive capacities for imitation (Ethiraj *et al.*, 2008), thus buffering the focal firm from imitation threats. Lead time advantages, i.e., advantages stemming from early timing of developing and introducing new products or processes, are another mechanism through with a focal firm with a high commitment to R&D can deter imitation (James *et al.*, 2013). The preemptive access to scarce assets, learning-curve effects, and switching costs are assumed to make the imitation of first-mover firms costly and time-consuming for others (Lawson *et al.*, 2012; Lieberman and Montgomery, 1988). In sum, we propose that:

H6. *A focal firm's internal R&D intensity will moderate the positive association between the variety of its innovation partnership portfolio and its risk of being affected by imitation, in such a way that this relationship will be weaker the higher the R&D intensity.*

Figure 1 summarises our conceptual model.

Methods

Research design and sample

This study draws on data from two consecutive waves of the Mannheim Innovation Panel (MIP) collected in 2007 and 2008. The MIP is commissioned by the German Federal Ministry of Education and Research and carried out by the Centre for European Economic Research (ZEW). It follows the methodology for large-scale firm-level innovation surveys outlined in the Oslo Manual (OECD, 2005). The MIP has been designed to collect information on the innovation activities of German firms operating in 22 different industry sectors. In 2008 (2007), 6,684 (4,914) of the 18,109 (25,862) firms surveyed returned usable questionnaires, yielding a response rate of 36.9 (19.0)%. Non-response analyses using telephone interviews were conducted and provided no evidence of any non-response bias that might be a source of concern for our study (Klingebiel and Rammer, 2014).

Our main analyses are based on a subsample of German manufacturing firms. Often competing on the basis of technology leadership, these firms are not only particularly likely to engage in collaborative innovation activities, but also face the highest risk of being imitated by others given their strong manufacturing and technological capabilities (Li *et al.*, 2008). To test our hypotheses, we matched

Table 1. Sample description.

Industry membership		Innovation partnership type[a]	
Food	5.85%	Innovation partnerships	83.81%
Textiles	5.48%	Horizontal innovation partnerships	10.34%
Paper	11.21%	Vertical innovation partnerships	80.45%
Chemicals	7.85%	Scientific innovation partnerships	39.10%
Plastics	6.48%	Domestic innovation partnerships	82.57%
Glass	5.73%	Continental innovation partnerships	48.82%
Metal	16.56%	International innovation partnerships	28.64%
Engineering	12.45%	Early-stage innovation partnerships	77.58%
eTechnology	9.71%	Mid-stage innovation partnerships	70.63%
Medical instruments	10.96%	Late-stage innovation partnerships	85.18%
Vehicle construction	4.11%		
Furniture	3.61%		
Firm size		**Imitation[b,c]**	
< 50 Employees	48.07%	In general	37.90%
50–249 Employees	35.24%	At home	14.96%
> 249 Employees	16.69%	From abroad	15.69%
Breakdown by continent		**Breakdown by country (top 5)[b]**	
1. Europe[d]	51.42%	1. Germany	42.51%
2. Asia	44.94%	2. China	33.20%
3. North-America	3.64%	3. USA	3.64%
4. Oceania,		4. India, Turkey	3.24%
South-America	0.00%	5. Taiwan	2.83%

Notes: 803 total observations; [a]share of firms with at least one specific innovation partnership, [b]does not add up to 100% since multiple answers were possible.[c]247 firms reported to have been affected by at least one instance of IP imitation between 2005 and 2007, [d]including imitation in Germany.

data from the 2007 and 2008 MIP waves, yielding a final sample of 803 manufacturing firms that provided usable responses to both waves. Table 1 describes the composition of our final sample of 803 German manufacturing firms. About 83.31% of these firms are small- and medium-sized enterprises (SME) with up to 250 employees — a stylised fact that reflects the importance of SMEs in the German economy. A total of 83.81% cooperated with at least one innovation partner, with the average firm engaging in 5.00 distinct forms of innovation partnerships as described by unique combinations between partner type (e.g., customers, suppliers) and innovation phase (e.g., idea generation, design). About 82.57% engaged in domestic innovation partnerships, while 48.82% cooperated with innovation partners from Europe and 28.64% with partners located elsewhere

abroad. Taking a closer look at partner type variety, 80.45% collaborated with suppliers or customers (vertical innovation partnerships) and 39.10% drew on knowledge from universities and other research institutions (scientific innovation partnerships). However, only 10.34% partnered with competitors (horizontal innovation partnerships). Innovation partnerships occurred across all three stages of the innovation process, with early- (77.58%) and late-stage partnerships (85.18%) being notably more frequent than mid-stage partnerships (70.63%). Table 1 also reveals that imitation was a highly pervasive problem that affected 37.90% of all firms in our sample during the period from 2005 to 2007, with 42.51 percent of imitators originating from within Germany, followed by China (33.2%), and the USA (3.64%).

Measures

Dependent variables

In absence of a standard metric, we develop our measure for imitation by drawing on four binary indicators. These capture whether a focal firm was affected by the imitation of its (1) technical inventions, (2) products and business models, (3) brands and descriptions, or (4) designs between 2005 and 2007. Based on these self-reports of experienced IP infringement, we compute an overall imitation score as the count of the distinct types of imitation the focal firm was affected by. Accordingly, our measure ranges from 0 (no imitation) to 4 (all four types of imitation) and reflects the extent to which the focal firm is affected by imitation.

Independent variables

Partnership variety. We measure the variety of a focal firm's innovation partnership portfolio as the number of distinct partnerships it was engaged in between 2005 and 2007. For this purpose, we count for each firm the number of unique binary "partner type"-"innovation stage" combinations. We consider the six innovation partner types (i) business customers, (ii) consumers, (iii) material suppliers, (iv) service providers, (v) competitors as well as (vi) universities and research institutes along with the five innovation stages (i) idea generation, (ii) R&D, (iii) design, (iv) testing and production preparation, and (v) implementation and market introduction. A firm's overall partnership variety can consequently range from 0 (no partnership type used) to 30 (innovation partnerships with all six partner types across all five innovation stages). To examine the role of partner type (Hypothesis 2), partner location (Hypothesis 3), and innovation phase (Hypothesis 4), we construct three sub-indices for each.

As for *partner type*, we develop separate indices for horizontal innovation partnerships (number of innovation stages with at least one active innovation partnership with a competitor, range from 0 to 5), vertical innovation partnerships (number of innovation stages with at least one active innovation partnership with business customers, consumers, material suppliers, or service providers, range from 0 to 20), and scientific innovation partnerships (number of innovation stages with at least one active innovation partnership with a university or research institute, range from 0 to 5).

As for *partner location*, the sub-index for domestic innovation partnerships is computed as the count of unique combinations among the six innovation partner types introduced above and three partner location types within Germany. These are (i) local partnerships (i.e., within 20 km from the focal firm), (ii) regional partnerships (i.e., between 20 km and 100 km from the focal firm), and (iii) national partnerships (i.e., more than 100 km from the focal firm). The resulting index hence ranges from 0 (no domestic innovation partnerships) to 18 (innovation partnerships with all six partner types in all three German locations). Similarly, the indicator for continental (international) innovation partnerships emerges as the count of unique combinations among the same six innovation partner types and the partner location within Europe (outside of Europe). This index is thus limited to the interval between 0 (no continental (international) innovation partnerships) and 6 (innovation partnerships with all six partner types in European (non-European) countries).

Finally for *innovation phase*, we calculate indices for early-stage innovation partnerships (number of innovation partner types in the idea generation and R&D stages, range from 0 to 12), mid-stage partnerships (number of innovation partner types in the design and testing stages, range from 0 to 12)[1] and late-stage partnerships (number of innovation partner types in the implementation and market introduction stage, range from 0 to 6). All innovation partnership variables were finally standardized for formal testing of Hypotheses 2–4.

Moderating variables

Our first moderating variable IP protection is binary and captures whether the focal firm relies on (i) patents, (ii) registered designs, (iii) design patents, (iv) trademarks, or (v) copyrights for protecting its IP rights. Following prior research (Laursen and Salter, 2006; Leiponen and Helfat, 2010), we calculate a focal firm's R&D intensity as the ratio of its annual R&D expenditures to its annual sales.

[1]We consider early-stages (i.e., idea generation and R&D) to comprise efforts related to developing the critical technical characteristics of a product, whereas efforts in mid-stages (design and prototyping) comprise the aesthetic design and prototyping important for successful production.

Control variables

We include a number of control variables widely used in the innovation literature to account for possible confounding factors (Laursen and Salter, 2006; Leiponen and Helfat, 2010). First, we control for firm size measured as the natural logarithm of the total number of employees, as larger firms are more visible and hence more likely to become the target of imitation. Second, we follow (Cassiman and Veugelers, 2006) and include export intensity to account for inter-firm differences in internationalisation and hence global visibility to potential imitators. Third, we use the percentage of employees holding a university degree as a proxy for a firm's human capital. Fourth, we employ a full set of industry dummies to control for potential inter-industry differences in firm performance and exposure to imitation.

Analysis

The dependent variable employed for testing Hypotheses 1–6 (i.e., imitation) is a count variable with non-negative integer values assumed to follow a Poisson distribution. Its standard deviation (0.92) exceeds its mean value (0.50), indicating overdispersion. This overdispersion, however, is accounted for by excess zeros (Greene, 2011), with 37.90 percent of all observations having a non-zero value for imitation. A significant Vuong statistic ($z = 4.41; p < 0.01$) points to the superiority of a Zero-Inflated Poisson model correcting for overdispersion due to excess zeros (Vuong, 1989). The first step of this two-step approach involves estimating the probability of zero-observations by means of a Logit model. As German manufacturing firms are less likely to be at the centre of imitators' attention if they have been performing poorly with respect to their innovation activities in the past three years (Ethiraj and Zhu, 2008), or are located in the still deprived Eastern part of Germany (Grimpe and Kaiser, 2010), we use past innovative performance and a firm location dummy (0 for West and 1 for East Germany) in addition to the constant as our zero-inflation parameters. To measure a focal firm's past innovative performance, we draw on data from the 2007 MIP wave and capture the 2006 revenue share from new and significantly improved products launched between 2004 and 2006. As part of the second step, a standard Poisson model with robust standard errors is employed to explain inter-firm differences in the exposure to imitation.

Results

Descriptive results

Table 2 depicts the descriptive statistics and pairwise correlations for the full sample of 803 firms. The table shows that a focal firm's imitation probability

Table 2. Descriptive statistics and correlations.

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Imitation	1																	
2. Innovation partnerships	0.25*	1																
3. Horizontal innovation partnerships	0.01	0.28*	1															
4. Vertical innovation partnerships	0.24*	0.95*	0.14*	1														
5. Scientific innovation partnerships	0.18*	0.58*	0.12*	0.34*	1													
6. Domestic innovation partnerships	0.15*	0.60*	0.20*	0.56*	0.36*	1												
7. Continental innovation partnerships	0.21*	0.47*	0.16*	0.44*	0.30*	0.45*	1											
8. International innovation partnership	0.19*	0.38*	0.13*	0.35*	0.28*	0.39*	0.63*	1										
9. Early-stage innovation partnerships	0.27*	0.89*	0.25*	0.83*	0.59*	0.59*	0.46*	0.37*	1									
10. Mid-stage innovation partnerships	0.17*	0.88*	0.24*	0.84*	0.49*	0.47*	0.38*	0.30*	0.62*	1								
11. Late-stage innovation partnerships	0.19*	0.72*	0.22*	0.73*	0.29*	0.40*	0.33*	0.28*	0.48*	0.58*	1							
12. IP protection	0.32*	0.36*	0.03*	0.32*	0.33*	0.31*	0.33*	0.29*	0.36*	0.27*	0.26*	1						
13. R&D intensity	0.11*	0.29*	0.10*	0.20*	0.38*	0.25*	0.27*	0.34*	0.30*	0.22*	0.20*	0.26*	1					

Table 2. (*Continued*)

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
14. Past innovative performance	0.20*	0.25*	0.10*	0.19*	0.26*	0.20*	0.24*	0.25*	0.26*	0.18*	0.16*	0.29*	0.38*	1				
15. Firm size	0.07*	0.08	−0.01	0.06	0.09	0.03	0.01	0.02	0.10*	0.04	0.02	0.07	0.04	0.02	1			
16. Export intensity	0.21*	0.23*	0.01*	0.18*	0.28*	0.13*	0.38*	0.38*	0.24*	0.18*	0.11*	0.35*	0.24*	0.24	0.10*	1		
17. Human capital	0.15*	0.24*	0.05*	0.17*	0.31*	0.20*	0.19*	0.26*	0.24*	0.16*	0.19*	0.26*	0.46*	0.33	0.05	0.21*	1	
18. Firm location	−0.17*	0.00	0.01	−0.01	0.05	0.02	−0.08	−0.08	−0.04	0.03	0.06	−0.12*	0.05	−0.03	−0.06	−0.18*	0.13*	1
Mean	0.50	5.00	0.14	4.10	0.75	3.74	1.14	0.52	2.55	1.76	0.70	0.59	0.02	1.22	243	0.29	3.10	0.34
S.D.	0.92	3.91	0.51	3.28	1.11	3.13	1.48	0.98	2.07	1.65	0.86	0.49	0.04	1.94	2011	0.28	2.12	0.47
Min	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0
Max	4	24	5	17	5	18	6	6	10	10	6	1	0.15	8	55562	0.85	8	1

Notes: 803 total observations*$p < 0.01$.

increases most notably with the variety of its continental, vertical, and early-stage innovation partnerships as well as with its use of IP protection mechanisms. It is also worth noting the mean export intensity of 29% among our sample firms, which is a feature that is not only characteristic of German manufacturing, but also most strongly correlated with the risk of imitation.

Regression results

Table 3 presents the results from Zero-inflated Poisson regression analyses explaining inter-firm differences in imitation. Our base model (Model 1) only contains the zero-inflation parameters in step 1 and the full set of control variables in step 2. In line with our expectations, the selection equation of the base model reveals firms with low past innovative performance located in East Germany to be less likely to be affected by imitation. Our key variable sets of interest are then introduced sequentially in Models 2–6.

Consistent with our arguments, the relationship between the variety of a focal firm's innovation partnership portfolio and its exposure to imitation is positive and statically significant in Model 2. Hypothesis 1 is hence supported. The incidence rate ratio (IRR) not reported here indicates that a focal firm's risk of being

Table 3. Zero-inflated Poisson regression analyses explaining imitation.

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Step 2: *Poisson regression*[b]						
Control variables						
Constant	0.294	−0.237	−0.260	−0.238	−0.272	−0.199
	(0.257)	(0.240)	(0.244)	(0.232)	(0.256)	(0.240)
Firm size[a]	0.077	−0.082	−0.077	−0.039	−0.074	−0.079
	(0.057)	(0.066)	(0.065)	(0.063)	(0.066)	(0.068)
Export intensity	0.226	0.237	0.245	0.111	0.269	0.236
	(0.248)	(0.257)	(0.256)	(0.254)	(0.257)	(0.257)
Human capital	0.020	−0.010	−0.011	−0.004	−0.020	−0.014
	(0.034)	(0.034)	(0.034)	(0.034)	(0.035)	(0.034)
Industries	included	included	included	included	included	included
Main effects						
IP protection[a]		0.601***	0.596***	0.636***	0.592***	0.580***
		(0.110)	(0.111)	(0.110)	(0.110)	(0.108)
R&D intensity[a]		−0.114*	−0.115*	−0.126*	−0.120*	−0.072
		(0.065)	(0.067)	(0.066)	(0.063)	(0.064)
Innovation partnerships[a]		0.231***				0.364***
		(0.061)				(0.091)
Horizontal innovation partnerships[a]			−0.035			
			(0.062)			

Table 3. (*Continued*)

Variable	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Vertical innovation partnerships[a]			0.213*** (0.054)			
Scientific innovation partnerships[a]			0.041 (0.052)			
Domestic innovation partnerships[a]				0.015 (0.059)		
Continental innovation partnerships[a]				0.153** (0.073)		
International innovation partnerships[a]				−0.038 (0.074)		
Early-stage innovation partnerships[a]					0.214*** (0.064)	
Mid-stage innovation partnerships[a]					−0.045 (0.070)	
Late-stage innovation partnerships[a]					0.105** (0.046)	
Moderating effects						
Innovation partnerships × IP protection						−0.178* (0.107)
Innovation partnerships × R&D intensity						−0.094* (0.049)
Step 1: *Zero-inflation logit regression*[b]						
Constant	0.245 (0.198)	−0.284 (0.253)	−0.264 (0.253)	−0.152 (0.224)	−0.272 (0.256)	−0.281 (0.240)
Past innovative performance	−0.320*** (0.101)	−0.249** (0.106)	−0.266** (0.116)	−0.268** (0.116)	−0.275** (0.120)	−0.251** (0.109)
Firm location	1.082*** (0.245)	1.146*** (0.284)	1.123*** (0.289)	1.036*** (0.276)	1.129*** (0.289)	1.123*** (0.282)
Total observations	803	803	803	803	803	803
Zero observations	579	579	579	579	579	579
Nonzero observations	224	224	224	224	224	224
Maximum Likelihood R^2	0.114	0.184	0.185	0.177	0.188	0.191
Chi-squared	41.124***	120.803***	127.32***	112.932***	136.127***	124.5***

Notes: 803 total observations; zero-inflated Poisson model with "innovative performance" and "firm location" as zero-inflation parameters; robust standard errors in parantheses; [a]standardized measures; [b]step 1: logit regression estimating probability of not being imitated; step 2: Poisson regression estimating the extent of imitation experienced.

***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

infringed increases by a factor of 1.26 (26.6%) for every one standard-deviation increase in its partnership portfolio variety.

Hypothesis 2 suggested that a focal firm would be exposed to greater imitation risks when engaging in horizontal as opposed to vertical and scientific innovation partnerships. The estimates presented in Model 3, however, indicate that vertical innovation partnerships are associated with the greatest imitation threat, significantly exceeding the risk induced by both horizontal (Chi-squared = 9.30; $p < 0.01$) and scientific innovation partnerships (Chi-squared = 5.10; $p < 0.05$). Indeed, we find the effect of horizontal and scientific innovation partnerships to remain statistically insignificant, thus offering no support for Hypothesis 2.

In Hypothesis 3, we proposed continental innovation partnerships to be associated with a lower imitation threat than their domestic or international counterparts. Contrary to our theoretical arguments, Model 4 reveals that only continental innovation partnerships exhibit a statistically significant imitation-enhancing effect. The difference in coefficient estimates, however, fails to reach statistical significance with regards to both domestic (Chi-squared = 1.57; $p > 0.1$) and international innovation partnerships (Chi-squared = 2.43; $p > 0.1$). Hypothesis 3 is thus not supported.

According to Hypothesis 4, we expected a focal firm's risk of being infringed to be higher for early-stage than for mid- and late-stage innovation partnerships. In line with this expectation, the coefficient of early-stage partnerships in Model 5 is positive and statistically significant, indicating that early-stage innovation partnerships notably increase the imitation threat a focal firm is exposed to. In relative terms, early-stage innovation partnerships carry a significantly greater imitation risk than mid-stage innovation partnerships (Chi-squared = 5.41; $p < 0.05$). Interestingly, we also detect an imitation-enhancing effect of late-stage innovation partnerships. Although the coefficient estimate is notably smaller relative to early-stage innovation partnerships, the difference fails to achieve statistical significance (Chi-squared = 2.12; $p > 0.1$). Hypothesis 4 is thus partially supported.

Figure 2 illustrates how the imitation threat a focal firm is exposed to varies with the functional (i.e., partner type), geographical (i.e., partner location), and temporal (i.e., innovation phase) configuration of the innovation partnership portfolio.

As for the moderating role of IP protection postulated in Hypothesis 5, our analyses reveal a weakly significant negative interaction effect between IP protection and innovation partnerships (Model 6). This corroborates our theoretical expectation that IP protection has the potential to shield the focal firm against partnership-induced imitation. This offers support for Hypothesis 5. Similarly, in

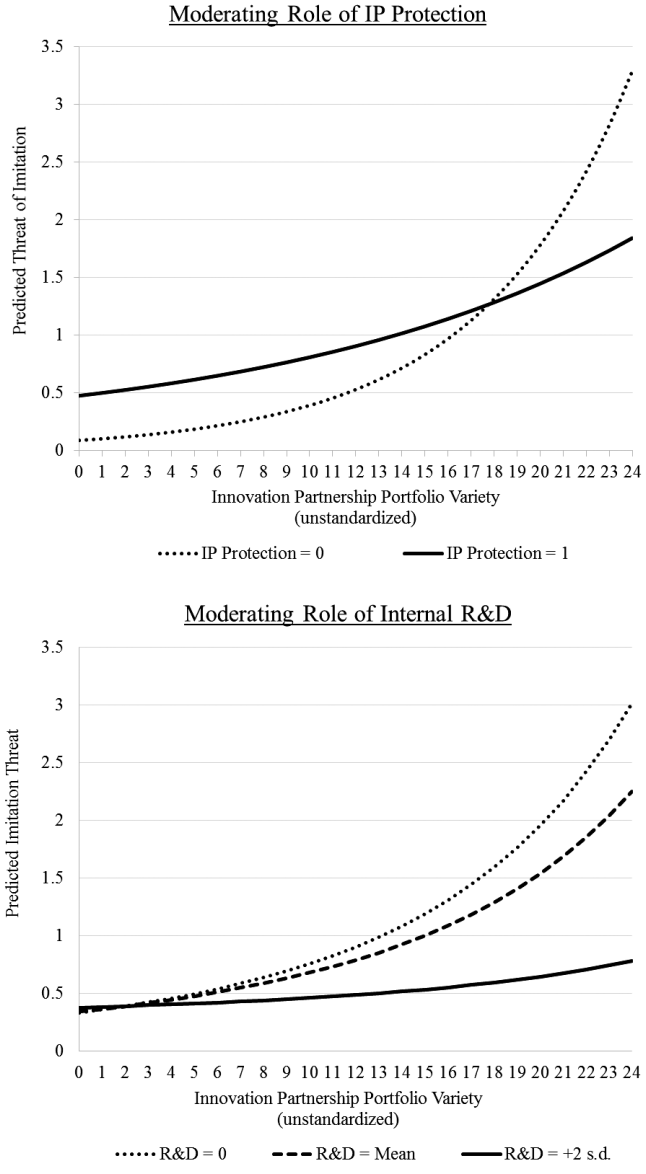

Fig. 2. The moderating role of IP protection and R&D.

support for Hypothesis 6, Model 6 reveals a marginally significant negative interaction effect of R&D intensity on the link between innovation partnerships and imitation. Figure 3 illustrates the practical effectiveness of both moderators in buffering the focal firm from collaboration-induced imitation especially at high levels of partnership portfolio variety.

Table 4 provides a summary of the key findings presented thus far.

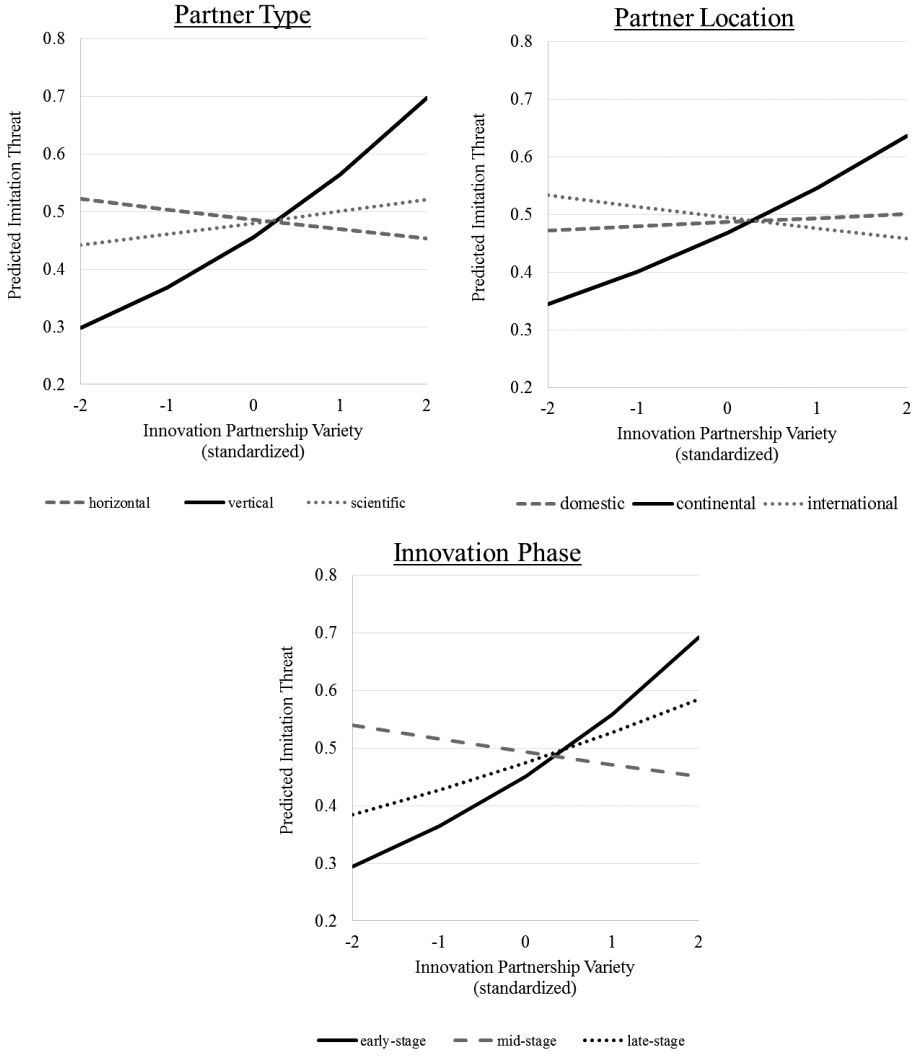

Fig. 3. The effect of partner type, partner location and innovation phase.

Post hoc analyses

We performed several robustness checks to examine the sensitivity of our main results presented above to changes in estimation procedure, construct measurement, and sample selection. We also conducted additional analyses to illuminate questions that emerged during our analyses and sought to rule out alternative explanations.

As for the *robustness checks* performed, we found fully consistent results when using alternative estimation techniques for count data including standard Poisson,

Table 4. Summary of results.

	Hypothesis	Result	Conclusion
H1	Innovation partnerships	supported	The imitation probability a focal firm is exposed to tends to increase with the variety of its innovation partnerships.
H2	Horizontal >vertical and scientific innovation partnerships	not supported	The size of the general imitation-inducing effect of innovation partnerships is largest for vertical innovation partnerships, followed by horizontal and scientific innovation partnerships.
H3	Continental > domestic and international innovation partnerships	not supported	Only continental innovation partnerships exhibit a statistically significant imitation-inducing effect. That said, the differences in effect sizes relative to both domestic and global innovation partnerships fail to reach statistical significance.
H4	Early- > mid- and late-stage innovation partnerships	partially supported	The size of the general imitation-inducing effect of innovation partnerships is larger for early-stage than for mid-stage, but not for late-stage innovation partnerships.
H5	IP protection × innovation partnerships	supported	The size of the general imitation-inducing effect of innovation partnerships is smaller for firms with than without formal IP protection mechanisms.
H6	R&D intensity × innovation partnerships	supported	The size of the general imitation-inducing effect of innovation partnerships is smaller for firms with than without strong internal R&D activities.

Notes: All conclusions are based on the average effects observed in our study of German manufacturing firms.

Negative Binominal and Zero-Inflated Negative Binominal regression. Similarly, consistent, though less efficient estimates emerged when operationalising imitation as a dichotomous variable and replicating all main analyses by means of probit models. Results also remained stable when excluding all non-collaborating manufacturing firms (16.19% of the sample) or all non-innovating firms (41.34% of the sample) from our analyses. Moreover, we introduced and tested an alternative measure for partnership variety. We constructed it as the number of relevant innovation partnerships types used or not used in the innovation process (i.e., (i) business customers, (ii) consumers, (iii) material suppliers, (iv) service providers, (v) competitors as well as (vi) universities and research institutes). Accordingly,

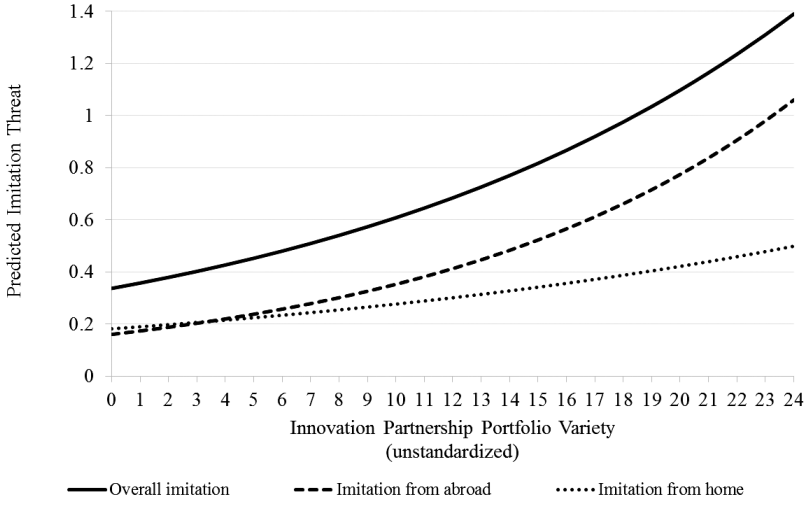

Fig. 4. The main effect of innovation partnership variety on imitation.

this alternative ranges from 0 (no innovation partnerships) to 6 (innovation partnerships with all six types). Our results remained fully robust when using this variable in our estimations. The same applies when using an ordered instead of a binary measure of IP protection.

As for the *additional analyses* conducted, we first sought to explore the role of imitators' geographical origin. For this purpose, we created two count variables capturing the extent of IP infringement a focal firm experienced at home (i.e., from imitators located in Germany) and from abroad (i.e., from imitators located outside of Germany). Several noteworthy findings emerged from these more granular analyses. Interestingly, IRRs revealed a one standard-deviation increase in innovation partnerships to be associated with a 17.91% increase in the imitation risk experienced at home and a 35.59% increase in the imitation risk from abroad. As illustrated in Fig. 4, innovation partnerships induce first and foremost imitation threats from abroad and to a lesser extent from home.

Second, we examined possible differences between illegal imitation (i.e., imitation of a technical invention, product, brand, or design that was legally protected at the time of imitation) and legal imitation (i.e., imitation of a technical invention, product, brand, or design without any legal protection at the time of imitation). Interestingly, we found the variety of a focal firm's innovation partnership portfolio and its constitutive functional, geographical, and temporal dimensions to be associated with a greater threat of *illegal* imitation, though not of *legal* imitation. This reinforces the adverse nature of partnership-induced imitation that German manufacturing firms are exposed to. Third, we examined the extent to which the results obtained for all manufacturing firms in our sample equally hold for firms

operating either in high-tech or in low-tech industries. Despite comparable results with regards to Hypotheses 1–4, three notable differences emerged: These pertain to (i) the higher exposure of high-tech firms to imitation risks fueled by scientific innovation partnerships, (ii) the greater effectiveness of formal IP protection as an isolating mechanism for high-tech firms, and (iii) the greater effectiveness of R&D as an isolating mechanism for their low-tech counterparts. Fourth, we found smaller firms to be more vulnerable to partnership-induced imitation probability than larger firms, a finding that might be explained by their limited opportunities to engage in selective revealing and IP enforcement activities (Ketchen *et al.*, 2007). Last but not least, we sought to unveil the effect of being imitated on the financial performance of the focal firm. For this purpose, we matched data from the 2009 wave of the MIP and captured a focal firm's return on sales in 2008, measured on an ordinal scale from 1 ($< 0\%$) to 7 ($> 15\%$). This allows for a temporal sequencing of imitation and performance. Financial performance is an ordinal variable measured on an unequally distributed interval scale. An ordered probit regression model is hence most appropriate (Greene, 2011). As depicted in Table A.1, the coefficient estimate of imitation is negative and statistically significant. This supports the traditional assumption of resource-based scholars that falling victim to imitation tends to come at the cost of tangible decreases in financial performance (Ordanini *et al.*, 2008).

Finally, we sought to rule out *alternative explanations* for the main findings presented in our study. In particular, our main argument rests on the assumption that a broader innovation partnership portfolio leads to the focal firm being more exposed to imitation risks. Although, panel or experimental data appear needed for a conclusive assessment, we examined this critical issue of causality conceptually, quantitatively, and qualitatively. Conceptually, the threat of positive reverse causality, i.e., of greater imitation incidents leading to an even broader innovation partnership portfolio, does not appear plausible apart from a theoretically possible tit-for-tat pattern leading firms that have fallen victim to imitation to expand their partnership portfolio in a retaliatory effort to engage in imitative behaviour themselves. Imitation incidents triggering a sequential closure of the innovation process, in contrast, is a reaction consistent with behavioural arguments suggesting that organisations adapt their search rules, when the current search mode yields unsatisfactory outcomes (Cyert and March, 1963). In presence of such negative reverse causality, we would tend to under- rather than overestimate the true effect of the variety of a focal firm's innovation partnership portfolio on the imitation threat it is exposed to. In addition to reverse causality, our findings might be compromised by unobserved heterogeneity. Perhaps most intuitively, a focal firm's reputation for technology and innovation leadership could affect its attractiveness as both an innovation partner and an imitation target leading to

potentially spurious estimates. We took several measures to address this issue quantitatively. First, all our models contained a focal firm's past innovative performance as a proxy for its reputation for technology and innovation leadership. Second, we conducted a sub-sample analysis, as part of which we examined the main effect separately for firms with below- and above-median levels of innovative performance. The imitation-enhancing effect of partnership variety emerged in both sub-samples and thus appears to affect firms with low and high levels of innovative performance. Third, as both reverse causality and unobserved heterogeneity might give rise to endogeneity bias, we instrumented partnership variety within a two-stage least-squares (2SLS) framework (Garriga *et al.*, 2013). Importantly, valid instruments needed to be correlated with the partnership variety though not with the threat of imitation. These conditions were satisfied for external R&D (dummy variable to indicate whether the focal firm issued R&D contracts to third parties) and a dummy variable that indicates whether the focal firm had introduced administrative innovations for organising external relations with other firms of public institutions during the period from 2004 to 2006. 2SLS analyses using these two instruments enabled us to replicate our main effect of partnership variety on the threat of imitation at the same level of statistical significance. The size of our main effect declined only moderately from 0.231 ($p < 0.01$) in the original model to 0.168 ($p < 0.01$) in the instrumented model. Overall, our conceptual arguments and supplementary quantitative analyses render alternative explanations for our main conclusion that broad innovation partnership portfolios increase the threat of imitation a focal firm is exposed to less probable. To corroborate this claim also qualitatively, we conducted five interviews with R&D professionals routinely involved in innovation partnerships. Interviewees highlighted that being embedded in a broad portfolio of innovation partnerships will often come at the cost of a greater exposure to imitation risks. The primary challenge hence consists in sharing sufficient knowledge to make the diverse set of partnerships work, while at the same time protecting parts of the knowledge base to contain the threat of imitation. The following quote is particularly insightful in that it illustrates both the substantial imitation threat of vertical partnerships and the buffering role of IP protection.

> *"A client in Asia received from us a solution to a problem on which they had requested assistance. The solution included a proprietary element of ours, which emerged at a later date as their proprietary technology. [...] We immediately engaged prominent attorneys in that country to represent us despite the history of litigation by foreigners in that environment working against us, and fairly quickly resolved the dispute through a*

proper licensing agreement and reimbursement for the substantial legal costs. That same client has been back now twice for assistance in resolving technology problems, in a relationship that operates on a more congenial basis now."

Discussion and Conclusion

The purpose of this study was to examine, both theoretically and empirically, the underexplored value appropriation challenges in innovation partnership portfolios. Drawing on the RBV, we developed and tested a conceptual model linking salient structural attributes of a focal firm's innovation partnership portfolio and the imitation threat it is exposed to. Two main findings emerged after testing the proposed model with data from German manufacturing firms. First and most importantly, having a broad portfolio of innovation partnerships indeed increases the risk of falling victim to illegal imitation. Importantly, this effect persists even after controlling for past innovative performance and instrumenting the partnership variety to account for its potential endogeneity. The magnitude of the imitation threat depends on the specific configuration of the innovation partnership portfolio along the three dimensions partner type (i.e., highest for suppliers and customers), partner location (i.e., highest for continental partners), and innovation phase (highest for early-stage partnerships). Second, firms can partially mitigate partnership-induced imitation threats by employing formal IP protection and internal R&D as isolating mechanisms. These findings have several important implications for research and theory, which we discuss below.

Implications for research and theory

First, our findings provide novel insights into the challenges of imitation that occur in complex innovation partnership portfolios and go above and beyond those commonly observed in dyadic alliances (Kale *et al.*, 2002; McEvily *et al.*, 2004; Oxley and Sampson, 2004). Consistent with the idea that firms engaged in collaborative innovation face a trade-off between maximising the incoming knowledge flows and minimising unintended spillovers (Alexy *et al.*, 2013; Boudreau, 2010), we found that the broader the variety of a focal firm's innovation partnership portfolio, the higher the likelihood of being imitated. This supports the proposition that portfolio diversity in terms of partners' functional role, geographic origin, and temporal involvement increases not only complexity, but also the risk of goal conflict and opportunistic behaviour (Cui and O'Connor, 2012; Duysters and Lokshin, 2011). The imitation threat induced by a diverse partnership portfolio

will hence typically exceed the sum of the individual risks associated with each alliance (Li *et al.*, 2012). Partnership-induced imitation that increases with the variety of the partnership portfolio might therefore act as one of the causal mechanisms underpinning the frequently observed decreasing marginal returns to both alliance portfolio diversity (Cui and O'Connor, 2012; Jiang *et al.*, 2010; Lavie and Miller, 2008; Sivakumar *et al.*, 2011) and open innovation (Laursen and Salter, 2006; Salge *et al.*, 2013).

Second and related, we revealed how the specific configuration of a focal firm's partnership portfolio affects the imitation risk it is exposed to. More specifically, our study complements extant alliance portfolio research by illuminating the role of specific partner characteristics — most notably partner type, partner location, and innovation phase — in shaping value appropriation rather than value creation (Cui and O'Connor, 2012; Jiang *et al.*, 2010; Lavie, 2007; Lavie and Miller, 2008). Perhaps most importantly, our findings indicate that the collaboration-induced imitation threat a focal firm is exposed to tends to be more pronounced the larger the share of vertical, continental, and early-stage partnerships, and the lower the use of IP protection and internal R&D as isolating mechanisms. Surprisingly, vertical rather than horizontal innovation partnerships emerged as the partner type associated with the highest imitation threat. The German manufacturing firms, we studied appear to anticipate such challenges with only 10.34% of them engaging in innovation partnerships with competitors. This might be indicative of careful partner selection, where preference is given to competitors with high levels of relational trust and a reputation for successful partnering. Contrary to our expectations, we also found that the strongest imitation threats emanated from continental rather than domestic or international partnerships. Although, this finding might be explained by the unique combination of sufficient partner-specific absorptive capacity, moderate institutional distance, and relative difficulties to establish informal safeguards that characterises continental partners, it appeared inconsistent with previous studies showing firm performance to be highest at low or moderate international diversity of the alliance portfolio (Cui and O'Connor, 2012; Goerzen and Beamish, 2005; Lavie and Miller, 2008). More generally, our study illustrates how the relative salience of appropriation concerns is contingent on the specific configuration of the partnership portfolio and the effectiveness of the isolating mechanisms employed. This insight will be of interest for the contingency literature on open innovation, which argues that the returns from innovation partnerships tend to be contingent on specific project, firm, and partnership characteristics (Laursen and Salter, 2006; Gesing *et al.*, 2015; Salge *et al.*, 2012), but has yet to examine the role of portfolio characteristics as contingency factors. As the locus of innovation gradually shifts to the level of the broader network of relationships, interorganisational structures such as a focal firm's partnership

portfolio move into the foreground. It is against this backdrop that our study demonstrates empirically how the structure of the innovation partnership portfolio affects the imitation threat with regards to (i) technical inventions, (ii) products and business models, (iii) brands and descriptions, and (iv) designs in a way that is statistically and practically significant. Importantly, we show that partnership portfolio structures are multifaceted processing not least a functional (i.e., partner type), geographical (i.e., partner location), and temporal (i.e., innovation phase) dimension. This inner structure of partnership portfolios is both complex and consequential in that it can reduce — or indeed amplify — the threat of collaboration-induced imitation. This highlights the need to carefully tailor the partnership portfolio grounded in an in-depth understanding of not only its benefits, but also its costs, risks, and tradeoffs.

As a third contribution, our study adds to resource-based theorising by unpacking how both portfolio structures and isolating mechanisms affect resource inimitability as a critical precondition for sustained competitive advantage (Ordanini *et al.*, 2008). As such, it illuminates a persisting puzzle in resource-based theorising. This puzzle pertains to the persistent ambiguity of the RBV regarding whether innovation partnerships facilitate resource imitation given the greater permeability of organisational boundaries or rather impede imitation attempts by means of greater causal ambiguity stemming from complex partnership portfolios that span multiple firms with different structures, capabilities, and cultures (Ketchen *et al.*, 2007). Our results support the former argument in that broad innovation partnership portfolios increase the risk of imitation. By providing partners with insights into its operations, the focal firm seems to violate a key principle of the RBV, according to which reducing the observability of knowledge is a necessary condition for protection against imitation (Barney, 1991; Liebeskind, 1996). Causal ambiguity, in contrast, is more likely to deter imitation attempts of outside actors (e.g., through reverse engineering), rather than of opportunistic innovation partners. In line with scholars emphasising the need to adopt a contingent RBV (Aragon-Correa and Sharma, 2003; Brush and Artz, 1999), this implies that the inimitability of a resource depends not only on its attributes and the environmental context in which it is used, but also on the characteristics of the imitating organisation. Inimitability is a critical attribute of resources needed to appropriate the economic rents accruing from novel products or services and sustain competitive advantages (Newbert, 2007). Succeeding with innovation partnerships therefore requires striking a subtle balance between knowledge revealing to enable fruitful collaboration and knowledge concealing to minimise the threat of imitation in a way that does justice to both the functional, geographical, and temporal dimensions of the partnership portfolio and the focal firm's strategic aspirations.

Limitations and future research directions

As with any study, our results should be considered in light of several limitations that suggest directions for future research. First, while the MIP offers a valuable complement to archival measures frequently used in alliance portfolio research, its reliance on single respondents' subjective accounts of a firm's partnership portfolio and imitation experience poses a limitation. Although, Harman's single-factor test revealed six factors with eigenvalues greater than 1, the most salient of which explained 25.5% of the total variance, indicating that substantial common method bias is unlikely (Podsakoff *et al.*, 2003), future research might wish to integrate data from multiple data sources. Triangulating managers' subjective perception of being imitated by others with litigation data, for instance, would provide additional information about the extent to which a firm's IP rights are infringed upon and by whom. Moreover, by applying imitation measures that capture the intensity of imitation (actual number of imitation attempts), future studies could nicely complement our research that does not provide this information. Advancing the measurement of imitation appears particularly important given the lack of any established standard metric to quantify the imitation threat a focal firm is exposed to (Ordanini *et al.*, 2008), with previous studies using, for example, dichotomous measures or assessing related aspects such as the time to imitation (Giachetti and Lanzolla, 2016).

Second, lack of data availability precluded us from examining certain aspects relevant to the research problem at hand. Among others, we were unable to explore the role of alternative, informal safeguards such as secrecy, partnership experience, and relational trust that manufacturing firms can rely upon to shield themselves against imitation. Moreover, a firm's partnership-induced imitation risks might be driven by partnership portfolio characteristics other than the value chain position, geographic origin, and temporal involvement of its innovation partners, as done in this study. In particular, future research might benefit from an appreciation of the intensity and history of these partnerships (Love *et al.*, 2014). Unfortunately, lack of fine-grained dyadic data prevented us from examining this important aspect in sufficient detail. In order to understand the antecedents of imitation, exploring this qualitative and longitudinal dimension of a focal firm's innovation partnership portfolio is indeed a promising avenue for future research. Although, our *post hoc* analyses indicated that our main effect is robust to different model specifications including those that explicitly account for the potential endogeneity of partnership variety, longitudinal or experimental data promise to yield additional insights into the causal and temporal structure of this effect. As a case in point, it appears worthwhile to

explore not only the extent to which the effect persists over time, but also how focal firms affected by imitation from partners adjust their partnership portfolio in response.

Third, there might be concerns regarding the generalisability of the findings to other contexts given our reliance on data from German manufacturing firms. Thus, future research in other countries is needed to corroborate our findings. Cross-national comparative studies would be most welcome, as they are well equipped to explore possible system-level contingencies such as differences in national appropriability regimes, which are likely to affect both the prevalence of partnership-induced imitation and the effectiveness of managerial remedies.

In conclusion, further research is required, to further strengthen the theory, evidence, and practical guidance available on how innovation partnership portfolios should be configured to reduce imitation threats and avoid getting caught on the wrong foot.

Appendix

Table A.1. Ordered probit regression analyses explaining financial performance.

Variable	Model A1	Model A2
Control variables		
Past financial performance	0.799 (0.061)***	0.800 (0.061)***
Past innovative performance	0.059 (0.032)*	0.068 (0.032)**
IP protection	−0.126 (0.099)	−0.086 (0.101)
R&D intensity	2.050 (1.625)	1.916 (1.614)
Firm size	−0.064(0.035)*	−0.059 (0.035)*
Export intensity	−0.208 (0.195)	−0.161 (0.196)
Human capital	−0.009 (0.027)	−0.011 (0.027)
Firm location	−0.077 (0.099)	−0.105 (0.100)
Industries	included	included
Main effects		
Imitation		−0.12 (0.047)**
Total observations	616	616
McFadden's R^2	0.265	0.267
Chi-squared	225.9 (0.000)***	230.4 (0.000)***

Notes: 616 total observations; ordered probit model; robust standard errors in parantheses; ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

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