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Match and manage: the use of knowledge matching and project management to integrate knowledge in collaborative inbound open innovation

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Abstract

Despite mounting evidence on the potential benefits of inbound open innovation, little is known about how firms purposefully manage inflows of knowledge. We investigate the use of two knowledge governance procedures—project management and knowledge matching—in collaborative inbound open innovation. Our findings suggest that, in addition to "knowledge-precursors," which the literature on open innovation and absorptive capacity has shown to be important for the integration of external knowledge, the firm's choice of knowledge governance matters for innovation performance.

JEL classification: O31, O32, C21.

1. Introduction

Practices related to inbound open innovation can be advantageous for firms' efforts to introduce process and product innovations (Chesbrough, 2003; Laursen and Salter, 2006; Dahlander and Gann, 2010; West and Bogers, 2014). Combining inflows of external knowledge with internally held knowledge is often an attractive alternative to reliance solely on in-house research and development (R&D). Inflows of external knowledge allow firms to spread the risks and costs inherent in R&D activities, and provide access to a larger pool of knowledge which substantially increases the chances of successful knowledge recombination (Clausen *et al.*, 2012; Laursen, 2012; Leiponen, 2012).

The open innovation literature discusses how and why external knowledge is important for firms' innovation processes, and several studies show that contextual factors moderate the relationship between open innovation and performance (e.g., Chesbrough, 2003; Laursen and Salter, 2006; Vega-Jurado *et al.*, 2009; Berchicci, 2013; Garriga *et al.*, 2013; Love *et al.*, 2014). Based on an overview of this large literature, West and Bogers (2014) identify three major steps in the process of open innovation: obtaining knowledge (both the search for and acquisition of knowledge), integrating knowledge, and commercializing knowledge. In this article, we focus on how external knowledge is integrated with the focal firms' internal knowledge. Most work on the integration of external knowledge adopts an absorptive capacity approach (West and Bogers, 2014). In their ground-breaking contribution, Cohen and Levinthal (1990: 128) highlight absorptive capacity as a cornerstone of innovation performance and define it as the "ability to identify, assimilate, and exploit knowledge from the environment." However, in much of the subsequent research drawing on the notion of absorptive capacity in relation to assimilation as knowledge integration, the focus is on knowledge-related precursors to absorptive capacity reflected in the firm's internal R&D activity (e.g., Grimpe and Sofka, 2009; Rothaermel and Alexandre, 2009; Spithoven *et al.*, 2010; Volberda *et al.*, 2010; Schildt *et al.*, 2012; Berchicci, 2013; Bertrand and Mol, 2013). This stream of work includes research on open innovation and collaboration for innovation more generally. However, very few studies of open innovation and interfirm innovation collaboration study the explicit organizational procedures that facilitate absorptive capacity and knowledge integration (however, see Badir *et al.*, 2009; and Foss *et al.*, 2011). Given the fairly general consensus on the potential benefits of open innovation, this is surprising—not least since it has been observed that open innovation collaborations are likely to fail in the absence of appropriate organizational procedures (see, for instance, Dahlander and Piezunka, 2014).

Drawing on knowledge integration and knowledge governance theories (Grant, 1996; Grandori, 2001; Postrel, 2002; Nickerson and Zenger, 2004; Foss *et al.*, 2010; Tell, 2011), we contribute to filling this gap in the literature by proposing an analysis of knowledge integration via inbound open innovation collaboration seen as a knowledge governance problem—specifically pertaining to agents' motivations to collaborate and coordination of knowledge problems. We investigate the use and effects of two knowledge governance procedures—*project management* and *knowledge matching*—in collaborative, inbound open innovation in manufacturing firms in Finland, Italy, and Sweden.

By project management, we mean the firm's overall use of project management techniques, such as formal plans and milestones, formal evaluations of collaborative projects, and provision of incentives to increase collaborative partners' efforts, aimed at controlling and managing collaborative projects. Project management involves managerial efforts to mitigate agency and cooperation problems in collaborative inbound open innovation. Knowledge matching refers to the firm's efforts to achieve a good match among collaborating partners' technological competences, to obtain access to partners' knowledge resources, and to ensure complementarity and synergies among partners' knowledge bases, which, in turn, allow informal and tacit coordination of the joint activity. We focus on the inflow of external knowledge within an open innovation process involving R&D collaboration with important external knowledge sources such as value chain partners, universities and research institutes, and firms in other industries. To our knowledge, this is the first study showing that interfirm knowledge governance, in terms of organizational procedures, is an important determinant of innovation performance derived from (inbound open) innovation collaboration.

In line with the mainstream open innovation literature (e.g., Chesbrough, 2003; Laursen and Salter, 2006; West and Bogers, 2014), our unit of analysis is the focal firm which engages in collaborative inbound open innovation, and we propose a model in which collaborative innovation projects are governed by firm-level organizational procedures rather than one in which knowledge governance procedures are specific to each collaborative project. Our assumption is supported by empirical evidence suggesting that, due to organizational imprinting, firms' organizational procedures are persistent over time (see e.g., Hannan *et al.*, 1996; Baron *et al.*, 1999), and that these organizational procedures are ingrained in individuals operating across organizational boundaries (Higgins, 2005; McEvily *et al.*, 2012).

Our econometric analysis supports the idea that both project management and knowledge matching are associated with performance gains in open innovation involving different types of partners. We find empirical support also for the idea that knowledge matching is important regardless of the collaboration partner breadth of the focal firm, and that project management matters relatively more for open innovation involving numerous different types of collaboration partners. However, contrary to our theoretical expectations, we find that knowledge matching matters for open innovation-related gains across all stages of the open innovation process, while project management has a significant influence only in the idea stage of the process. In other words, our results do not support the idea that the relative importance of project management procedures compared to knowledge-matching procedures increases in the later stages of the innovation process.

2. Theoretical background and prior literature

2.1 Open innovation and knowledge governance

How firms manage and organize knowledge flows in interorganizational relationships are central to collaborative inbound open innovation. As stated above, we adopt a knowledge governance approach to analyze this context. This approach to open innovation is related closely to knowledge-based theories of the firm (Williamson and Winter, 1991; Kogut and Zander, 1992; Grant, 1996). Organizing innovation involves a choice among governance modes: *hierarchy*, *market,* or *hybrid.* While Chesbrough (2003) refers to hierarchy as closed innovation, the market mode refers to transactions in the markets for technology (cf. Arora *et al*., 2001), and examples of hybrid governance can be found in collaborations among organizations (cf. Powell, 1987; Williamson, 1991). Felin and Zenger (2014) distinguish four open innovation knowledge governance settings: markets/contracts, partnerships/alliances, contests/tournaments/platforms, and users/communities. We are interested primarily in the hybrid or partnerships and alliances form of governance, which is concerned specifically with collaborative innovation. Note that in this study we do not investigate other types of inbound open innovation efforts such as the markets for technology and ideas (Arora and Gambardella, 2010; Gans and Stern, 2010), intellectual property rights strategies (Somaya, 2012; Granstrand and Holgersson, 2013; Laursen and Salter, 2014; Zobel *et al*., 2016), or crowdsourcing (Afuah and Tucci, 2012; Seidel and Langner, 2015). Our focus is on firms that have chosen an inbound open innovation strategy, which implies relationships with one or more partners, to acquire and integrate knowledge (see e.g., Fey and Birkinshaw, 2005). From the perspective of the knowledge-seeking firm, these relationships can be described as *collaborative inbound open innovation.*

It is often claimed that there are two fundamental organizational design problems in organizational economics: those due to lack of motivation and those due to coordination failures. When an individual becomes part of an organization, he or she needs to be motivated to act since the full consequences of his or her actions are not borne by the individual, and also the individual's activities need to be coordinated to be productive (see, for instance, Milgrom and Roberts, 1992; Postrel, 2009). According to Heath and Staudenmayer (2000): 156: "In order to accomplish their work, organizations must solve two problems: motivating individuals so that their goals are aligned (the agency problem), and organizing individuals so that their actions are aligned (the coordination problem). Almost all of the founding texts in organizational economics emphasize the importance of both problems: agency and coordination . . . "

Agency problems create the need for safeguards and control mechanisms in order to assure alignment of incentives (Roberts, 2004). Coordination problems stem from the trade-off between the benefits derived from specialized knowledge, and the need for some shared knowledge in order to integrate specialized knowledge (Postrel, 2002; Grant and Baden-Fuller, 2004; Tell, 2011). This calls for knowledge governance mechanisms to coordinate specialized knowledge efficiently, and to minimize the costs related to redundancy of complex knowledge (Grant, 1996; Grandori, 2001; Johansson *et al*., 2011). Conceptually, collaborative inbound open innovation knowledge governance contexts are characterized by the use of bilateral and multilateral, and also socially embedded communication channels, combined with both high-powered and cooperative incentives (Felin and Zenger, 2014). This implies a setting that is complex and can lead to problems for knowledge-seeking firms trying to devise procedures to induce and coordinate knowledge flows. Drawing on Grant (1996) and Srikanth and Puranam (2011, 2014), we can distinguish between "formal and explicit" and "informal and implicit" coordination. The former mechanism relies on rules and routines, while the latter relies on frequent communication and/or tacit awareness of the knowledge held by other individuals and partner firms (see Srikanth and Puranam, 2011).

Chesbrough and Bogers (2014: 17) describe open innovation as: "a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model." This definition emphasizes the purposive management of knowledge flows across organizational boundaries. We would suggest that such purposive management is related to the two central problems considered by organizational economics—agency and coordination. These problems are important for both the firm's internal organization and hybrid organizational forms, such as collaborative inbound open innovation, in which knowledge integration across organizational borders is critical.

Knowledge governance has direct links to contemporary research on open innovation, absorptive capacity, and external knowledge acquisition. The integration of external knowledge with the firm's internal R&D activities is an important stage in open innovation (West and Bogers, 2014). It requires the capabilities to assimilate external knowledge. The integration of external knowledge is a central issue in the literature on absorptive capacity, which suggests that the firm's innovation performance is related to its capacity to absorb external knowledge (Cohen and Levinthal, 1990; Lane and Lubatkin, 1998; Zahra and George, 2002; Lim, 2009; Berggren *et al.*, 2016). Although absorptive capacity refers fundamentally to multiple learning processes, it is conceived by Cohen and Levinthal (1990) and several more recent studies as referring to internal R&D (see e.g., Hoang and Rothaermel, 2010; Bertrand and Mol, 2013). For instance, empirical studies conducted by Rothaermel and Alexandre (2009) and Berchicci (2013) demonstrate the central role of internal R&D for balancing internal and external innovation activities to maximize innovation output. Similarly, in a study of high-tech Taiwanese manufacturing firms, Hung and Chou (2013) find that internal R&D positively moderates the relationship between the management of inbound open innovation and firm performance. Absorptive capacity contributes to the integration of external knowledge through both firm-level (i.e., increased knowledge diversity increases the ability to absorb external knowledge) and relationship-level (i.e., increased similarity of knowledge bases among partners increases the ability to absorb that partner's knowledge) effects (Lane and Lubatkin, 1998; Schildt *et al.*, 2012). Thus, the absorptive capacity of knowledge-seeking firms is crucial for the integration of external knowledge through collaborative inbound open innovation. However, an extensive review of the absorptive capacity literature (Volberda *et al.*, 2010: 941) highlights the relative neglect of the organizational design antecedents to integrating external knowledge. To address this gap, we complement absorptive capacity with knowledge governance theories to inform our study of knowledge integration in collaborative inbound open innovation.

Firms that engage in inbound open innovation are likely to search for the competencies required for this strategy to be effective (West and Bogers, 2014). Some of these competencies are related to the governance of knowledge in open innovation to achieve the successful integration of external and internal knowledge. Governance, as a set of explicit organizational procedures, has been identified as important for open innovation (Vanhaverbeke and Cloodt, 2006; Dahlander *et al.*, 2008; Huizingh, 2011), but there is little systematic evidence on the governance procedures related to inbound open innovation and knowledge flows in the open innovation process. One exception is Foss *et al.* (2011), which examines how external knowledge in the form of customer knowledge is incorporated in the focal firm's innovation process, and how the focal firm's formal organization (organizational practices including what we describe here as knowledge governance procedures) enables this process. However, Foss and coauthors focus on one specific knowledge source, and consider only intraorganizational knowledge governance procedures. A related contribution is Badir *et al.* (2009), which provides in-depth comparative case studies of three collaborative new product development projects to investigate how intraorganizational design antecedents of "network lead companies" influence communication in the performance of such projects with strategic alliance partners. In the present article, we investigate a broader range of partners and focus on the interorganizational procedures used by focal firms to facilitate collaborative inbound open innovation between partners.

2.2 Project management and knowledge matching

We distinguish between two types of empirically observable knowledge governance procedures in collaborative inbound open innovation: project management and knowledge matching. Project management includes motivation and coordination of partner activities through the setting of goals and formulation of plans, combined with monitoring, evaluation, and incentives (Du Chatenier *et al.*, 2010). Knowledge matching involves the coordination of knowledge assets and the establishment of learning processes among partners in order to benefit from knowledge complementarities and to create synergies (Cassiman and Veugelers, 2006). Project management includes mechanisms for motivation and formal, explicit coordination, while knowledge matching involves both informal (i.e., via ongoing communication) and tacit coordination (i.e., which does not require ongoing communication). Project management procedures include goal setting, performance assessment, and provision of incentives, aimed at motivating the individuals participating in the collaborative activity and at aligning the incentives among participating firms to mitigate opportunistic behavior and moral hazard in the interests of the common activity (Williamson, 1985; Grandori, 2001; Roberts, 2004). At the same time, project management is aimed also at coordinating the collaborative activity through formal rules and routines (Cyert and March, 1963; Grant, 1996).

Knowledge matching is related to achieving a good match among the collaborating partners' technological competencies, obtaining access to the partners' knowledge resources, and ensuring synergies among partners' knowledge bases. As noted above, it involves informal and tacit coordination of activities. Tacit coordination mechanisms have been defined as "mechanisms that enable the formation and leverage of common ground without the need for direct, ongoing communication" (Srikanth and Puranam, 2011: 850). Central to our argument is that knowledge matching provides the basis for this common ground, which, in turn, may also promote informal as well as tacit coordination mechanisms that involve the formation of common identities and shared representations (Brown and Duguid, 1991; Kogut and Zander, 1996), group problem-solving processes (Grant, 1996), and related clan control (Ouchi, 1980; Turner and Makhija, 2006). Despite being distinct procedures, project management and knowledge matching are not mutually exclusive.

3. Hypotheses

3.1 Project management in collaborative inbound open innovation

As argued above, project management procedures are aimed at coordinating collaborative activities through formal rules and routines, and at motivating individuals and aligning the interests of collaborating partners. We would argue that these aspects of collaborative innovation management are crucial. Project management endows the focal firm with the capacity to identify and specify the order of events (Nickerson and Zenger, 2004), which, given the strong explorative element of open collaborative innovation, is especially important. Project management can be used to mitigate the challenges that arise in open innovation related to high levels of uncertainty and constraints on resource availability. All innovation activities tend to be complex and uncertain (Dosi, 1988; Holmström, 1989; Aghion and Tirole, 1994). Inbound collaborative open innovation is especially complex and uncertain (Laursen *et al.*, 2012) and benefits from the structure and coordination provided by formal plans and milestones and formal evaluations of the collaborative activity, which are part of project management. In addition, since open innovation collaborations are often resource constrained, formal coordination through project management procedures can help to ensure that limited resources are not overstretched.

Given the complexity and uncertainty of innovation there is also a need to motivate the participating parties. In the absence of plans, milestones, or incentives, open innovation collaborations can be vulnerable to shirking behavior by the participating individuals and organizations. At the same time, open innovation collaborations are also vulnerable to the collaborators' opportunistic behaviors, and to moral hazard (Pisano, 1990). Project management procedures render the participating parties explicitly accountable, and help to align incentives in order to avoid these problems. Thus, we hypothesize that:

H1a The use of project management contributes positively to the performance of collaborative inbound open innovation.

3.2 Knowledge matching in collaborative inbound open innovation

While project management procedures set the conditions for knowledge governance by setting formal objectives, milestones, and incentives, mechanisms to achieve complementarities and synergies are also required for knowledge integration and subsequent innovation, through procedures for knowledge matching. Close collaboration among the partner companies is required to create "the necessary complementary technology inputs enabling these companies to capitalize on economies of scope through joint efforts" (Hagedoorn, 1993: 372). Given the complexity and level of unpredictability of joint innovation activities, they require informal as well as implicit/tacit coordination. As Grant (1996): 115 argues, in general, efficiency in organizations tends to be associated with the enforcement of rules, routines, and other mechanisms that economize on communication and knowledge transfer, with (costly) informal and tacit coordination reserved for "unusual, complex, and important tasks." We would argue that collaborative inbound open innovation activities are unusual, complex, and important. Informal coordination can involve ongoing communication between the involved parties, and is expensive, but helps to minimize transfer of redundant knowledge. Tacit coordination involves awareness (without the need for ongoing communication) of a collaboration partner's technological knowledge, which, again, reduces knowledge redundancy and costly knowledge transfer. Knowledge matching promotes efficient knowledge transfer and integration since it enables the coordination of mutual learning and collaboration activities (Demsetz, 1988; Brown and Duguid, 1991; Kogut and Zander, 1996; Carlile, 2002, 2004; Bechky, 2003). As already mentioned, knowledge matching is based on building a common ground that enables different specialists to communicate with each other, facilitates tacit understanding, allows assessment of each other's domain specific knowledge, and enables problem solving (Bechky, 2003; Enberg *et al.*, 2006; Badir *et al.*, 2009). Knowledge integration is achieved by identifying complementary knowledge assets and technologies in order to achieve cross-fertilization of scientific disciplines and fields of technology (see e.g., Grant and Baden-Fuller, 2004; Lin and Chen, 2006; Parmigiani and Rivera-Santos, 2011). Consequently, in collaborative inbound open innovation, knowledge governance based on knowledge-matching procedures is expected to have a positive impact on performance derived from collaborative open innovation activities. Thus, we hypothesize that:

H1b The use of knowledge matching contributes positively to the performance of collaborative inbound open innovation.

3.3 Project management and knowledge matching in the stages of the innovation process

The innovation problem requiring a solution may vary through the stages of the product development process (Cooper, 2008; Gronlund *et al.*, 2010); some firms may be more active in the early stages, and some may be more active in the later stages of the collaborative activity. Here, we consider the idea, implementation, and commercialization stages, and we expect the relative importance of project management and knowledge matching in inbound collaborative innovation to vary according to the stages of the innovation process in which the focal firm is engaged. This is based on three main reasons.

First, knowledge matching is an organizational procedure aimed at matching the partners' technological competencies, obtaining access to the partners' knowledge resources, and ensuring synergies with partners' knowledge bases. This allows access to specialized knowledge and the results of the collaborating partners' innovation efforts. The pooling of this knowledge can produce economies of scale in R&D (Ahuja, 2000). Accordingly, knowledge matching should facilitate knowledge recombination directly and, since the idea-generation stage involves knowledge recombination very intensely (Kogut and Zander, 1992; Fleming and Sorenson, 2004), knowledge matching should promote innovation outcomes for firms that collaborate in this particular stage of the process. At the same time, project management involves formalization, which can restrict the number of organizational members with access to the external partners' knowledge (Jansen *et al.*, 2005). This can restrict the opportunities for knowledge recombination, which is crucial in the early stages of innovation. This "exploration disadvantage" related to formal project management is likely to be less of a problem in the later, more exploitative stages, which are focused more on solving concrete problems and finalizing the collaborative innovation activity.

Second, knowledge-matching procedures can provide common ground for both ongoing communication and tacit information (through awareness) about the knowledge possessed by collaboration partners. Ongoing communication provides informal coordination of these complex activities, while awareness enables tacit coordination (Srikanth and Puranam, 2011) of the relevant innovation activities and reduces knowledge redundancy and costly knowledge transfer. Given that the early stage of open innovation activities depends on what Srikanth and Puranam (2011) term "complex interdependence" among the participants, tacit coordination may be particularly beneficial since the later implementation and commercialization stages rely less on knowledge recombination. In other words, firms that engage in open innovation collaboration in the early stages should derive more benefit from knowledge-matching procedures than from project management. The later stages of innovation also require a level of complex interdependence, but this is arguably less crucial than in the early stage.

Third, the early stage of the open innovation process tends to be precompetitive, while the later implementation and commercialization stages involve some level of competition, which can result in the emergence of opportunistic behavior. Knowledge matching *per se* does not protect against opportunistic behavior, but project management procedures can include formal safeguards such as hostage exchanges of assets, and third-party mediation to resolve conflicts (Pisano, 1990). Given that opportunistic behavior is more likely in the later stages, formal project management should be relatively more important to successful collaborative activity for firms that collaborate in the later stages, compared to knowledge governance controlled by knowledge matching. These arguments lead to the following two hypotheses:

H2a The use of project management, compared to knowledge matching, contributes more to open innovation-related performance for firms that collaborate in the later implementation and commercialization stages of open innovation.

H2b The use of knowledge matching, compared to project management, contributes more to open innovation-related performance for firms that collaborate in the early, idea-generation stage of open innovation.

3.4 The relative importance of project management and knowledge matching for high and low partner breadth

Collaborating in open innovation with a large set of diverse partners with different functions, i.e., partner breadth, can improve innovation outcomes because the cooperation provides greater scope for knowledge recombination due to the variety of skills, relationships, and other assets held by collaborators (Baum *et al.*, 2000; Faems *et al.*, 2005; Laursen and Salter, 2006; van Beers and Zand, 2014). However, each partner type (e.g., customers, suppliers, competitors, external R&D suppliers, universities, etc.) requires specific managerial attention if it is to be utilized effectively in the context of innovation (Laursen and Salter, 2006; Bengtsson *et al.*, 2015). Also, the need for coordination of activities and the mechanisms for motivation increase with the range of collaboration partner types. Due to the cognitive limitations of managers and the complexity of the interactions among a set of different partners, a large number of different types of partners (i.e., high partner breadth) is inherently more difficult to manage. Collaboration related to open innovation can result in lack of knowledge recombination or recombination of the wrong type of knowledge to the detriment of innovation novelty. Thus, the need for coordination through formal project management procedures increases with the number of collaboration partner types. In addition, since complexity increases with the number and range of collaboration partner types, the possibility of opportunistic behavior and the risk of moral hazard also increase since, under these circumstances, such behavior is less likely to be recorded and eventually sanctioned.

Knowledge matching directly facilitates knowledge recombination and provides coordination since it provides a basis for ongoing communication and awareness of the partners' distinctive specialized knowledge bases. We contend that both these effects are important in the context of innovation, regardless of the number and type of the focal firm's collaborators. Firms engaged in collaborations with a few (i.e., low partner breadth) or many and more dissimilar partners (i.e., high partner breadth) need to invest in knowledge-matching procedures to achieve the benefits of open innovation activities; knowledge recombination requires explicit managerial attention. In other words, a necessary condition for successful knowledge matching is the establishment of appropriate organizational procedures. Coordination among a few similar partners using knowledge matching may be sufficient to achieve a successful outcome. However, in the case of collaboration among multiple and different partners, governance via knowledge matching is not enough to manage the complexities involved. In these circumstances, formal coordination, monitoring, and incentives are required for successful knowledge governance. In other words, project management becomes essential to secure reasonably effective knowledge integration. In sum, and based on these arguments, we posit that:

H3a The use of project management contributes more to open innovation-related performance in situations where open innovation collaboration involves high partner breadth rather than low partner breadth.

H3b The use of knowledge matching contributes to open innovation-related performance independent of whether open innovation collaboration is characterized by high or low partner breadth.

4. Methodology and data

Our analysis is based on a firm-level survey of open innovation in Finland, Italy, and Sweden. The population consists of manufacturing firms (NACE Rev.2 codes 10–32 and 98) with more than 10 employees. In each country, data collection was based on a randomized stratified (defined by number of employees) sample of 1000 manufacturing firms representing the target population. The surveys used common guidelines and common data collection processes in order to ensure comparability of the results across countries (Forza, 2002). In order to improve the quality of the instrument, pilot tests were conducted with expert academic colleagues and target respondents in selected firms.

The data were collected in late autumn 2012 and early spring 2013, via questionnaires distributed by email to firm respondents' knowledgeable about open innovation—mainly R&D managers. The data were collected in the three countries in parallel. We obtained 415 completed questionnaires from firms stating that they had had open innovation processes in place during the previous 5 years. The 415 responses refer to 87 firms in Finland, 152 firms in Italy, and 176 firms in Sweden. The number of employees varies between 10 and 56,000, with a mean value of 867 employees (standard deviation 4239 and median 50 employees).

Since the distribution among industries is skewed, and some industry classes are represented by a very few firms, we split the firms into four clusters for low-tech, medium low-tech, medium high-tech, and high-tech firms. This classification follows an approach used by Eurostat and Statistics Sweden (SCB, 2014), which uses technological intensity (reflecting differences in R&D intensity) in different sectors as one selection parameter. Firms belonging to industry codes 10–18 and 31–32 are classified as low-tech (e.g., food, furniture), firms belonging to codes 19 and 22–25 are regarded as medium low-tech (e.g., coke, petroleum, rubber, plastics), firms in codes 20 and 27–30 are classified as medium high-tech (e.g., chemicals, electric products, automotive), and firms belonging to codes 21 and 26 are regarded as high-tech (e.g., pharmaceutical products, computer, electronic and optical products). Among the 415 firms, 68 did not provide an industry class and were put into a fifth group.

The dependent variable is innovation performance, which we measure based on responses to the question: "Please indicate how well collaboration with external partners in innovation activities has performed against the following objectives over the last 3 years" (see also Appendix). Innovation performance is the result of a factor analysis based on three items that draw on Lazzarotti *et al.* (2011) and reflect open innovation-related performance aligned to the firm's objectives, in terms of new or improved products/services, new or improved processes, or new markets (Cronbach's alpha 0.81; 7-point Likert scale with 1 = not at all and 7 = to a great extent, see Table A1 in Appendix).

The main independent variables capture the use of project management and knowledge matching in collaborative inbound open innovation. Project management is a factor based on three items, each measured on a 7-point Likert scale, ranging from 1 = strongly disagree to 7 = strongly agree (Cronbach's alpha 0.68). The items reflect the use of project management techniques in collaboration with open innovation partners, performance assessment of collaborative activities, and reward and incentive systems, based on Dekker (2004). The factor representing knowledge matching is measured according to three items adapted from Lin and Chen (2006): matching of partners' technological competences, access to partners' knowledge resources, and synergy created by combining knowledge among firms (Cronbach's alpha 0.82; Likert scale, ranging from 1 = strongly disagree to 7 = strongly agree). Note that our analysis assumes that if firms collaborate for innovation, they need to share knowledge to integrate it.

Openness during different innovation stages was captured by asking to what extent (scale 1–7) the focal firm had collaborated with external partners during the previous 5 years, in the following innovation stages: idea generation, experimentation, design, manufacturing, and commercialization. This follows the approach in Lazzarotti *et al.* (2011), building on Gassmann and Enkel (2004) and Lazzarotti and Manzini (2009). To simplify our analysis, we applied an exploratory factor analysis to reduce the number of stages (since they are correlated). The first two were combined into the early stage, the third and fourth stages represent the implementation stage, while commercialization is our third stage. In order to analyze potential differences related to knowledge governance in our three stages, we compare firms with higher involvement of external partners in their collaborative innovation processes than the average of all firms in each of the three stages analyzed.

To capture the character and control for the type of collaborative inbound open innovation cases studied, we apply the notion of collaboration openness, which we define as level of collaboration with a specific type of partner, and number of partner types (i.e., partner depth and breadth, cf. Laursen and Salter, 2006). To define these control variables, respondents were asked to rate the intensity of collaboration in open innovation during the previous 5 years, with 8 suggested partner types: universities and R&D centers, innovation intermediaries, government agencies, customers, suppliers, consumers, competitors, and companies in other industries. This approach is adapted from Laursen and Salter (2006), but uses a finer-grained, 7-point scale to measure the intensity of each external knowledge source. The responses represent the depth of collaboration with each partner type. Partner breadth is defined as the number of different partner types (not the number of partners) that engaged in open innovation with the focal firm. We found that some firms (14.5%) had collaborated with a wide variety (all eight suggested types) of partners in their open innovation activities during the previous 5 years. Among the remaining firms, 9.2% had collaborated with only one or two suggested partner types. The median of partner breadth is 5, mean value 5.26, and standard deviation 1.95. In our analysis, firms' openness to external collaboration is a control variable. However, we use this variable as the basis for computing an important moderating variable for whether partner breadth can be considered high or low (for details, see Section 5 below).

We include additional control variables for the participating countries Finland, Italy, and Sweden (dummies). Sweden is the baseline country. We also include industry (as described above) as control variables, with the low-tech industry as the baseline. Other control variables are firm size (natural logarithm of number of employees), subsidiary (1 indicates that the firm is a division or plant that is part of a bigger group), and the extent to which R&D is outsourced to an external partner (scale 1–7). We include control variables for the extent to which the firm prioritizes radical as opposed to incremental innovation (scale 1–7), and whether R&D and marketing are core competencies of

Table 1. Descriptive statistics and correlations

Variable	Mean	Stand. Dev.	N	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	15.	17.	18.	19.	20.	21.	22.	23.	24.
1. Innovation performance	4.13	1.27	415																								
2. Project management	0.00	1.00	415	0.418																							
3. Knowledge matching	0.00	1.00	415	0.342	0.260																						
4. Partner breadth	5.26	1.95	415	0.162	0.356	0.101																					
5. Universities and research centers	3.45	2.06	415	284	0.361	0.230	0.466																				
6. Innovation intermediaries	2.85	1.80	415	0.168	0.322	0.122	0.454	0.307																			
7. Government agencies	2.28	1.58	415	0.134	0.341	0.105	0.571	0.446	0.354																		
8. Customers	4.32	1.79	415	148	0.162	0.139	0.359	0.199	0.183	0.186																	
9. Suppliers	3.99	1.66	415	0.194	0.200	0.133	0.402	0.097	0.229	0.162	0.418																
10. Consumers	2.12	1.68	415	085	0.270	0.005	0.478	0.170	0.253	0.237	0.304	0.315															
11. Competitors	1.71	1.15	415	0.122	0.120	0.066	0.452	0.092	0.076	0.179	0.163	0.273	0.246														
12. Firms in other industries	2.74	1.68	415	317	0.325	0.128	0.492	0.324	0.308	0.387	0.287	0.294	0.305	0.257													
13. Size (log)	4.37	1.78	397	−0.081	0.104	0.041	0.277	0.280	0.048	0.224	0.056	0.058	0.012	−0.006	0.021												
14. External R&D	3.45	1.39	415	0.356	0.241	0.210	0.157	0.338	0.204	0.163	0.095	0.126	0.054	0.101	0.198	−0.037											
15. Subsidiary	0.24	0.42	412	−0.190	−0.115	−0.083	−0.044	−0.059	−0.051	−0.082	−0.083	−0.043	−0.038	−0.082	−0.191	0.195	−0.121										
16. Radical innovation	3.17	1.55	415	0.328	0.272	0.207	0.168	0.212	0.117	0.230	0.171	0.190	0.092	0.009	0.177	0.084	0.187	−0.097									
17. Italy	0.37	0.48	415	0.310	0.328	−0.052	−0.103	0.070	0.117	−0.033	−0.119	−0.030	0.106	−0.044	0.154	−0.270	0.166	−0.215	−0.032								
18. Finland	0.21	0.41	415	−0.125	−0.058	−0.179	0.050	0.021	−0.257	0.108	−0.047	−0.137	−0.100	0.017	−0.108	0.216	−0.098	0.077	0.129	−0.392							
19. Sweden	0.42	0.49	415	−0.199	−0.271	0.198	0.059	−0.085	0.097	−0.056	0.155	0.142	−0.021	0.029	−0.062	0.079	−0.081	0.145	−0.075	−0.652	−0.442						
20. Low tech	0.31	0.46	415	0.059	0.004	−0.007	−0.052	0.021	−0.003	−0.065	−0.068	0.062	−0.076	−0.067	−0.016	0.005	0.039	0.005	−0.024	0.069	0.035	−0.096					
21. Med low tech	0.25	0.44	415	0.057	0.155	0.010	0.096	0.116	0.072	0.153	0.026	−0.011	0.069	0.055	0.072	−0.111	0.062	−0.101	0.045	0.202	−0.082	−0.129	−0.393				
22. Med high tech	0.14	0.35	415	−0.041	−0.022	0.145	0.018	−0.032	0.118	−0.022	0.029	0.060	−0.053	−0.043	−0.011	0.117	−0.010	0.092	0.035	−0.234	−0.173	0.371	−0.272	−0.235			
23. High tech	0.13	0.34	415	−0.019	−0.068	−0.092	0.015	−0.095	−0.035	−0.038	0.035	−0.022	0.080	0.101	−0.004	−0.040	−0.034	0.003	−0.090	−0.012	−0.004	0.015	−0.299	−0.258	−0.178		
24. NoIndData	0.16	0.37	415	−0.019	−0.068	−0.092	0.015	−0.095	−0.035	−0.038	0.035	−0.022	0.080	0.101	−0.004	−0.040	−0.034	0.003	−0.090	−0.012	−0.004	0.015	−0.299	−0.258	−0.178	−0.171	
25. Internal competencies	3.71	1.82	415	0.196	0.304	0.203	0.219	0.236	0.069	0.210	0.114	0.068	0.049	0.033	0.157	0.278	0.097	−0.070	0.417	0.014	0.213	−0.189	−0.028	−0.020	0.026	0.091	−0.048

Note: Correlation coefficients > |0.10|, significant at the 0.05 level.

Table 2. Regression analyses explaining innovation performance derived from open innovation collaboration

Variable	Model 1		Model 2		Model 3		Model 4		Model 5	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E	Coefficient	S.E.	Coefficient	S.E.
Sweden vs Italy	0.812***	(0.138)	0.847***	(0.149)	0.666***	(0.141)	0.473**	(0.147)	0.609**	(0.147)
Sweden vs Finland	−0.017	(0.159)	0.034	(0.170)	0.018	(0.160	−0.038	(0.158)	0.144	(0.160)
Low tech vs med low tech			−0.122	(0.162)	−0.230	(0.145)	−0.244^	(0.142)	−0.227	(0.139)
Low tech vs med high tech			0.061	(0.206)	−0.002	(0.180)	−0.031	(0.177)	−0.059	(0.173)
Low tech vs High tech			−0.180	(0.205)	−0.157	(0.181)	−0.121	(0.177)	−0.130	(0.173)
Low tech vs NoIndData			−0.044	(0.188)	0.075	(0.166)	0.101	(0.163)	0.123	(0.159)
Partner breadth					−0.041	(0.048)	−0.046	(0.047)	−0.028	(0.046)
Universities and research					0.096**	(0.034)	0.086*	(0.034)	0.067*	(0.033)
Innovation intermediaries					0.012	(0.036)	−0.004	(0.036)	0.000	(0.035)
Government agencies					−0.026	(0.045)	−0.046	(0.044)	−0.049	(0.043)
Customers					0.033	(0.035)	0.027	(0.035)	0.023	(0.034)
Suppliers					0.065	(0.039)	0.058	(0.039)	0.052	(0.038)
Consumers					−0.045	(0.037)	−0.057	(0.037)	−0.047	(0.036)
Competitors					0.109	(0.057)	0.104^	(0.055)	0.084	(0.054)
Firms in other industries					0.115**	(0.041)	0.107**	(0.040)	0.105**	(0.039)
Size (log)					−0.044	(0.035)	−0.053	(0.034)	−0.047	(0.034)
External R&D					0.155***	(0.042)	0.146**	(0.042)	0.132**	(0.041)
Subsidiary					−0.152	(0.131)	−0.150	(0.129)	−0.118	(0.126)
Radical innovation					0.189***	(0.040)	0.171***	(0.039)	0.160***	(0.038)
Internal competencies					0.020	(0.034)	0.003	(0.034)	−0.018	(0.033)
Knowledge gov. procedures										
Project management							0.262*b**	(0.066)	0.207**	(0.066)
Knowledge matching									0.252***	(0.058)
N	396		396		396		396		396	
F	20.538***		7.058***		10.076***		10.734***		11.605***	
Adj R2	0.090		0.084		0.315		0.341		0.371	
R2	0.095		0.098		0.350		0.376		0.406	

Note: ^$P < 0.1$, *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$.

the focal company (scale 1–7). The latter two variables provide information on firm-level skills and capabilities. Table 1 presents the descriptive statistics, and correlations among the variables, most of which are quite high, suggesting possible multicollinearity problems (see Section 5 for further analysis of this issue).

A normality test indicates that the variables and constructs used in the analysis are all normally distributed. The test of internal consistency (see Table A1 in Appendix) shows Cronbach's alpha for the factors well above the recommended threshold value of 0.60 for new scales (Nunnally, 1978). The factor representing the implementation stage is somewhat lower, which is a limitation, although inter-item correlation (value 0.41) is acceptable.

5. Regression analysis

In order to test Hypotheses 1a and 1b related to the importance of project management and knowledge-matching procedures in collaborative inbound open innovation, we performed a regression for the complete data set (see Table 2). Given that our dependent variable is continuous, we use ordinary least squares estimations. Models 1–3 include the control variables and firms' openness to external collaboration. Model 4 includes the impact of project management, and the Model 5 regression includes knowledge matching. This procedure compares the models with respect to their ability to predict the outcome variable (Field, 2013).

We performed additional regressions to test Hypotheses 2a and 2b regarding the relative importance of knowledge governance along the innovation process. Table 3 presents the impact of project management and knowledge matching during the three stages of the open innovation process, taking the different controls into account. We tested

Table 3. Regression analyses explaining innovation performance derived from open innovation collaboration in the stages of the innovation process

Variable	Idea stage		Implementation		Commercialization	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E
Sweden vs Italy	0.365^	(0.189)	0.636*	(0.215)	0.522*	(0.221)
Sweden vs Finland	0.172	(0.217)	0.504^	(0.267)	−0.162	(0.244)
Low tech vs med low tech	−0.077	(0.191)	−0.283	(0.201)	−0.089	(0.218)
Low tech vs med high tech	−0.129	(0.241)	−0.243	(0.235)	−0.022	(0.260)
Low tech vs high tech	−0.049	(0.247)	−0.440	(0.280)	−0.153	(0.281)
Low tech vs NoIndData	0.185	(0.206)	−0.054	(0.241)	0.197	(0.239)
Partner breadth	0.056	(0.064)	−0.049	(0.070)	−0.108	(0.074)
Universities and research centers	0.042	(0.039)	0.085^	(0.048)	0.076	(0.049)
Innovation intermediaries	−0.002	(0.045)	0.011	(0.048)	0.007	(0.053)
Government agencies	−0.065	(0.055)	−0.071	(0.057)	−0.066	(0.064)
Customers	0.024	(0.047)	0.080^	(0.047)	0.084	(0.054)
Suppliers	−0.003	(0.048)	−0.003	(0.054)	−0.021	(0.059)
Consumers	−0.061	(0.045)	−0.008	(0.046)	−0.085^	(0.049)
Competitors	0.044	(0.063)	0.120	(0.078)	0.203*	(0.084)
Firms in other industries	0.108*	(0.048)	0.116*	(0.052)	0.097^	(0.058)
Size (log)	−0.126*	(0.043)	−0.042	(0.048)	0.028	(0.047)
External R&D	0.112*	(0.050)	0.128*	(0.058)	0.085	(0.068)
Subsidiary	0.064	(0.181)	0.067	(0.191)	−0.213	(0.195)
Radical innovation	0.133*	(0.052)	0.235***	(0.055)	0.141*	(0.060)
Internal competencies	0.024	(0.049)	−0.065	(0.047)	0.013	(0.053)
Knowledge gov. procedures						
Project management	0.284**	(0.080)	0.123	(0.095)	0.146	(0.093)
Knowledge matching	0.283**	(0.083)	0.233**	(0.088)	0.268**	(0.090)
N	188		189		162	
F	5.710***		6.241***		4.743***	
Adj R2	0.357		0.380		0.338	
R2	0.432		0.453		0.429	

Note: ^$P < 0.1$, *$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

the effect of the independent variables on innovation performance for firms reporting involvement of external partners in these stages, at above the mean for all firms (see Appendix for the question and items related to the stages). This resulted in a total of three multiple regression models. In order to test Hypotheses 3a and 3b, we performed an analysis to explore whether the number of different types of partners matters for how knowledge is governed in open innovation. We compared firms with high partner breadth (defined by collaborating with more than the average number of different types of partners) with firms with low partner breadth (i.e., below the average number of partner types). The effects of project management and knowledge matching on innovation performance are tested in two multiple regression models.

We used the variance inflation factor (VIF) to assess any potential multicollinearity problems. In the above models, the VIF factors are well below the typically recommended threshold of 10 (Belsey *et al.*, 1980), and except for partner breadth (with a value of 3.18) are well below 2. To investigate this further, we estimated a separate model omitting partner breadth. The main results did not change.

Single respondent research designs, such as the online survey that was the data source for this study, can suffer from common method variance. There might be a tendency for managers to overemphasize the success of the firm's collaborative efforts. However, there seems no strong reason why they would want to inflate the results of their open innovation activities over internal activities (the possibility of a not invented here syndrome would go against this), which could limit the problem. In addition, since the practices included in the survey are fairly objective (e.g., whether the firm formally assesses the performance and results of collaborative projects), there would seem to be no reason for managers to overemphasize the use of our two knowledge governance procedures. If our dependent variable is inflated to a degree and the independent variables are accurately observed, our results are downward rather than upward biased.

Nevertheless, we conducted a Harman single-factor test using exploratory factor analysis. In the presence of substantial common method variance, we would expect either a single factor to emerge from the factor analysis or one general factor to account for most of the covariance among the items (Podsakoff *et al.*, 2003). The exploratory factor analysis results in six distinct factors, each with an eigenvalue greater than 1. Together, these factors account for 60% of the total variance. Also, the biggest factor does not account for a large amount of the variance (15%). Therefore, it can be concluded that there is no single general factor present, and that the test does not indicate common method variance (Podsakoff *et al.*, 2003).

To address the issue further, we included a marker variable in our analysis to check for any indication of the presence of common method variance. It has been argued that if a variable can be identified on theoretical grounds, which should be unrelated to the other variables included in the study, then it can be used as a marker, since any observed relationships between it and any of the other variables, can be assumed to be due to common method bias (Lindell and Whitney, 2001; Podsakoff *et al.*, 2003). We included a variable reflecting the use of Internet-based systems to facilitate the search for potential partners (measured on a 1–7 scale). Theoretically, this variable should not be related to either our dependent variable or our central independent variables. When this variable is entered into the regressions, it has no explanatory power, which further supports our results not being driven by common method variance. Overall, our tests suggest that it is unlikely that common method variance is affecting the results to any great extent. In order to check the robustness of the results, given that we have a few very large firms in our sample, we performed an additional regression which excluded the largest firms (>1000 employees), but our main results did not change.

6. Results

The results of the first regression analyses, reported in Table 2, support Hypotheses 1a and 1b. Models 4 and 5 show that the effects of the two knowledge governance procedures are strongly significant for innovation performance stemming from open innovation collaboration. Further, the models' explanatory power improves when we add project management and knowledge matching, respectively.

Contrary to our expectations, we did not find support for Hypotheses 2a and 2b (see Table 3). Project management has a significant impact on performance in the early stages of the innovation process, but not in the later stages. Also, knowledge-matching procedures are significantly and strongly related to performance in all the stages, not just in the earlier stages. Consequently, our analysis does not display the expected differences in the relative importance of knowledge matching in the front-end versus the back-end of the innovation process. Thus, Hypotheses 2a nor 2b are not supported.

Table 4 displays the results when the sample is split into firms that collaborate with a few or with numerous different partner types. Hypotheses 3a and 3b are supported. The coefficient of project management is significant for high partner breadth. For low partner breadth, the coefficient is nonsignificant and lower than the coefficient of high partner breadth. This is in line with Hypothesis 3a. In relation to knowledge matching, the coefficients of both high and low partner breadths are significant. These findings are in line with Hypothesis 3b.

Finally, we discuss the control variables. Starting with openness, collaboration with university/research centers, customers, consumers, competitors, and firms in other industries positively influence innovation performance in the later stages of the innovation process. Firms from other industries seem to be important for innovation performance regardless of the stage of the innovation process. There are also some country differences. In addition, we find that the outcome of open innovation is explained by the amount of R&D performed by external partners, and the extent to which the firm prioritizes radical over incremental innovation. Firm size, industry, internal competencies, and whether or not it is a subsidiary appear to have no effect on innovation performance.

7. Discussion and conclusion

The aim of this article was to contribute to emerging theories of open innovation by explaining how the phenomenon of open innovation is related to organizational economics, knowledge-based theories of the firm, and knowledge governance. Specifically, in a knowledge-based conceptualization of collaborative inbound open innovation, we

Table 4. Regression analyses explaining innovation performance derived from open innovation collaboration—sample split according to high and low partner breadth

Variable	Low partner breadth		High partner breadth	
	Coefficient	S.E.	Coefficient	S.E.
Sweden vs Italy	0.672**	(0.229)	0.345	(0.215)
Sweden vs Finland	0.320	(0.272)	0.115	(0.193)
Low tech vs med low tech	−0.461*	(0.226)	−0.113	(0.173)
Low tech vs med high tech	−0.016	(0.289)	−0.022	(0.217)
Low tech vs high tech	−0.109	(0.259)	−0.280	(0.240)
Low tech vs NoIndData	0.210	(0.246)	−0.023	(0.210)
Universities and research centers	0.074	(0.050)	0.071	(0.046)
Innovation intermediaries	−0.030	(0.053)	0.054	(0.045)
Government agencies	−0.024	(0.083)	−0.048	(0.047)
Customers	0.048	(0.047)	−0.015	(0.053)
Suppliers	0.103^	(0.054)	−0.027	(0.055)
Consumers	−0.035	(0.067)	−0.035	(0.043)
Competitors	−0.078	(0.103)	0.171**	(0.057)
Firms in other industries	0.081	(0.059)	0.121*	(0.051)
Size (log)	−0.054	(0.065)	−0.066^	(0.040)
External R&D	0.189**	(0.069)	0.103^	(0.053)
Subsidiary	−0.039	(0.188)	−0.163	(0.169)
Radical innovation	0.194**	(0.058)	0.114*	(0.050)
Internal competencies	−0.089^	(0.050)	0.058	(0.045)
Knowledge gov. procedures				
Project management	0.155	(0.107)	0.277**	(0.083)
Knowledge matching	0.245**	(0.089)	0.258**	(0.080)
N	201		195	
F	5.174***		8.785***	
Adj R2	0.305		0.457	
R2	0.378		0.516	

Note: ^$p < 0.1$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

suggested that the choice of knowledge governance—in terms of interfirm organizational procedures—plays a pivotal role in innovation performance. Our econometric analysis demonstrated that project management and knowledge-matching procedures by focal firms have a positive influence on innovation performance derived by those focal firms from collaborative inbound open innovation.

We also found distinct effects of project management and knowledge matching by relating them to partner breadth in collaborative inbound open innovation. As discussed in the literature, partner breadth is a fundamental issue in search and open innovation. Several studies show that increased breadth leads to increased innovation performance (Laursen and Salter, 2006; Leiponen and Helfat, 2010; Love *et al.*, 2014). At the same time, several studies (Laursen and Salter, 2006; Leiponen and Helfat, 2010) show that there is a curvilinear relationship between partner breadth and innovation, suggesting that increased knowledge differentiation and diverse motivations (Grandori, 2001) associated with increased partner breadth create an integration challenge for firms pursuing collaborative inbound innovation. For instance, Bertrand and Mol (2013) show that while knowledge heterogeneity associated with a broad range of partners promotes innovation through recombination, increased cognitive distance (Nooteboom, 2009) calls for some purposive activity. Our study sheds light on the procedures for bridging cognitive distance and aligning incentives, which are required as partner breadth increases. While coordination through knowledge matching is important regardless of the number of types of partners, we suggest that increased partner breadth results in more divergent motivations to contribute, resulting in the need for project management to align and control the partners. These relationships are confirmed by our empirical data. In line with Felin and Zenger (2014), we argue that specific collaborative inbound open innovation conditions provide incentives to engage in problem solving, which, in turn, warrants specific knowledge governance procedures.

More generally, and in response to recent calls in the open innovation literature (West and Bogers, 2014), our findings question the simple equating of knowledge search for innovation through recombination in open innovation, with the procedures used by firms to govern knowledge flows to integrate knowledge effectively. Our study provides empirical evidence of important and distinctive effects of the use of project management and knowledge matching for innovation performance. Despite their different characteristics and contrary to our predictions, our empirical results suggest that project management has a positive effect on the performance of firms engaged primarily in collaboration in the early ideation stage of the innovation process, while knowledge integration seems beneficial for performance in every stage—from idea generation, to implementation, to commercialization. We speculate that this latter result might be because all the stages of innovation involve a high level of creativity and knowledge recombination, despite differences in the levels of exploration and exploitation. It could be that these creative and knowledge recombination processes—across all stages—require knowledge matching in order to be effective (as our empirical findings would suggest). Another, closely related, explanation for the significance of knowledge matching during all stages may be the assumed linearity of the innovation process. Although it is common to depict open innovation as a linear process, involving many partners, in an open and distributed activity to achieve innovation, it may also imply a network-like structure of activities which are not always distinguishable in the sequential stages (see e.g., Dittrich and Duysters, 2007).

Our findings indicate that previous research (e.g., Cooper, 2008; Gronlund *et al.*, 2010), emphasizing the distinctiveness of the challenges that arise in different stages of the innovation process, may underestimate the need for a degree of structure imposed by project management procedures in the early stages of the innovation process. Certainly, the results obtained for project management contrast with our assumptions, suggesting rather that these kinds of formalized procedures might open the way to broader collaboration between internal and external actors and enhance the possibilities for knowledge recombination in the early stages. Another explanation might be that the need for project management to guard against opportunistic behavior is not limited to the later stages of the innovation process, and is particularly important in the early stages involving the selection of partners. Further research is needed to examine how collaborative inbound open innovation is organized in time and space, and to identify novel ways of partitioning sets of activities, including the effects on innovation performance.

From a managerial viewpoint, we recognize that previous research on open innovation makes it clear that different contingencies affect the decision to "go open" and the conditions that make open innovation more likely to be successful. However, the present study sheds new light on the procedures used by firms to ensure that the potential benefits accruing from open innovation can be captured by managerial interventions. In particular, the study demonstrates that while both project management and knowledge matching are appropriate and important devices for managing collaborative inbound open innovation, the magnitude of role of project management increases with increasing partner variety. This calls for some rethinking by managers about the use and appropriateness of the different project management tools available in such situations.

This study has some limitations. Our analysis involves discussion of knowledge governance only in collaborative inbound open innovation and does not examine governance of outbound innovation. Future research could adopt a practice-based approach and consider the influence of knowledge governance mechanisms in a range of open innovation practices, such as those suggested by Alexy *et al.* (2016). Also, we do not discuss open innovation in relation to the markets for technology and intellectual property strategies.

That collaborative innovation projects are governed by firm-level organizational procedures is a strong assumption. There may be circumstances that might give rise to heterogeneity across the firm's various collaborative projects—for instance, related to the level of incremental/radical innovation the particular collaboration involves. However, based on previous research, we argue that due to organizational imprinting, firms' organizational procedures are persistent over time, and the same organizational procedures are deep-rooted in the individuals who work in collaborative settings. Also, although our sample included a few very large firms, the median number of employees for the firms in the study is 50. Among small and medium-sized firms, it is likely that the use of organizational procedures to manage open innovation collaboration is relatively homogeneous. However, the assumption that collaborative innovation projects are governed by firm-level organizational procedures remains a fundamental limitation of the current study. Another limitation is that we were unable to factor in that some multi-partner collaborations might involve an independent central authority. In line with Badir *et al.* (2009), future research should conduct multilevel analyses that factor in the firm and project levels simultaneously. Moreover, although we consider a 5-year time window to observe collaboration is sufficient in most cases, it does not cover all the stages of collaboration in all cases.

Although the study relies on a rich and detailed cross-section of innovative firms in three different countries, the data make it difficult to draw strong causal inferences about the relationship between decisions pertaining to the application of governance procedures and open innovation outcomes. It would be useful to have panel data or experimental data, especially at the level of innovation projects, in order to draw definite conclusions concerning the direction of the relationship. In addition, we focus on only two types of knowledge governance procedures and downplay the role of the market; future research could consider a broader set of governance procedures (see also, Rothwell, 1994; Felin and Zenger, 2014).

How open innovation in general could best be governed over the stages of the innovation process, and in the case of the involvement of a few or many partners, would appear to be an exciting area for future research. In addition, how the benefits of open innovation are appropriated (Laursen and Salter, 2014), combined with the choice of governance, have yet to be explored. We suggest that future research could benefit from integrating our approach with that of Zobel *et al.* (2016) and Alexy *et al.* (2016). This could imply further investigation of the interaction between specific intellectual property rights (e.g., patents) and human capital investments, with the knowledge governance types discussed here. The insights gained from research integrating these constructs could be informative for managers engaging in open innovation processes.

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References

Afuah, A. and C. L. Tucci (2012), 'Crowdsourcing as a solution to distant search,' *Academy of Management Review*, **37**(3), 355–375.

Aghion, P. and J. Tirole (1994), 'The management of innovation,' *The Quarterly Journal of Economics*, **109**(4), 1185–1209.

Ahuja, G. (2000), 'Collaboration networks, structural holes and innovation: a longitudinal study,' *Administrative Science Quarterly*, **45**(3), 425–455.

Alexy, O., E. Bascavusoglu-Moreau and A. J. Salter (2016), 'Toward an aspiration-level theory of open innovation,' *Industrial and Corporate Change*, **25**(2), 289–306.

Arora, A., A. Fosfuri and A. Gambardella (2001), 'Markets for technology and their implications for corporate strategy,' *Industrial and Corporate Change*, **10**(2), 419–451.

Arora, A. and A. Gambardella (2010), 'Ideas for rent: an overview of markets for technology,' *Industrial and Corporate Change*, **19**(3), 775–803.

Badir, Y. F., B. Büchel and C. L. Tucci (2009), 'The performance impact of intra-firm organizational design on an alliance's NPD projects,' *Research Policy*, **38**(8), 1350–1364.

Baron, J. N., M. T. Hannan and M. D. Burton (1999), 'Building the iron cage: determinants of managerial intensity in the early years of organizations,' *American Sociological Review*, **64**(4), 527–547.

Baum, J., T. Calabrese and B. S. Silverman (2000), 'Don't go it alone: alliance networks and startups' performance in Canadian biotechnology,' *Strategic Management Journal*, **21**(3), 267–294.

Bechky, B. A. (2003), 'Sharing meaning across occupational communities: the transformation of understanding on a production floor,' *Organization Science*, **14**(3), 312–330.

Belsey, D. A., E. Kuh and R. E. Welsch (1980), *Regression Diagnostics: Identifying Influential Data and Sources of Collinearity*. John Wiley: Hoboken, NJ.

Bengtsson, L., N. Lakemond, V. Lazzarotti, R. Manzini, L. Pellegrini and F. Tell (2015), 'Open to a select few? Matching partners and knowledge content for open innovation performance,' *Creativity and Innovation Management*, **24**(1), 72–86.

Berchicci, L. (2013), 'Towards an open R&D system: internal R&D investment, external knowledge acquisition and innovative performance,' *Research Policy*, **42**(1), 117–127.

Berggren, C., J. Sydow and F. Tell (2016), 'Relating knowledge integration and absorptive capacity: knowledge boundaries and reflective agency in path-dependent processes,' in F. Tell, C. Berggren, S. Brusoni and A. van de Ven (eds), *Managing Knowledge Integration across Boundaries*. Oxford University Press: Oxford, UK.

Bertrand, O. and M. J. Mol (2013), 'The antecedents and innovation effects of domestic and offshore R&D outsourcing: the contingent impact of cognitive distance and absorptive capacity,' *Strategic Management Journal*, **34**(6), 751–760.

Brown, J. S. and P. Duguid (1991), 'Organizational learning and communities-of-practice: toward a unified view of working, learning, and innovation,' *Organization Science*, **2**(1), 40–57.

Carlile, P. R. (2002), 'A pragmatic view of knowledge and boundaries: boundary objects in new product development,' *Organization Science*, **13**(4), 442–455.

Carlile, P. R. (2004), 'Transferring, translating, and transforming: an integrative framework for managing knowledge across boundaries,' *Organization Science*, **15**(5), 555–568.

Cassiman, B. and R. Veugelers (2006), 'In search of complementarity in innovation strategy: internal R&D and external knowledge acquisition,' *Management Science*, **52**(1), 68–82.

Chesbrough, H. (2003), *Open Innovation*. Harvard University Press: Cambridge, MA.

Chesbrough, H. and M. Bogers (2014), 'Explicating open innovation: clarifying an emerging paradigm for understanding innovation,' in H. Chesbrough, W. Vanhaverbeke and J. West (eds), *New Frontiers in Open Innovation*. Oxford University Press: Oxford, UK.

Clausen, T., M. Pohjola, K. Sapprasert and B. Verspagen (2012), 'Innovation strategies as a source of persistent innovation,' *Industrial and Corporate Change*, **21**(3), 553–585.

Cohen, W. M. and D. A. Levinthal (1990), 'Absorptive capacity: a new perspective on learning and innovation,' *Administrative Science Quarterly*, **35**(1), 128–152.

Cooper, R. G. (2008), 'Perspective: the stage-gate® idea-to-launch process - update, what's new, and nexgen systems,' *Journal of Product Innovation Management*, **25**(3), 213–232.

Cyert, R. M. and J. G. March (1963), *A Behavioral Theory of the Firm*. Prentice-Hall: Englewood Cliffs, NJ.

Dahlander, L., L. Frederiksen and F. Rullani (2008), 'Online communities and open innovation,' *Industry and Innovation*, **15**(2), 115–123.

Dahlander, L. and D. Gann (2010), 'How open is innovation?,' *Research Policy*, **39**(6), 699–709.

Dahlander, L. and H. Piezunka (2014), 'Open to suggestions: how organizations elicit suggestions through proactive and reactive attention,' *Research Policy*, **43**(5), 812–827.

Dekker, H. C. (2004), 'Control of inter-organizational relationships: evidence on appropriation concerns and coordination requirements,' *Accounting, Organizations and Society*, **29**(1), 27–49.

Demsetz, H. (1988), 'The theory of the firm revisited,' *Journal of Law, Economics, and Organization*, **4**(1), 141–161.

Dittrich, K. and G. Duysters (2007), 'Networking as a means to strategy change: the case of open innovation in mobile telephony,' *Journal of Product Innovation Management*, **24**(6), 510–521.

Dosi, G. (1988), 'Sources, procedures and microeconomic effects of innovation,' *Journal of Economic Literature*, **26**(3), 1120–1171.

Du Chatenier, E., J. A. Verstegen, H. J. Biemans, M. Mulder and O. S. Omta (2010), 'Identification of competencies for professionals in open innovation teams,' *R&D Management*, **40**(3), 271–280.

Enberg, C., L. Lindkvist and F. Tell (2006), 'Exploring the dynamics of knowledge integration: acting and interacting in project teams,' *Management Learning*, **37**(2), 143–165.

Faems, D., B. Van Looy and K. Debackere (2005), 'Interorganizational collaboration and innovation: toward a portfolio approach,' *Journal of Product Innovation Management*, **22**(3), 238–250.

Felin, T. and T. R. Zenger (2014), 'Closed or open innovation? Problem solving and the governance choice,' *Research Policy*, **43**(5), 914–925.

Fey, C. F. and J. Birkinshaw (2005), 'External sources of knowledge, governance mode, and R&D performance,' *Journal of Management*, **31**(4), 597–621.

Field, A. (2013), *Discovering Statistics using IBM SPSS Statistics*. Sage: London, UK.

Fleming, L. and O. Sorenson (2004), 'Science as a map in technological search,' *Strategic Management Journal*, **25**(8/9), 909–928.

Forza, C. (2002), 'Survey research in operations management: a process-based perspective,' *International Journal of Operations & Production Management*, **22**(2), 152–194.

Foss, N. J., K. Husted and S. Michailova (2010), 'Governing knowledge sharing in organizations: levels of analysis, governance mechanisms, and research directions,' *Journal of Management Studies*, **47**(3), 455–482.

Foss, N. J., K. Laursen and T. Pedersen (2011), 'Linking customer interaction and innovation: the mediating role of new organizational practices,' *Organization Science*, **22**(4), 980–999.

Gans, J. S. and S. Stern. (2010), 'Is there a market for ideas?,' *Industrial and Corporate Change*, **19**(3), 805–837.

Garriga, H., G. von Krogh and S. Spaeth (2013), 'How constraints and knowledge impact open innovation,' *Strategic Management Journal*, **34**(9), 1134–1144.

Gassmann, O. and E. Enkel (2004), 'Towards a theory of open innovation: three core process archetypes,' R&D Management Conference, Taiwan, Vol. 6, pp. 1–18

Grandori, A. (2001), 'Neither hierarchy nor identity: knowledge-governance mechanisms and the theory of the firm,' *Journal of Management and Governance*, **5**(3–4), 381–399.

Granstrand, O. and M. Holgersson (2013), 'Managing the intellectual property disassembly problem,' *California Management Review*, **55**(4), 184–210.

Grant, R. (1996), 'Toward a knowledge-based theory of the firm,' *Strategic Management Journal*, **17**, 109–122.

Grant, R. M. and C. Baden-Fuller (2004), 'A knowledge accessing theory of strategic alliances,' *Journal of Management Studies*, **41**(1), 61–84.

Grimpe, C. and W. Sofka (2009), 'Search patterns and absorptive capacity: low- and high-technology sectors in European countries,' *Research Policy*, **38**(3), 495–506.

Gronlund, J., D. R. Sjodin and J. Frishammar (2010), 'Open innovation and the stage-gate process: a revised model for new product development,' *California Management Review*, **52**(3), 106–131.

Hagedoorn, J. (1993), 'Understanding the rationale of strategic technology partnering: interorganizational modes of cooperation and sectoral differences,' *Strategic Management Journal*, **14**(5), 371–385.

Hannan, M. T., M. D. Burton and J. N. Baron (1996), 'Inertia and change in the early years: employment relations in young, high technology firms,' *Industrial and Corporate Change*, **5**(2), 503–536.

Heath, C. and N. Staudenmayer (2000), 'Coordination neglect: how lay theories of organizing complicate coordination in organizations,' *Research in Organizational Behavior*, **22**, 153–191.

Higgins, M. C. (2005), *Career Imprints: Creating Leaders across an Industry*. Jossey-Bass: San Francisco, CA.

Hoang, H. and F. T. Rothaermel (2010), 'Leveraging internal and external experience: exploration, exploitation, and R&D project performance,' *Strategic Management Journal*, **31**(7), 734–758.

Holmström, B. (1989), 'Agency costs and innovation,' *Journal of Economic Behavior and Organization*, **12**, 305–327.

Huizingh, E. (2011), 'Open innovation: state of the art and future perspectives,' *Technovation*, **31**(1), 2–9.

Hung, K. P. and C. Chou (2013), 'The impact of open innovation on firm performance: the moderating effects of internal R&D and environmental turbulence,' *Technovation*, **33**(10–11), 368–380.

Jansen, J. J. P., F. A. J. van den Bosch and H. W. Volberda (2005), 'Managing potential and realized absorptive capacity: how do organizational antecedents matter?,' *Academy of Management Journal*, **48**(6), 999–1015.

Johansson, M., M. Axelson, C. Enberg and F. Tell (2011), 'Knowledge integration in inter-firm R&D collaboration,' in C. Berggren, A. Bergek, L. Bengtsson, M. Hobday and S. Söderlund (eds), *Knowledge Integration and Innovation*. Oxford University Press: Oxford, UK, pp. 148–169.

Kogut, B. and U. Zander (1992), 'Knowledge of the firm, combinative capabilities, and the replication of technology,' *Organization Science* **3**(3), 383–397.

Kogut, B. and U. Zander (1996), 'What firms do? Coordination, identity, and learning,' *Organization Science*, **7**(5), 502–518.

Lane, P. J. and M. Lubatkin (1998), 'Relative absorptive capacity and interorganizational learning,' *Strategic Management Journal*, **19**(5), 461–477.

Laursen, K. (2012), 'Keep searching and you'll find: what do we know about variety creation through firms' search activities for innovation?,' *Industrial and Corporate Change*, **21**(5), 1181–1220.

Laursen, K., F. Masciarelli and A. Prencipe (2012), 'Regions matter: how localized social capital affect innovation and external knowledge use,' *Organization Science*, **23**(1), 177–193.

Laursen, K. and A. Salter (2006), 'Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms,' *Strategic Management Journal*, **27**(2), 131–150.

Laursen, K. and A. J. Salter (2014), 'The paradox of openness: appropriability, external search and collaboration,' *Research Policy*, **43**(5), 867–878.

Lazzarotti, V. and R. Manzini (2009), 'Different modes of open innovation: a theoretical framework and empirical study,' *International Journal of Innovation Management*, **13**(4), 615–636.

Lazzarotti, V., R. Manzini and L. Pellegrini (2011), 'Firm-specific factors and the openness degree: a survey of Italian firms,' *European Journal of Innovation Management*, **14**(4), 412–434.

Leiponen, A. (2012), 'The benefits of R&D and breadth in innovation strategies: a comparison of Finnish service and manufacturing firms,' *Industrial and Corporate Change*, **21**(5), 1255–1281.

Leiponen, A. and C. E. Helfat (2010), 'Innovation opportunities, knowledge sources, and the benefits of breadth,' *Strategic Management Journal*, **31**(2), 224–236.

Lim, K. (2009), 'The many faces of absorptive capacity: spillovers of copper interconnect technology for semiconductor chips,' *Industrial and Corporate Change*, **18**(6), 1249–1284.

Lin, B.-W. and C.-J. Chen (2006), 'Fostering product innovation in industry networks: the mediating role of knowledge integration,' *The International Journal of Human Resource Management*, **17**(1), 155–173.

Lindell, M. K. and D. J. Whitney (2001), 'Accounting for common method variance in cross-sectional research designs,' *Journal of Applied Psychology*, **86**(1), 114–121.

Love, J. H., S. Roper and P. Vahter (2014), 'Learning from openness: the dynamics of breadth in external innovation linkages,' *Strategic Management Journal*, **35**(11), 1703–1716.

McEvily, B., J. Jaffee and M. Tortoriello (2012), 'Not all bridging ties are equal: network imprinting and firm growth in the Nashville legal industry, 1933–1978,' *Organization Science*, **23**(2), 547–563.

Milgrom, P. and J. Roberts (1992), *Economics, Organization & Management*. Prentice Hall: Upper Saddle River, NJ.

Nickerson, J. A. and T. R. Zenger (2004), 'A knowledge-based theory of the firm—the problem-solving perspective,' *Organization Science*, **15**(6), 617–632.

Nooteboom, B. (2009), *A Cognitive Theory of the Firm: Learning, Governance and Dynamic Capabilities*. Edward Elgar Publishing: Cheltenham, UK.

Nunnally, J. (1978), *Psychometric Methods*. McGraw-Hill: New York, NY.

Ouchi, W. G. (1980), 'Markets, bureaucracies, and clans,' *Administrative Science Quarterly*, **25**(1), 129–141.

Parmigiani, A. and M. Rivera-Santos (2011), 'Clearing a path through the forest: a meta-review of interorganizational relationships,' *Journal of Management*, **37**(4), 1108–1136.

Pisano, G. (1990), 'The R&D boundaries of the firm: an empirical analysis,' *Administrative Science Quarterly*, **35**(1), 153–176.

Podsakoff, P. M., S. B. MacKenzie, J. Y. Lee and N. P. Podsakoff (2003), 'Common method biases in behavioral research: a critical review of the literature and recommended remedies,' *Journal of Applied Psychology*, **88**(5), 879–903.

Postrel, S. (2002), 'Islands of shared knowledge: specialization and mutual understanding in problem-solving teams,' *Organization Science*, **13**(3), 303–320.

Postrel, S. (2009), 'Multitasking teams with variable complementarity: challenges for capability management,' *Academy of Management Review*, **34**(2), 273–296.

Powell, W. W. (1987), 'Hybrid organizational arrangements - new form or transitional development,' *California Management Review*, **30**(1), 67–87.

Roberts, J. (2004), *The Modern Firm*. Oxford University Press: Oxford, UK.

Rothaermel, F. and M. Alexandre (2009), 'Ambidexterity in technology sourcing: the moderating role of absorptive capacity,' *Organization Science*, **20**(4), 759–780.

Rothwell, R. (1994), 'Towards the fifth-generation innovation process,' *International Marketing Review*, **11**(1), 7–31.

SCB (2014), *Innovationsverksamhet i svenska företag 2010–2012*. Statistiska Centralbyrån: Sweden.

Schildt, H., T. Keil and M. Maula (2012), 'The temporal effects of relative and firm-level absorptive capacity on interorganizational learning,' *Strategic Management Journal*, **33**(10), 1154–1173.

Seidel, V. P. and B. Langner (2015), 'Using an online community for vehicle design: project variety and motivations to participate,' *Industrial and Corporate Change*, **24**(3), 635–653.

Somaya, D. (2012), 'Patent strategy and management an integrative review and research agenda,' *Journal of Management*, **38**(4), 1084–1114.

Spithoven, A., B. Clarysse and M. Knockaert (2010), 'Building absorptive capacity to organise inbound open innovation in traditional industries,' *Technovation*, **30**(2), 130–141.

Srikanth, K. and P. Puranam (2011), 'Integrating distributed work: comparing task design, communication, and tacit coordination mechanisms,' *Strategic Management Journal*, **32**(8), 849–875.

Srikanth, K. and P. Puranam (2014), 'The firm as a coordination system: evidence from software services offshoring,' *Organization Science*, **25**(4), 1253–1271.

Tell, F. (2011), 'Knowledge integration and innovation: a survey of the field,' in C. Berggren, A. Bergek, L. Bengtsson, M. Hobday and J. Söderlund (eds.), *Knowledge Integration and Innovation: Critical Challenges facing International Technology-based Firms*. Oxford University Press: Oxford, UK, pp. 20–58.

Turner, K. L. and M. V. Makhija (2006), 'The role of organizational controls in managing knowledge,' *Academy of Management Review*, **31**(1), 197–217.

van Beers, C. and F. Zand (2014), 'R&D cooperation, partner diversity, and innovation performance: an empirical analysis,' *Journal of Product Innovation Management*, **31**(2), 292–312.

Vanhaverbeke, W. and M. Cloodt (2006), 'Open innovation in value networks,' in H. Chesbrough, W. Vanhaverbeke and J. West (eds), *Open Innovation: Researching a New Paradigm*. Oxford University Press: Oxford, UK, pp. 258–281.

Vega-Jurado, J., A. Gutiérrez-Gracia and I. Fernández-de-Lucio (2009), 'Does external knowledge sourcing matter for innovation? Evidence from the Spanish manufacturing industry,' *Industrial and Corporate Change*, **18**(4), 637–670.

Volberda, H. W., N. J. Foss and M. A. Lyles (2010), 'Perspective-absorbing the concept of absorptive capacity: how to realize its potential in the organization field,' *Organization Science*, **21**(4), 931–951.

West, J. and M. Bogers (2014), 'Leveraging external sources of innovation: a review of research on open innovation,' *Journal of Product Innovation Management*, **31**(4), 814–831.

Williamson, O. and S. G. Winter (eds.) (1991), *The Nature of the Firm: Origins, Evolution, and Development*. Oxford University Press: New York, NY.

Williamson, O. E. (1985), *The Economic Institutions of Capitalism*. Free Press: New York, NY.

Williamson, O. E. (1991), 'Comparative economic organization: the analysis of discrete structural alternatives,' *Administrative Science Quarterly*, **36**(2), 269–296.

Zahra, S. A. and G. George (2002), 'Absorptive capacity: a review, reconceptualization, and extension,' *Academy of Management Review*, **27**(2), 185–203.

Zobel, A.-K., B. Balsmeier and H. Chesbrough (2016), 'Does patenting help or hinder open innovation? Evidence from new entrants in the solar industry,' *Industrial and Corporate Change*, **25**(2), 307–331.

Appendix

Table A1. Factor loadings

Factors	Innovation performance	Project management	Knowledge matching	Ideation	Implementation	Commercialization
Performance						
New or improved product/services	0.816					
New or improved processes	0.841					
New markets	0.751					
Project management						
Project management techniques		0.736				
Assessment of performance results		0.872				
Rewards and incentive systems		0.728				
Knowledge matching						
Matching of partners' technological competences			0.856			
Access to partners' knowledge resources			0.852			
Synergy by combining knowledge among firms			0.861			
Innovation stages						
Idea				0.837		
Experimentation				0.856		
Engineering					0.749	
Manufacturing					0.873	
Commercialization						0.950
Variance explained	64.6%	61.1%	73.3%	33.9%	27.2%	20.8%
Cronbach's alpha	0.719	0.675	0.817	0.691	0.584	
N	415	415	415	415	415	415

Appendix—Survey questions and items

Innovation performance: Please indicate how well collaboration with external partners in innovation activities has performed against the following objectives over the last 3 years: - Introduce new or significantly improved products or services - Introduce new or significantly improved process of producing our products or services - Opening of new markets	1 (not at all)–7 (to a great extent)
Project management: Please indicate your agreement with each of the following statements with respect to your firm's organisational and managerial actions regarding collaboration with external partners in innovation activities: - We use project management techniques to manage the collaborations - We formally asses the performance and results of collaborative projects - We have a reward and incentive system to recognise the benefits of collaborative innovation	1 (strongly disagree)–7 (strongly agree)
Knowledge matching: Please indicate your agreement with each of the following statements with respect to your firm's experience in collaboration in innovation with external partners: - Partners' technological competences match up - Access to partners' knowledge resources - Synergy created by combining knowledge among participating firms	1 (strongly disagree)–7 (strongly agree)

Partner depth: Please indicate the extent to which your firm has collaborated with the following stakeholders in innovation activities over the last 5 years: - Universities and research centres - Innovation intermediaries - Government agencies - Customers - Suppliers - Consumers - Competitors - Companies operating in other industries	1 (not at all)–7 (to great extent)
External R&D: Please estimate how much of the total R&D activities in your development project that is done by external partners	1 (not at all)–7 (to great extent)
Radical strategy: Please indicate your agreement with each of the following statements with respect to your firm's strategy: - We focus on radical rather than incremental innovation	1 (strongly disagree)–7 (strongly agree)
Internal competencies: Please indicate your agreement with each of the following statements with respect to your firm's strategy: - R&D and marketing are our core competencies	1 (strongly disagree)–7 (strongly agree)
Stages: Please indicate the extent to which your firm has collaborated with external partners in the following stages of the innovation process over the last 5 years: - Idea generation/exploratory research - Experimentation - Engineering - Manufacturing - Commercialisation	1 (not at all)–7 (to great extent)