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Openness to Competitors and Firm Innovation

Nengzhi(Chris) Yao

A thesis submitted in fulfilment of the requirements of the degree of Doctor of

Philosophy in Management

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Declaration

I hereby declare that this thesis has not been previously submitted to any other universities or institutes for any degrees. I further declare that this thesis is the result of my original investigation, with the assistance and guidance of my supervisors, Prof Christos Tsinopoulos and Dr. Ji Yan. The idea, theory framing, literature investigation, data cleaning, data analysis, writing and revising are finished by me. During the process, they provide me useful suggestions and guidance. For the three articles to be sent for journals in future, I will be the leading author of the three studies, and they should be listed as co-authors.

Abstract

This thesis aims to explore how firms can be open to competitors to innovate, mainly focusing on the determinants of openness to competitors, whether they should adopt knowledge-protection mechanisms and why they select different openness modes. Through a systematic review of the literature on the determinants of open innovation, I find that previous studies have provided insights in improving our understanding of the topic from a range of theoretical perspectives. Yet, extant research has shown diversities and discrepancies in the findings about how internal factors affect open innovation (i.e., “internal factors of open innovation success”). By identifying four dimensions of organization factors (i.e., resource investment, organizational structure, human capital and individual attitudes) and reviewing their effects on the implementation of open innovation, I generate a literature framework and discuss several directions for future research. Based on this, I focus on open innovation in competitive contexts, i.e., the openness to competitors, a field that has received relatively less attention. Then, I conduct two empirical studies using the data from the Spanish Community Innovation surveys. The first examines the determinants of openness to competitors from the absorptive capacity (ACAP) view. This study extends this view by adding a perspective of selective openness. The results suggest that after innovation failures, firms with more R&D investments are more likely to search for knowledge from competitors (competitor search), whereas they are less likely to build formal cooperation with them (competitor cooperation). Further analysis suggests that this risk-averse propensity is because of managers’ fear of the risks from competitors. The second empirical study examines whether or not a firm should adopt knowledge-protection mechanisms. I follow the ACAP view and conceptualize the process of absorbing competitors’ knowledge to innovate into two stages: potential and realized. I try to uncover the process through which R&D investment affects innovation performance by establishing the absorption of competitors’ knowledge as a mediator. My findings reveal that a firm’s R&D investment will increase its innovation performance, which can be achieved by absorbing knowledge from competitors. In addition, knowledge protection positively moderates the relationship between R&D investment and the absorption of competitors’ knowledge, while it negatively moderates the relationship between the absorption of competitors’ knowledge and innovation performance. Overall, this thesis contributes to the ACAP view and the literature on open innovation by exploring the

determinants of openness to competitors, and by reconciling the debate on the paradox of openness and protection.

Keywords: open innovation, absorptive capacity, R&D, paradox, selective openness, knowledge protection, competitor search, competitor cooperation

A Brief Introduction of Ph.D. Thesis (three studies)

Open innovation supports the use of knowledge from multiple external sources and calls for “a distributed innovation process based on purposively managed knowledge flows across organizational boundaries” (Chesbrough & Bogers, 2014: 17; Chesbrough, 2003b). Given the increasingly expanded boundary of modern businesses, open innovation has become a richly adopted mode in practice and a widely studied topic in academia. Attesting to this importance, much research has focused on innovation performance outcomes that are influenced by open innovation (Bogers et al., 2017; Ehls, Polier, & Herstatt, 2020; Randhawa, Wilden, & Hohberger, 2016; Stanko, Fisher, & Bogers, 2017; West & Bogers, 2014 for literature reviews), while these reviews also suggest that relatively less attention has been paid to the antecedents of the implementation of open innovation.¹ This thesis aims to fill the gap by examining what factors determine firms’ openness to others.

In particular, among partnerships, relationship with competitors is very “special”, showing both bright and dark sides. While competitors can be a valuable knowledge source, collaborating with them may be risky. Thus, calls have been made for more investigation on how firms can be open to competitors to innovate (Hoffmann, Lavie, Reuer, & Shipilov, 2018; Stanko et al., 2017: 551). To answer these questions, I have conducted three related studies.

The first study titled “Exploring the determinants of open innovation: a literature framework” develops a literature framework based on existing studies on the determinants of open innovation. I started with the perspective of “reductionism” and focused on resource-related factors, which are believed to have primary explanatory power (Barney, Ketchen Jr, & Wright, 2011; Foss, 2011). A review of 154 publications from management and innovation journals helped me identify four dimensions of organizational factors—resource investment (*what* or *how many* resources are being invested), organizational structure (where resources are being attributed), human capital (*who* or *what* individual-level characteristics are) and the attitudes of individuals (*how*

¹ Here, by the implementation of open innovation, I mean open innovation-related strategy and performance outcomes, such as openness modes, search breadth/depth, open innovation propensity and open innovation effectiveness (see the literature review). In following sections, when I use the term “open innovation”, it refers to a multi-dimension concept, namely, “the implementation of open innovation”, unless I point out specific dimensions, such as openness.

resources are being treated—as the determinants of open innovation. I reviewed the main theories that have been used to explain this relationship, and identified a series of moderating and mediating mechanisms. In so doing, I developed a literature framework that can explain the determinants of open innovation and thus can direct future research. Furthermore, I propose that the four dimensions affect open innovation by influencing firms' absorptive capacity, and that the effect is contingent upon factors that affect transaction costs. In addition, I find that previous scholars have mainly considered openness to non-competitors (e.g., users, suppliers, universities), largely ignoring the context of openness to competitors.

The second paper titled “The determinants of openness to competitors: Innovation failure and the selection of openness modes” is an empirical (quantitative) paper that aims to address the following questions:

- What factors determine a firm's openness to competitors?
- How do they balance the benefits and the risk of openness to competitors?

The ACAP view suggests that firms that invest more in R&D are more able to be open to outsiders (Cohen & Levinthal, 1989, 1990). Zahra and George (2002) extended this view and added that the locus of technological search can be influenced by activation triggers, which were defined as “events that encourage or compel a firm to respond to specific internal [such as performance failures, firm crisis] or external stimuli [such as government policies or industrial shifts]” (2002: 193). They argue that internal triggers, such as innovation failures, will prompt firms to invest to acquire external knowledge so that they can avoid the limitations of self-developments. According to this view, experiencing failure will strengthen the relationship between R&D investment and openness to outsiders (Todorova & Durisin, 2007; Zahra & George, 2002). This is because firms that have experienced innovation failures are under pressure to reduce technology risk, which may encourage them to learn from others. However, this view tends to be challenged in competitive contexts because unlike non-competitive relationships (e.g., customers, suppliers and universities which tend to be the foci of prior studies), relationships with competitors come with significant competition risk. Threats come from opportunistic behaviors, knowledge leakages or intellectual-property theft (Giarratana & Mariani, 2014; Laursen & Salter, 2014).

I draw upon the view of selective openness which emphasizes the “rationality” of managers—i.e. the view that they tend to selectively choose different openness modes that can capture external benefits and reduce technology risk (Alexy, George, & Salter, 2013; Balka, Raasch, & Herstatt, 2014; Giarratana & Mariani, 2014; Henkel, 2006). In particular, *competitor search* and *competitor cooperation* are two important openness modes with different implications in relation to cutting costs and capturing benefits (e.g., Dahlander & Gann, 2010; West, Salter, Vanhaverbeke, & Chesbrough, 2014). Competitor search, such as scanning, observing, monitoring, or indirect imitating, is a type of unilateral strategy designed to learn from competitors (Katila, 2002; Katila & Ahuja, 2002; Laursen & Salter, 2014). Thus, searching activities typically do not require close interactions and are dominated by the focal firm. By contrast, competitor cooperation involves a bilateral relationship and straightforward information exchanges, which requires intensive interaction and a mutually dependent relationship (Dahlander & Gann, 2010; Laursen & Salter, 2014). The perceived level of competition risk of cooperation is higher than that of knowledge search. I then developed the “selective-openness” idea and proposed that after innovation failures, firms with higher R&D investments will act in a more risk-averse way. They tend to increase competitor search over competitor cooperation. I also contend that such selectiveness in openness modes is because of managers’ fear of competition risk. I tested these ideas with panel data of Spanish manufacturing and service firms during 2006-2016.

The third paper is “Is it possible to absorb competitors’ knowledge to innovate? A synthetic view of absorptive capacity and the paradox of openness and protection”. This paper aims to answer the following question:

- How can firms be open to competitors to innovate, with a focus on whether they should adopt knowledge-protection mechanisms (i.e., the paradox of openness)?

Knowledge protection is particularly important in the process of absorbing competitors’ knowledge to innovate. Yet, previous studies offer conflicting views on its role. Some scholars emphasize its positive role in preventing knowledge leakages and reducing losses (e.g., Chesbrough, 2003a; Estrada, Faems, & de Faria, 2016; Ritala & Hurmelinna-Laukkanen, 2013). Others argue that knowledge protection is detrimental to innovation as it discourages partners from information sharing and knowledge exchange (e.g., Wadhwa, Bodas Freitas, & Sarkar, 2017; Wang, Libaers, & Park, 2017).

I believe that the inconsistent views on knowledge protection partly derive from the implicit assumption in prior empirical studies that the knowledge-creation process is static (Volberda, Foss, & Lyles, 2010). As Volberda et al. (2010: 936) criticized, “very few empirical studies of AC [absorptive capacity] fully capture the development, lagged, and path-dependent characteristics of AC. Most authors continue to frame their arguments in a very static way.” To reconcile the divergent views on knowledge protection, I draw upon an ACAP view (Todorova & Durisin, 2007; Zahra & George, 2002) and conceptualize a knowledge-creation process through absorbing competitors’ knowledge into two stages: potential (i.e., identify and acquire knowledge) and realized (i.e., integrate and transform knowledge). The potential stage emphasizes how R&D investment that build ACAP can help firms to identify and acquire external knowledge, and it thus connects the link between R&D investment and the absorption of competitors’ knowledge. In the realized stage, firms transform the acquired knowledge into new one, which is reflected by higher innovation performance. Based on these arguments, I establish the absorption of competitors’ knowledge as a theoretical important mediator between R&D investment and innovation performance. Furthermore, I propose that the potential stage underlines a firm’s ability to absorb knowledge, which is strengthened by knowledge protection. In contrast, the efficiency of the realized stage relies on information sharing and knowledge exchange with competitors, thus allowing the protection initiatives to restrain the creation of new knowledge. These ideas achieved support with a test on panel data of Spanish firms during 2006-2016.

With these three studies, I added to a discussion and made several important contributions to the ACAP view and open innovation literature.

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**Chapter 1: Exploring organizational determinants of open innovation:
towards a conceptual framework**

Abstract: This paper aims to develop a conceptual framework for explaining organizational determinants of open innovation (OI). A review of 154 publications taken from management and innovation journals makes us identify four dimensions of “resource-related” organizational factors that can determine OI: resource investment (*what* or *how many* resources are being invested), organizational structure (*where* resources are being attributed), human capital (*who* or *what* individual characteristics are) and the attitudes of individuals (*how* resources are being treated). We also identify core theoretical lenses and propose moderating and mediating mechanisms that can explain the relationship between the dimensions and OI. Based on this, we generate a conceptual framework and propose that the effect of organizational factors on the implementation of OI is contingent upon transaction cost-related factors, and that these effects can be indirectly achieved through influencing firms’ absorptive capacity. We also suggest several directions for addressing relevant unexplored questions within the framework. Overall, our work provides a conceptual framework regarding the relationship between organizational factors and OI, and outlines several key themes for future research.

Keywords: open innovation, absorptive capacity, organizational structure, centralization, Not-Invented-Here, Not-Shared-Here

Introduction

Open Innovation (OI) was coined by Chesbrough (2003) and has been defined as “a distributed innovation process based on purposively managed knowledge flows across organizational boundaries ” (Chesbrough & Bogers, 2014: 17). Over the past decade, OI has become one of the most popular areas in innovation research, and, as a result, has attracted significant attention (Stanko, Fisher, & Bogers, 2017; West & Bogers, 2014).

Given that an organization’s resources’ and operational attributes (organizational factors, hereafter) play critical roles in shaping its strategy implementation and performance, researchers have aroused a scholarly interest in exploring organizational factors as determinants of OI (Bogers et al., 2017b; West, Salter, Vanhaverbeke, & Chesbrough, 2014b). The literature has mainly centred around the question: *What and how organizational factors affect the implementation of OI?*² OI implementation reflects OI-related strategy and performance outcomes, such as external search breadth/depth, OI propensity and OI effectiveness. The purpose of this work is to develop a conceptual framework for organizational factors and OI.

In practice, it is difficult to conclude or give practical suggestions for a firm on how to make efforts to embrace OI. Rather, it would be more operable to separate multiple factors into primary dimensions and focus on each one. For example, in response to the challenges of Artificial Intelligence (AI), International Business Machines Corporation (IBM) advanced R&D efforts in terms of seven dimensions, such as more long-term investments, better sharing environment and more professional R&D workforce.³ The company recognized that compared to a general strategy, detailed designs of an R&D system and specific decisions on which organizational aspects to promote might have more practical implications for developing AI technology in a competitive market. In so doing, IBM provided a guidance on each organizational aspect and meanwhile encouraged to adopt a stakeholder-participation approach such that they can launch open initiatives to address AI issues. Giving specific suggestions

² When we use the term “OI” in this paper it refers to a multi-dimension concept, namely, “OI implementation” or “implementation of OI”, unless we point out specific dimensions, such as “OI propensity”.

³ More details related to IBM’s strategy for developing AI technology, see <https://www.ibm.com/blogs/policy/ibm-response-to-rfi-on-national-ai-rd-strategic-plan/>

on each dimensional design is more aligned with the need and requirement of departmental employees due to strategic operability, particularly when they work in an open environment.

In research, while the relationship between organizational factors and OI has attracted significant scholarly attention (see Figure 1), extant literature has shown inconsistencies and discrepancies in the findings. For example, on the one hand, scholars have argued that OI propensity is hindered by organizational factors, such as internal social contexts (Caloghirou, Kastelli, & Tsakanikas, 2004; Capron & Mitchell, 2009), technological overinvestment (Dong & Netten, 2017) and fear of capabilities leakage (Monteverde & Teece, 1982; Pisano, 1990). On the other hand, much evidence based on capability development view has suggested that well-endowed technology companies (usually with high resource endowment) have a higher ability to extract external resources (Brusoni, Prencipe, & Pavitt, 2001; Zhang, Li, Hitt, & Cui, 2007b).

These research inconsistencies and fragmentations are partly attributed to the considerations of different dimensions of organizational factors (Pisano, 2011, 2015). Since it is able to discern the fundamental elements of organizational factors, classifying these factors into different dimensions can achieve explanatory primacy in explaining their different implications on OI (Coleman, 1994; McKelvey, 1998). Doing this is also consistent with the practical method adopted by companies like IBM that design its R&D system as a combination of several aspects of specific plans. Theoretically, resource-based perspectives are believed to dug further than other perspectives and have shifted the analytical focus from complex phenomena to the resources that firms control (Foss, 2011; Lippman & Rumelt, 2003b). Given that resource is placed at a fundamental level than firm strategy and it has achieved explanatory primacy in strategic management (Barney, Ketchen Jr, & Wright, 2011; Foss, 2011), we focus on resource-related dimensions, i.e., *what*, *where*, *who* and *how*, to classify organizational factors and explore their effects on OI. Transferring attention from a general organization design (which involves multiple aspects) to resource-related *what*, *where*, *who* and *how* allows us to identify, classify the dimensions of organizational factors and analyse fundamental mechanisms from extant work. As our analysis and coding of 154 articles suggest, four “resource-related” dimensions were identified to capture the determinants of OI: resource investment (*what* or *how many*

resources are being invested), organizational structure (where resources are being attributed), human capital (*who* or *what* individual characteristics are) and the attitudes of individuals (*how* resources are being treated).

Moreover, the fragmentation of prior research exploring the determinants of OI is also due to the disciplinary theoretical lenses examined in the literature. Scholars have drawn on a variety of theoretical perspectives to frame their work (see Vanhaverbeke & Cloudt, 2014 for a discussion), such as the resource-based view in management, and the transaction-cost logic in economics. However, existing reviews have not integrated these theoretical perspectives or highlighted synergies of different theories regarding the relationship between organizational factors and OI. Echoing the call for integrating mainstream theories with OI issues (e.g., Vanhaverbeke & Cloudt, 2014; West, Salter, Vanhaverbeke, & Chesbrough, 2014a), we synthesize predominant theories used to explain the relationship between the four dimensions and OI. We also propose a moderating mechanism (namely a series of moderators), and a mediating mechanism (with absorptive capacity as a mediator) underlying the relationship. Combining the relationship with moderating and mediation mechanisms, we generate a conceptual framework that helps us to achieve a comprehensive understanding of *what* (i.e., what are the effects of organizational factors on OI?), *when* (i.e., when do organizational factors affect OI more?) and *how* (i.e., how do organizational factors affect OI?) questions.

Our review contributes to extant literature in several ways. First, our work responds to the agenda of “organizational determinants of OI success” in OI scholarship (Bogers et al., 2017b; Lüttgens, Pollok, Antons, & Piller, 2014), an important topic characterized by inconsistency and divergence. Integrating these factors is essential, because they not only cover diversified drivers of OI activities (Spithoven & Teirlinck, 2015), but they also reflect main challenges of firms’ OI practices (Sieg, Wallin, & Von Krogh, 2010). As a large body of empirical and theoretical literature has suggested, designing an appropriate organizational is key to OI success (Berchicci, 2013; West & Gallagher, 2006). Second, our work outlines a clear overview about the determinants of OI and identifies relevant questions being explored and unexplored. It thus can provide ample opportunities for future research. Third, we develop a literature framework that explains the relationship between organizational factors and OI. To

make the relationship explainable, we synthesize the findings of the literature and the predominantly used theories. With the identification of a series of moderators and mediators, we further propose the influential mechanisms and boundary conditions that can reinforce or weaken the relationship and thereby make the research framework more comprehensive. For the academy, our work will open avenues for future research, and guide scholars in the formation of a structured view on key OI questions within this research stream. For firms facing OI challenges, it also has great practical implications relating to designing an appropriate organization to embrace OI.

Method

Classifying Organizational Factors into Four Dimensions.

Existing research has demonstrated the inconsistency and discrepancy with regard to the research on exploring the determinants of OI. For example, scholars have shown the negative effects of technological overinvestment (Dong & Netten, 2017) or fear of capability leakage (Monteverde & Teece, 1982; Pisano, 1990) on OI, whereas more research rooted resource-based view or capability development perspective suggests that positive drivers can arise from in-house resource endowments and effective system designs (e.g., Brusoni et al., 2001; Zhang et al., 2007b). Still, several scholars (e.g., Brunswicker & Vanhaverbeke, 2015; Mol, 2005) have reported that there is no constant relationship between technological development and the propensity for OI adoptions. The inconsistency and fragmentation partly derive from the multi-dimensionality of organizational factors (e.g., Berchicci, 2013; Pisano, 2011, 2015). That is, when exploring determinants of OI, some scholars might consider which or how many resources invested, whereas others weigh other aspects more, such as how these resources being allocated or treated.

The literature fragmentation motivates us to classify factors into four dimensions for outlining a clear overview of this topic. “From the perspective of reductionism, the advent of RBT [Resource-based Theory] was a distinct advance because it literally dug deeper than rival perspectives by placing the primary explanatory burden on the resources controlled by a firm ...” (Foss, 2011: 1417-1418). Lippman and Rumelt (2003a, 2003b) and Barney et al. (2011) also regard the resource-based perspective as

the foundation of managing firm strategies. Consistent with their logic, we relate organizational determinants of OI to the level involving resources that a firm can control and propose that the determinants can be classified into resource-related *what*, *where*, *who* and *how*. This consideration is also well-inspired by Pisano (2011) who considered an organization's R&D design as a combination of resource portfolio (what), organization architecture (where), people characteristics (who) and coordination process (how). Pisano argues that an appropriate organization for innovation is like an organic system that results from the interaction of decisions and choices in terms of factors within the organization. These organizational factors should be designed to simplify a firm's strategic intentions—how to win. Similarly, we consider an appropriate organization for OI to be *a pattern of in-house decisions in the dimensions of resource investment, organizational structure, human capital and individual attitudes for achieving OI goals*. Since constructs based on resource can represent the microfoundation of organizational design (Coleman, 1994; Teece, 2007), these four resource-based dimensions can capture primary factors within an organization. Specifically, resource investment reflects *what* or *how many* resources firms invest; organizational structure reflects *where* or *how* resources are organized or attributed among R&D units; human capital is a type of strategic resources that reflect "*who*" matters or individual characteristics; attitudes reflect *how* resources are being treated or *what* attitudes that are held in relation to resources. It is worthwhile to note that our definition about organizational factors emphasizes resource-related factors (that firms can control), typically within the organization. Although some scholars believe that social capital, as a type of resource, can facilitate co-operation and mutually supportive relations in communities, such resource does not belong to the scope of organizational factors.

Scope of the Literature Review

In this section, we provide details of the process of composing the literature regarding organizational determinants of OI. We modelled the journal selection process on the related work of West and Bogers (2014), a highly cited literature review paper published in the *Journal of Product Innovation Management*. Firstly, we included all 25 most frequently cited management journals that publish technology and innovation

management studies that as identified by Linton and Thongpapanl (2004).⁴ The journals' importance was determined based on citation analysis. Within the list, we searched for articles published between 2003 and 2018 with the term "open innovation" appearing in the title, abstract or keywords.⁵ We used Scopus, the largest database of peer-reviewed literature, and found 368 relevant articles. The aim of this paper is to review the research exploring the effect of organizational factors on OI implementation (as dependent variables), rather than those on other performance outcomes. To ensure the selected articles are specifically targeting OI implementation, we reviewed each in detail and excluded those that investigate other performances, such as innovation performance and financial performance. A process of iterative refinement was used to narrow down the list and at the same time to identify OI research themes (Eisenhardt, 1989). Through our review, we found two main streams of research that explores OI topic: how organizational factors affect OI (i.e., the antecedents of OI) and how OI affects innovation performance outcomes (i.e., the consequences of OI). Extant reviews have largely focused on the OI outcomes, whereas we aim to work on its antecedents. Organizational factors refer to factors typically in relation to resources, processes or operational attributes within an organization, as we discussed earlier, which can be classified into dimensions including R&D (resource or knowledge) investment, resource distributions, human capital and individual attitudes toward resources.

Based on this classification, we re-examined each article and manually coded the basic information (i.e., name of the authors and publication year) as well as the inductively formalized thematic information, including key questions, dimensional constructs, theoretical lenses, OI constructs, and predicting directions. This work finally allowed us to precisely identify the four dimensions that are in relation to the determinants of OI (N1=94): resource investment, organizational structure, human

⁴ This list includes six general management journals known for scholarship on innovation management (*Academy of Management Journal*, *Academy of Management Review*, *Administrative Science Quarterly*, *Strategic Management Journal*, *Management Science* and *Organization Science*), ten technology and innovation specialty journals (*IEEE Transaction on Engineering Management*, *Industrial and Corporate Change*, *International Journal of Technology Management*, *Journal of Product Innovation Management*, *Long Range Planning*, *R&D Management*, *Research Policy*, *Research-Technology Management*, *Technological Forecasting and Social Change* and *Technovation*), three practice-oriented journals (*California Management Review*, *Harvard Business Review* and *MIT Sloan Management Review*), as well as six journals in other disciplines (*American Economic Review*, *Economic Journal*, *Journal of Marketing*, *Journal of Marketing Research*, *Journal of Political Economy* and *MIS quarterly*).

⁵ Scholars usually regard Chesbrough's book *Open innovation: The new imperative for creating and profiting from technology* (2003) as the starting point of OI research.

capital and individual attitudes. Figure 1 presents the trend of research on these dimensional factors as determinants of OI between 2003 and 2018.

<Figure 1 Here>

Next, we supplemented the sample with a list of papers from *Google Scholar* investigating “external innovation”. This was done in order to address the concern that OI might overlap with external innovation-related concepts (Groen & Linton, 2010; Trott & Hartmann, 2009). As such, some scholars did not state them as OI, especially before the term OI was coined by Chesbrough (2003). The supplemented list of research (N2=60) mainly includes highly cited articles (with over 200 citations) and several recent articles (generally after 2017) on related fields such as co-creation, R&D alliances, joint ventures, university-enterprise collaboration, technology acquisitions or user innovation (appearing as keywords in their abstracts). They also belong within the scope of OI (Chesbrough, 2017). A similar process was used to code the information of each article. Finally, we obtained a list of (N1+N2=) 154 articles. We classified the articles into three periods of six, five and five years respectively (2003-2008, 2009-2013 and 2014-2018) to illustrate the research trend. As shown in Table 1, the topic has seen a general increase in both quantitative and qualitative papers, whereas the number of conceptual papers remains relatively stable. There has also been a proliferation of papers for each dimension of organizational factors. These increases may be attributed to the fact that more and more OI modes have been adopted in practice, thus attracting scholarly interest.

<Table 1 Here>

Analysis of the Literature

Our review suggests that scholars have mainly considered five types of dependent variables in relation to OI implementation: external search (i.e., breadth or depth of external search), mode choice (i.e., make-buy-ally choice, or OI modes choice), OI propensity (i.e., the frequency with which OI mode is adopted), OI effectiveness (i.e., value or returns created by OI), and OI practices (i.e., general OI practices mainly

discussed in qualitative papers). Table 2 classifies the literature by matching four dimensions of organizational factors with each OI-related variable. Among the 154 papers, 47 investigate OI propensity, which makes up the biggest proportion (30.5%).

<Table 2 Here>

Table 3 presents the theory applications concerning organizational factors as the determinants of OI. There are seven predominant theories that were adopted from management and economics: resource-based view (RBV), structural contingency theory (SCT), upper-echelon theory (UET), asset specificity theory (AST), absorptive capacity view (ACAP view), knowledge-based view (KBV) and transaction-cost economics (TCE). In addition, we noted that 22 of 154 papers did not draw on the above theories but followed the OI-mode logic described by Gassmann and Enkel (2004) and Chesbrough (2006). That is, they reason that innovation performance benefits from opening up innovation processes through which valuable knowledge has flowed into the organization. We also identified 37 papers without clear theory lenses. These papers mainly started from a practical OI practice and conducted qualitative research to explore the organizational challenges of OI practices. For each dimension, both differences and commonalities existed in theory applications (see Table 3). It is worth noting that among the 73 papers that applied the theories (i.e., RBV, SCT, UET, AST, ACAP view, KBV, TCE and multi-theory), 17 were based on a multi-theory perspective. This suggests that in some cases, it might be difficult to explain OI issues by means of a single theory. These statistics thus initially suggest that classifying different dimensions will help to explain the relationship between organizational factors and OI.

<Table 3 Here>

Conceptual Framework about the Effect of Organizational Factors on Open Innovation

Based on above literature analysis, we generate a framework (see Figure 2) that explains organizational factors as the determinants of OI. It is also worthwhile to note that our analysis on the organizational factors and OI variables mainly reside at the firm level.

As an improvement, we take a further step to propose moderating and mediating mechanisms, thereby improving the framework. Next, we analyze how theories used to explain the effect of each dimensional factor on OI and discuss the mediating and moderating mechanisms, respectively.

<Figure 2 Here>

The Effect of Organizational Factors on OI

Resource Investment

Resource investment reflects organizational resource inputs which include both financial and nonfinancial resources investment within organizations. It is often measured through R&D expenditure, R&D spending, resource or knowledge investment in innovation activities. As the core source of a firm's knowledge base and product innovation, resource investment plays a key role in determining OI.

RBV (Barney, 2001; Barney, 1991; Wernerfelt, 1984) has been the theory most commonly used to argue for the positive role of resource investment with regard to OI. It stresses that accumulated resources that are valuable, rare, imperfectly imitable and not substitutable can allow firms to achieve a state of sustainable competitive advantage. In their review on research that addressed outsourcing issues from RBV, Espino-Rodríguez and Padrón-Robaina (2006) found that the success of outsourcing activities can be attributed to two aspects of resources' characteristics: the heterogeneity of resources and the persistence of that heterogeneity. In OI context, research has mainly suggested the role of the first characteristic of resources. For example, research has found that firms in possession of valuable resources can grasp more technological opportunities to expand innovative activities (Villalonga & McGahan, 2005) and increase their value (Sikimic, Chiesa, Frattini, & Scalera, 2016). Therefore, we propose:

P1a: The investment of R&D resources has a positive relationship with the implementation of open innovation.

RBV mainly points out the positive effect of resource investment on OI, whereas the article "The two faces of R&D" (Cohen & Levinthal, 1989; Griffith, Redding, &

Reenen, 2004) provides a comprehensive view of the dual role of internal R&D. It holds that internal R&D efforts do not only generate new knowledge within organizations, but also enable firms to externally exploit or explore potential knowledge. This view of R&D in the innovation field has received much attention. There are two main mechanisms that we can identify from the extant literature to explain this. One important avenue of research was opened up by Mowery (1983), Cohen and Levinthal (1989, 1990) who emphasized the importance of in-house resource investments in building capabilities (i.e., ACAP) for promoting firm growth. The second stream examined the role of firm boundaries' expansion in relation to transaction-cost economics (TCE) (Almirall & Casadesus-Masanell, 2010; Grossman & Hart, 1986; Pisano, 1990).

In the first stream, ACAP holders maintained that learning is a path-dependent process of knowledge development and of experience accumulation (Cohen & Levinthal, 1990). A firm's ability (labelled "ACAP") is rooted in the accumulation of knowledge and processes but has extended implications. Research that is drawing on ACAP view tends to combine KBV with the logic of knowledge-absorbing. There are at least two benefits to accumulating knowledge. First, knowledge broadness enables firms to integrate dispersed knowledge and build up extensive collaborations with diversified partners (Zhang & Baden-Fuller, 2010). Second, long-term accumulated knowledge is usually architecturally structured. It prevents data and knowledge from unwanted disclosure or leakage when connecting with others (Brusoni et al., 2001). Much empirical research has confirmed these benefits. For example, it has found that resource investment enhances firms' ability, allowing them to learn from other organizations (Lane & Lubatkin, 1998) and simultaneously curb partners' opportunistic behaviors (Kale, Singh, & Perlmutter, 2000); to facilitate interfirm collaborations (De Faria, Lima, & Santos, 2010) (with an exception for Barge-Gil, 2010) and perform highly efficiently in such remote cases (De Jong & Freel, 2010); to assimilate and utilize external afflatus (Caloghirou et al., 2004) and to conduct exploration and exploitation more deeply and broadly (Keupp & Gassmann, 2009). From a capability-building perspective, high-ability firms are more likely to implement OI and do much better. This view is consistent with the logic of Cohen and Levinthal (1990), who show that increased ACAP benefits firms' external innovations.

The second stream of resource-investment research has drawn on a transaction-cost perspective. Holders of this perspective admitted that the accumulation of technological resources is a critical source of firms' ability development. However, they added that besides building capabilities through self-development, "firms can tap the R&D capabilities of competitors, suppliers, and other organizations through such contractual arrangements as licenses, R&D agreements, and joint ventures." (Pisano, 1990: 153). They considered the cost arising from asset specificity of organizational resources and potential opportunistic behaviours, i.e., the transaction cost (Williamson, 1975, 1985). First, since R&D efforts (i.e., specific investments) tend to have specific internal needs, these efforts seem to work less effectively if the firm is to conduct other activities like external innovation. Using internally developed abilities to conduct OI is of high costs.

Ironically, according to Chesbrough (2006), firms usually conduct open innovation in order to save costs. Therefore, when costs (risks) are so low that it can be compensated through returns from partnering, firms' willingness to be more open will increase. By contrast, under high costs, firms may resort to internal development and strengthen property protection and the appropriability regime, rather than promoting the likelihood of being open. For example, Ahuja (2000) suggested that firms with abundant expertise or core resources might have fewer incentives to share key information and establish external linkages, since they are afraid of the outflow of key resources or skills. Following transaction-cost logic, we propose:

P1b: The specificity of R&D resources has a negative relationship with the implementation of open innovation.

Organizational Structure

How can resources be organized and attributed among organizational units in order to promote innovation? This relates to the design of the organizational structure, the second dimension. It refers to the organization's architecture, in which the units interact with the technology centre according to a certain hierarchy (DeSanctis, Glass, & Ensing, 2002; Pugh, Hickson, Hinings, & Turner, 1968). While organizational structure may involve complex hierarchical arrangements (e.g., formal/informal, vertical/horizontal, mechanistic/organic), our review suggests that empirical work in OI research field

mainly looks at whether resources or power are concentrated into one header quarter, or are dispersed among R&D units or departments, i.e., centralization or decentralization (or a hybrid of the two) (DeSanctis et al., 2002). This may be due to difficulties in identifying forms of organizational structure. To identify the structure, scholars need to penetrate into an organization's skeleton and inspect it thoroughly with "analytical precision and theoretical rigor" (Zollo & Singh, 2004). As such, some scholars have tried to use other measurements for organizational structure, such as allocation of patents to affiliates of the parent firm (e.g., Arora, Belenzon, & Rios, 2014).

A small range of literature has directly explored how organizational structure relates to OI activities. Based on a research institute's survey of 71 diversified corporations' R&D executives, Argyres and Silverman (2004) coded organizational structure by analyzing laboratory and staff information, and measured decentralization and centralization according to the ratio of corporate to divisional researchers. They found that compared to a decentralized structure, firms with a centralized configuration are more likely to pursue innovative activities that have broader effects on technological evolution and are more likely to source from external organizations. Explanations behind these hypotheses mainly touch on the functional nuances of different structures in terms of communications, coordination, linkage or resource configuration. Similar explanations were also mentioned in the following works (e.g., Arora et al., 2014; Zhang, Baden-Fuller, & Mangematin, 2007a). For example, Zhang et al. (2007a) suggested that in centralized firms, communication within laboratories and between researchers can be better controlled to prevent knowledge spillovers, and facilitate effective knowledge exchange with partners. A centralized structure is always accompanied by more efficient use of technological resources and more concentrated project portfolios, both of which increase firms' ACAP (Cohen & Levinthal, 1990; DeSanctis et al., 2002; Jansen, Van Den Bosch, & Volberda, 2005). Due to these structural features, firms with a centralized structure are more likely to build new alliances.

However, some scholars may suggest an opposite conclusion when using other variable constructs. For example, Arora et al. (2014) used the extent of patents assigned to affiliates to construct a centralization proxy. They found that centralized firms have a lower propensity to acquire patents, whereas decentralization is correlated with a

greater number, and a higher patent level, of acquisitions. While these findings cannot be interpreted to be causality relationships, they can be attributed to the fact that innovation activities in centralized structures undergo deeper integration than activities conducted independently among discrete entities. According to Arora et al. (2014), a centralized organizational design seems to make firms to focus on exploiting existing resources rather than exploring outsiders'.

As discussed above, existing research has reached no consensus on which organizational structure (centralized or decentralized) is better for OI. This in fact accords with the central proposition of structural contingency theory (Drazin & Van de Ven, 1985), which stresses the importance of “fit” between an organization's strategies with its structure, in shaping firm performance. Firms' structures should be flexible enough to match the strategy they have adopted. For example, holding a dynamic view, Boumgarden, Nickerson, and Zenger (2012) analyzed the structural changes of two companies: Hewlett-Packard (over a 25-year time period) and USA Today Online (over a 15-year time period). They found that these firms tended to strategically change their structures, because both centralization and decentralization have operational issues (e.g., inertia, bureaucratism) when continually being adopted over the long term. Firms need to flexibly adjust their structures in order to avoid these structural inertia issues. Taking a contingency perspective, scholars (e.g., Aoki & Wilhelm, 2017; Fang, Lee, & Schilling, 2010; Jansen, Simsek, & Cao, 2012) have more recently suggested that structural flexibility is adopted so that firms can achieve a balance between exploration and exploitation, in order to create sustainable value. We follow these studies and hold a contingent perspective on the effect of organization structure on OI:

P2: The relationship between centralized or decentralized structure and the implementation of open innovation is contingent upon whether or it fits the firm's strategies and external environments.

Human Capital

The third dimension of success factors of OI is human capital. Human-side factors have deep implications for strategic decisions regarding resource utilization. This has recently ignited research interest in the OI area (e.g., Ahn, Minshall, & Mortara, 2017;

Ahn, Minshall, & Mortara, 2018). Extant research on exploring the effect of human capital on OI can be categorized into two types: firm leader and employee.

Leader. Upper-echelon theory states that organizational outcomes can be partly explained by the background characteristics of top management teams (Hambrick, 2007; Hambrick & Mason, 1984). In the OI area, our review suggests that such characteristics mainly arise from top managers' psychological qualities (e.g., innovation awareness, risk-taking propensity) and demographical factors (e.g., education, work experience). Ahn et al. (2017) comprehensively investigated the effects of CEO characteristics on the choices of OI modes in the context of manufacturing SMEs. Generally, they found CEOs with good qualities (e.g., positive attitudes, entrepreneurial innovativeness) usually have a higher tendency to adopt outbound OI. For demographic characteristics, they found that education in engineering and prior experience working within a technological discipline leads to more interfirm collaborations and Mergers & Acquisitions. For CEO's characteristics, a positive relationship between leaders' abilities and OI effectiveness has been implied by other scholars (e.g., Chesbrough & Garman, 2009; Chiaroni, Chiesa, & Frattini, 2011; Di Minin, Frattini, & Piccaluga, 2010) and a consensus seems to have been achieved in recent literature (e.g., Ahn et al., 2018; da Mota Pedrosa, Välling, & Boyd, 2013). Where the particular experience of CEOs is concerned, the conclusion might be different. For example, Shi, Hoskisson, and Zhang (2017) found that CEOs who experienced an independent director's death will have less motivation for post acquisitions. A general proposition we can make is:

P3a: CEOs' good qualities that are related to innovation will increase the performance of open innovation.

Employee. Top-level management cannot completely reflect the whole composition of human capital in innovative activities (Østergaard, Timmermans, & Kristinsson, 2011). Employees, as front-line participators in innovation activities, play an important role in OI success. For example, Mortara, Napp, Slacik, and Minshall (2009) compiled four types of OI skills: introspective, extrospective, interactive and technical. Chatenier, Verstegen, Biemans, Mulder, and Omta (2010) were the first to identify the main tasks and challenges that R&D staff are likely to face in OI activities. They and subsequent scholars (Salter, Criscuolo, & Ter Wal, 2014) have provided a practice-oriented profile that highlights a series of abilities that OI professionals should have, such as being

capable of brokering solutions and developing partnerships. More recently, Vanhaverbeke, Cheng, and Chesbrough (2017) explored OI managers' characteristics through their LinkedIn profiles. Based on this, content analysis work was conducted by Dąbrowska and Podmetina (2018), who identified key requirements and associated techniques (e.g., excellent communication and leadership) that candidates must have when competing for OI specialists' jobs.

In addition to the qualitative research mentioned above, a few quantitative studies have appeared, and the majority of them have bridged Human Resource Management (HRM) and OI. HRM is concerned with how to plan recruitment, how to choose staff, how to appraise staff, how to compensate staff and how to train and develop staff (Schuler & Jackson, 1987). For example, Teirlinck and Spithoven (2013) found that firms recruiting more highly qualified employees (e.g., with Ph.D. degrees) have a higher propensity to engage in research cooperation. Incompetent employees need professional training or a superior's guidance to develop required skills. Podmetina, Volchek, Dąbrowska, and Fiegenbaum (2013) comprehensively confirmed the positive role of HRM practices (i.e., motivation, learning, training and appreciation) in supporting different OI modes (i.e., external partnering, technology sourcing and acquisition). These empirical investigations suggest that HRM is important for OI.

P3b: HRM practices that are related to open innovation will increase the performance of open innovation.

Asset Specificity Theory (Artz, 1999; McGuinness, 1994; Williamson, 1983) can be applied to explain the role of HRM practices in influencing OI. HRM practices improve the specificity of leaders and employees in implementing OI (Fleming & Waguespack, 2007). This type of asset specificity has a higher value for OI occupations than for other purposes. Moreover, better HRM practices have been found to increase asset diversity (decrease asset specificity) and thus benefit OI. Firstly, firms that have access to diverse human capital (e.g., recruiting experts from different domains) can exploit new markets more efficiently (Gruber, Harhoff, & Hoisl, 2013). Secondly, diverse expertise and all-round skills might allow employees to be adaptable to different circumstances (Bogers, Foss, & Lyngsie, 2018; Østergaard et al., 2011). This is particularly important for the success of OI when considering different collaboration partners.

P3c: HRM practices adopted for conducting certain specific open innovation modes will decrease the implementation of other types of open innovation modes.

Individual Attitudes

Bringing new resources into an organization where norms have been formed is not straightforward. It is determined by individual attitudes, which is the fourth dimension. In our context, attitudes refer to individual evaluations of an object of thought in relation to innovation activities (Antons & Piller, 2015; Vogel & Wanke, 2002). Since knowledge is actually utilized and put into practice by employees, their attitudes will determine the effectiveness of OI. Existing research has mainly suggested that employees always embrace negative attitudes to external resource and outsourcing activities (e.g., Herzog & Leker, 2010) (with exception Menon & Pfeffer, 2003) because of the fear of capabilities leakage (Monteverde & Teece, 1982; Pisano, 1990). In the OI context, the literature focused on individual attitudes in particular has rarely moved beyond highlighting two attitudes: “Not-Invented-Here” (NIH) and “Not-Shared-Here” (NSH).

The NIH concept was introduced earlier in knowledge exploration (Clagett, 1967; Katz & Allen, 1982), after which followers like Chesbrough (2003) emphasized the complementary concept: NSH. In the external exploration process, NIH syndrome refers to a negative attitude that employees hold toward external knowledge (Clagett, 1967; Katz & Allen, 1982). Clagett (1967) induced the NIH term from case studies and described it as a state of “resistance to change” which is “spoken of as if it were disease” (1967: II). In terms of the knowledge-exploitation process, Chesbrough (2003) described NSH as a situation in which employees hold a negative attitude to exploiting knowledge beyond the boundary of the firm. According to this work, both NIH and NSH imply adverse consequences for OI.

Our review indicates that research on the negative connotations of NIH and NSH can be classified into three categories according to the degree to which NIH/NSH hurts OI: (1) A biased or wrong evaluation of external technology (e.g., Agrawal, Cockburn, & Rosell, 2010; Mehrwald, 1999; Menon & Pfeffer, 2003); (2) Suboptimal utilization of inbound OI (e.g., de Araújo Burcharth, Knudsen, & Søndergaard, 2014; Mehrwald,

1999) or stickiness of outbound OI (e.g., de Araújo Burcharth et al., 2014); (3) The ultimate failure of an OI practice (e.g., Clagett, 1967; Huston & Sakkab, 2006; Lidwell, Holden, & Butler, 2010). For example, de Araújo Burcharth et al. (2014) confirmed two hypotheses: NIH and NSH syndrome would decrease the frequency of both inbound and outbound OI practices. Inbound OI refers to activities of sourcing knowledge from other companies, such as buying patents, whereas outbound OI means that internal inventions should be taken outside the company, such as spin-offs. For innovation failure, it is also possible that some OI projects failed because of NIH/NSH. However, this causality has not been empirically tested in innovation research, not least in OI contexts. We obtained insights from the following industrial cases. Eastman Kodak Company existed as a successful technology company excelling in imaging and cameras. It occupied 90% of the U.S. film market share, but eventually it went bankrupt. This is partly due to the firm's failure to adapt during the digital photography revolution (Grant & Baden-Fuller, 2004). Kodak had a very strong centralization tendency and a relatively closed organizational norm. The bureaucratic culture allowed employees to form a type of rigid mindset that hinders managers from quickly responding to emerging disruptive technologies. Similar patterns can also be found in the case of German piloting companies, whose internal cognitive barriers lead to the failure of crowdsourcing initiatives (Lüttgens et al., 2014). Another example is the widely known mobile phone firm, Nokia. To some extent, Nokia's insistence on a relatively closed Symbian operating system, and their resistance to the Android system, meant that they lost out to competitors like Samsung. According to the level to which NIH/NSH affects OI, we have following propositions:

P4a: NIH/NSH will lead to biased evaluation of open innovation opportunities.

P4b: NIH/NSH will lead to suboptimal utilization of open innovation opportunities.

P4c: NIH/NSH will lead to negative performance of open innovation.

Overall, the review above suggests that prior research has addressed a number of questions regarding the determinants of OI along with several theoretical lenses. Table 4 summarizes these key questions and predominant theories we discussed above.

Moderating Mechanisms: Factors that Affect Transaction Cost

Transaction-cost logic explains firms' choice to either expand or contract R&D boundaries, as well as the choice between different OI modes. While firms can take advantage of searching for external knowledge, doing so may be costly due to transaction costs. Whether firms resort to self-development or adopt OI modes depends on factors that bring transaction costs.

Our review suggests that factors related to transaction costs can come from both internal (factors within the boundary of the focal firm) and external (factors that spread beyond the boundary of the focal firm). Villalonga and McGahan (2005) comprehensively investigated a series of transaction factors in the context of their influence on boundary expansion and contraction, including relatedness, governance specification and recency of experience. In their research, theories such as RBV and TCE were combined to explore the effects of both internal and external factors on the boundary of R&D activities. In addition, internal factors can be ACAP (Veugelers, 1997), vocational training (de Araújo Burcharth et al., 2014), and innovation stage (Kirschbaum, 2005). Likewise, external factors include but are not limited to environmental dynamism (Popa, Soto-Acosta, & Martinez-Conesa, 2017), industrial competition (e.g., Laursen & Salter, 2004), and partners' willingness to cooperate (Schenk, Guittard, & Pénin, 2017). Despite considering different contingencies, these studies follow a similar logic. That is, the factors either enhance a firm's costs to acquire knowledge from external environment or strengthen a firm's propensity to outsource because they decrease environmental uncertainties and searching costs. When transaction costs increase to a level that is higher over potential benefits, the effect of organizational factors on OI implementation weakens. We thus propose:

P5: The effect of R&D investment, organizational structure, human capital and individuals' attitudes on open innovation is contingent upon the factors that affect transaction costs.

Mediating Mechanisms: Absorptive Capacity

The ACAP view can explain the mechanism with regard to the effects of organizational factors on OI. For resource investment and including human capital, scholars have found that in-house efforts (such as more investment in training employees and educating the workforce) as the basis of ACAP, would facilitate innovation cooperation and performance (Chen & Huang, 2009; Veugelers, 1997). For organizational structure, Teece (2007) has emphasized the key role of the reconfiguration of assets and organizational structures in enhancing dynamic capability.⁶ With regard to individual attitudes, a supportive culture such as employee learning orientations would benefit firm performance, since it is usually embedded in the process of building ACAP (Hsu & Wang, 2012; Hung, Yang, Lien, McLean, & Kuo, 2010). Therefore, ACAP can be an intermediary through which organizational factors affect OI.

Although some scholars did not test these mediating effects directly, their theoretical arguments actually followed a mediating logic. They emphasize the importance of resource accumulation or adaption in developing the mindset and skills regarding how to employ resources to better implement OI (e.g., Bercovitz & Feldman, 2007; Laursen & Salter, 2004; Sikimic et al., 2016). More directly, some scholars constructed ACAP in light of knowledge accumulation and measured it directly by using (accumulated) R&D spending (e.g., Cohen & Levinthal, 1990; Lin, Wu, Chang, Wang, & Lee, 2012; Stock, Greis, & Fischer, 2001; Tsai, 2001). This approach to measurement, based on the “accumulation” perspective, also provides evidence for supporting the mediating role of ACAP. We thus have following proposition:

P6: The effect of R&D investment, organizational structure, human capital and individual attitudes on open innovation can be direct, or indirect which is achieved through affecting ACAP.

<Table 4 Here>

⁶ Literature concerning dynamic capability and absorptive capability suggests that these two concepts have differences and similarities. However, comparing them is not the purpose of our work. Our argument on firm capability follows Teece’s (2007:1319) definition of dynamic capability, therefore regarding absorptive capacity as one type of dynamic capability, namely, “the capacity to seize opportunities.”

Suggestions for Future Research

As discussed above, research on the organizational determinants of OI is still prevalent. The identification of theoretical lenses and relevant questions that were explored for each dimension also highlight future opportunities.

For example, our review suggests that extant research on how resource investment affects OI mainly works from a static perspective. However, the evolution of organizational resources is a key component in the technology lifecycle, which means that the static RBV is less able to explain changes in competitive advantages or disadvantages over time (Helfat & Peteraf, 2003). As such, a critical but uninvestigated question is *how does resource investment affect OI over time?* In terms of structure, our review on SCT has suggested that firms will intentionally adjust their structure to fit with their OI strategy. But in practice, multiple structures might exist at the same time. This academy-industry discrepancy also needs further attention. In terms of human-side factors, CEO has the most administrative power, whereas CTO is responsible for technology and innovation. How their relationship or conflict affect OI would be an interesting topic for further research.

Moreover, the logic of asset complementarity motivates us to investigate the joint effects of dimensions of organizational factors on OI. Complementary (or substitutable) assets are defined as resources for which an increase in any one of them raises (or decreases) the marginal return of the other(s) (Milgrom & Roberts, 1995). We believe resource investment, organizational structure, human capital and attitudes are not mutually independent but closely interrelated. For example, a risk-taking CEO might change employees' attitudes and behaviors to external innovation. A small range of research on this subject has appeared, such as the investigation into the interaction effects between knowledge base and structure conducted by Zhang et al. (2007a), and work on NIH/NSH and employee training (de Araújo Burcharth et al., 2014). In general, interactions have not been explored sufficiently. Studying two or more dimensions in combination would yield unique insights on *what* the joint effect of dimensions on OI is or *when* the effect is stronger. Potential findings may be more valuable for firms' practice. For example, a complementary conclusion might guide firms to increase the pertinence of resource searching or selective revealing (Henkel, 2006). A substitution

conclusion will benefit firms that are short of certain resources, because in such conditions they can shift to other asset configurations (Stieglitz & Heine, 2007). Given these potential implications, firms' behavior with regard to selective revealing and purposive absorbing also needs further attention. We believe future research should draw on this theoretical perspective to contribute to this research agenda. Table 5 summarizes the key questions discussed above that need to be addressed in the future.

It should be noted that our identification of above future research questions still focuses on organizational factors, i.e., four dimensions of organizational factors. We consider and classify OI implementation variables (OI-related strategy and performance) according to openness modes or relevant consequences rather than the types of who a firm is open to. About this, a general finding is that extant research has mainly focused on non-competitive contexts (i.e., openness to non-competitors, such as users, suppliers or research institutes). This notion is consistent with extant reviews on OI (Bogers et al., 2017a; Hoffmann, Lavie, Reuer, & Shipilov, 2018; Stanko et al., 2017). Thus, scholars may want to enrich our research by considering the determinants and consequences of openness to competitors. Because competitors on the hand can be a source of valuable knowledge and on the other hand, they compete against each other. Thus, they likely bring both benefits and risks. How firms can be open to competitors to innovate is rarely studied.

<Table 5 Here>

Discussions and Conclusion

This work seeks to develop a conceptual framework for explaining the determinants of OI, namely how organizational factors affect the implementation of OI. We firstly classify these factors into four resource-related dimensions and then analyze theories used to explain each dimension's effects. We then refine the framework by proposing its moderating mechanism and mediating mechanisms. It should be noted that the four dimensions and the two mechanisms are by no means completely exhaustive. However, this work has outlined a clear framework based on the current literature that provides

the theoretical lenses for explaining OI that is influenced by primary organizational factors, as well as some practical insights for firms on how to make efforts for embracing OI.

Firstly, our work contributes to the topic of “internal factors of OI success” (Bogers et al., 2017b; Lüttgens et al., 2014; Stanko et al., 2017). Previous research has uncovered diversities in analyzable perspectives and showed discrepancies in findings. Starting from the idea that resource-related factors construct the foundation of firm strategy, we classify organizational factors into four dimensions (i.e., resource investment, organizational structure, human capital and individual attitudes). We analyze the effects of four dimensions of organizational factors on OI and analyze the predominant theories that have been applied for explaining their effects. This work provides a solid explanation base for scholars aiming to explore organizational determinants of OI, to see why the discrepancies exist and how the discrepancies can be explained by multiple theories. Such value is more likely to be highlighted given that this topic is, and will continue to be, prevalent within academia (Stanko et al., 2017).

Secondly, we advance understanding of the relationship between organizational factors and OI by proposing its moderating and mediating mechanisms. The identification of a series of moderators suggests that the effect of organizational factors on OI is unconditionally fixed. It is contingent upon factors related to the transaction cost. These contingent factors can derive not only from external circumstances, such as market uncertainty, but also from other factors within the organization, such as its own ability. These factors account for when the effect of organizational factors is stronger, whereas in other situations the effect is weakened. Additionally, our review also suggests that organizational factors do not necessarily exert a direct effect on OI, but can do so indirectly by affecting a firm’s ACAP. This mediating mechanism suggests that organizational designs in terms of R&D investment, structure, human capital and individual attitudes can enhance a firm’s ability to absorb external knowledge, thus being able to conduct OI more effectively.

Thirdly, our review also offers practical implications regarding how to organize resources to implement OI in terms of at least four aspects. This is especially important, given that OI mode has become a trend in the business world. In practice, it is difficult to conclude or give a general suggestion about how to make efforts for implementing

OI better. Notably, our analysis of resource-related dimensions of organizational factors is in accordance with the principle of feasibility and operability. Since the four dimensions are relatively analyzable and operable, and in managerial practice, to a large extent, they reflect the critical determinants of OI success and the main challenges of OI adoption in firms (Sieg et al., 2010), our review provide some insights. For example, managers should consider more detailed and specific dimensions of organizational R&D efforts rather than a macro, rough or single-aspect guide. As the IBM example shows, in response to the challenges of AI technology, IBM made and revised a firm strategy by detailing several micro-level dimensions. These specific dimensional designs gave them more practical and operable insights on how to embrace AI. Moreover, managers who aim to design an appropriate organization for embracing OI should consider at least four aspects of R&D efforts. It may be not enough for firms that only invest more money or hire talented scientists. They also need to consider how these resources are allocated and treated by employees.

In conclusion, our review shows that organizational factors can be primarily classified into four dimensions: resource investment, organizational structure, human capital, and individual attitudes. These dimensional factors exert different effects on OI directly or indirectly through affecting firm capability (absorptive capacity). Moreover, the effects of these factors on OI are also contingent upon both internal and external transaction factors. We hope our work has provided a view in a comprehensible manner for research exploring the determinants of OI.

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Tables and Figures of Chapter 1

Table 1. Paper description concerning the determinants of OI in the category of each dimension during 2003-2018

Period	Organizational factors					Paper types			Total
	Resource investment	Organizational structure	Human capital	Individual attitudes	Multi-dimension	Empirical		Conceptual	
						Quantitative	Qualitative		
2003-2008	13	5	4	5	7	19	8	7	34
2009-2013	8	9	12	10	10	21	21	7	49
2014-2018	18	6	20	12	15	39	24	8	71
Total	39	20	36	27	32	79	53	22	154

Notes: Open innovation was coined by Chesbrough (2003), which is regarded as the starting point of OI research; among the supplemented articles, those published before 2003 (11 articles) were categorized into the period 2003-2008; multi-dimension means more than one dimension in one paper.

Table 2. Four dimensions of organizational factors and OI

Organizational factors	OI-related outcomes (the implementation of OI)						
	External search strategy	OI mode choice	OI propensity	OI effectiveness	OI practices	Multi-variable	Total
Resource investment	8	7	9	5	5	5	39
Organizational structure	0	2	7	3	3	5	20
Human capital	7	3	9	7	9	1	36
Individual attitudes	2	2	10	4	7	2	27
Multi-dimension	1	3	12	6	8	2	32
Total	18	17	47	25	32	15	154

Notes: External search includes search breadth (usually measured through types of outsourcing activities), depth (usually measured through the strength or repetitive times of one outsourcing activity). Some scholars conceptualized both breadth and depth as openness, while others define openness as the choice between openness modes, including closed-open choice, make-buy-ally choice and choice between OI modes; propensity usually refers to the likelihood, strength or frequency to which OI mode is adopted; effectiveness refers to the returns or values obtained from OI; OI practices refer to types of general practices, their conditions or related outcome performance, which are usually qualitative or practice-oriented research; multi-variable means more than one OI implementation variables; multi-dimension means more than one dimension of organizational factors.

Table 3. Theories applied to explain the relationship between organizational factors and OI

Organizational factors	RBV	SCT	UET	AST	ACAP view/ KBV	TCE	Multi-theory	OIL	Others	Null	Total
Resource investment	4	1	0	0	11	6	2	3	7	5	39
Organizational structure	0	7	0	0	1	1	3	2	2	4	20
Human capital	1	0	5	3	4	2	1	5	10	5	36
Individual attitudes	0	0	0	0	2	0	2	6	2	15	27
Multi-dimension	2	1	0	1	4	0	9	6	1	8	32
Total	7	9	5	4	22	9	17	22	22	37	154

Note: RBV=Resource-Based View, SCT= (Structural) Contingency Theory, UET=Upper-Echelon Theory, AST=Asset Specificity Theory, ACAP view=Absorptive Capacity/Dynamic Capability Theory, KBV=Knowledge-Based View, TCE=Transaction-Cost Economics, Multi-theory=more than one aforementioned theories, OIL=Open Innovation Logic; Null means that there is no clear theory used; since papers drawing on KBV usually make arguments on absorption of knowledge (absorptive capacity is regarded as a type of learning ability), we put ACAP and KBV into one category.

Table 4. Predominant theoretical perspectives and questions regarding the relationship between organizational factors and OI

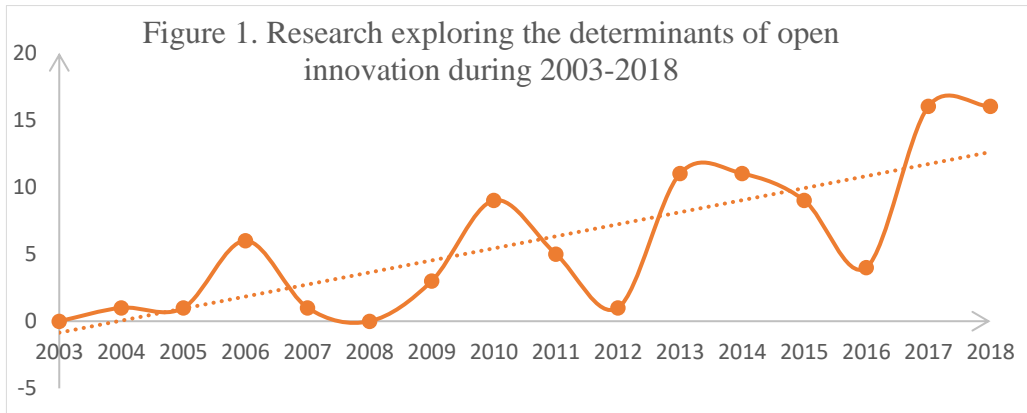
Mechanisms	Predominant explainable theories	Core assumptions related to OI	Main explored research questions	Selected Examples
Resource investment	Resource-based view	Organizational resources are regarded as the source of achieving sustainable competitive advantage. These resources are valuable, rare, imperfectly imitable and not substitutable in promoting OI.	What is the effect of organizational resources on OI?	Villalonga and McGahan (2005); Zhang et al. (2007b); Brunswicker and Vanhaverbeke (2015)
Organizational structure	Structural contingency theory	Organizational effectiveness is not depending on one level of structure, but depending on its fit or misfit with organization context or strategy.	What are the different characteristics of OI between firms with different structures? How do firms adopt different structures to match their external strategies?	Bercovitz and Feldman (2007); Fang et al. (2010); Boumgarden et al. (2012); Arora et al. (2014)
Human capital	Upper-echelon theory	Organizational innovation performance can partly be determined by the characteristics of TMT.	What are the effects of CEO characteristics (psychological and demographical) on OI?	Ahn et al. (2017); Shi et al. (2017); Ahn et al. (2018)

	Asset specificity theory	Because of asset specificity, when one certain asset invested to support one transaction has the largest value, its value will decline when being transferred to other purposes.	What are the professional abilities, skills required for OI managers? What are the effects of employees' characteristics on OI?	Vicent-Lorente Vicente-Lorente (2001); Teirlinck and Spithoven (2013); Bogers et al. (2018)
Individual attitudes	Null	Null	What are the effects of NIH/NSH on OI?	de Araújo Burcharth et al. (2014); Antons and Piller (2015)

Table 5. Future research questions on organizational factors as determinants of OI

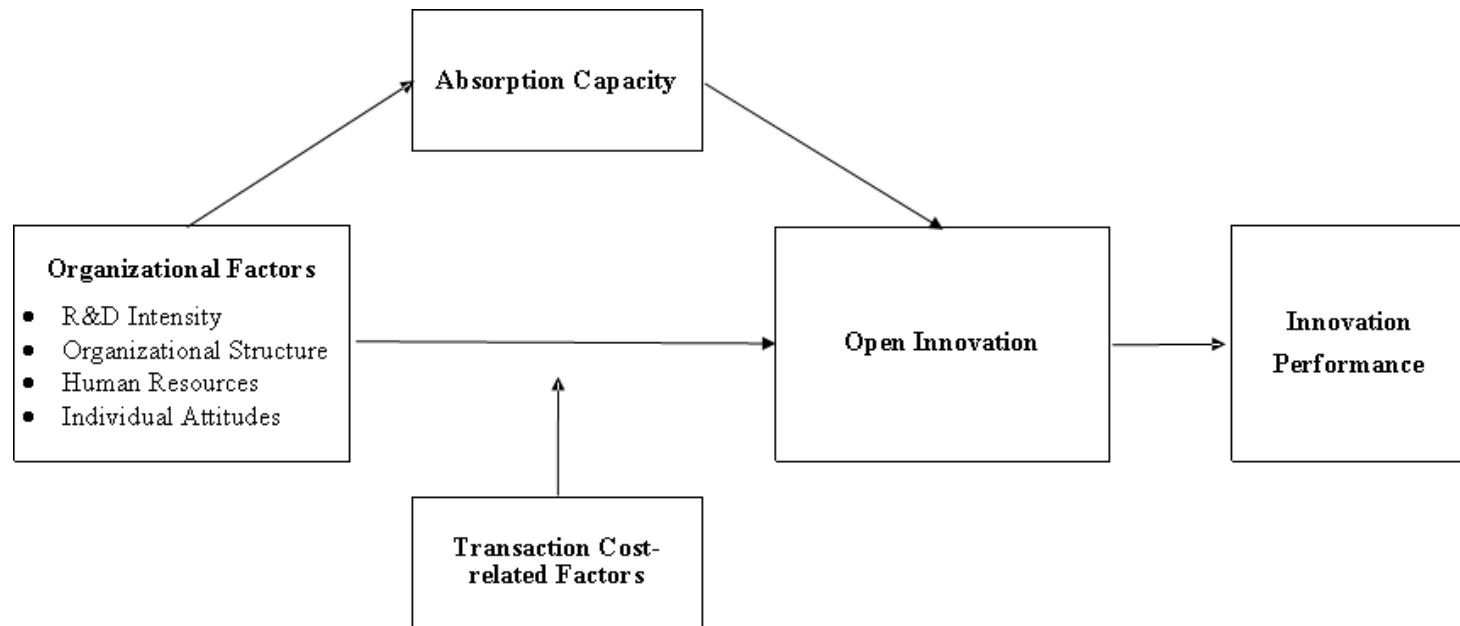
Organizational factors	Theories	Future research questions
Resource investment	Resource-based view	How does resource investment affect OI over time? How does resource dependence affect the implementation of OI?
	Absorptive capacity view	How does external knowledge interact, renew or replace existing knowledge? How does knowledge structure affect the absorption of external knowledge?
	Knowledge-based view	What are the different effects of tacit and explicit knowledge on OI? What is the process of internal knowledge assimilating external knowledge?
Organizational structure	Structural contingency theory	What is the effect of the co-existence of different structures (e.g., centralized and decentralized) on OI? How do firms change their structures to address internal inertia and in the meanwhile fit with the external environment?
Human capital	Upper echelon theory	What is the effect of leaders' relationship/conflict (e.g., CEO and CTO) on OI? What is the effect of TMT's external relationships (e.g., managerial ties) on OI?
	Asset specificity theory	What is the effect of asset (employee) mobility on OI? What are the different effects of generalists and specialists on OI?
Individual attitudes	Null	How do firms cope with NIH or NSH attitudes to better implement OI? How do employees' attitudes change in different stages of OI implementation?

Combination	Asset Complementary Logic	What is the interaction effect of dimensions of organizational factors (i.e., resource investment, organizational structure, human capital and individual attitudes) on OI?
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Note: The term “open innovation” was formally coined in 2003; to show this trend, we excluded the supplemental “external innovation” literature because some of them were published before 2003.

Figure 2. A conceptual framework concerning the relationship between organizational factors and open innovation



Note: Though this paper does not examine the link between open innovation and innovation performance, we add the link for comprehensiveness.

Chapter 2: The Determinants of Openness to Competitors: Innovation Failure and the Selection of Openness Modes

Abstract

Absorptive capacity view suggests that innovation failure as an activation trigger may intensify a firm's efforts to engage in same type of openness modes to use external knowledge. This view appears to be challenged when applied to competitive contexts whereby the firm may be sensitive to competitors' threats. We contribute to the modifications of the view with a selective openness perspective: innovation failure triggers a firm to use competitors' knowledge, whereas deep interaction also exposes the firm to competition risk (risk derived from potential imitation and opportunism). In such situations, managers may strategically select a unilateral openness mode over a bilateral one to avoid the risk. Using panel data from Spanish manufacturing and service firms during 2006–2016, we find that high R&D investment, combined with innovation failures, will increase firms' competitor search (a typical unilateral openness mode), while weakening their propensity to build competitor cooperation (a typical bilateral openness mode). We further find that such a selective openness can be explained by managers' fear of competition risk. Our work adds to the absorptive capacity view and open innovation literature by highlighting firms' selectiveness in choosing openness modes.

Keywords: absorptive capacity, open innovation, activation trigger, innovation failure, knowledge search, selective openness, cooperation

Introduction

The expanding boundaries of modern businesses have fueled continuing interest in how firms source knowledge from outsiders to promote innovation (Chesbrough, 2003; Stanko, Fisher, & Bogers, 2017; West & Bogers, 2014). Competitors, for instance, are a crucial component of a firm's innovation system. When working with competitors, firms can access valuable knowledge resources (Gnyawali & Park, 2011; Winter, 2003), develop their managerial skills (Lane & Lubatkin, 1998; Luo, Rindfleisch, & Tse, 2007), and strengthen their technological capabilities (Dussauge, Garrette, & Mitchell, 2000). Attesting to the importance of competitors, the extant literature has mainly considered competitors' positive and negative influence, while largely neglecting the determinants of openness to competitors (Bengtsson & Raza-Ullah, 2016; Hoffmann, Lavie, Reuer, & Shipilov, 2018; Stanko et al., 2017: 551).

One of the most influential theories in predicting firm openness is the absorptive capacity (ACAP) view. In their seminal work, Cohen and Levinthal (1989, 1990) define ACAP as organizational routines for acquiring, assimilating, and exploiting external knowledge; it is primarily developed by past R&D investments in the relevant knowledge field. Further, scholars suggest that whether a firm will intensify its efforts to source external knowledge depends on *activation triggers*, which are defined as negative events that lead to technology risk and thus compel the firm to seek new knowledge: with innovation failure being a prominent example (Todorova & Durisin, 2007; Zahra & George, 2002). Using external knowledge is expected to address the limitations and failures of self R&D efforts (Chesbrough, 2003; Rosenkopf & Nerkar, 2001; Volberda, Foss, & Lyles, 2010). In this light, managers whose firms experienced failures tend to be more open to outsiders in order to reduce technology risk (Lane, Koka, & Pathak, 2006; Zahra & George, 2002).

Nevertheless, there is a reason to posit that managers' decisions in selecting specific openness modes are more complex in a competitive context. While being open to competitors may allow inward benefits, this openness also comes with significant risks. *Competition risk* derived from imitation and opportunism behaviors (Brandenburger & Nalebuff, 1996; Giarratana & Mariani, 2014; Williamson, 1983) can bring about knowledge leakage and intellectual-property theft (Katila, Rosenberger, & Eisenhardt, 2008; Laursen & Salter, 2014; Luo et al., 2007). This is subject to problems, especially when the focal firm's weaknesses are used opportunistically by competitors to develop competing products or launch calibrated attacks (Cui, Yang, & Vertinsky, 2018; Hamel, 1991; Hamel, Doz, & Prahalad, 1989). For example, facing failures in developing 5th-generation (5G) technology, Chinese telecom equipment manufacturer Huawei takes a "selective" attitude toward competitors: the company supports concerted efforts with global competitors to facilitate 5G technology in the forms of sharing, incorporating, and learning experiences in source code and hardware design,⁷ but not in the form of building bilateral cooperation with them (known as "independent innovation" strategy) (Lin, Liu, Han, & Chen, 2018). We expect managers to be cautious and selective in choosing specific openness modes in competitive context.

To address the theoretical inadequacies about the determinants of openness to competitors, we follow the literature on selective openness (Alexy, George, & Salter, 2013; Giarratana & Mariani, 2014) and propose that managers will strategically choose between different openness modes to reduce technology risk and avoid competition risk. We examine two openness modes that are central to the paradigm of open innovation: competitor search and competitor cooperation (Dahlander & Gann, 2010). We define *competitor search* as the extent to which

⁷ See: https://consumer.huawei.com/ph/community/details/Huawei-is-ready-to-share-its-5G-technology-including-source-code-for-global-innovation/topicId_122488/

firms learn informally or indirectly from competitors (e.g., by monitoring, imitating, and using competitors' information without being contractually bound to them). It is a unilateral form of open innovation. *Competitor cooperation* refers to whether there is a direct and formal collaborative relationship with competitors. It thus creates a bilateral interaction that requires constant exchanges, close contact, and deeply mutual interdependence with competitors, thus involving relatively higher competition risk (Dussauge et al., 2000; Laursen & Salter, 2014). When experiencing failures, managers expect to reduce technology risk but also fear for competition risk (Giarratana & Mariani, 2014; Katila et al., 2008). As a result, managers might try to achieve a balance by increasing competitor search while reducing competitor cooperation. Our ideas are supported with panel data from a sample of Spanish manufacturing and service firms during 2006-2016.

Our findings contribute to the literature in several ways. First, our study adds to open innovation literature by considering competitors as an important source of external knowledge. While scholars have considered multiple partnerships as knowledge sources, empirical studies on competitors have examined their performance outcomes (benefits and risks), largely neglecting to explain how firms manage the duality if they are to be open to them (Hoffmann et al., 2018; Strese, Meuer, Flatten, & Brettel, 2016). Responding to the call for more investigation on competitors, this study thus adds to the scant literature (e.g., Cozzolino & Rothaermel, 2018) that explores the antecedents of openness to competitors by establishing R&D investment as an important driver.

Second, innovation failure has been proposed as a critical activation trigger in the ACAP view. It influences the reconfiguration of knowledge resources and the selection of "open" activities. As the extant literature is largely at conceptual levels (Todorova & Durisin, 2007; Zahra & George, 2002), we contribute to the literature by empirically confirming the moderating role of innovation failure between R&D

investment and firm openness to competitors. To the best of our knowledge, we are among the very few to analyze openness modes in relation to competitors based on a longitudinal database. Our study thus adds to extant literature that has mainly relied on qualitative data to examine competitors' influence (see Bengtsson & Raza-Ullah, 2016 for a review).

Third, and more importantly, we contribute to the modifications of the ACAP view by evidencing opposing moderating effects of innovation failure on the relationship between R&D investment and different openness modes. Though both competitor search and competitor cooperation are openness modes to sourcing external information, the extant literature cautions that these approaches can be exposed to different levels of risks from outsiders (e.g., Dahlander & Gann, 2010; Laursen & Salter, 2014; West, Salter, Vanhaverbeke, & Chesbrough, 2014). Building on previous elaborations on the difference between search and cooperation (Dahlander & Gann, 2010; Laursen & Salter, 2014), our work sheds lights on the implications of openness modes characterized by different levels of competition risk: they influence managers' selection in openness modes. In so doing, we add to the literature on selective openness (Alexy et al., 2013; Balka, Raasch, & Herstatt, 2014) and suggest that the ACAP view should be combined with a selective openness perspective to explain firm openness.

Theory, Literature Background, and Hypothesis Development

Absorptive Capacity View and Firm Openness to Competitors

A key organizational attribute that can explain a firm's propensity to innovate through engaging the competition is its ACAP (Lane et al., 2006; Zahra & George, 2002). Seeing technology knowledge as public goods, Cohen and Levinthal (1989, 1990), in their seminal paper, argue that firms can use external knowledge

(including those from competitors) with low costs when they have well-developed routines to recognize, assimilate, and ultimately transform the knowledge. A typical requirement for doing so is having sufficient R&D investments in the relevant knowledge field because they form the basis of ACAP and prompt firms to go beyond self R&D efforts by enhancing their scope and skills to comprehend diverse knowledge (Cohen & Levinthal, 1989, 1990; Zahra & George, 2002).⁸

Scholars further suggest that a firm's ability (developed by past R&D investment) alone may not be sufficient to explain firms' "open" propensity because the configuration of resources and consequent selection of innovation activities can be changed in risky situations; managers must consider particular experience that activates firms to be open, with innovation failure being a prominent one (Todorova & Durisin, 2007; Zahra & George, 2002).⁹ *Innovation failure* refers to weaknesses in relation to innovation processes where actual performance is below the level of the firm's aspiration (Cyert & March, 1963; March & Simon, 1958), which could come in forms such as projects being abandoned, commercial failures, or other unwelcome events that lead to weaker innovation performance relative to a referenced group of firms (Khanna, Guler, & Nerkar, 2016; Leoncini, 2016; Tsinopoulos, Yan, & Sousa, 2019; Zahra, Kaul, & Bolívar-Ramos, 2018). Despite these failures being non-threatening to firm survival, they indicate to managers the inadequacies or inefficiencies of innovation processes (relative to comparable firms) and thus challenges the status quo (Khanna et al., 2016).

To reduce the risk of innovation failure (i.e., *technology risk*, hereafter) and

⁸ Although many studies have operationalized ACAP with R&D investment, we argue from a knowledge-based perspective, that R&D investment forms the basis of ACAP because ACAP may involve other dimensions like knowledge content, routines, or processes (Zahra & George, 2002).

⁹ Strictly speaking, activation triggers also include external factors, such as industrial shifts and government policies. However, our theories that emphasize managers' selectiveness in openness modes primarily concern innovation failures (which can be heterogeneous between firms) rather than macro environmental factors (which tend to be homogeneous among firms).

avoid self-development limitations, firms with high R&D investments tend to make more efforts toward accessing outsiders' knowledge (Chesbrough, 2003; Giarratana & Mariani, 2014), for example in the form of observing what competitors are doing (Gnyawali & Park, 2011; Lieberman & Asaba, 2006). In their simplest form, *competitors* are firms that coexist in similar environments and offer similar products or services in shared markets (Porter, 1998). Being able to keep competitive positions and provide low-cost and differential offerings, competitors usually view problems with different perspectives (Porter & Millar, 1985; Teece, Pisano, & Shuen, 1997). Possessing complementary knowledge, idiosyncratic capabilities, and unique understandings of products make competitors be a critical source of knowledge (Fiol & Lyles, 1985; Katila, 2002; Lane & Lubatkin, 1998). For instance, one firm's failure in promoting products in new markets may compel the manager to observe and imitate competitors' marketing strategies. Katila and Chen (2008) find that searching after competitors helps firms avoid previous mistakes and to introduce new products quickly and efficiently. Although such a strategy may decrease a product's novelty, having competitors as a benchmark helps to avoid risky attempts and makes technological strategies more reliable (Lieberman & Asaba, 2006).

Nevertheless, whether or not a firm with more R&D investments will be more open depends on more than technology risk. Managers also fear external competition, such as the unauthorized use or imitation of technologies, brands, and designs (Giarratana & Mariani, 2014). This is especially problematic in a competitive context because competitors by nature compete against each other and will likely act opportunistically (Derfus, Maggitti, Grimm, & Smith, 2008; Luo et al., 2007). We thus consider *competition risk* as the threat of losing proprietary knowledge derived from possible imitation and opportunistic behaviors of competitors. Moreover, different openness modes are characterized by different

levels of competition risk (Dahlander & Gann, 2010; Laursen & Salter, 2014; West et al., 2014). Therefore, we expect that high R&D investment, combined with innovation failure, will not necessarily increase firms' engagement in all types of openness modes. Rather, at this stage, we have following hypothesis:

Baseline hypothesis: Innovation failure can positively or negatively moderate the relationship between R&D investment and firm openness to competitors.

The Selection of Openness Modes: Knowledge Search or Formal Cooperation

How can firms achieve a trade-off between the reduction of technology risk and the increase of competition risk of being open? Open innovation scholars introduce the concept of “selective openness,” which underscores managers' strategical selection between different openness modes: managers will choose modes that can minimize the costs (risks) of being open (Alexy et al., 2013; Giarratana & Mariani, 2014; Henkel, 2006). For example, Alexy et al. (2013) theorize that building a direct cooperation usually involves high uncertainties; to avoid such costs, managers may purposely disclose specifically selected information that is problem-oriented and reflects their needs. In so doing, they increase the likelihood of initiating compatible and committed collaboration activities in which the benefits outweigh the costs. Similarly, examining users' involvement in online innovation communities, Balka et al. (2014) find that a balance between openness benefits and risks can be achieved by designing different openness modes characterized by distinct transparency, accessibility, and replicability.

Competitor search and competitor cooperation are two important but distinct modes for acquiring competitors' information. Competitor search, such as scanning, observing, monitoring, or indirect imitating, is a type of unilateral strategy designed to learn from competitors indirectly (Katila & Ahuja, 2002; Laursen & Salter, 2014).

These activities typically do not require close interactions and are dominated by the focal firm. By contrast, Competitor cooperation involves a bilateral relationship and straightforward information exchanges, which requires intensive interaction and a mutually dependent relationship with competitors (Dahlander & Gann, 2010; Laursen & Salter, 2014). Despite possible contractual binding, competitor cooperation cannot always avoid opportunistic influence because of inevitable unexpected actions or behaviors that were unobservable or were purposely hidden (Lado, Boyd, & Hanlon, 1997; Luo, 2008). Below, we posit that competitor search and competitor cooperation are two distinct choices for managers after innovation failures. Figure 1 depicts the conceptual model, where R&D investment forms the base of ACAP; innovation failure is a type of activation trigger; competitor search and competitor cooperation are two forms of absorbing competitors' knowledge. This model is adapted from Zahra and George (2002).

<Figure 1 Here>

Innovation Failures as Positive Triggers of Competitor Search

When innovation failures happen, managers are under pressure to find useful knowledge and feasible solutions to reduce technology risk (i.e., address technical problems and negative performance). Competitor search is a relatively unilateral and flexible approach to sourcing competitors' knowledge (Dahlander & Gann, 2010; Laursen & Salter, 2014). With the increase of R&D investment, competitor search tends to be a safe option for firms experiencing failures.

To avoid being noticed and retaliated, some firms learn from competitors indirectly by scrutinizing product announcements, checking patents, or monitoring market activities (Kronmeyer, Eilers, Wustmans, & Moehrl, 2020; Laursen &

Salter, 2014), while others rely on analyzing competitors' suppliers, users, or their political partners to gauge the competitive landscape (Insead & Chatain, 2008). In the global market, Banerjee, Prabhu, and Chandy (2015) find that indirect learning through the observation, incorporation, and sharing of other firms in developed markets explains the success and international growth of emerging-market firms relative to their peers. Since these searching activities are usually characterized by high discretion and flexibility, managers perceive a lower risk of imitation, competitive response, or opportunistic behaviors (Chen, 1996; Dahlander & Gann, 2010; Laursen & Salter, 2014). This should strengthen managers' willingness to allocate more R&D resources to engage in searching activities, because they have fewer concerns about their knowledge misappropriation and normally do not need to negotiate contracts or manage competitive relationships (Dahlander & Gann, 2010; Gulati & Singh, 1998).

In other words, firms engaging in competitor search will face fewer constraints and interventions from competitors as it eschews direct imitation and opportunism (Chen, 1996; Dahlander & Gann, 2010). Just like individuals who have performed badly hope to learn from rivals without being noticed, competitor search is likely to be carried out by firms that have experienced failures. We therefore predict the following:

Hypothesis 1: Innovation failure positively moderates the relationship between R&D investment and competitor search such that high R&D investment, combined with innovation failure, will increase firms' propensity to search for knowledge from competitors.

Innovation Failures as Negative Triggers of Competitor Cooperation

Firms can also tap into competitors' knowledge for reducing technology risk by

building direct cooperation with them. Such a mode requires intensive interaction and interfirm embeddedness, which make the focal firm deeply interdependent with competitors at least when it comes to agenda issues (Rindfleisch & Heide, 1997; Ritala & Hurmelinna-Laukkanen, 2013). As Dahlander and Gann (2010) suggest, maintaining a bilateral relationship entails high risks relative to unilateral modes—those arising from potential imitation and opportunism. Especially after innovation failures, competitor cooperation can sometimes create problems for firms.

When innovation failures happen, competitor cooperation may bring complementary knowledge that helps to address problems, whereas such expectations are based on the premise of reciprocal commitments (Lado et al., 1997). As Lhuillery and Pfister (2009) observe, because of the misalignment of interests and intentions to reap private benefits, most rivalry cooperation end up in failure (Gulati & Singh, 1998; Park & Russo, 1996). Sinha and Cusumano (1991) add that firms cannot achieve risk sharing and collective benefits from collaborative work unless both parties provide complementary offerings (also see Ritala, 2012).

Although the focal firm can adopt appropriation regimes to protect its intellectual properties from being leaked to competitors, its refusal to share failure-related information makes it difficult to address the failures. This is because the protection behavior lowers the likelihood of receiving information from competitors that is complementary, compatible, or problem-specific is low (Alexy et al., 2013; Estrada, Faems, & de Faria, 2016; Lado et al., 1997). In other words, the more managers expect their failures to be addressed, the more likely they need to communicate the failure information to competitors; therefore, there is a higher risk of the firm's strategies being imitated or its knowledge being leaked. As Heiman and Nickerson (2004: 402) point out, it is highly possible that “the value created by the collaboration from transferring knowledge may be eclipsed by the value of the knowledge expropriated.”

In addition to potential knowledge loss, the overweighing of competition risk should be further strengthened by potential opportunistic behaviors (Cui et al., 2018; Luo et al., 2007; Williamson, 1985). Competitor cooperation requires deep interaction and, as a result, the combination of a high R&D investment and innovation failure allows competitors a more precise understanding of the focal firm's innovation schemes and technical problems. This will help competitors identify the firm's strengths and weaknesses, resulting in incentives to compete rather than cooperate for pursuing private benefits (Luo et al., 2007), even at the cost of finding common interests (Hamel, 1991; Hamel et al., 1989). Further, the precise understanding of a firm's innovation failure can be used to launch calibrated attacks, which in turn make the firm take higher risks (Cui et al., 2018). For example, competitors may terminate the relationship after being aware of the focal firm's failures of projects; they may also launch similar projects, or even develop competing products. Although agreement on common benefits may help to maintain cooperative relationships (Dussauge et al., 2000; Khanna, Gulati, & Nohria, 1998), opportunistic incentives and competition usually cannot be avoided unless the two firms create spaces for new discoveries, and their long-term interest are more aligned (Cui et al., 2018). Managers who expect to address immediate failures will find it unsuitable to engage in such risky modes.

Failure events in our context mainly arise in the natural course of the innovation process—generally tolerable, albeit unwelcome events—whereas calibrated attacks can be seriously problematic or even threaten the survival of a firm (Mitchell & Singh, 1996). In this case, managers would not believe that the reduction of technology risk outweighs the competition risk (Audia & Greve, 2006). With high fear of competition risk, managers will reconfigure resource allocation in a way that reduces the effect of R&D investment on competitor cooperation. After its failure to enter the U.S. market to build 5G networks, Huawei's fear of competitor

imitation and opportunism is an example of why the company refuses to co-conduct costly R&D projects with their U.S. peers. Therefore, we propose the following:

Hypothesis 2: Innovation failure negatively moderates the relationship between R&D investment and competitor cooperation such that high R&D investment, combined with innovation failure, will decrease firms' propensity to cooperate with competitors.

Finally, we advance a prediction concerning risk-averse propensity, which we refer to as the propensity of competitive research relative to competitive cooperation. As we argued earlier, high R&D investment, combined with innovation failure, increase managers' fear of competition risk. This risk-averse propensity will be reflected in the choices between different governance modes (Gulati & Singh, 1998; Williamson, 1985). Thus, the joint effect of innovation failure and R&D investment should be positive with respect to firms' choice of competitor search over competitor cooperation.

Hypothesis 3: Innovation failure positively moderates the relationship between R&D investment and relative risk-averse propensity such that high R&D investment, combined with innovation failure, will increase firms' propensity to search for knowledge from competitors relative to formally cooperating with them.

Methodology

Empirical Setting, Sample, and Data

We chose manufacturing and service firms in Spain as the research setting. Though economically developed, Spain ranks as an above-average country in technological innovation (Dutta, Lanvin, & Wunsch-Vincent, 2014). As a member of the European Union, Spain has close business relationships with other member

countries, while its domestic business environment has become dynamic and diversified. The government attempts to establish a market that encourages a continuous flow of technological investment, labor forces, and market-based information, which in turn facilitates interfirm communication and deep collaboration (Gonzalez, Llopis, & Gasco, 2013). As a result, the coexistence of innovation flows and relational connections allows Spanish firms to adopt diverse openness modes to use external knowledge. Some firms may choose to build formal collaborative relationships, whereas others may prefer to rely on external search. Thus, such a mixed pattern emphasizing a high heterogeneity in openness modes makes Spain a suitable context for exploring the determinants of firm openness to competitors.

The data came from eleven waves of national innovation surveys (2006-2016) known as the Spanish Community Innovation Survey (CIS). The survey was designed based on the conceptual principles regulated in the Oslo Manual (OECD, 2005) and methodological recommendations by the Statistical Office of the European Communities (Eurostat). As a part of EU science and technology statistics, CIS data has proven to be a critical and reliable source of innovation studies (e.g., Laursen & Salter, 2006; Laursen & Salter, 2014; Leiponen & Helfat, 2010; Wadhwa, Bodas Freitas, & Sarkar, 2017).¹⁰ The surveys are mainly carried out by the Spanish National Statistics Institute with official technological and statistical departments. Spanish manufacturing and service firms are the object of the survey, covering almost all firms that have more than 100 employees and also engage in innovation activities. The manufacturing category consists of 39 subsectors, and the service category consists of four subsectors (at the level of two-digit classification codes of NACE rev. 2.0). For the survey, each questionnaire

¹⁰ More introduction about CIS database can be found through European Statistics website: <https://ec.europa.eu/eurostat/web/microdata/community-innovation-survey>.

contains specific items asking about the past three years, mainly including basic information, internal and external R&D activities, and innovation performance. A three-year set is believed to be reasonable when considering the period of innovation cycle.

The advantages of using Spanish CIS data over that of other countries (e.g., the U.K., see Laursen & Salter, 2006) are that first, the survey is conducted every year, thus generating a richer longitudinal record for each firm's innovation development. Second, the survey has twenty pages of questions and captures detailed information about R&D activities and innovation dynamics. For example, very few surveys offer innovation failure details. Third, the survey is mandatory (mainly via mail and phone surveys with firm leaders, technical directors, or managers in charge of innovation affairs), which is considered to be of higher quality and have greater accuracy. The data we used for the analysis was drawn from the surveys from 2006 to 2016, which constructs an unbalanced panel.

Variables and Measurement

Dependent Variables

Our dependent variables are the two forms of openness to competitors: competitor search and competitor cooperation. CIS classifies external innovation activities into two categories: search and cooperation. External search reflects the extent to which a firm sources information from outsiders. The survey lists a number of external sources of information, including suppliers, clients, competitors, research institutes, and other sources. Gaining insights from prior research (Laursen & Salter, 2006; Laursen & Salter, 2014; Leiponen & Helfat, 2010), we measured competitor search using the respondents' evaluations on the degree to which the information from competitors (or other companies from the same branch of activity) was drawn by

the focal firm for its own innovation activities. This variable captures the indirect use of competitors' knowledge (Laursen & Salter, 2014). The variable takes values from 1 to 4, indicating the degree of importance from “not used,” “low,” “medium,” to “high.”

For cooperation information, the questionnaire considered a variety of opportunities, including both market participants (e.g., suppliers, clients, competitors, and others) and non-commercial bodies (e.g., universities and research centers). Competitor cooperation is a dummy variable based on the question indicating whether the respondent firms had a formal cooperation with competitors (or other companies from the same branch of activity). According to the CIS questionnaire, only “effective” cooperation was counted in the evaluation. This helps to exclude cooperation activities without active participation or interaction.¹¹

To measure relative risk-averse propensity, we followed Giarratana and Mariani (2014)'s approach in measuring relative propensity of external over internal knowledge sourcing and constructed the relative propensity variable by following ratio: $\frac{(Competitor\ Search+1)-(Competitor\ Cooperation+1)}{(Competitor\ Search+1)+(Competitor\ Cooperation+1)}$.¹² Here, the competitor search was transformed into a dummy variable with the value 1 for “medium or high importance,” while 0 indicated “low importance or not used.” The higher the ratio is, the higher managers' propensity to engage in knowledge search relative to formal cooperation.

¹¹ The correlation between competitor cooperation and competitor search is only 0.17 (significant at 95% confidence level), which indicates that managers very likely treat these two forms of openness differently.

¹² As a robustness check, we also adopted an approach developed by Laursen and Salter (2006) who measured the relative performance variable by calculating the difference between radical and incremental innovation performance. We first normalized competitor search and competitor cooperation and then measured relative risk-averse propensity by the normalized competitor search minus the normalized competitor cooperation. We obtained generally similar results (available upon request, Appendix 1).

Independent Variable

A firm's R&D investment was measured by its R&D spending on innovation activities, which has been a widely used proxy for R&D-related efforts (Lane et al., 2006). Scherer (1986) has suggested that a proportion of a firm's R&D spending to its employee number is more stable, whereas R&D spending per sale likely has statistical bias due to business cycles and accounting manipulations. Such statistic weakness is likely an issue in our research, as our data involves a long period during which firms probably experienced several business cycles. Thus, consistent with prior research (e.g., Baysinger, Kosnik, & Turk, 1991; Cohen & Levinthal, 1990), we computed R&D spending per employee as the measurement of R&D investment. Both R&D spending and the number of employees were reported in CIS questionnaire.

Moderating Variable

Innovation failure in our context reflects a firm's weaknesses in the innovation process. After reviewing recent literature (Khanna et al., 2016; Leoncini, 2016; Tsinopoulos et al., 2019; Xu, Zhou, & Du, 2019; Zahra et al., 2018), we considered two types of innovation failure: historical and social innovation failure, such that the former refers to an account of factual failures occurred within a firm, while the latter is judged with comparable firms as the reference point.¹³ As one firm coexists with its competitors and they struggle for market share, its innovation performance needs to be compared with major competitors (Greve, 1998). For example, one firm may still suffer serious market losses or revenue shortfalls when introducing a new

¹³ Although the two types of innovation failures may have different effects on firm strategies and innovation performance, elaborating on such potential differences is not the task of this study.

product later than its competitors.

Historical innovation failures can happen in different stages of innovation projects (Khanna et al., 2016), including conceptional, initial, developmental, and commercial stages in the CIS questionnaire technologies (e.g., Leoncini, 2016; Tsinopoulos et al., 2019). Thus, we generated a dummy variable with a value of 1 for firms that had at least one of the following experiences: (1) innovation activities or projects were abandoned during the conception stage; (2) innovation activities or projects were abandoned once the activity or project began; (3) innovation activities or projects suffered significant delay; (4) turnover was decreased by over 10% due to declining sales. Otherwise, the variable is coded as 0 if there were none of the above failures.¹⁴

Although some firms had none of the above failures and had successfully commercialized new-to-company products, these products likely had already existed. In other words, they failed to introduce new products in a race with their competitors: that is, a social innovation failure. This variable was coded as 1 for firms that failed to introduce a new or significantly improved product/service in the market before their competitors, and 0 indicated that they introduced new products to the market before their competitors did.

Control Variables

We controlled for several important variables at the firm and environment levels that may influence competitor search and competitor cooperation. “Start-up” is a dummy variable indicating whether a firm was newly built (with a firm age of less

¹⁴ Khanna et al. (2016) pointed out that failures in different stages may affect innovation output differently. We also analyzed potential effects of failure stages on openness to competitors. Yet we do not find significant timing effects related to innovation failure.

than 3 years). It was coded with a value of 1 for new firms and, otherwise, 0. We also controlled for whether the firm engaged in biotechnological activities because biotechnology companies often involve the research, development, and application of advanced science and technology, which is likely overrepresented in our sample. Since larger firms usually possess more financial resources and market channels to conduct external innovation activities than small firms, firm size was added through the number of full-time employees (after logarithmic transformation). In addition, whether or not a firm belongs to a part of a group of companies (is bound up with such relationships as parent-son, affiliate, joint or associate company) is important. This is because such firms are likely to obtain innovation benefits from their group partners, such as information sharing and operational synergies (Sköld & Karlsson, 2012; Wadhwa et al., 2017). The group variable takes a value of 1 when the firm was a part of company group and 0 otherwise.

Moreover, external buying activities likely influence a firm's innovation ability because such activities can acquire new knowledge (Arora, Belenzon, & Rios, 2014; Wadhwa et al., 2017), complement internal R&D efforts (Cassiman & Veugelers, 2006; Veugelers & Cassiman, 1999), and increase the likelihood of knowledge recombination (Galunic & Rodan, 1998). In line with Wadhwa et al. (2017), we measured buying activities via the ratio of firm's expenditure in purchasing or acquiring R&D-related resources such as machines, equipment, hardware, or buildings. For environment-level factors, market uncertainty likely influences firm decisions on strategy choice. The variable market uncertainty was measured by respondents' evaluation of the degree to which uncertainties about customers' demands for new goods and services hinder firm innovation activities. The variable ranges from 1 (not important) to 4 (highly important). Finally, we computed industry and year dummies to address industrial and time heterogeneity.

Analyses and Results

We used stepwise regressions to test our hypotheses. To predict the effects of R&D investment and innovation failure on firm openness to competitors, we employed firm random-effects (industry/year fixed-effects) models because our hypotheses primarily concern between-firm variance (difference among firms) (Certo, Withers, & Semadeni, 2017; Greene, 2008).¹⁵ We used linear models to predict competitor search and relative risk-averse propensity and chose logistic analysis to deal with the discrete nature of competitor cooperation.

All explanatory variables are lagged by one period. In so doing, we are able to mitigate both the concern of endogeneity arising from potential reverse causality (Semykina & Wooldridge, 2010) and that of common method bias, as the likelihood that the same people answered all questions is low (MacKenzie & Podsakoff, 2012). It also helps to capture the effects of R&D investment and innovation failure on firm openness because the effects need ample time to manifest (Khanna et al., 2016; Wadhwa et al., 2017). To test the interaction effects, we mean-centered R&D investment and generated its interactional items with historical and social innovation failure (Aiken, West, & Reno, 1991).

Table 1 presents the information of main variables in analysis: means, standard deviations and Pearson correlation coefficients (using the sample of regression on competitor search). It suggests no major concerns about multicollinearity among explanatory variables.¹⁶ This is further confirmed with a close look at the variance of inflation factor (VIF) of key variables, which ranges from 1.04 to 1.92 (well

¹⁵ We also ran fixed-effects models and a Hausman test (using the full model; $p=0.230$), which suggests no significant systematic difference in the coefficients between random-effect and fixed-effect approaches.

¹⁶ The correlation between firm size and company group is 0.48. Yet the inclusion or exclusion of the company group variable does not influence our findings.

below the threshold 10) (Hair, Black, Babin, Anderson, & Tatham, 1998).

<Table 1 Here>

Table 2 and Table 3 report on the regression results of our hypotheses.

Hypothesis 1 posits that the positive relationship between R&D investment and competitor search is strengthened for firms with innovation failure. Model 1 indicates that R&D investment has a significant and positive effect on competitor search ($b=0.026$, $p<0.001$). Results in Model 2 and Model 3 indicate that the interactions between R&D investment and innovation failure are positively associated with competitor search (historical: $b=0.01$, $p<0.001$; social: $b=0.005$, $p<0.05$), thus supporting hypothesis 1. The results are still robust in the full model (Model 4).

For hypothesis 2, we consider a negative moderating role of innovation failure in the relationship between R&D investment and competitor cooperation. We find that R&D investment has a positive effect on competitor cooperation (Model 5: $b=0.282$, $p<0.001$). Although the direct effect of innovation failure on competitor cooperation is positive, we find that the interaction of R&D investment and innovation failure is negatively associated with competitor cooperation (historical: $b=-0.04$, $p<0.01$; social: $b=-0.106$, $p<0.001$). The results are similar in full models. This means that a firm that experienced innovation failures would reduce its R&D-investment influence for building competitor cooperation, as hypothesis 2 argues.

To achieve a better understanding of our hypotheses, we display the moderating effects visually. We follow Aiken et al. (1991)'s recommendation and Royston (2013)'s procedure (Stata code: *marginscontplot*) to draw the marginal values of competitor search and cooperation predicted by R&D investment at different levels

of innovation failures. As Figure 2 and Figure 3 exhibit, historical and social innovation failure strengthen the positive effect of R&D investment on competitor search. In contrast, the positive effect of R&D investment on competitor cooperation is weakened when firms experience historical (Figure 4) or social innovation failure (Figure 5).

< Table 2 Here >

< Figure 2, 3, 4 and 5 Here >

For hypothesis 3, the results are reported in Table 3. We find that the effect of R&D investment on the risk-averse propensity is strengthened when firms experienced social innovation failures ($b=0.01$, $p<0.001$), but no significant moderating effects are found for the type of historical failure. In addition, Table 3 shows that the effect of R&D investment on relative risk-averse propensity is positive and significant ($b=0.003$, $p<0.001$). All told, these results suggest that regardless of failure experience, firms with higher R&D investments are more likely to engage in competitor search than competitor cooperation; such a risk-averse propensity is strengthened by innovation failures.

<Table 3 Here>

Regarding the effects of control variables, firms that perform biotechnological businesses, are larger in size, and belong to a business group generally have a higher openness to competitors; market uncertainty decreases firms' propensity to engage in competitor search and cooperation. External buying is negatively associated with

competitor search and the relative risk-averse propensity.

Supplemental Analyses

One assumption we made about managers' risk-averse propensity is that the combination of costly R&D investment with innovation failures will arouse managers' fear of competition risk. To test this, we gained insights from Giarratana and Mariani (2014) and relied on knowledge protection activities as an indirect proxy for managers' fear of losing proprietary knowledge. In the CIS, respondents were asked whether or not they adopt protections in terms of patenting, industrial model registrations, trademark registrations, and copyrights. We generated a variable—*knowledge protection breadth*—an indirect proxy for perceived competition risk. The four types of protection approaches are summed up, with firms scoring 0 if no protections are used, while 4 indicates that all approaches are adopted. Our regression results indicate that the joint effect of R&D investment and historical innovation failure on knowledge protection breadth is positive ($b=0.009$, $p<0.001$) and that knowledge protection breadth is positively associated with relative risk-averse propensity ($b=0.008$, $p<0.001$). These results help to rule out alternative explanations.

Robustness Check

We added several analyses to test the sensibility of our results. First, Laursen and Salter (2014) had well-established arguments about the differences between search and cooperation (the former is a “soft” form, typically with indirect learning approaches, whereas the latter is “hard,” which usually involves deep interaction). As a robustness check, we computed the value difference between competitor search and competitor cooperation as *indirect search* variable. That is, we coded

indirect search with 1 for firms that used competitors' knowledge with a medium or higher degree of importance but had no bilateral relationships and 0 indicating otherwise. In so doing, this variable is much "purer" as an indicator of unilateral openness mode. Our results about the interaction effects on indirect search follow a pattern similar with early findings, although the significance level of some variables is reduced (historical: $b=0.00$, $p>0.1$; social: $b=0.02$, $p<0.05$).

Third, endogeneity concerns of our results can be mitigated by using the panel data and by lagging the explanatory variables. Since a proportion of firms in our sample do not have R&D investment, we attempted to address potential selection bias because of unobservable firm attributes. For example, high-quality firms are often preferred by venture capital investors and are thus able to build risky cooperative relationships. We used two-stage Heckman models (Heckman, 1979) to rule out the influence of unobserved firm heterogeneity by pre-estimating the likelihood of having R&D investment. In the first *probit* model (with the dummy of R&D investment as dependent variable), we included two-period lagged variables, including *R&D investment*, *external funding support* (a dummy variable indicating whether or not a firm received external financial support) as well as biology dummy, firm size, and market uncertainty.¹⁷ This model generated a reverse mills ratio and we included it in the second set of models (which predict firm openness). Our results are very similar to earlier analyses. That is, the interaction of R&D investment and innovation failure is positively associated with competitor

¹⁷ Statistically, the correlation between $R\&D\ investment_{(t-2)}$ and $R\&D\ investment_{(t-1)}$ is 0.592, while its correlations with competitor search, competitor cooperation, and relative risk-averse propensity are only 0.189, 0.152 and 0.096, respectively. The correlation between external funding support_(t-2) and $R\&D\ investment_{(t-1)}$ is 0.312, while its correlation with competitor search, competitor cooperation, and relative risk-averse propensity is 0.134, 0.205 and 0.012, respectively. These results initially support the appropriateness of R&D investment and external funding support as the explanatory in the *probit* model (The first-stage results can be found in Appendix 2).

search (historical: $b=0.011$, $p<0.001$; social: $b=0.005$, $p<0.05$) and relative risk-averse propensity (historical: $b=0.00$, $p>0.1$; social: $b=0.002$, $p<0.001$). By contrast, the interaction effect of R&D investment and innovation failure on competitor cooperation is significantly negative (historical: $b=-0.026$, $p<0.1$; social: $b=-0.109$, $p<0.001$).

Discussion and Conclusion

This study has explored the factors that drive a firm to be open to competitors. Building on the ACAP view, we suggest a positive relationship between R&D investment and two forms of openness to competitors: competitor search and competitor cooperation. We further find that innovation failure, on the one hand, triggers a firm to intensify its technological efforts to search competitors' knowledge; on the other hand, it enhances managers' fear of competition risk and thus weakens the effects of R&D investment on competitor cooperation. Our findings offer several important contributions to the ACAP view and open innovation literature.

First, our work adds to the conversation on open innovation literature by introducing the ACAP view in a competitive context. Responding to calls for considering competitors as a component of a firm's innovation system (Bengtsson & Raza-Ullah, 2016; Stanko et al., 2017), our work suggests that R&D investment plays an important role in shaping firms' propensity to interact with competitors in terms of both search and cooperation. These results support the ACAP view that technological accumulation helps to build a firm's ability to absorb external knowledge. In other words, a firm's absorption scope can be extended to cover competitive relationships. This finding also helps to explain the phenomenon, observed by Gnyawali and Park (2011), that technological giants (more R&D

investments) are more likely than small firms to engage in co-opetition and build competitive alliances.

The second important finding of our research is that the relationship between R&D investment and firm openness to competitors is contingent upon innovation failure. While the original version of the ACAP view makes a unique contribution to understanding firm openness, recent theoretical works point out that the view is not sufficient to explain complex choices without considering the factors that trigger these choices (Todorova & Durisin, 2007; Zahra & George, 2002). This is because although high R&D investments enable firms to be more open, being open is far from automatic (especially in competitive context). Working with competitors may only be activated by managers' need to reduce self-development limitations or by external industrial shocks. By evidencing the moderating role of innovation failure (a typical activation trigger), our work adds to the important contingency perspectives. Empirically, we follow the literature on performance feedback (Cyert & March, 1963; Greve, 1998) (which equates failures with performance below firm historical and social aspirations) and consider historical and social innovation failures. We obtain similar findings on the influence of two types of failures related to competitor search. That is, with higher R&D investments, innovation failure will prompt firms to search for competitors' knowledge to reduce technology risk. These findings advance current understandings about the moderating role of activation factors and thus sheds lights on boundary conditions for the enabling effects of R&D investment on external knowledge search.

However, the findings of hypothesis 2 and hypothesis 3 suggest that high R&D investment, combined with innovation failure, will reduce risk-taking behaviors. While prior studies have recognized the value-creation mechanisms of different openness modes, recent scholars caution that cooperation involves deeper interactions and thus leads to high risks relative to knowledge search (Dussauge et

al., 2000; Laursen & Salter, 2014). Especially considering that the risks are salient due to competing behaviors (Cui et al., 2018; Luo et al., 2007), we offer a rationale as to why managers experiencing failures will not build cooperation with competitors. That is, the combination of high R&D investment and innovation failure increases managers' fear of losing proprietary knowledge in competitive context; such fear makes managers behave in risk-averse ways, selectively choosing competitor search over competitor cooperation.

Exploring these two contrasting moderating hypotheses, we emphasize that innovation failure, as a typical activation trigger, can be positive and negative, depending on the types of openness modes. This insight adds to a selective openness view. Prior research on selective openness has mainly focused on either a “closedness-or-openness” decision—whether or not a firm should be open (Almirall & Casadesus-Masanell, 2010; Felin & Zenger, 2014). Highlighting the risk implications of different openness modes, our work shifts the attention from “whether a firm should be open” to “how to be open” (Alexy et al., 2013; Balka et al., 2014). Additionally, scholars have previously analyzed openness decisions mainly based on how firms should manage different modes to obtain superior innovation results (e.g., Balka et al., 2014). Our findings bring us to a more “practical” position on managers: they not only consider the benefits of openness to competitors but also the risks that such actions may bring. These results also resonate with Giarratana and Mariani (2014)'s claim that firms tend to internalize technological activities in places where outsiders show strong ACAP; in such locations, firms will suffer higher risks from outsiders' imitation.

Our study also offers important suggestions for managers who practice open innovation in competitive context. Going back to his original book, Chesbrough (2003) noted that one critical decision for open innovation practices is how managers should select an appropriate openness mode. The choice is particularly

important regarding openness to competitors. In this light, our work provides an answer—selective openness—which helps to achieve the balance between benefits and risks of being open to competitors. As Rindfleisch and Heide (1997: 44) conclude, firms can protect themselves by “pursuing a variety of unilateral and bilateral hybrid governance mechanisms.” We suggest that managers should adopt more unilateral searching activities, such as monitoring, overserving, imitating or indirectly learning from their competitors, while reducing bilateral interaction, such interfirm collaboration or joint work. This is because such bilateral activities will make the focal firm be bound up with their competitors, thus bring high competition risk.

Limitation and Future directions

Our research is not without limitations. First, we focus only on R&D investment and argue on behalf its role in forming the basis of ACAP. However, ACAP is a multidimensional concept; others suggest that firm’s structure (Arora et al., 2014), individual-level factors (Dahlander, O'Mahony, & Gann, 2016), and culture (Antons & Piller, 2015) may also influence a firm’s ability to be open. Future research could enrich our work by exploring the influence of these aspects. Second, our research confirms managers’ risk-averse propensity in terms of selecting openness modes. But we cannot thoroughly check managers’ perceptions concerning the expected benefits and risks of openness to competitors. Additionally, managers’ perceptions and subsequent decisions may be contingent upon cooperation contexts where firms have different goals, strengths, or power structures. Future research may want to delve into such cognitive characteristics by employing in-depth interviews. Third, future research could also go beyond an emphasis on inbound open innovation modes and add perspectives about

selectiveness on outbound open innovation such as free sharing and selective revealing (Alexy et al., 2013; Henkel, 2006). Finally, our research context encompasses manufacturing and service firms in Spain, a country that is not technologically cutting-edge but also not lacking in innovative ideas. The generalizability of our findings and the implications of our theories can be extended by using the CIS data of other countries that are characterized by different economic, cultural, and institutional features.

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Figures and Tables of Chapter 2

Figure 1. Conceptual model

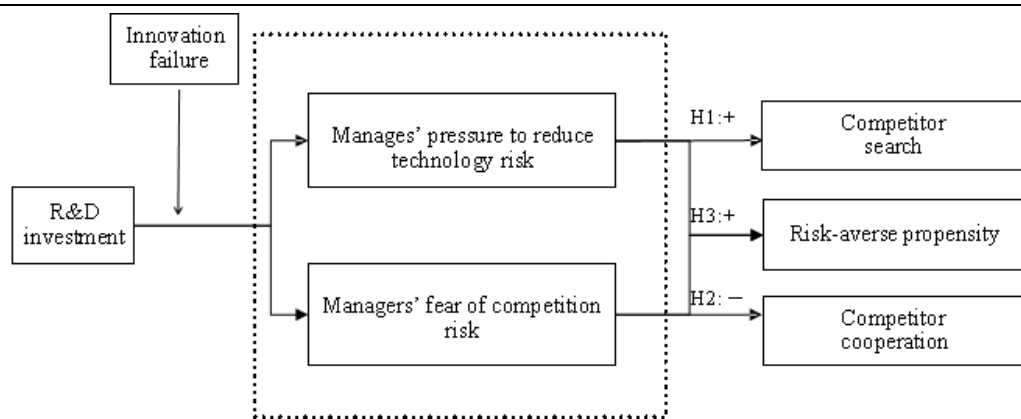


Figure 2. The moderating role of historical innovation failure between R&D investment and competitor search.

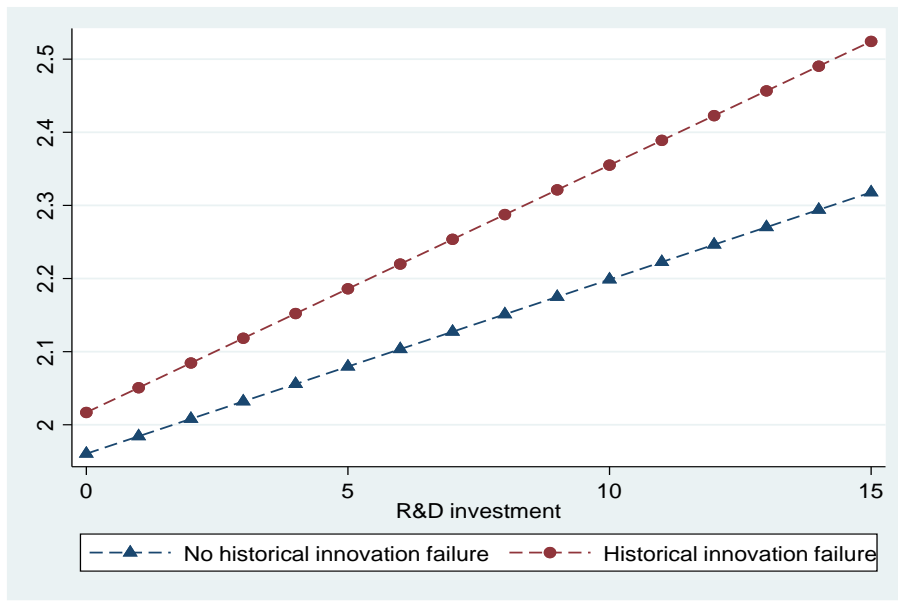


Figure 3. The moderating role of social innovation failure between R&D investment and competitor search.

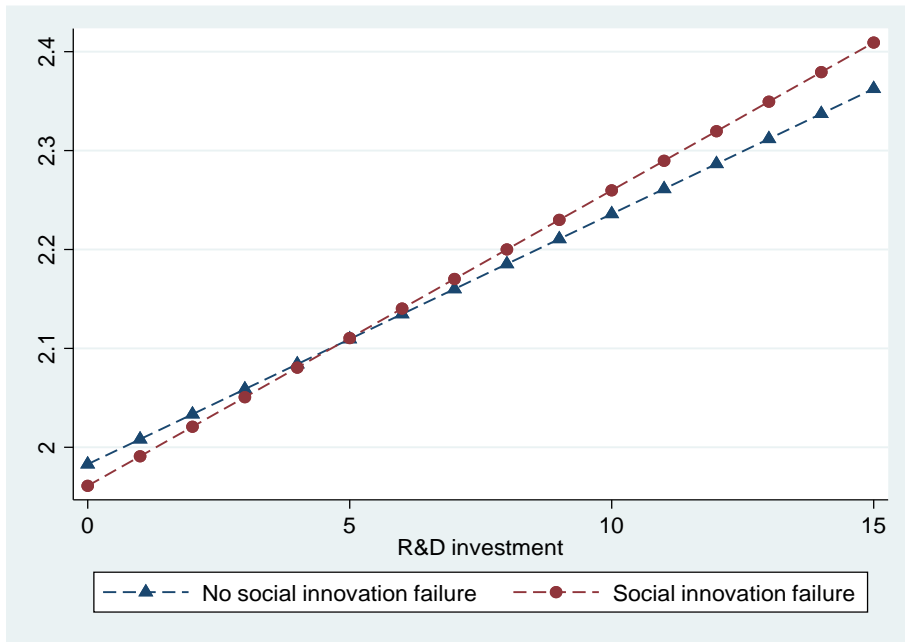


Figure 4. The moderating role of historical innovation failure between R&D investment and competitor cooperation.

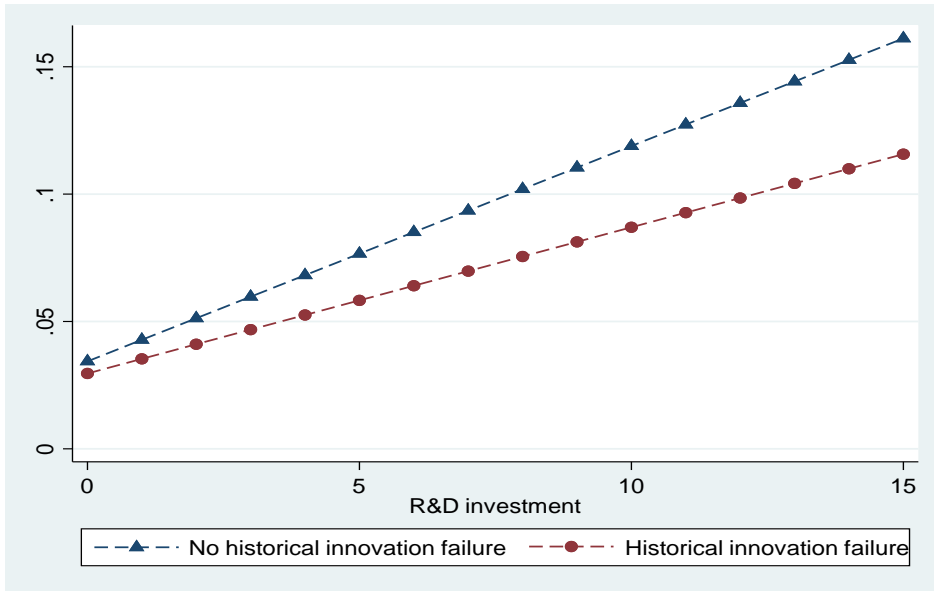
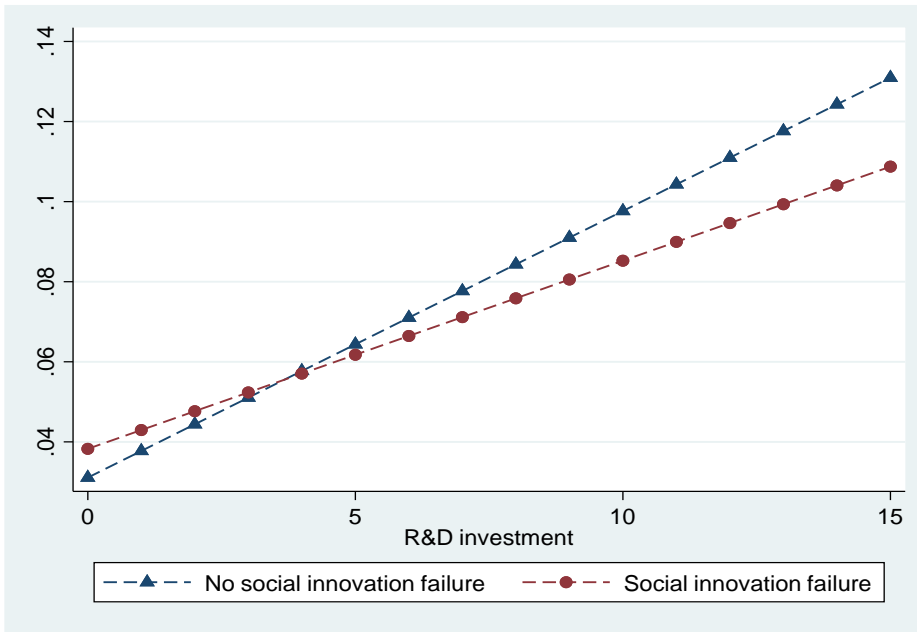


Figure 5. The moderating role of social innovation failure between R&D investment and competitor cooperation.



	Mean	S.D.	1	2	3	4	5	6	7	8	9	10	11
Competitor search	2.198	1.034											
Competitor cooperation	0.093	0.290	0.17*										
Relative risk-averse propensity	0.192	0.172	0.65*	-0.43*									
R&D investment _(t-1)	6.887	3.382	0.20*	0.16*	0.10*								
Historical innovation failure _(t-1)	0.273	0.445	0.12*	0.09*	0.06*	0.07*							
Social innovation failure _(t-1)	0.270	0.444	0.04*	-0.04*	0.05*	0.01*	-0.01*						
Start up _(t-1)	0.009	0.096	0.01	0.01	0.00	0.07*	0.00	0.03*					
Biology dummy _(t-1)	0.057	0.233	0.04*	0.08*	-0.01*	0.14*	0.03*	-0.02*	0.02*				
Firm size _(t-1)	4.228	1.571	0.05*	0.08*	0.01	-0.17*	0.04*	-0.01*	-0.09*	-0.05*			
Company group _(t-1)	0.426	0.495	0.06*	0.04*	0.03*	-0.02*	0.05*	-0.00	-0.03*	0.00	0.48*		
Buying activities _(t-1)	9.952	21.971	0.01*	0.04*	-0.01	0.17*	-0.01*	-0.01	0.01*	0.03*	0.04*	0.07*	
Market uncertainty _(t-1)	2.393	1.026	-0.13*	-0.05*	-0.08*	-0.12*	-0.11*	-0.04*	-0.01	-0.02*	0.12*	0.08*	0.01

Notes: Pearson's correlation coefficients; * p<0.05; N=79733.

Table 2. Random effects model—the determinants of competitor search and competitor cooperation								
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
	Competitor search				Competitor cooperation			
Start up _(t-1)	0.041	0.039	0.039	0.038	0.044	0.047	0.078	0.079
	(0.034)	(0.034)	(0.034)	(0.034)	(0.165)	(0.165)	(0.166)	(0.165)
Biology dummy _(t-1)	0.065**	0.064**	0.065**	0.064**	0.608***	0.608***	0.606***	0.606***
	(0.020)	(0.020)	(0.020)	(0.020)	(0.095)	(0.095)	(0.095)	(0.095)
Firm size _(t-1)	0.071***	0.070***	0.070***	0.070***	0.451***	0.452***	0.450***	0.451***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.023)	(0.023)	(0.023)	(0.023)
Company group _(t-1)	0.050***	0.050***	0.050***	0.050***	-0.044	-0.045	-0.043	-0.044
	(0.011)	(0.011)	(0.011)	(0.011)	(0.058)	(0.058)	(0.058)	(0.058)
Buying activities _(t-1)	-0.001***	-0.001***	-0.001***	-0.001***	0.002+	0.002+	0.002+	0.002+
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
Market uncertainty _(t-1)	-0.057***	-0.057***	-0.057***	-0.057***	-0.146***	-0.145***	-0.144***	-0.144***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.020)	(0.020)	(0.020)	(0.020)
Historical innovation failure _(t-1)	0.125***	0.056***	0.125***	0.057***	0.402***	0.730***	0.398***	0.683***
	(0.008)	(0.017)	(0.008)	(0.017)	(0.041)	(0.122)	(0.041)	(0.123)
Social innovation failure _(t-1)	0.010	0.010	-0.022	-0.021	-0.065	-0.068	0.785***	0.762***
	(0.008)	(0.008)	(0.018)	(0.018)	(0.045)	(0.045)	(0.138)	(0.138)
R&D investment _(t-1)	0.026***	0.024***	0.025***	0.023***	0.282***	0.293***	0.300***	0.308***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.008)	(0.009)	(0.009)	(0.010)
R&D investment _(t-1) *		0.010**		0.010**		-0.040**		-0.035*
Historical innovation failure _(t-1)		(0.002)		(0.002)		(0.014)		(0.014)
R&D investment _(t-1) *			0.005*	0.004*			-0.106***	-0.103***
Social innovation failure _(t-1)			(0.002)	(0.002)			(0.016)	(0.016)
Constant	1.806***	1.813***	1.808***	1.816***	-6.538***	-6.577***	-6.581***	-6.613***
	(0.061)	(0.062)	(0.061)	(0.061)	(0.302)	(0.302)	(0.302)	(0.302)
Number of observations	79733	79733	79733	79733	117745	117745	117745	117745
R-square/Log likelihood	0.1467	0.1468	0.1461	0.1462	-17731.07	-17727.15	-17711.71	-17708.74
Year	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Chi2	2189.826	2211.081	2194.610	2215.714	2667.272	2652.137	2666.475	2652.636
Notes: Standard errors in parentheses; ⁺ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.								

Openness to Competitors and Firm Innovation

Table 3. The relative propensity of competitor search over competitor cooperation				
	Model 1	Model 2	Model 3	Model 4
Start up(t-1)	0.004 (0.006)	0.004 (0.006)	0.004 (0.006)	0.004 (0.006)
Biology dummy(t-1)	-0.006+ (0.004)	-0.006+ (0.004)	-0.006+ (0.004)	-0.006+ (0.004)
Firm size(t-1)	0.005*** (0.001)	0.005*** (0.001)	0.005*** (0.001)	0.005*** (0.001)
Company group(t-1)	0.006** (0.002)	0.006** (0.002)	0.006** (0.002)	0.006** (0.002)
Buying activities(t-1)	- 0.000*** (0.000)	- 0.000*** (0.000)	- 0.000*** (0.000)	- 0.000*** (0.000)
Market uncertainty(t-1)	- 0.007*** (0.001)	- 0.007*** (0.001)	- 0.007*** (0.001)	- 0.007*** (0.001)
Historical innovation failure(t-1)	0.010*** (0.001)	0.010*** (0.003)	0.010*** (0.001)	0.010*** (0.003)
Social innovation failure(t-1)	0.003* (0.001)	0.003* (0.001)	-0.007* (0.003)	-0.007* (0.003)
R&D investment(t-1)	0.003*** (0.000)	0.003*** (0.000)	0.003*** (0.000)	0.003*** (0.000)
R&D investment(t-1) * Historical innovation failure(t-1)		0.000 (0.000)		0.000 (0.000)
R&D investment(t-1) * Social innovation failure(t-1)			0.001*** (0.000)	0.001*** (0.000)
Constant	0.176*** (0.010)	0.176*** (0.010)	0.177*** (0.010)	0.177*** (0.010)
Number of observations	79733	79733	79733	79733
R-square	0.075	0.075	0.074	0.074
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Chi2	1144.899	1145.558	1157.811	1158.460
Notes: Standard errors in parentheses. + p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001				

Appendix

Appendix 1. Using the difference of normalized competitor search and normalized competitor cooperation as an alternative variable of risk-averse propensity	
	Model
	Nor(competitor search) – Nor(competitor cooperation)
Start up(t-1)	0.046 (0.067)
Biology dummy(t-1)	-0.116** (0.043)
Firm size(t-1)	-0.031*** (0.008)
Company group(t-1)	0.062** (0.021)
Buying activities(t-1)	-0.001** (0.000)
Market uncertainty(t-1)	-0.030*** (0.007)
Historical innovation failure(t-1)	0.029* (0.014)
Social innovation failure(t-1)	0.028+ (0.015)
R&D investment(t-1)	0.002 (0.002)
R&D investment(t-1) * Historical innovation failure(t-1)	-0.006 (0.004)
R&D investment(t-1) * Social innovation failure(t-1)	0.011** (0.004)
_cons	-0.102 (0.093)
<i>Number of observations</i>	79733
<i>R-squared</i>	0.066
Year	Yes
Industry	Yes
Chi2	705.459
Notes: Standard errors in parentheses + $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.	

Openness to Competitors and Firm Innovation

Appendix 2. The first-stage Heckman results	
	The likelihood of having R&D investment
R&D investment(t-2)	0.213 ^{***}
	(0.002)
External funding support(t-2)	0.289 ^{***}
	(0.016)
Biology dummy(t-2)	0.250 ^{***}
	(0.041)
Firm size(t-2)	0.215 ^{***}
	(0.005)
Market uncertainty(t-2)	-0.056 ^{***}
	(0.006)
_cons	-1.591 ^{***}
	(0.076)
Number of observations	105381
Year	YES
Industry	YES
Log likelihood	-3.7e+04
Chi2	2.7e+04
Notes: Standard errors in parentheses	
+ p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001.	

Chapter 3: Is it possible to absorb competitors' knowledge to innovate? A synthetic view of absorptive capacity and the paradox of openness

Abstract

Using the longitudinal panel data of Spanish manufacturing and service firms during 2006-2016, we examine whether firms with a higher R&D investment can absorb knowledge from competitors to innovate, as well as whether or not they should adopt knowledge-protection mechanisms. We draw upon an absorptive capacity (ACAP) view and propose that innovation development can be achieved through absorbing competitors' knowledge (ACK). The process includes two stages—potential (i.e., the firm develops its ability to identify and acquire knowledge from competitors by more R&D investment) and realized (i.e., the firm transforms and exploits the acquired knowledge with the result of innovation development). Based on this process, our work finds that a firm's R&D investment in the past (which forms the base of ACAP) will increase innovation performance in the future; this can be achieved by ACK, in forms of searching for knowledge from, and cooperating with, competitors. Moreover, the positive and negative roles of knowledge protection pertain to different stages: it strengthens the effect of R&D investment on ACK (in the potential stage), whereas it weakens the efficiency of ACK in fostering innovation (in the realized stage). Highlighting ACK as a process factor, our work extends the ACAP view to competitive context and helps to resolve the debate on the paradox of openness and knowledge protection.

Keywords: R&D investment, absorptive capacity, open innovation, knowledge protection, paradox of openness

Introduction

As a critical source of innovation development, a firm's absorptive capacity (ACAP) is its ability to acquire, assimilate, and transform ideas acquired from external environments into new knowledge (Cohen & Levinthal, 1990; Teece, 1992). Given that valuable knowledge may reside outside an organization, researchers have recently become more interested in innovation performance that can be fostered by absorbing knowledge from external parties (Ehls, Polier, & Herstatt, 2020; Love, Roper, & Vahter, 2014; West & Bogers, 2014). A large body of empirical work has confirmed the values of external knowledge sources. Examples of such sources include customer feedback as a generator of novel ideas (Poetz & Schreier, 2012), university-enterprise collaborations as drivers of breakthrough innovations (Perkmann et al., 2013), and licensing-in as an accelerator of innovation (Leone & Reichstein, 2012).

However, how firms can absorb competitors' knowledge to innovate has received very little attention (Hoffmann, Lavie, Reuer, & Shipilov, 2018; Stanko, Fisher, & Bogers, 2017: 551). This is an important omission in research, because competitors may not only "provide" valuable knowledge, but they may also strive and compete against focal firms (Katila & Chen, 2008; Luo, Rindfleisch, & Tse, 2007). The absorption of competitors' knowledge (ACK)¹⁸ requires firms to draw knowledge from competitors' fields, while competitors may purposively capture the involuntary spillovers of, or even steal, focal firms' knowledge (McGahan & Silverman, 2006). As extant literature discusses, close linkages with competitors, for instance, in the forms of formal collaborations (Hamel, Doz, & Prahalad, 1989;

¹⁸ In this paper, we use the absorption of competitors' knowledge and absorbing competitors' knowledge (ACK) interchangeably.

Wu, 2014) or strategic alliances (Dussauge, Garrette, & Mitchell, 2000; Luo et al., 2007), may allow firms to access advanced technological skills and maximize the benefits of knowledge recombination. However, such linkages may also leave the firms exposed to the risks of knowledge spillovers, which are the results of imitation (Giarratana & Mariani, 2014; Lieberman & Asaba, 2006), opportunism (Luo et al., 2007; Park & Russo, 1996; Williamson, 1985), or value misappropriation (Buss & Peukert, 2015; Gulati & Singh, 1998; Laursen & Salter, 2014).

To minimize the abovementioned risks, effective knowledge-protection mechanisms are required, such as patents, copyrights, or trademark registrations. Such mechanisms have aroused scholarly debates on the paradox of openness and protection (Arora, Athreye, & Huang, 2016; Lauritzen & Karafyllia, 2019; Laursen & Salter, 2014).¹⁹ Some scholars have argued that protective measures could prevent information leakages (Buss & Peukert, 2015; Chesbrough, 2003; Estrada, Faems, & de Faria, 2016) and speed up the acquisition of new knowledge (Katila, Rosenberger, & Eisenhardt, 2008; Ritala & Hurmelinna-Laukkanen, 2013). However, other scholars view knowledge protection as detrimental to innovation, because it represents a defensive position and willingness to control resources (McGahan & Silverman, 2006; Somaya, 2012). As such, knowledge protection can discourage partners from information sharing and knowledge exchange (e.g., Wadhwa, Bodas Freitas, & Sarkar, 2017; Wang, Libaers, & Park, 2017), and can also delay knowledge integration (Alexy, Criscuolo, & Salter, 2009; Nelson, 2016). The tension between the enabling and restraining effects of knowledge protection highlights the need for a better understanding of these effects on innovation through

¹⁹ Some scholars may also regard the paradox debate as paradoxical relationship between information sharing and protection. The paradox of openness in this study centers on the roles of knowledge protection in value creation.

ACK.

This study aims to answer *how* firms can absorb knowledge from competitors to innovate and focuses on *whether* these firms should adopt knowledge-protection mechanisms. We believe that inconsistent views on knowledge protection are derived partly from the implicit assumptions in prior studies that the knowledge creation process is static (Todorova & Durisin, 2007; Volberda, Foss, & Lyles, 2010). Volberda et al. (2010: 936) criticize these assumptions: “Very few empirical studies of AC [absorptive capacity] fully capture the development, lagged, and path-dependent characteristics of AC. Most authors continue to frame their arguments in a very static way.” Consisting of different stages, the process of innovating through ACK should involve the time and path of change. As the seminal work (Cohen & Levinthal, 1990: 136) points out, a firm’s ACAP, which is accumulated through prior knowledge, permits that firm to understand and exploit knowledge in the future. A recent extension of the ACAP view details these characteristics, noting that to innovate, firms should first invest to build technological capacity to recognize and acquire external knowledge (the potential stage). Then, the acquired knowledge can be exploited and transformed into innovations (the realized stage) (Todorova & Durisin, 2007; Zahra & George, 2002). These two stages construct the whole process of innovating achieved through absorbing external knowledge.. The potential stage, during which a firm intensifies efforts to acquire knowledge, is dominated by the focal firm. This potential stage emphasizes the roles played by past R&D investments in forming the base of the firm’s ACAP. The realized stage requires joint efforts between partners and includes knowledge sharing, interfirm communications, and mutual coordination, thus highlighting the effectiveness (outcomes) of ACK (i.e., generating innovations). These stages underpin different theoretical implications and empirical logic.

Scholars have called for empirical investigation to unlock the process of innovating through ACK (Hoffmann et al., 2018; Lauritzen & Karafyllia, 2019).

To fill the knowledge gap, this study draws upon the ACAP view (Cohen & Levinthal, 1990; Zahra & George, 2002) and uncovers the process through which R&D investment leads to innovation performance by establishing ACK as a mediator. That is, a firm's past R&D investment increases its abilities for ACK. Then, the firm benefits from the increased ACK in fostering innovation. Regarding the forms of ACK, we consider not only whether a firm establishes formal cooperation with competitors, i.e., *competitor cooperation* (Gnyawali & Park, 2011; Wu, 2014), but also consider the extent to which the firm draws knowledge from its competitors, i.e., *competitor search* (Katila, 2002; Laursen & Salter, 2006). Moreover, knowledge protection is established as a theoretically important moderator, and we theorize that the enabling and restraining roles of knowledge protection pertain to different stages (Ritala & Stefan, 2021). The potential stage underlines a firm's ability to absorb knowledge, which is strengthened by knowledge protection. In contrast, the efficiency of the realized stage relies on joint efforts with competitors, thus allowing the protection initiatives to restrain the creation of new knowledge.

Our ideas are supported by panel data collected from a sample of manufacturing and service firms in Spain from 2006 to 2016. Our findings contribute to the ACAP view and the literature on open innovation in several ways. First, our study answers the recent call to add competitors to a firm's innovation system by delineating that the competitors could be a critical source of new knowledge. Second, by highlighting ACK as a process factor, our study uncovers an influential mechanism that explains the relationship between R&D investment and innovation performance. We suggest that ACK can be a channel through which

a firm intensifies technological efforts to foster innovation. Finally, and most importantly, our work helps to reconcile the debate on the paradox of openness and protection by demonstrating the dynamic and dual role of knowledge protection in the process of innovating through ACK.

Knowledge Absorption and Innovation Performance

Cohen and Levinthal (1989, 1990) viewed technological knowledge as public goods that could be used without excessive costs, as long as firms have well-developed abilities to “identify, assimilate, and exploit knowledge from the environment”. They termed this ability as ACAP by emphasizing “the two faces of R&D”: R&D investment not only enables a firm to develop new knowledge within organizations but also enhances the firm’s ability to acquire external knowledge.

While the seminal framework (Cohen & Levinthal, 1989, 1990) implies that knowledge absorption is akin to a dynamic learning process, a formal and explicit development emphasizing this dynamic nature is in more current versions (Lane, Koka, & Pathak, 2006; Volberda et al., 2010; Zahra & George, 2002). As Zahra and George (2002: 186) pointed out: “[Previous] studies do not always capture the rich theoretical arguments and the multidimensionality of the ACAP construct.” They theorized that the process of innovating through absorbing external knowledge should consist of the four sub-processes of acquisition, assimilation, transformation, and exploitation. Of these, the former two are conceptualized as the potential stage, while the latter two are regarded as the realized stage (also see Todorova & Durisin, 2007). Both stages are necessary to construct the whole process of innovating through absorbing external knowledge. Without first developing ability to recognize and acquire valuable knowledge, firms cannot exploit and transform that

knowledge. Similarly, having the ability to acquire knowledge from outsiders does not guarantee the creation of new knowledge. For example, start-ups and market-oriented enterprises usually have a good sense of technological directions and can identify market opportunities (potential stage), but they do not perform as effectively in transforming and applying the opportunities to commercial ends (realized stage) (Ritala & Hurmelinna-Laukkanen, 2013). The two stages underline different theoretical perspectives and forms of empirical logic, thus offering us the opportunity to develop contrasting theoretical arguments (Jansen, Van Den Bosch, & Volberda, 2005). Given both the bright and dark sides of competitors, the ACAP view tends to be especially meaningful in a competitive context. Managers must be able to evaluating the potential values of competitive relationships before working with their competitors to prevent the shouldering of risks that outweigh the returns.

In this study, we zoom in on the process of innovating through ACK and divide the process into two stages. The first stage is *the potential stage*, in which a focal firm invests to build its ability to identify and acquire competitors' knowledge, i.e., in the forms of competitor search or competitor cooperation. Relying on R&D investments in relevant fields of knowledge, the firm can accumulate experience while developing its skills and processes for identifying and grasping external opportunities (Cohen & Levinthal, 1990). For example, De Jong and Freel (2010) find that R&D expenditure helps firms to relief geographical limitations and enable the firm to collaborate with distant partners. They can do this because these R&D efforts help firms overcome cognitive constraints and develop their abilities to evaluate and comprehend diverse knowledge (Zahra & George, 2002). Thus, the potential stage solves the problem of how a firm could increase ACK by highlighting R&D investment as a critical antecedent.

The second stage is *the realized stage*, which is about transforming and

exploiting the knowledge acquired in the potential stage (Zahra & George, 2002). Here, a firm refines and leverages existing routines that incorporate ACK and facilitates the generation of new combinations with the elements at hand. Such generation usually requires coordination among employees and joint efforts between competitor firms through typical approaches such as inter-organizational learning (Lane & Lubatkin, 1998) or the development of a set of interfirm routines (Dyer & Singh, 1998). Thus, knowledge sharing plays an important role in this stage. For example, Estrada et al. (2016) found that knowledge sharing is necessary for firms to benefit from cooperating with competitors, as it fosters information exchange among employees and disseminates the knowledge from competitors. A study at the interfirm level by Dyer and Singh (1998) argues that developing knowledge-sharing routines is critical to permitting the exchange, recombination, and creation of partner-specific knowledge in collaborative contexts. The outcomes of the realized stage are the creation of new knowledge in the forms of new products, services, or technologies (Grant & Baden-Fuller, 1995). Thus, the realized stage is subject to the relationship between ACK and its innovation outcomes (Volberda et al., 2010; Zahra & George, 2002).

Since the process of innovating through ACK is likely to leave a firm exposed to the risks derived from potential competition behaviors, it should be considered together with knowledge-protection mechanisms (Arora et al., 2016; Lauritzen & Karafyllia, 2019; Laursen & Salter, 2014). By *knowledge protection*, we mean the strength of activities undertaken to protect and appropriate the advantages and benefits of new products, technologies or processes (Arora et al., 2016; Laursen & Salter, 2014; Wadhwa et al., 2017). Such activities include patents, trademark registrations, and copyrights, among others (Cohen, Nelson, & Walsh, 2000). Ritala and Stefan (2021) suggested that the paradox of openness can be addressed by

separating protection efforts according to innovation stages. Such efforts may not only influence the effectiveness of R&D investment for ACK, but also affect the process by which external knowledge is transformed and combined with the firms' internal elements (Somaya, 2012; Wadhwa et al., 2017). Thus, we expect knowledge protection to play a opposite role in the potential and realized stages.

Literature Background and Hypotheses Development

R&D Investments, Absorption of Competitors' Knowledge (ACK), and Firm innovation

R&D investments increase firm innovation, whereas such impact may not be direct. Drawing upon the insights of the ACAP view to a competitive context, we posit that R&D investments will increase innovation performance, which can partly be achieved through enhancing ACK activities, e.g., searching and cooperation.

When R&D investments increase, firms should have greater ability and propensity for ACK activities (the potential stage). This is because the development of a knowledge base delimits the extent to which the firms can shoulder the risks of being open to competitors (Cohen & Levinthal, 1990; Gnyawali & Park, 2011; Grant & Baden-Fuller, 1995). When R&D investment levels are relatively low, managers may worry about their abilities to appropriate intellectual outputs from their large-sized partners (Leiponen & Byma, 2009); they may feel that the potential risks derived from opportunistic or invasive behaviors would be difficult to bear (Yang, Zheng, & Zhao, 2014). As Bleeke and Ernst (1995) observed, a competitive alliance may evolve into a situation in which small firms rely on their partnerships and gradually lose their own proprietary knowledge.

As R&D investments increase, however, firms are better able to identify knowledge transfer opportunities and increase potential combinations, due to the increased likelihood of encountering complementary and compatible elements (Dussauge et al., 2000; Fleming, 2001; Lane & Lubatkin, 1998). Accumulations in diverse technologies and perspectives enable firms to find matched models more easily. With more experience, the costs of searching and transacting in competitive fields may also decrease because of learning effects (Cassiman & Valentini, 2016). Indirect evidence of cost-savings was provided by De Jong and Freel (2010), who found that investments in developing ACAP (operationalized by R&D investments) enable firms to cooperate distantly because of the reduced cognitive constraints and barriers to knowledge exchange imposed by geographical distances. In terms of risk, providing additional resources support allows firms to be aware of how to handle uncertainties with competitors and reduce the risks of failures in cooperation (Gnyawali & Park, 2011; Lhuillery & Pfister, 2009). For instance, professional consultants who reconcile complex competitive relationships have expertise in establishing agreements.

By increasing ACK, a firm can improve its innovation performance (the realized stage). First, competitors are believed to be references that act as indicators of market and industrial changes (Amit, Domowitz, & Fershtman, 1988; Katila, 2002). With competitors as benchmarks, firms can avoid the mistakes of prior searches and make technological activities more reliable (Katila & Chen, 2008). In addition, following industrial leaders enables firms to gain up-to-date information that may signal current market needs and upcoming technological opportunities. The acquisition of such information helps firms acquire early mover advantages (Katila, 2002).

Second, competitors serve as good partners for creating collective strengths.

They usually face shared challenges, such as entry threats, technological revolutions, or industrial unrest, some of which cannot be handled by a single firm. By investing in joint efforts, firms expect to leverage collective efficiency, which is an advantage that cannot be achieved when the firms work alone or independently (Mesquita & Lazzarini, 2008; Schmitz, 1999). More importantly, competitors usually possess unique knowledge and skills regarding how to deploy resources (Barney, 1991; Gnyawali & Park, 2011; Grant, 1996). Such idiosyncratic capabilities enable competitors to co-exist, as well as to provide low-cost and differential offerings in the same environments (Porter, 1985; Porter & Millar, 1985).

Third, competitors usually have closely-related competence bases and similar dominant logics (Dussauge et al., 2000; Mesquita & Lazzarini, 2008). A dominant logic reflects the way of how managers “conceptualize the business and make critical resource allocation decisions” (Prahalad & Bettis, 1986: 490). These characteristics ease any difficulties in terms of comprehending each other’s thinking patterns and engaging in inter-organizational learning (e.g., Fiol & Lyles, 1985; Lane & Lubatkin, 1998). In their conceptual work, Lado, Boyd, and Hanlon (1997) described “co-opetition” (simultaneously cooperate and compete, see Brandenburger & Nalebuff, 1996; Nalebuff, Brandenburger, & Maulana, 1996) as a syncretic rent-seeking strategy. Such a syncretic model views the conflicts among rivals as “functional”, meaning that such rivalry can facilitate knowledge exchange and mutual learning. Competition is like a race that can ignite each competitor’s potential. Similarly, Luo et al. (2007: 73) argued that co-opetition was not necessarily a “win–lose” game because it could “accomplish both competitive and cooperative goals and boost profits in a ‘win–win’ manner.” Other scholars (Dussauge et al., 2000; Ritala & Hurmelinna-Laukkanen, 2009) have also

suggested that competitive interactions demonstrate quicker knowledge transfers and higher potential than non-competitive interactions, in terms of creating returns on innovation.

In summary, we suggest that a firm's past R&D investments could increase ACK by means of searching or cooperation (the potential stage), which then, in turn, improves innovation performance (the realized stage). Thus, ACK serves as a mediating mechanism that enables firms to exploit the potentials of their R&D investments. Hence, we have the following hypothesis.

Hypothesis 1: ACK mediates the relationship between R&D investment and innovation performance, such that R&D investment will indirectly increase innovation performance by increasing ACK.

The Moderating Role of Knowledge Protection in the Potential Stage

Managers fear unwanted knowledge spillovers and intellectual property (IP) infringements during the process of innovating through ACK (Buss & Peukert, 2015; Giarratana & Mariani, 2014). Such incidents are especially problematic in the knowledge fields of competitors (Laursen & Salter, 2014), as competitors, by definition, are characterized by conflicting goals. To catch up with its peers (Chen, 1996; Hamel, 1991) or to avoid dethronement (Ross & Sharapov, 2015), competitors may purposively monitor, collect, and even steal the focal firm's information. To prevent such risks, managers are likely to adopt protections that will limit the illegal usage of their products, technologies, or IPs (Cassiman & Veugelers, 2002; Cohen et al., 2000). We posit that high R&D investment combined with knowledge protection will increase a firm's propensity for ACK.

First, protection activities can weaken managers' fear of spillovers of internal knowledge. As Alexy et al. (2009) observed, some firms follow a “no patent, no talk” policy with competitors. When a protection regime is present, a firm limits the illegal usage of its ideas, technologies, or models (Cohen et al., 2000). Managers may also guide their employees on what can and cannot be shared (Somaya, 2012). Such guidance ensures the safety of the firm's valuable knowledge before that firm enters in co-opetition or searches for external opportunities (Katila et al., 2008). With reduced concerns about knowledge spillovers, managers are likely to intensify their R&D efforts and access knowledge from competitors.

Second, the development of ACAP needs well-established protection mechanisms. When protection is absent, firms may have to resort to integrating vertically and focus on limited technological activities (that are under protection) (Teece, Pisano, & Shuen, 1997). In such circumstances, the role of knowledge investments in developing ACAP is not being exploited fully because the scope and space of technological activities are constrained. In contrast, with protections, firms have more space to develop ideas and enjoy the benefits of technological developments more adequately (e.g., Teece, 2007; Teece et al., 1997). Firms can better understand their existing knowledge base and therefore behave more flexibly to acquire knowledge from outsiders. As Ritala and Hurmelinna-Laukkanen (2013) argued, building firms' ACAP and competitive advantages needs to set obstacles to external imitation and to understand knowledge base comprehensively. Accordingly, Ritala and Hurmelinna-Laukkanen (2013: 161) found that “a well-developed and multifaceted [protection] regime ... could (*sic*) expect to help in terms of reaping the benefits of potential ACAP more effectively”.

For the above reasons, knowledge protection should strengthen the roles played by R&D investment in reinforcing the ability to absorb knowledge from

competitors. Therefore, we propose the following hypothesis:

Hypothesis 2: The positive effects of R&D investments on ACK are strengthened when knowledge protection is present.

The Moderating Role of Knowledge Protection in the Realized Stage

The realized stage requires knowledge exchange, information sharing, and other joint efforts between the focal firm and that firm's competitors. We posit that protection activities in this stage will impair effective knowledge transformation.

First, knowledge protection reflects a firm's strength in appropriating innovation returns. Yet, it could be interpreted by competitors as defensive, because it represents the reserving or controlling of resources (McGahan & Silverman, 2006; Somaya, 2012). For example, patents make exclusive commercial promises related to a firm's technologies and make knowledge difficult to access. Therefore, they strengthen the firm's territorial awareness and safeguard its interests, thereby limiting rivals' ability to use the protected technologies. Furthermore, in the presence of patents, competitors may doubt that the focal firm will openly be contributing useful information to any joint work (Ritala & Hurmelinna-Laukkanen, 2009). They are also more likely to be concerned that the focal firm may act opportunistically (Hamel, 1991) and appropriate their returns on innovation (Ritala & Hurmelinna-Laukkanen, 2009). These concerns will, thus, hurt relational commitment and mutual trust (Kale, Singh, & Perlmutter, 2000), negatively affecting the willingness to share knowledge (Kathoefer & Leker, 2012) and subsequent innovation development (Antons & Piller, 2015).

Second, when a firm becomes heavily embedded in a protective and

confidential culture, the cost of combining knowledge with its external partners' increases (Gulati & Singh, 1998; Leiponen & Byma, 2009). For instance, managers must coordinate different departments and negotiate with colleagues in different R&D units, while employees must follow complex procedures to unlock the protected technologies. Furthermore, firms with strong protective cultures tend to lack high-quality interactions and rich communication channels (Wadhwa et al., 2017). Nelson (2016) found that researchers in firms that emphasize secrecy can neither obtain knowledge effectively nor provide timely feedback. The increased cost of coordination and communication can delay innovation projects. In contrast, an open and inclusive atmosphere supports more communication, knowledge exchange, and mutual learning among researchers, thus increasing collaboration efficiency (Arora et al., 2016) and innovation outcomes (Jensen & Webster, 2009).

We should admit that when protection is limited, a firm may unwittingly leak some information. However, these leakages – albeit unwelcome – tend to be highly random and non-specific (Alexy, George, & Salter, 2013), and we believe the loss of the non-specific linkages to be much smaller than the benefits created by purposively disclosed knowledge. Alexy et al. (2013) argued that randomly revealed information is merely captured by firms but is of negligible use to their innovation, due to the information's low complementarity. In contrast, disclosures that reflect particular needs and specific requirements can bring complementary and compatible offerings (Alexy et al., 2013; Henkel, 2006; Nelson, 2016). When innovating with competitors, the knowledge purposively disclosed by the focal firm should be more specific and complementary than knowledge that is unintentionally leaked. These complementary offerings shorten the knowledge matching process, speed up knowledge recombination, and maximize the likelihood of innovation success (Alexy et al., 2013).

For these reasons, we propose that knowledge protection negatively impacts the effectiveness of knowledge transformation.

Hypothesis 3: The positive effects of ACK on innovation performance are weakened when knowledge protection is present.

Methodology

Data and Sample

Figure 1 depicts the conceptual model developed above. Responding to the call for a longitudinal design to examine the process of innovating through ACK (e.g., Lane et al., 2006; Todorova & Durisin, 2007), we used a set of database constructed by eleven-wave Spanish Community Innovation Surveys (CIS) during 2006-2016. CIS has been proved to be a valid and reliable database in innovation studies (e.g., Laursen & Salter, 2006; Love et al., 2014; Wadhwa et al., 2017). The survey, as an important part of European Union Science and Technology Statistics, was conducted annually by the Spanish National Statistics Institute and other official departments. The survey object is Spanish manufacturing and service firms, almost covering all firms that have more than 100 employees and meanwhile engage in innovation activities. The manufacturing category consists of 39 subsectors and the service category consists of 4 subsectors (at the level of two-digit classification codes of NACE rev. 2.0). The survey mainly involves firm innovation-related information, including internal and external R&D activities, funding support, knowledge protection and innovation performance. The respondents of the survey (usually CEOs, general managers, or technological executives) were asked to report this information in the past three years. A three-year lag can avoid reporting biased

performance that derives from a temporally abnormal revenue or one-time negative experience. It also covers a typical innovation cycle according to the European Union Science and Technology Statistics, as the influence of R&D investment for firm innovation needs to take time to manifest (Christensen, Verlinden, & Westerman, 2002; Wadhwa et al., 2017).

Compared to other countries' surveys, the Spanish CIS has several strengths. First, it provides more details, such as knowledge protection activities. Most datasets contain only patenting information, without reporting such protection information as industrial models or copyrights registration. Second, it was conducted every year, generating a longitudinal structure that tracks the development of firm innovation. Third, the survey is officially mandatory for Spanish firms and requires respondents to provide as accurate information as possible. More introduction about CIS can be found on the European Statistic website.²⁰

<Figure 1 inserted about here>

Variables and Measurement

Dependent Variable

Our dependent variable is innovation performance. In line with the approaches of extant studies based on CIS (e.g., Laursen & Salter, 2006; Leiponen & Helfat, 2011), we measured innovation by firms' sales revenues from newly introduced products or services (after logarithmic transformation). The turnover reflects the added

²⁰ See <https://ec.europa.eu/eurostat/web/microdata/community-innovation-survey>

commercial values because of its newly added innovations, thus indicating the level to which the firm is good at generating new knowledge. In the CIS questionnaire, respondents were asked how many commercial sales of new goods or services were introduced to the company and market during the past three years. We computed the variable by adding the two parts—new-to-company and new-to-market products or services—and regarded the total turnover as the innovation performance.

Mediating Variable

Regarding the forms of knowledge absorption from competitors, we consider both *competitor search* and *competitor cooperation*. The former is more aligned with a problem-solving process that involves the relocation, recombination, and manipulation of competitors' ideas to create new knowledge (Katila, 2002; Katila & Chen, 2008; Laursen & Salter, 2006), while the latter refers to a formal collaborative relationship with competitors, which emphasizes simultaneous cooperation and competition, i.e., co-opetition (Gnyawali & Park, 2011; Wu, 2014). Previous research has suggested that both forms can create new knowledge.²¹

Gaining insights from extant literature (Laursen & Salter, 2006; Laursen & Salter, 2014), we measured competitor search by accessing respondents' evaluations on the extent to which the information sourced from competitors is important for advancing innovation activities. The survey lists a series of sources of information such as suppliers, clients and competitors, and requires respondents

²¹ Though Dahlander and Gann's (2010) typology work suggests that different forms may have different implications, our theory (from the absorptive capacity view) primarily concerns the absorption of knowledge and regards competitor search and competitor cooperation as two typical forms. Distinguishing their difference is beyond the task of this study.

to evaluate the degree of importance of each source (ranging from 1-“not used” to 4-“high-importance”). Since competitor search may only happen when reaching some importance levels, we followed Laursen and Salter (2006) and Leiponen and Helfat (2010) and generated a binary indicator as the proxy for competitor search. It was coded as 1 for firms that used competitor’s knowledge at the “middle-” or “high-importance” level, and 0 indicating otherwise.

We measured competitor cooperation by looking at whether or not the firm in question had formal cooperation with competitors. The variable was coded as 1 for firms that have competitors as their cooperation partners, and 0, otherwise.

Moderating Variables

The moderator in the current study is knowledge-protection mechanisms, which involve a range of possible methods adopted by firms to protect IP rights. Consistent with prior research using CIS data (e.g., Estrada et al., 2016), we created a binary variable, *knowledge protection*, according to respondents’ feedback on whether or not the firm had at least one of the following protection methods: patents, industrial models registration, trademark registration and copyrights registration in the past three years.²² The variable was coded as 1 for firms that did so, and 0 indicating otherwise. Since our theoretical interest concerns primarily the roles of knowledge protection in the potential and realized stages, this variable was measured twice at both the potential and realized stages to test hypothesis 2 ($\text{knowledge protection}_{(t-2)}$) and hypothesis 3 ($\text{knowledge protection}_{(t-1)}$),

²² We have also analyzed possible differences regarding the moderating roles of different knowledge protections, and yet, our results are not significant. Though this is not the task of this study, results are available upon request.

respectively.

Independent variable

A firm's R&D investment is typically measured by its spending on innovation activities. R&D investment reflects a firm's efforts in developing knowledge base and has very commonly been used as proxies for knowledge-related investment (Lane et al., 2006). Both R&D spending and the number of employees were reported in the CIS questionnaire. Although some studies used R&D spending scaled by total sales as the proxy, a proportion of a firm's R&D spending to its employee number tends to be more stable and is less likely to be affected by business cycles and accounting manipulations (Scherer, 1986). Such statistical issues can be salient in our context as our empirical design includes fourteen separate surveys across a long period during which firms may have experienced several business cycles. Thus, consistent with prior research (e.g., Baysinger, Kosnik, & Turk, 1991; Cohen & Levinthal, 1990), we computed the R&D spending per employee (after logarithmic transformation) as the measurement of R&D investment.

Control Variables

We controlled for several variables that may influence firm innovation performance. First, *start-up* measures whether the firm was newly built or not. If "the company was newly created", we assigned a value of 1 for the variable and 0 indicating otherwise. As high-technology firms (i.e., biotechnology firms in our context) might demonstrate unique attributes (Zhang & Baden-Fuller, 2010), we controlled

for *biotechnology firms* to avoid potential bias. If “the company performs any activities based on sciences and technologies applied to living organisms or compounds obtained from these, to acquire knowledge or products of value”, we coded the variable with the value of 1, and 0, otherwise. Moreover, since large firms usually possess more financial assets and human capital, *firm size* was controlled through the total number of employees. In addition, whether the firm is one part of a firm group (including subsidiary company, affiliate, joint company and associate company) might affect their external networks and further affect innovation activities. Thus, a binary variable, *company group*, was added as a control.

Research has suggested that a firm’s external R&D activities influence its knowledge protection (Laursen & Salter, 2014) and innovation performance (Wadhwa et al., 2017). Thus, to rule out this effect that potentially biases our results, we controlled for the strength of *external spending* by calculating the ratio of the monetary investment in purchasing R&D products or technologies from external companies, universities or other institutions (multiplied by 100). As a firm’s strategy is possibly contingent upon environmental factors, we also controlled for *market uncertainty* to capture the effect of the market dynamism. This variable was measured by respondents’ evaluations on the extent to which the uncertainty in customers’ demand for new products or services hinders the firm’s innovation activities. The value was coded from 1-“not applicable” to 4-“high”. Finally, we generated *year* and *industry* dummy variables to control for period and industry heterogeneity. Table 1 summarizes the above variables in the analysis.

Analyses and Results

The Spanish CIS data constructs an unbalanced panel. We employed firm-random

(industry/year-fixed) effects estimation models because our theoretical interest concerns both between-firm and within-firm variances. That is, we aim to explore the dynamic roles of knowledge protection in the innovation process, which is assumed to be time-variant and heterogeneous between firms. Such time-variant heterogeneity and between-firm variances can be captured by firm-random models, whereas the between-firm variance would be discarded by fixed models (Certo, Withers, & Semadeni, 2017; Greene, 2008). For continuous variables, innovation performance, we conducted linear regressions, whereas for mediating variables, (i.e., competitor search and competitor cooperation), we employed logistic analyses to deal with its bivariate nature. In all models involving interactions, continuous variables were centered to calculate interaction items. No variance inflation factors of variables (VIFs) are higher than ten, and the mean values are all smaller than two, which suggests that multicollinearity is not a big concern (Hair, Black, Babin, Anderson, & Tatham, 1998). Table 1 describes the mean, standard deviation and correlation of the variables.

<Insert Table 1 about here>

We followed Baron and Kenny (1986) procedure to test the mediation hypothesis, i.e., hypothesis 1. Theoretically, a process view was implied in this hypothesis. Therefore, we lagged R&D investment and controls by one period when predicting competitor search/cooperation; we lagged R&D investment by two periods and competitor search/cooperation and other controls by one period when predicting innovation performance. In so doing, the path ($R\&D\ investment_{(t-2)} \rightarrow knowledge\ absorption_{(t-1)} \rightarrow innovation\ performance_{(t-0)}$) reflects the dynamics of the innovation process

(Newsom, Jones, & Hofer, 2013). Empirically, controlling for the lagged independent variable can mitigate the endogeneity concern aroused by potential reverse causality (Semykina & Wooldridge, 2010). We also included the lagged dependent variable by one period (i.e., $\text{innovation performance}_{(t-1)}$) as a control when predicting $\text{innovation performance}_{(t-0)}$. In so doing, our models can capture potential serial correlation of the error from autoregressive regression and account for the accumulation effects of past innovation growth (Newsom et al., 2013; Robert Baum & Wally, 2003; Rodríguez & Nieto, 2016). To examine the moderation effects, i.e., hypothesis 2 and 3, we generated the interaction between $\text{R\&D investment}_{(t-2)}$ and $\text{knowledge protection}_{(t-2)}$, as well as that between $\text{competitor search}_{(t-1)}/\text{cooperation}_{(t-1)}$ and $\text{knowledge protection}_{(t-1)}$.

Moreover, since a small proportion of firms in our sample have no R&D investments, we adopted a two-stage Heckman model to address potential selection bias (Heckman, 1979). In the first step, we estimated the likelihood of having R&D investment using a previous *xtprobit* model. We used *external funding support* (a dummy variable indicating whether or not a firm received external financial support) (Rodríguez & Nieto, 2016) and above stated control variables to predict the likelihood of having R&D investment. We lagged these variables by two periods ($t-2$) (results see Appendix 1). In doing so, we generated inverse mills ratios and added them to regression models (i.e., the second step). More specifically, the first half of hypothesis 1 and hypothesis 2 were tested as follows:

$$\begin{aligned}
 \text{Model 1 – Model 4: } & (\textit{Competitor search or competitor cooperation})_{(t-1)} \\
 & = \alpha_0 + \beta_1(\textit{R\&D investment})_{(t-2)} \\
 & + \beta_2(\textit{knowledge protection})_{(t-2)} \\
 & + \beta_3(\textit{R\&D investment})_{(t-2)} \\
 & \times (\textit{knowledge protection})_{(t-2)} + \beta_4(\textit{inverse mills ratio})_{(t-1)} \\
 & + \beta_{i-4}(\textit{controls})_{(t-2)} + \varepsilon_i
 \end{aligned}$$

Following economic specification was used to test the second half of hypothesis 1:

$$\begin{aligned}
 \text{Model 5 – Model 7: } & \textit{Innovation performance}_{(t-0)} \\
 & = \alpha + \beta_1(\textit{knowledge protection})_{(t-1)} \\
 & + \beta_2(\textit{competitor search or competitor cooperation})_{(t-1)} \\
 & + \beta_3(\textit{innovation performance})_{(t-1)} \\
 & + \beta_4(\textit{knowledge protection})_{(t-2)} + \beta_5(\textit{R\&D investment})_{(t-2)} \\
 & + \beta_6(\textit{inverse mills ratio})_{(t-0)} + \beta_{i-6}(\textit{controls})_{(t-2)} + \varepsilon_i
 \end{aligned}$$

Then, the following economic specification was used to test hypothesis 3:

$$\begin{aligned}
 \text{Model 8 – Model 10: } & \textit{Innovation performance}_{(t-0)} \\
 & = \alpha + \beta_1(\textit{knowledge protection})_{(t-1)} \\
 & + \beta_2(\textit{competitor search or competitor cooperation})_{(t-1)} \\
 & + \beta_3(\textit{competitor search or competitor cooperation})_{(t-1)} \\
 & \times (\textit{knowledge protection})_{(t-1)} \\
 & + \beta_4(\textit{innovation performance})_{(t-1)} \\
 & + \beta_5(\textit{R\&D investment})_{(t-2)} + \beta_5(\textit{knowledge protection})_{(t-2)} \\
 & + \beta_6(\textit{inverse mills ratio})_{(t-0)} + \beta_{i-6}(\textit{controls})_{(t-2)} + \varepsilon
 \end{aligned}$$

In all the above models, α_0 is the constant, β_i is the coefficient of variables, and ε_i

is the error term. Table 2 and Table 3 report the regression results of our hypotheses.

<Insert Table 2 about here>

<Insert Table 3 about here>

In Table 2, Model 1 and Model 3 indicate that R&D investment_(t-2) has a significant and positive relationship with competitor search_(t-1) ($b=0.081$, $p<0.01$) and competitor cooperation_(t-1) ($b=0.278$, $p<0.01$). At the same time, Model 5 in Table 3 shows that R&D investment_(t-2) has a significant and positive relationship with innovation performance_(t) ($b=0.239$, $p<0.01$). According to Baron and Kenny (1986), if a variable (mediating variable) introduced into the regression has a significant relationship with the dependent variable, and meanwhile, the significance of the independent variable decreases, the mediation effect is supported. This is indeed in Model 6 and Model 7 (Table 3). Both competitor search_(t-1) and competitor cooperation_(t-1) have a significant and positive relationship with innovation performance_(t) ($b=0.508$, $p<0.01$; $b=0.449$, $p<0.01$). A further calculation according to Table 3 shows that the inclusion of competitor search reduces the significance of R&D investment_(t-2) from $z=52.97$ (Model 5) to $z=39.70$ (Model 6); the inclusion of competitor cooperation reduces it to $z=52.90$ (Model 7). Thus, the partial mediating effects in terms of both competitor search and cooperation are supported.

To estimate the direct and indirect effects of R&D investment, we conducted Sobel (1982) test and bootstrapping techniques (Hayes, 2009; Preacher, Rucker, & Hayes, 2007), with results reported in Table 4. The indirect effect through competitor search is 0.009, and the bootstrapping test suggests that the confidence

interval was [0.007, 0.010]. The ratio of indirect effect to total effect is 4.002%. The indirect effect achieved through competitor cooperation is 0.009, and the confidence interval of the bootstrapping test is [0.008, 0.010]. The ratio of the indirect effect exerted by R&D investment (through competitor cooperation) on total effect is only 4.02%. These results confirm the mediating role of ACK between R&D investment and innovation performance.

Hypothesis 2 posits a negative moderating role of knowledge protection in the potential stage of competitor search and cooperation. In Table 2, model 2 indicates that the interactional effect of knowledge protection_(t-2) and R&D investment_(t-2) on competitor search_(t-1) is positive and significant ($b=0.018$, $p<0.05$), whereas the coefficient of the interaction in predicting competitor cooperation achieves no significance. Thus, hypothesis 2 is supported only for the form of competitor search in our context. To depict the moderating effect, we followed Aiken, West, and Reno (1991)'s procedure and estimated the predicted marginal effects of R&D investment at high and low levels of knowledge protection. Figure 2 displays the positive moderating effect of knowledge protection between R&D investment and competitor search.

<Insert Figure 2 about here>

Hypothesis 3 posits that knowledge protection weakens the effect of R&D investment on innovation performance. Similarly, we modeled the procedure in testing hypothesis 2 to test this hypothesis. As Model 8 and 10 demonstrate, the interaction between competitor search_(t-1) and knowledge protection_(t-1) ($b=-0.181$, $p<0.05$), and that between competitor cooperation_(t-1) and knowledge protection_(t-1) ($b=-0.207$, $p<0.1$) are significant and negative. Accordingly, knowledge protection

plays a weakening role in the realized stage of absorbing knowledge from competitors in terms of both competitor search and cooperation, as hypothesis 3 argues. Figure 3 and Figure 4 display the weakening roles of knowledge protection between competitor search, competitor cooperation and innovation performance, respectively.

<Insert Figure 3 about here>

<Insert Figure 4 about here>

Supplemental Analysis and Robustness Check

We added several analyses to test the sensibility of our results. First, we performed the analyses without inverse mills ratio, and then without the autoregressive terms (innovation performance_(t-1) and/or knowledge protection_(t-2)). All results are very similar to earlier analyses (see Appendix 2).

Second, given that patenting may be one of the most commonly used protection tools (Arora et al., 2016; Laursen & Salter, 2014), we generated an alternative measure (*patenting*) for knowledge protection, i.e., whether or not the firm is granted patents (1 for yes and 0 for no). We re-conducted regressions and the results are generally consistent with earlier analyses (see Appendix 3).

Third, firms in the service sector may do not pursue innovation heavily and thus they are possibly under-presentative in our sample. To have a more balanced sample, we re-conducted our regression analyses by narrowing attention to only manufacturing firms. The results are still very similar with earlier analyses, which suggest that industry heterogeneity does not bias our results (see Appendix 4).

Theoretical and Practical Implications

This study was conducted to answer the question of how firms can innovate by ACK and whether they should adopt knowledge protections. We find that ACK can be a channel through which a firm increases its R&D investments to foster innovation. Moreover, knowledge protection strengthens the effects of R&D investments on ACK activities in the forms of competitor search and competitor cooperation, whereas knowledge protection weakens the effects of ACK activities on innovation. Our findings offer several important contributions to the existing literature on open innovation and practices.

First, many prior studies examining competitors' influences have been limited to situations where there is a formal cooperation arrangement in place, such as alliances (see Bengtsson & Raza-Ullah, 2016 for a review). Scholars in the field of open innovation, however, see competitors more broadly and identify them as important sources of knowledge that firms could draw upon via both bilateral cooperation and unilateral searching (e.g., observation, monitoring, or indirect imitation) (Dahlander & Gann, 2010; West & Bogers, 2014). Responding to calls to incorporate competitors into a firm's innovation system (Hoffmann et al., 2018; Stanko et al., 2017) and to consider different forms of absorption (e.g., Dahlander & Gann, 2010; Laursen & Salter, 2014), our analysis demonstrates the positive effects of ACK in terms of competitor search and cooperation. Furthermore, by establishing ACK as a theoretically important mediator, we have developed a finer-grained theoretical model to explain the relationship between R&D investment and innovation performance. We find that ACK partially mediates the effects of R&D investment on firm innovation. Our finding of the influential process extends research that emphasizes the direct influence of R&D investment on innovation. A

firm's past R&D investments can foster firm innovation. However, the positive effects of R&D investments are partially achieved through ACK. Therefore, our results support the "two faces of R&D" view (Cohen & Levinthal, 1989, 1990) and extend that view's explanatory scope to a competitive context by emphasizing the critical role of engaging with competitors as a means of exploiting the potentials of R&D investment.

Second, and more importantly, our findings on the opposite moderating roles of knowledge protection help to reconcile conflicting views on whether or not knowledge protections should be adopted in the process of innovating through ACK. Whereas most prior studies explored knowledge absorption in a static manner, scholars have recently called for dynamic perspectives (Hoffmann et al., 2018; Ritala & Stefan, 2021) and longitudinal designs (Todorova & Durisin, 2007; Zahra & George, 2002) to solve the paradox of openness. Responding to this call, this study adopts the ACAP view and identifies two stages that capture the antecedent of ACK and its innovation outcomes. We find that the propensity for ACK (i.e., competitor search) in the potential stage, where investments in ACAP explain increases in ACK, is strengthened when knowledge protection is present. This finding confirms those of Ritala and Hurmelinna-Laukkanen (2013), who noted that the positive role of potential ACAP in acquiring external knowledge may be achieved only with effective protection mechanisms. Wadhwa et al. (2017) also implied that the risks of knowledge spillovers and IP thefts in open innovation activities can be reduced by protection mechanisms, such as employee retention and secrecy. The confluence of R&D investment and knowledge protection provides firms a unique ability to innovate by engaging competition. It is worthwhile to note that we did not see the significant moderating role played by knowledge protection in shaping the effects of R&D investment on competitor

cooperation. This is possibly because cooperation is usually built upon statutory contracts which can protect collective interests and duplicate the function of knowledge protection mechanisms.

Interestingly, we have found that the presence of knowledge protection in the realized stage weakens the effects of ACK on firm innovation. This occurs because the purpose of the realized stage is to achieve knowledge transformation, which requires joint efforts such as information exchange, integration, and mutual dependence between partners. Similarly, Wadhwa et al. (2017) found that restrictions on access to knowledge cause firms to bear high coordination costs during knowledge internalization and integration. Ritala and Hurmelinna-Laukkanen (2009) stated that the dark side of protection mechanisms in a competitive context is more salient, because of the competitors' conflicting goals. Hence, these scholars acknowledge the need for integrating protection mechanisms and innovative activities. Our finding—that a trusty and friendly atmosphere is important if firms are to profit from ACK—is partly consistent with their views.

Our investigation of knowledge protection in both the potential and realized stages sheds light on the double-edged sword of knowledge protection's effects on firm innovation. Protection enables firms to leverage R&D efforts to absorb competitors' knowledge but weakens the effectiveness of ACK for generating innovations. Our study suggests that knowledge protection should be considered, not only from an integrative, but also from a dynamic perspective (Lauritzen & Karafyllia, 2019). A critical decision facing managers occurs “when firms make decisions to exercise or abandon the options embedded in patents” (Somaya, 2012: 1099). This issue is especially important in the field of research into co-opetition (Hoffmann et al., 2018; Ritala, 2012), given the heated debate on the paradox of openness (Lauritzen & Karafyllia, 2019; Ritala & Stefan, 2021). By explaining the

enabling and restraining roles played by knowledge protection in the potential and realized stages, respectively, our study provides a new answer to the question.

Our findings also provide some important managerial insights. First, managers should be much more aware of the value of competitors' knowledge. Although competitors are usually actors who strive against the focal firm, they are also important sources of knowledge. Competitors can provide industrial references and can be collaborative partners. Managers should understand the forces exerted by technological investments on the abilities of their firms to absorb knowledge from competitors. Managers should also acknowledge that their firms could benefit from searching and cooperating activities in the knowledge field of competitors. For example, Xiaomi, a smartphone manufacturer founded in 2010, is about to become one of the top three global smartphone providers in terms of market share in 2021. Besides having direct collaborations with competitors, such as Samsung, who supplies their display screens, Xiaomi has been closely following and imitating industrial leaders, such as Apple (Sampere, 2014).

Second, managers should manage knowledge protections from a "life cycle perspective", as well as from a "steady-state perspective" (Winter & Szulanski, 2001). Lauritzen and Karafyllia (2019) identified two organizational practices used to achieve "innovation through paradox": (1) a process of integration that combines the benefits of both poles of openness and protection, and (2) a differentiation pattern that involves separating the poles temporally. Consistent with this view, our findings suggest that managers should recognize the insufficiency of solely making technological investments in the potential stage of promoting ACK and acknowledge the need for protection mechanisms. As Cassiman and Veugelers (2002) suggests, "firms should take care of protecting their proprietary information before engaging in ... [cooperative] agreements." However, when firms collaborate

with competitors, reducing their protection strengths helps the collaborators to avoid being perceived as strongly appropriate and defensive. In this case, the partners will be more willing to share knowledge. In conclusion, for firms to profit from ACK, managers should follow a “dynamic” principle and adjust their knowledge-protection strategies appropriately, according to the stages of innovating through ACK.

Limitations and Future Research

Our study is also subject to certain limitations that future research may want to address. First, we only focus on two forms of inbound open innovation, namely competitor search and cooperation, which may differ from the modes of outbound open innovation. Although most empirical studies have examined inbound modes, scholars working on the typology of open innovation have also mentioned the differences between inbound and outbound knowledge flows, or between different forms of the logic of knowledge exchange (Dahlander & Gann, 2010). For example, Alexy et al. (2013) proposed that a firm’s purposeful disclosure of some specifically-selected information (i.e., selective revealing) will not increase the firm’s risk of knowledge spillover. In contrast, the disclosure will actually increase the likelihood of obtaining complementary resources, thus lowering search costs. Following this line of reasoning, the adoption of knowledge protection seems to be unnecessary and very likely plays a different role from that which is covered in this paper. Future research may seek to explore the differences between the roles of knowledge protection in inbound and outbound modes. Second, this study uses longitudinal data from a sample of manufacturing and service firms in Spain, a country that is neither standing on the technological frontier nor lagging in global innovation competition. The use of CIS data from other countries could reasonably

be expected to extend the findings and implications of our study.

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Figures and Tables of Chapter 3

Figure 1. Conceptual model of being open to competitors for innovate

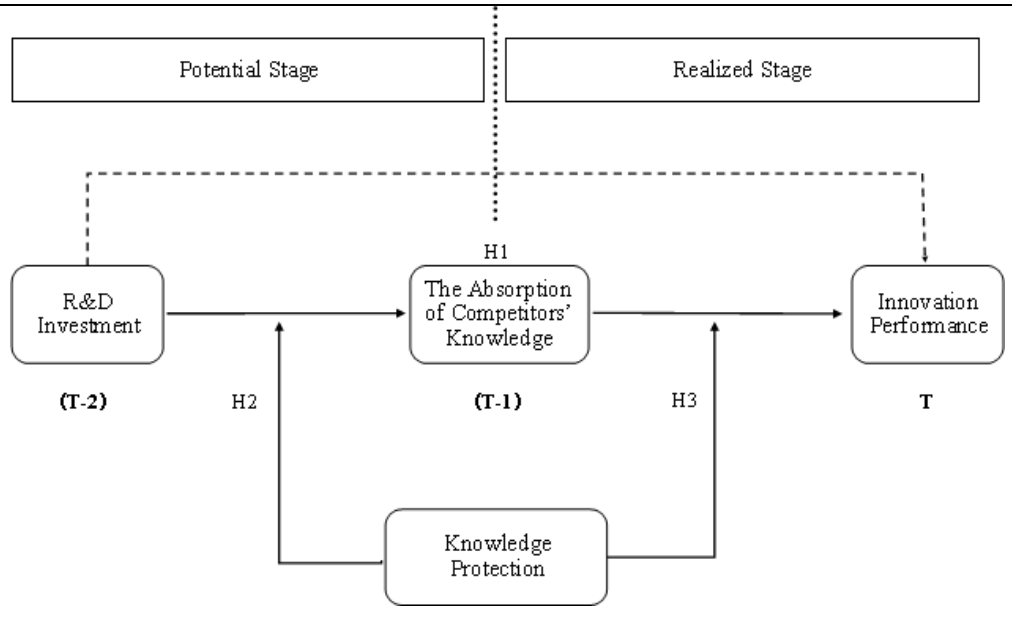


Figure 2. The moderating role of knowledge protection in potential stage (for competitor search)

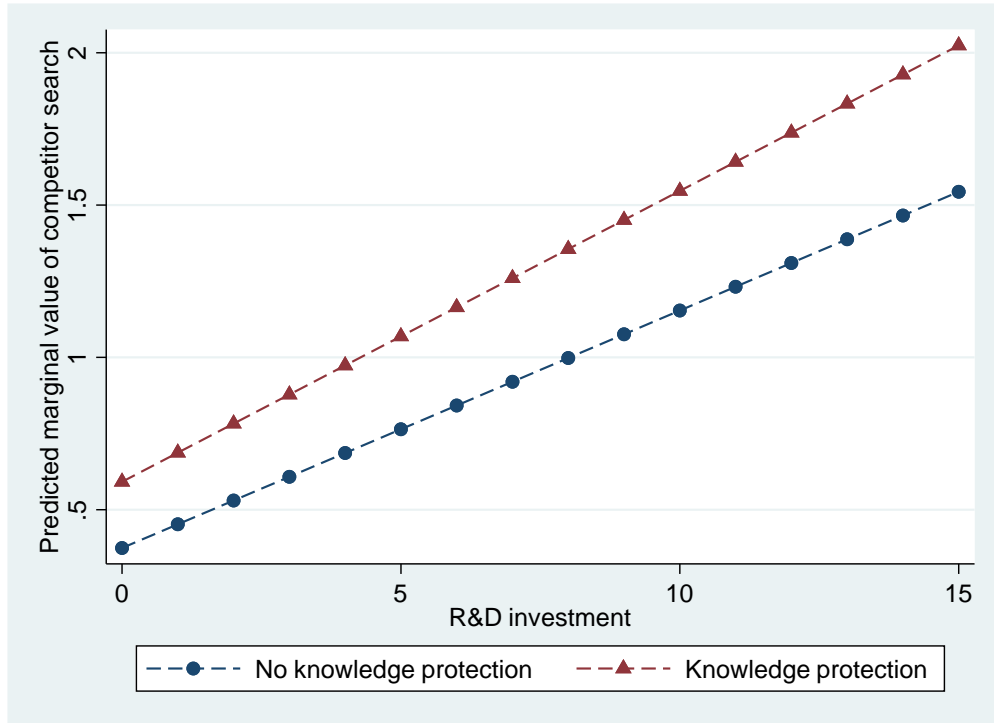


Figure 3. The moderating role of knowledge protection in realized stage (for competitor search)

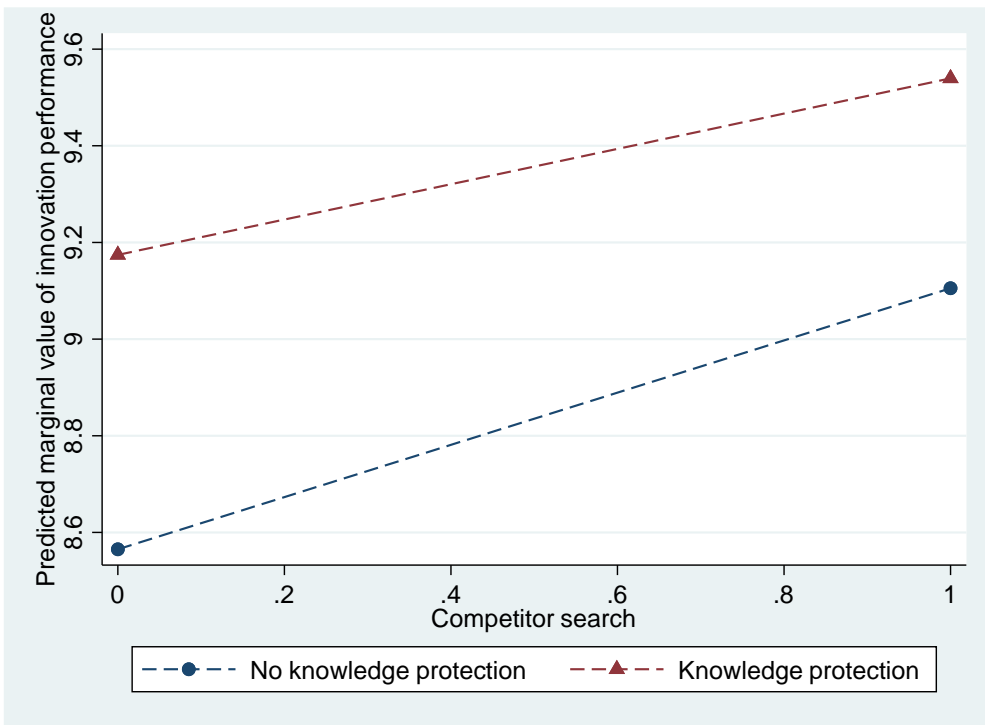


Figure 4. The moderating role of knowledge protection in realized stage (for competitor cooperation)

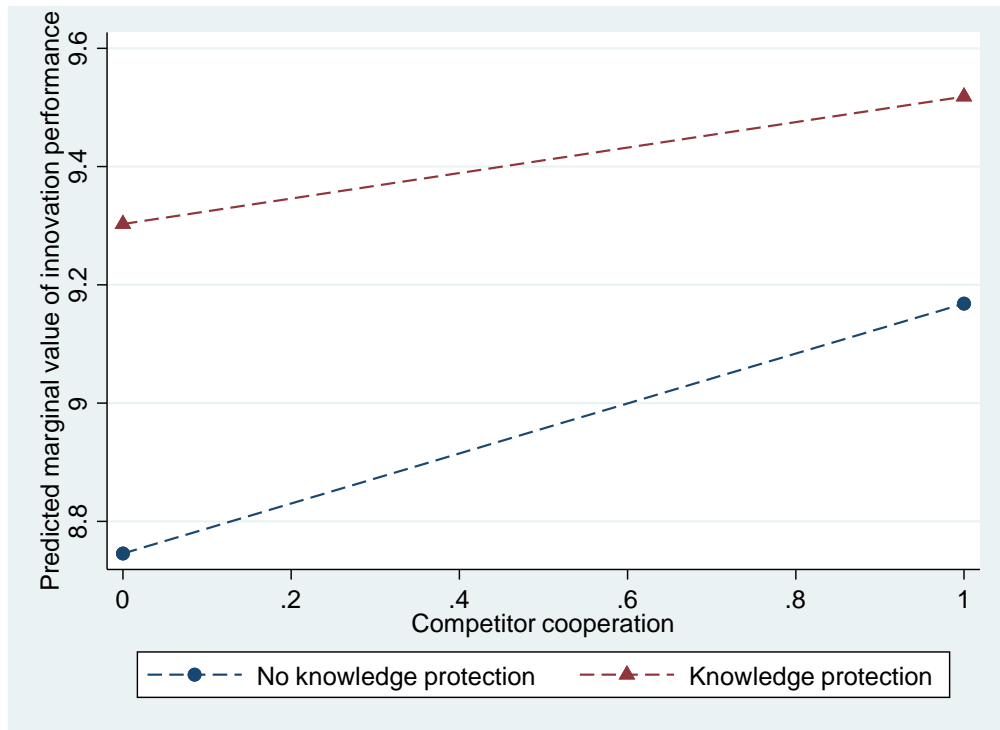


Table 1. The description and correlation of variables

	Mean	S.D.	Min	Max	1	2	3	4	5	6	7	8	9	10	11	12
Innovation performance _(t-0)	8.93	7.26	0	23.44												
Competitor search _(t-1)	0.41	0.49	0	1	0.18*											
Competitor cooperation _(t-1)	0.09	0.29	0	1	0.11*	0.15*										
Knowledge protection _(t-1)	0.29	0.45	0	1	0.21*	0.12*	0.11*									
Knowledge protection _(t-2)	0.31	0.46	0	1	0.19*	0.11*	0.10*	0.65*								
R&D investment _(t-2)	6.90	3.37	0	14.91	0.27*	0.15*	0.16*	0.18*	0.19*							
Innovation performance _(t-1)	9.40	7.10	0	23.44	0.74*	0.18*	0.11*	0.20*	0.19*	0.22*						
Start-up _(t-2)	0.01	0.10	0	1	-0.01	0.01	0.01	0.04*	0.04*	0.07*	0.01*					
Biotechnology firm _(t-2)	0.06	0.23	0	1	0.00	0.03*	0.08*	0.08*	0.09*	0.14*	-0.00	0.02*				
Firm size _(t-2)	4.23	1.57	0.69	10.63	0.18*	0.04*	0.08*	0.06*	0.05*	-0.18*	0.16*	-0.10*	-0.05*			
Company group _(t-2)	0.42	0.49	0	1	0.12*	0.05*	0.04*	0.02*	0.02*	-0.03*	0.11*	-0.03*	0.00	0.48*		
External spending _(t-2)	10.13	22.11	0	100	0.02*	0.00	0.04*	0.04*	0.04*	0.17*	0.01*	0.01*	0.03*	0.04*	0.06*	
Market uncertainties _(t-2)	2.39	1.03	1	4	-0.08*	-0.11*	-0.05*	-0.05*	-0.07*	-0.11*	-0.08*	-0.01	-0.02*	0.12*	0.08*	0.01

Notes: Pearson's correlation coefficients, * p<0.05.

Table 2. Regression analyses on absorption of competitors' knowledge				
	Model 1	Model 2	Model 3	Model 4
The absorption of competitors' knowledge				
	Competitor search _(t-1)		Competitor cooperation _(t-1)	
Start-up _(t-2)	0.053 (0.12)	0.045 (0.12)	-0.019 (0.17)	-0.022 (0.17)
Biotechnology firm _(t-2)	0.053 (0.08)	0.051 (0.08)	0.630*** (0.11)	0.629*** (0.11)
Firm size _(t-2)	0.172*** (0.04)	0.171*** (0.04)	0.547*** (0.06)	0.548*** (0.06)
Company group _(t-2)	0.110*** (0.04)	0.109*** (0.04)	-0.022 (0.06)	-0.022 (0.06)
External spending _(t-2)	-0.002*** (0.00)	-0.002*** (0.00)	0.002 (0.00)	0.002 (0.00)
Market uncertainties _(t-2)	-0.183*** (0.01)	-0.184*** (0.01)	-0.154*** (0.02)	-0.155*** (0.02)
Knowledge protection _(t-2)	0.342*** (0.03)	0.217*** (0.07)	0.303*** (0.04)	0.216 (0.15)
R&D investment _(t-2)	0.081*** (0.00)	0.078*** (0.00)	0.278*** (0.01)	0.277*** (0.01)
R&D investment _(t-2) × knowledge protection _(t-2)		0.018** (0.01)		0.010 (0.02)
Inversed Mills Ratio _(t-1)	-2.159** (1.09)	-2.183** (1.09)	3.100* (1.74)	3.104* (1.74)
_constant	0.292 (0.33)	0.318 (0.33)	-8.568*** (0.51)	-8.555*** (0.51)
<i>Number of observations</i>	75389	75389	110865	110865
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes
Log likelihood	-3.9e+04	-3.9e+04	-1.7e+04	-1.7e+04
Chi2	1971.465	1975.370	2483.693	2487.927
Notes: Standard errors in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.				

Table 3. Random-effect regression analyses on firm innovation performance						
	Innovation performance _(t-0)					
	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10
Innovation performance _(t-1)	0.693*** (0.00)	0.681*** (0.00)	0.692*** (0.00)	0.681*** (0.00)	0.692*** (0.00)	0.680*** (0.00)
Start-up _(t-2)	-1.188*** (0.16)	-1.125*** (0.18)	-1.179*** (0.16)	-1.126*** (0.18)	-1.179*** (0.16)	-1.120*** (0.18)
Biotechnology firm _(t-2)	-0.091 (0.07)	-0.104 (0.08)	-0.115 (0.07)	-0.104 (0.08)	-0.113 (0.07)	-0.119 (0.08)
Firm size _(t-2)	0.407*** (0.02)	0.432*** (0.03)	0.392*** (0.02)	0.433*** (0.03)	0.394*** (0.02)	0.421*** (0.03)
Company group _(t-2)	0.112*** (0.03)	0.065 (0.04)	0.114*** (0.03)	0.065 (0.04)	0.113*** (0.03)	0.067 (0.04)
External spending _(t-2)	-0.003*** (0.00)	-0.004*** (0.00)	-0.003*** (0.00)	-0.004*** (0.00)	-0.003*** (0.00)	-0.004*** (0.00)
Market uncertainties _(t-2)	-0.076*** (0.01)	-0.070*** (0.02)	-0.073*** (0.01)	-0.070*** (0.02)	-0.073*** (0.01)	-0.067*** (0.02)
Knowledge protection _(t-2)	0.141*** (0.04)	0.117** (0.05)	0.136*** (0.04)	0.118** (0.05)	0.137*** (0.04)	0.116** (0.05)
Knowledge protection _(t-1)	0.541*** (0.04)	0.536*** (0.05)	0.527*** (0.04)	0.618*** (0.06)	0.544*** (0.04)	0.628*** (0.06)
R&D investment _(t-2)	0.239*** (0.00)	0.239*** (0.01)	0.235*** (0.00)	0.239*** (0.01)	0.235*** (0.00)	0.236*** (0.01)
Competitor search _(t-1)		0.508*** (0.04)		0.563*** (0.04)		0.540*** (0.04)
Competitor cooperation _(t-1)			0.449*** (0.06)		0.521*** (0.07)	0.423*** (0.08)
Competitor search _(t-1) × knowledge protection _(t-1)				-0.181** (0.08)		-0.175** (0.08)
Competitor cooperation _(t-1) × knowledge protection _(t-1)					-0.173 (0.11)	-0.207* (0.13)
Inversed Mills Ratio _(t-0)	1.234*** (0.28)	-0.081 (0.40)	1.128*** (0.28)	-0.076 (0.40)	1.141*** (0.28)	-0.155 (0.40)
_constant	-1.395*** (0.18)	-1.356*** (0.24)	-1.326*** (0.18)	-1.376*** (0.24)	-1.338*** (0.18)	-1.326*** (0.24)
<i>Number of observations</i>	99436	73117	99436	73117	99436	73117
Year	Yes	Yes	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes	Yes	Yes

Chi2	2.0e+05	9.9e+04	2.0e+05	9.9e+04	2.0e+05	9.9e+04
<i>Overall R-square</i>	0.668	0.575	0.669	0.575	0.669	0.575
Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.						

Table 4. Sobel's test and bootstrapping test of direct and indirect effects ($X \rightarrow M \rightarrow Y$)					
Mediator	Effect type	Observed coefficient	Sobel's test Z-value	95% confidence interval	Proportion of total effect that is mediated
Competitor search	Direct effect	0.207	13.68***	(0.195, 0.219)	4.002%
	Indirect effect	0.009	37.26***	(0.007, 0.010)	
Competitor cooperation	Direct effect	0.215	53.99***	(0.206, 0.224)	4.020%
	Indirect effect	0.009	15.61***	(0.008, 0.010)	

Notes: Bootstrapping tests were conducted with 500 replications; ***p<0.001

Appendix

Appendix 1. Heckman approach the first stage regression results	
	The first stage: the likelihood of having R&D investment
External funding support	1.023*** (0.02)
Start up	1.377*** (0.13)
Biotechnology firms	0.942*** (0.06)
Firm size	0.204*** (0.01)
Company group	0.041* (0.02)
Market uncertainties	-0.167*** (0.01)
_cons	-0.369*** (0.14)
<i>Number of observations</i>	110865
Year	Yes
Industry	Yes
Log likelihood	-3.5e+04

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chi2	8243.522
Notes: Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.	

Appendix 2. Robustness check without Inverse Mills Ratio and autoregressive terms				
	Model 1	Model 2	Model 3	Model 4
	Competitor search	Competitor cooperation	Innovation performance	
Start-up _(t-2)	0.032 (0.12)	-0.003 (0.17)	-1.125*** (0.18)	-0.355 (0.22)
Biotechnology firm _(t-2)	0.112 (0.07)	0.552*** (0.10)	-0.114 (0.08)	-0.006 (0.14)
Firm size _(t-2)	0.250*** (0.01)	0.445*** (0.02)	0.432*** (0.01)	1.061*** (0.03)
Company group _(t-2)	0.107*** (0.04)	-0.022 (0.06)	0.066 (0.04)	0.228*** (0.08)
External spending _(t-2)	-0.002*** (0.00)	0.002* (0.00)	-0.004*** (0.00)	-0.006*** (0.00)
Market uncertainties _(t-2)	-0.183*** (0.01)	-0.155*** (0.02)	-0.067*** (0.02)	-0.155*** (0.02)
Knowledge protection _(t-2)	0.219*** (0.07)	0.217 (0.15)	0.116** (0.05)	
Knowledge protection _(t-1)			0.628*** (0.06)	1.407*** (0.07)
R&D investment _(t-2)	0.078*** (0.00)	0.277*** (0.01)	0.236*** (0.01)	0.358*** (0.01)
R&D investment _(t-2) × knowledge protection _(t-2)	0.017** (0.01)	0.010 (0.02)		
Innovation performance _(t-1)			0.680*** (0.00)	
Competitor search _(t-1)			0.540*** (0.04)	1.146*** (0.06)
Competitor cooperation _(t-1)			0.422*** (0.08)	1.074*** (0.11)
Competitor search _(t-1) × knowledge protection _(t-1)			-0.175** (0.08)	-0.366*** (0.10)
Competitor cooperation _(t-1) × knowledge protection _(t-1)			-0.208* (0.13)	-0.361** (0.16)
_cons	-0.212 (0.20)	-7.838*** (0.32)	-1.389*** (0.18)	-0.676 (0.41)
<i>Number of observations</i>	75389	110865	73117	73117
<i>R-square</i>	--	--	0.575	0.200
Year	Yes	Yes	Yes	Yes
Industry	Yes	Yes	Yes	Yes

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Log likelihood	-3.9e+04	-1.7e+04	--	--
chi2	1971.697	2478.692	9.9e+04	9432.740
Notes: Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.				

Appendix 3. Using patenting as an alternative variable			
	Model 1	Model 2	Model 3
	Competitor search	Competitor cooperation	Innovation performance
Start-up _(t-2)	0.062 (0.12)	0.025 (0.17)	-0.271 (0.22)
Biotechnology firm _(t-2)	0.113 (0.07)	0.558*** (0.10)	-0.017 (0.14)
Firm size _(t-2)	0.255*** (0.01)	0.447*** (0.02)	1.073*** (0.03)
Company group _(t-2)	0.106*** (0.04)	-0.027 (0.06)	0.210*** (0.08)
External spending _(t-2)	-0.002*** (0.00)	0.002* (0.00)	-0.006*** (0.00)
Market uncertainties _(t-2)	-0.188*** (0.01)	-0.158*** (0.02)	-0.161*** (0.02)
Patenting _(t-2)	0.079 (0.12)	0.355 (0.26)	
Patenting _(t-1)			1.582*** (0.10)
R&D investment _(t-2)	0.081*** (0.00)	0.280*** (0.01)	0.360*** (0.01)
R&D investment _(t-2) × Patenting _(t-2)	0.034** (0.01)	-0.001 (0.03)	
Competitor search _(t-1)			1.140*** (0.05)
Competitor cooperation _(t-1)			1.016*** (0.10)
Competitor search _(t-1) × Patenting _(t-1)			-0.530*** (0.13)
Competitor cooperation _(t-1) × Patenting _(t-1)			-0.300 (0.19)
<i>Number of observations</i>	75389	110865	73117

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<i>R-squared</i>	--	--	0.196
Year	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Log likelihood	-3.9e+04	-1.7e+04	--
Chi2	1900.196	2465.736	9220.397
Notes: Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.			

Appendix 4. Manufacturing firms			
	Model 1	Model 2	Model 3
	Competitor search	Competitor cooperation	Innovation performance
Start-up _(t-2)	0.093 (0.20)	-0.405 (0.35)	-0.756** (0.37)
Biotechnology firm _(t-2)	-0.012 (0.11)	0.434*** (0.15)	-0.218 (0.20)
Firm size _(t-2)	0.339*** (0.03)	0.462*** (0.04)	1.383*** (0.05)
Company group _(t-2)	0.098* (0.06)	0.102 (0.09)	0.198* (0.11)
External spending _(t-2)	-0.003*** (0.00)	0.007*** (0.00)	-0.007*** (0.00)
Market uncertainties _(t-2)	-0.171*** (0.02)	-0.144*** (0.03)	-0.107*** (0.03)
Knowledge protection _(t-2)	0.418*** (0.10)	-0.387 (0.28)	
Knowledge protection _(t-1)			1.388*** (0.10)
R&D investment _(t-2)	0.085*** (0.01)	0.251*** (0.01)	0.359*** (0.01)
R&D investment _(t-2) × knowledge protection _(t-2)	0.001 (0.01)	0.086*** (0.03)	
Competitor search _(t-1)			1.224*** (0.08)
Competitor cooperation _(t-1)			0.588*** (0.16)
Competitor search _(t-1) × knowledge protection _(t-1)			-0.447*** (0.13)
Competitor cooperation _(t-1) ×			-0.253

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knowledge protection _(t-1)			
			(0.24)
cons	-0.598***	-8.460***	1.417
	(0.15)	(0.29)	(0.94)
<i>Number of observations</i>	42027	54653	40848
<i>R-squared</i>	--	--	0.187
Year	Yes	Yes	Yes
Industry	Yes	Yes	Yes
Log likelihood	-2.1e+04	-7.6e+03	--
chi2	1043.797	815.594	8233.440
Notes: Standard errors in parentheses			
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.			

Chapter 4: Summary and Conclusions of Ph.D. thesis

I aim to gain a better understanding of open innovation in competitive context. I explore firstly, the current understanding of the determinants of open innovation (i.e., the literature review); secondly, the determinants of openness to competitors (i.e., the first empirical study); and thirdly, the paradox of openness and protection (i.e., the second empirical study). In the following sections, I summarize the main findings and contributions of each study, discuss the thesis's overall contributions, and conclude with the limitations and potential future directions.

Literature Review: Exploring the Determinants of Open Innovation: A Literature Framework

A very important question for managers is how they should organize resources to implement open innovation. Although scholars have attempted to answer this by looking at the organizational determinants of open innovation, extant studies have shown inconsistencies and discrepancies in their findings. This can partly be attributed to the considerations of different dimensions of organization factors (Pisano, 2011, 2015). Following the “reductionist” view, which suggests that resource-related factors have primary explanatory power in predicting firm strategy and performance (Barney, Ketchen Jr, & Wright, 2011; Foss, 2011), I identify four dimensions of organizational factors that influence open innovation. These are resource investment, organizational structure, human capital and individual attitudes. In this paper, I propose a conceptual framework that explains the relationship between the four dimensions and open innovation. In addition, I propose two mechanisms to explain the relationship. First, the effect of the four dimensions on open innovation is achieved through influencing absorptive capacity (i.e., mediating mechanism). Second, the effect is contingent upon transaction-cost related factors (i.e., moderating mechanism).

This review, first, contributes to open innovation literature by providing a systematic review on the organizational antecedents of open innovation. It complements existing

reviews that largely examine the performance outcomes of open innovation (e.g., Bogers et al., 2017a; Ehls, Polier, & Herstatt, 2020; Stanko, Fisher, & Bogers, 2017; West & Bogers, 2017). By reviewing relevant literature, I also identify questions that have been explored and unexplored, which can direct future research. Second, the analysis of the predominant theories that have been applied helps to provide a solid explanation base for following research to examine this topic. Future scholars can use this review as a roadmap to find theoretical lenses to explain the determinants of open innovation. Third, my review suggests that the relationship between the four dimensions and open innovation is partly explained by firms' absorptive capacity (i.e., mediating mechanism), and is contingent upon the factors that influence transaction costs (i.e., moderating mechanism). These two types of mechanisms help to develop the literature framework that explains the effects of the four dimensions on open innovation. It also points out potential theoretical boundaries and influential processes underlying the effects of the four dimensions on open innovation. Finally, this work responds to the agenda of "success factors of open innovation", an important question in open innovation practice (Bogers et al., 2017b; Lüttgens, Pollok, Antons, & Piller, 2014). Managers can gain insights from my analyses. To better implement open innovation and foster innovation performance, managers should design their firms by considering at least four aspects of organizational factors.

Empirical Study 1: The Determinants of Openness to Competitors: Innovation Failure and the Selection of Openness Modes

In this study, I draw upon the insights developed in the ACAP view (Todorova & Durisin, 2007; Zahra & George, 2002), and test whether the "activation" logic of the view still holds in competitive contexts. The activation logic is that innovation failure, as an activation trigger, will strengthen the positive effect of R&D investment on openness. This is because managers expect to avoid the limitations of closed development and reduce the risk of innovation failure (i.e., technology risk) by learning from others (Giarratana & Mariani, 2014). However, both open innovation and co-opetition literature have suggested that working with competitors also exposes firms to the risk of imitation and opportunism (i.e.,

competition risk) (Chen, 1996; Cui, Yang, & Vertinsky, 2018; Katila, Rosenberger, & Eisenhardt, 2008; Laursen & Salter, 2014).

I draw upon the insights of selective openness (Alexy, George, & Salter, 2013; Balka, Raasch, & Herstatt, 2014; Giarratana & Mariani, 2014), and focus on two important but distinct openness modes: *competitor search* and *competitor cooperation*. I contend that after innovation failures, managers, the firms of whom have more R&D investments, are under greater pressure to reduce technology risk, whereas they also have higher fear of competition risk. As a result, they will act in a risk-averse way: they will conduct more competitor search (a typical unilateral openness mode), while they will build less formal cooperation with competitors (a bilateral openness mode which has higher competition risk). My results further reveal *managers' fear of competition risk* as a reason for this risk-averse behavior (i.e., more competitor search than competitor cooperation).

I extend the ACAP view, which has largely been used to examine non-competitive innovation pertness (Obradović, Vlačić, & Dabić, 2021; Stanko et al., 2017), to competitive contexts, by examining the activating (moderating) role of innovation failure. My findings contribute to the modification of the ACAP view by adding the perspective of selective openness (Alexy et al., 2013; Balka et al., 2014; Giarratana & Mariani, 2014). I suggest that the ACAP view that activation triggers will compel firms to be more open is partly correct in competitive context; it only applies to low-risk openness modes (i.e., competitor search). Instead, I find that innovation failure will hinder managers in cooperating directly with competitors. In addition, I also add to the selective openness literature (Alexy et al., 2013; Balka et al., 2014; Giarratana & Mariani, 2014) by suggesting managers' fear of competition risk as a reason for the risk-averse propensity.

Empirical study 2: Is It Possible to Absorb Competitors' Knowledge to Innovate? A synthetic view of absorptive capacity and the paradox of openness and protection

This study moves from “why” firms can be open to competitors to “how” they can do so, mainly by joining the debate on whether firms should adopt knowledge-protection

mechanisms (i.e., the paradox of openness and protection) (Laursen & Salter, 2014; Wadhwa, Bodas Freitas, & Sarkar, 2017; Wang, Libaers, & Park, 2017). I believe that the conflicting views of previous studies on the role of knowledge protection is due to the assumption that knowledge absorption is static (Volberda, Foss, & Lyles, 2010) and that constructs have not been operationalized to reflect the dynamism of the process (Zahra & George, 2002). I conceptualize the innovation process achieved through absorbing competitors' knowledge into two stages: potential (where a firm's R&D investment increases its ability to absorb competitors' knowledge) and realized (where *the absorption of competitors' knowledge* improves innovation performance). I find that knowledge protection plays a positive moderating role in the potential stage and a negative moderating role in the realized stage.

These findings are important for at least two reasons. First, it is the first study to explore open innovation in competitive context from a dynamic perspective. Scholars have criticized the “static” assumption made in previous ACAP studies (see Volberda et al., 2010 for a discussion) and call for empirical designs to uncover the process through which R&D investment affects innovation performance (Todorova & Durisin, 2007), especially in competitive contexts (Hoffmann, Lavie, Reuer, & Shipilov, 2018). My research fills this important gap by emphasizing that the process through which R&D investment leads to innovation development should include both potential and realized stages. In so doing, I propose and uncover a new influential mechanism – the absorption of competitors' knowledge – which can bridge the link between R&D investment and innovation performance.

Second, I distinguish between the potential stage, which emphasizes the importance of reducing a focal firms' fear of knowledge spillovers, and the realized, which requires knowledge sharing and exchange with competitors. By doing so, I propose and find that the bright and dark sides of knowledge protection pertain to different stages. These findings help to reconcile the debate on the paradox of openness and protection. I suggest that managers should adopt knowledge protections in the potential stage to reduce their concern of spillovers of internal knowledge, while reducing protections in the realized stage

because information sharing and knowledge exchange matter for generating new knowledge. This "dynamic" perspective extends recent theoretical works, which contend that firms can live with the paradox to innovate as long as they separate protection efforts temporally (Lauritzen & Karafyllia, 2019; Ritala & Stefan, 2021).

Overall Contributions of this Thesis

Theoretical implications

In this section, I discuss the contribution of this thesis in a more combinative way. Open innovation, as a practice-based business mode, has been widely used in modern businesses and attracted considerable attention (see Chesbrough & Bogers, 2014; Ehls et al., 2020; Obradović et al., 2021; Stanko et al., 2017 for recent reviews). Scholars have also attempted to answer how managers can organize resources to better embrace open innovation, mainly by examining organizational factors as the determinants of open innovation (e.g., Kim, Kim, & Lee, 2015; Spithoven & Teirlinck, 2015; Strese, Meuer, Flatten, & Brettel, 2016). Despite these works, to the best of my knowledge, there are no systematic reviews explaining the determinants of open innovation. In particular, much less attention has been paid to openness to competitors.

I first reviewed past studies that explored the determinants of open innovation and identified four dimensions of organizational factors: resource investment, organizational structure, human capital and individual attitudes. I also provide a literature-based framework that explains the relationship between the four dimensions and open innovation. This review concludes with the identification of explored and underexplored questions. Therefore, it contributes to the literature on open innovation by addressing the discrepancies and inconsistencies in extant findings and suggests research opportunities for future research.

The two empirical studies are inspired by the literature review, which concludes that open innovation brings both benefits and risks. The transaction costs issue in competitive

contexts seems to be especially salient (due to competition risk), whereas openness to competitors has been a less examined topic. Thus, the empirical studies aim to answer “*why*” and “*how*” firms can be open to competitors, respectively. In other words, I respond to addressing two big challenges facing managers – how to manage the benefit and risk of openness to competitors (i.e., the first empirical study) and how to balance between openness and protection (i.e., the second empirical study). Both studies are based on the ACAP view, which is one of the most dominant theoretical frameworks for explaining the determinants of openness (according to my review work).

The first empirical study draws upon the activation logic of the ACAP view, which suggests a positive moderating role of activation triggers between R&D investment and firms’ ability to be open to outsiders (Todorova & Durisin, 2007; Zahra & George, 2002). Zahra and George (2002) defined activation triggers as negative events (e.g., innovation failures or crises) or environmental changes (e.g., policy or industrial shift) that compel or encourage firms to intensify their efforts to acquire external knowledge. Yet, previous studies have not empirically examined this activation logic. I theoretically develop this view and test its validity in competitive contexts by considering innovation failures as activation triggers. My results modify the ACAP view by adding the perspective of selective openness (Alexy et al., 2013; Balka et al., 2014; Giarratana & Mariani, 2014). That is, I find that after innovation failures, managers tend to be selective in choosing openness modes, i.e., they use more competitor search than competitor cooperation. This is because they are under pressure to capture the benefits of openness to competitors (i.e., reduce technology risk) and, meanwhile, they hope to avoid potential imitations and opportunistic behaviors (i.e., reduce competition risk). Thus, this study contributes to the open innovation literature and modifies the ACAP view by suggesting that activation triggers (innovation failures) can be positive or negative, and that this is contingent upon the types of openness modes.

The second empirical study shifts attention from “*why*” (the first empirical study) to “*how*” a firm can be open to competitors. It draws upon an ACAP view (Todorova & Durisin, 2007; Zahra & George, 2002) and conceptualizes the innovation processes

achieved through absorbing competitors' knowledge into potential and realized stages. By this conceptual work, I suggest a new theoretical process to explain the relationship between R&D investment and innovation performance. Furthermore, I find that knowledge protection is a positive moderator in the potential stage and a negative moderator in the realized stage. These findings help reconcile the conflicting views on openness and protection by suggesting that the role of knowledge protection is not constant. Managers should take a dynamic view when making decisions on knowledge protection.

Looking at the thesis (the literature review and two empirical studies) together, I have examined why and how firms can be open to competitors, mainly centering around how to capture benefits while avoiding risks. Extant literature has no consistent views on how to balance the benefits and risks. My thesis adds to extant literature by proposing a selective openness view and establishing the absorption of competitors' knowledge as a process factor. The new knowledge I provided is that firstly, the activation trigger logic of the ACAP view is partly correct when applying to competitive context. That is, I find that innovation failure, as a typical activation trigger, can be positive or negative, which depends on the forms of open innovation. It positively moderates the relationship between R&D investment and competitor search, while it negatively moderates the relationship between R&D investment and competitor cooperation. Secondly, I suggest that the effect of R&D investment on innovation performance is not necessarily direct; it can be indirectly achieved through absorbing knowledge from competitors. Thirdly, my thesis suggests that the role of knowledge protection is positive when firms invest to build ability for absorbing competitors' knowledge, while negative when the firms leverage the absorbed knowledge to innovate. Interestingly, recent theoretical and conceptual works have also suggested two approaches to resolve the tension between knowledge creation and knowledge capture: *selective openness* (see integration approaches noted by Lauritzen & Karafyllia, 2019; see separation mechanisms noted by Ritala & Stefan, 2021) and *temporal design* (see differentiation approaches noted by Lauritzen & Karafyllia, 2019; see restructuring mechanisms noted by Ritala & Stefan, 2021). For example, Ritala and Stefan (2021) defined separation mechanism as a compartmentalized approach which enables firms to

treat different knowledge components in different ways. Such an approach acknowledges the difference between different types of knowledge. Thus, it also emphasizes firms' selectiveness in openness (e.g., selectively protecting or sharing different knowledge). Lauritzen and Karafyllia (2019) proposed and regarded differentiation as a “separating” approach that prevents conflictual interactions. They contended that the tension between openness and protection can be dealt by “separating poles temporally”, namely, splitting control and openness in time. Thus, by extending these theoretical views to competitive contexts, my empirical studies make important contributions to the ACAP view and open innovation literature.

Practical implications

Relating to practical contributions, I provide several important suggestions for managers adopting openness modes. First, the findings of the literature review constitute important implications for managers about designing an effective organization to embrace open innovation. I suggest that managers could do this by considering at least four dimensions, not only *what or how many* resources they need to invest (resource investment), but also *where* (structure), *who* (human capital) and *how*-related (individual attitudes) questions about the resources. It is also important to note that some of the dimensions are substitutable or complementary, jointly influencing open innovation implementation and performance. When firms do not perform well in one dimension, they could hold a “portfolio” wisdom and resort to others to achieve open-innovation goals.

The first and second empirical studies generally offer insights on how managers address the challenges of being open to competitors. I suggest a selective openness approach to simultaneously reduce the technology risk of and avoid the competition risk of openness to competitors. Managers can capture competitors' benefits by indirectly learning from them (i.e., competitor search), while reducing formal cooperation with competitors (i.e., competitor cooperation) to reduce the risk of potential imitation and opportunism. The finding of the second study helps to address managers' dilemma between

openness and protection, namely, the scholarly debate on the paradox of openness. I suggest a dynamic perspective. That is, managers should take protections when they plan to interact with competitors, while reducing protections when they are working together with competitors. The adoption of protections is to reduce managers' fear and increase firms' ACAP, while the reduction of protections is to facilitate information sharing and knowledge exchange between firms.

Looking at the three studies together, a general suggestion provided for managers is that firms can not only be open to noncompetitors, but they can also search for, and cooperate with, competitors, for acquiring more knowledge. To balance the risks and benefits of openness, managers who aim to leverage competitors to innovate should engage in more competitor search over competitor cooperation (especially when they experienced innovation failures), as well as dynamically adopt their knowledge protection mechanisms.

Limitations, Future Directions and Conclusion

The limitations and future opportunities have been discussed in each study. Here, I summarize the most important points. First, to explore the determinants of open innovation, I followed a "reductionism" way and focused on organizational factors, i.e., factors that firms can operate and control. Yet, according to Cohen and Levinthal (1989, 1990), ACAP not only relates to R&D investment (organizational factors) but is also determined by the abundance of external knowledge, with subsequent empirical studies supporting this view (e.g., Garriga, Von Krogh, & Spaeth, 2013). Thus, future reviews may want to complement my review by exploring how external factors influence a firm's ACAP and the implementation of open innovation.

Second, in my empirical studies, I draw upon the ACAP view and argue that R&D investment forms the base of ACAP. Though this view is explicit in the original ACAP work (Cohen & Levinthal, 1989, 1990), more recent scholars (e.g., Song, Gnyawali, Srivastava, & Asgari, 2018) believe that the implication of ACAP is broad and it has multiple dimensions (my review also suggested so). Future research may want to refer to

my literature work and further test the validity of the theoretical models of my two empirical works by considering other factors in addition to R&D investment (e.g., organizational structure, human capital and individual attitudes noted by my literature work).

Third, the two empirical studies only examined the inbound open innovation, i.e., competitor search and competitor cooperation. Yet, typology works on open innovation (e.g., Dahlander & Gann, 2010) have suggested that the logic of outbound openness modes appears to be different in terms of creating and capturing knowledge. For example, managers' perceptions toward the risk of outbound modes (i.e., sharing, revealing in competitive context) tend to be lower, because they dominate and can largely control the implementation of these activities. Thus, comparative studies on the difference between inbound and outbound modes are highly encouraged.

Only examining inbound modes is also due to the use of data from the Spanish Community Innovation Survey in which outbound modes-related questions were touched in a very light way. This points out the fourth limitation – the two empirical studies were conducted only reflective of innovation conditions of firms in Spain, a country characterized by moderately developed innovation level. In other emerging countries, such as China and India, firms' innovative activities are constrained by the shortage of resources and relative conservative culture. They tend to be more closed than firms in developed countries. Given the rise of these emerging economies, whether my findings still hold in these countries needs particular attention.

Looking at the three studies together, I have provided a review about the organizational antecedents of open innovation and tested the validity of the ACAP view in competitive context. A very interesting research direction is to compare firms' open innovation strategies in noncompetitive and competitive contexts. Does R&D investment affect openness to competitors and openness to noncompetitors (i.e., users, suppliers, or universities) differently? Will managers still selectively engage in open innovation in noncompetitive context? Is the moderating effect of activation trigger (e.g., innovation

failure) strengthened or weakened in noncompetitive context? How will a firm's open innovation change when it shifts its businesses from noncompetitive context to competitive context? How does a firm adopt knowledge protections when it engages in both noncompetitive and competitive context? I do believe these questions to be addressed will greatly advance open innovation literature and co-opetition research.

In conclusion, with this thesis, I have responded to the calls for more investigation on the determinants of open innovation, especially in competitive context. It was conducted by (1) providing a literature framework that explains the relationship between four dimensions of organizational factors and the implementation of open innovation, (2) adding a selective openness perspective to the ACAP view and explaining why firms can be open to competitors (simultaneously manage the benefit and risk of openness to competitors), and (3) uncovering a process through which R&D investment leads to innovation development, which makes it possible to reconcile the debate on the paradox of openness and answer how managers should adopt knowledge protections. All in all, given the expanding boundaries of modern businesses, open innovation has achieved more and more attention in practice. Yet, scholarly research is still in its infancy and behindhand in explaining the practices (Felin & Zenger, 2020). Hopefully, this thesis helps and can somewhat encourage subsequent researchers to do more systematic investigation in open innovation domain.

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