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University-industry collaborations and product innovation performance: the moderating effects of absorptive capacity and innovation competencies

Sebastian Kobarg[1] · **Jutta Stumpf-Wollersheim**[1,2] · **Isabell M. Welpe**[1,3]

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Abstract While the performance implications of university-industry collaboration (UIC) have been the subject of extensive research, no study thus far has investigated the potential influence of absorptive capacity and innovation competencies on the relationship between UIC and product innovation performance. Based on a sample of 2061 German companies from two waves of the German Community Innovation Survey and using moderated multiple regression, this study examines these moderating effects and provides the following findings: (1) absorptive capacity in terms of internal R&D negatively moderates the relationship between UIC and incremental innovation performance and has no effect on the relationship between UIC and radical innovation performance; (2) absorptive capacity related to employee know-how has no moderating effect on the relationship between UIC and incremental innovation performance but positively moderates the relationship between UIC and radical innovation performance; and (3) innovation competencies exert no moderating effect on the relationship between UIC and incremental innovation performance but have a predominantly positive moderating effect on the relationship between UIC and radical innovation performance. In summary, our study provides relevant insights on the dynamics governing UIC relationships and provides evidence for potential negative effects of absorptive capacity in the context of collaborative R&D (substitution effect). Providing an in-depth analysis of UIC, this study offers insights for research in this field by explaining the variance in the outcomes of UIC. Moreover, our findings have the potential

✉ Sebastian Kobarg
sebastian.kobarg@tum.de

[1] TUM School of Management, Technische Universität München, Arcisstr. 21, 80333 Munich, Germany

[2] Faculty of Business Administration, Technische Universität Bergakademie Freiberg, Schlossplatz 1, 09599 Freiberg, Germany

[3] Bavarian State Institute for Higher Education Research and Planning, Prinzregentenstraße 24, 80538 Munich, Germany

to aid practitioners (e.g., innovation managers, researchers, and governing and funding bodies) in their decisions concerning their involvement in UIC.

Keywords University-industry collaboration · Innovation performance · Absorptive capacity · Innovation competencies

JEL Classification O32 · O33 · L24

1 Introduction

The increasing importance of university-industry collaborations (UICs) for the contemporary innovation ecosystem has been underscored in theory and practice. Due to the benefits for the creation of innovations across industries attributed to UIC by previous research the literature widely acknowledges the importance of UIC for various stakeholders in the innovation ecosystem, especially firms, research institutions, funding organizations and policymakers (Bishop et al. 2011; Bozeman et al. 2013; Cunningham and Link 2015; George et al. 2002). Because these stakeholders themselves identified the potential of UIC, UICs and strategic R&D partnerships between companies and research institutions take place frequently, and grants are often issued for collaborative R&D projects (Matt et al. 2012; Perkmann and Walsh 2007; Stephan 2001). While potentially also associated with disadvantages for the parties involved (Bozeman et al. 2013; Slaughter et al. 2002), the positive effects of UIC extend also to various benefits appropriable by individuals and organizations involved at the university side (Giunta et al. 2016; Lehmann and Menter 2016; Valentin and Jensen 2007). Consequently, one might argue that "the role of university–industry (U–I) collaborations in shaping the innovative performances of universities and firms has been a key issue in the recent debate on determinants of innovation" (Baba et al. 2009, p. 756).

Prior research examined the performance consequences of UICs and established a positive association of UIC and innovation performance (Aschhoff and Schmidt 2008; Belderbos et al. 2004a; Hanel and St-Pierre 2006; Maietta 2015). However, prior work indicates that this general positive association depends on both the scientists‘ quality on the university-side (Baba et al. 2009; Crescenzi et al. 2017) and university-side scientists' propensity to engage in collaborative research (Libaers 2015). Further studies conducted on factors that influence the relationship between UIC and firms' innovation performance found that the presence of technology transfer offices at universities and the proximity of partnering universities and companies positively influence innovation performance within UICs (Anderson et al. 2007; Bishop et al. 2011; Hewitt-Dundas 2013). Regarding company-internal factors, thus far, prior research has found that a greater openness to external ideas positively influences the innovation performance of UICs for the collaborating firms (Fey and Birkinshaw 2005). Although such studies offer valuable initial insights into the factors governing the relationship between UIC and innovation performance, there are important, potentially moderating factors on the company side that have not yet been investigated.

Of specific interest as potentially moderating factors on the relationship between UICs and innovation performance are absorptive capacity, i.e., "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal 1990, p. 128) and innovation competencies, i.e., a set of innovationdirected competencies of a firm pertaining to numerous fields of management (e.g., employee skills, technical systems, managerial systems) (Ritter 2006; Souitaris 2002a; Tidd 2006). Previous research underscores the relevance of absorptive capacities in the UIC context (Cozza and Zanfei 2016) and its role in generating competitive advantage in knowledge transfer settings (Liao et al. 2016). Kodama (2008) found that product-developing companies, which he hypothesizes to have a larger absorptive capacity, benefit more from university linkages in terms of patent applications than non-product-developing companies. Brehm and Lundin (2012) found that universities' impact on sector innovation among different manufacturing sectors is contingent on the sector's investment into absorptive capacity. Moreover, investment of companies into basic research, and thus absorptive capacity, has been shown to be associated with improved external search for inventions (Fabrizio 2009). Such studies underline the importance of absorptive capacity and innovation competencies in the context of UICs. However, they do not allow for inferences on the moderating effect of absorptive capacity and innovation competencies on the relationship between UICs and innovation performance on the company level. Consequently, we do not know whether or to what extent firms' absorptive capacity and innovation competencies influence the degree to which firms develop economically viable product innovations within UICs. While prior research reports several findings that speak to a moderating effect of both absorptive capacity and innovation competencies, the direction of this potential effect is less clear. On the one hand, one might argue that absorptive capacity and innovation competencies positively moderate the relationship between UIC and innovation performance because they serve as a foundation for successful collaborations through a larger knowledge base, better innovation processes, more resources for and reduced barriers to collaboration (Bruneel et al. 2010; Cohen and Levinthal 1990; de Jong and Freel 2010; Muscio 2007; Ritala and Hurmelinna-Laukkanen 2013; Zahra and George 2002). On the other hand, one might argue for a negative effect of absorptive capacity and innovation competencies on the relationship between UIC and innovation performance because absorptive capacity and innovation competencies are associated with inertia, rigidity, and path dependence within the firm (Atuahene-Gima 2005; Cassiman and Veugelers 2006; Leonard-Barton 1992) and with secretiveness, reduced incentives, and a substitution effect (Ritala and Hurmelinna-Laukkanen 2013; West and Bogers 2014).

The lack of research into the potential effects of absorptive capacity and innovation competencies on the relationship between UIC and innovation performance is regrettable, because a better understanding of this influence would not only expand our theoretical knowledge of the factors moderating the relationship between UIC and innovation performance but could also improve the ability of the various stakeholders of UIC to increase the efficacy and efficiency of collaborative R&D. Companies and product innovation managers could evaluate their absorptive capacity and innovation competencies with regard to their expectable influence on UIC before entering agreements and committing resources. Companies already involved in UIC activities and companies with the intention of doing so could consider adjusting levels of absorptive capacity and innovation competencies that are beneficial to the success of such collaborations. Universities and research institutions could evaluate the competencies of the collaboration partner to assess the potential impact of their collaborative R&D. Last, public institutions, which frequently grant funding for UICs, could include the partners' absorptive capacity and innovation competencies into their evaluation of potential grant receivers, with the goal of maximizing the efficacy resulting from their funding.

In this paper, we aim to close the aforementioned research gap by investigating the influence of absorptive capacity and innovation competencies on the positive relationship between UIC and firms' product innovation performance at the company level. To analyze these potential moderating effects, we use the well-established *Community Innovation Survey* (CIS) dataset of 2061 German companies. The remainder of this paper is organized as follows. First, we discuss the existing literature concerning the potential influence of absorptive capacity and innovation competencies on UIC. Second, we introduce the sample and the method that we used. Third, we present the results of our investigation and critically discuss our findings.

2 Theoretical background

2.1 Innovation performance, types of innovation, and UIC

Previous research shows a considerable divergence in the measurement of innovation and innovation performance. West and Bogers (2014) emphasized that innovation is often confused with constructs such as ideas, knowledge, or processes and note that while these constructs can together create an innovation, they do not constitute an innovation on their own. As a consequence of this divergence, previous studies use a wide array of measures for innovation, which often have a one-sided focus on technology and newness (e.g., indicators such as generated ideas or filed patents). While such measures capture technological novelty, they disregard the second important dimension of innovation, namely, the diffusion of the invention. In a narrow sense, however, an innovation is characterized by both technological novelty and its diffusion (Garcia and Calantone 2002; West and Bogers 2014). While diffusion can also be realized through non-commercial means, a successful innovation must be characterized as the commercialization of a technological novelty in the context of for-profit entities. In our study, we adopt this narrow definition of innovation. We thus argue that the innovation performance of a company is best captured by the degree to which it realizes commercial success through the sales of technologically novel products. In doing so, we follow previous studies examining innovation performance in the context of innovation collaboration (Belderbos et al. 2015; Laursen and Salter 2006; van Beers and Zand 2014).

Furthermore, previous research has established a differentiation between incremental and radical innovation, thereby focusing on the degree of novelty embodied in the innovation. Chandy and Tellis (2000, p. 2) describe a radical innovation as "a new product that incorporates a substantially different core technology and provides substantially higher customer benefits relative to previous products in the industry". Conversely, "[i]ncremental innovations involve relatively minor changes in technology and provide relatively low incremental customer benefits per dollar" (Chandy and Tellis 1998, p. 476). The substantial difference between radical and incremental innovations is also reflected in the different prerequisites and processes associated with them (Ettlie et al. 1984; Koberg et al. 2003; Laursen and Salter 2006; Subramaniam and Youndt 2005). Given these differences, it is reasonable to assume that the moderating effects of absorptive capacity and innovation competencies on the relationship between UIC and innovation performance also differ depending on whether innovation performance relates to radical or incremental innovations. Hence, we propose that in analyzing a potential effect of absorptive capacity and innovation competencies on the relationship between UIC and innovation performance, it is crucial to consider (1) the specific characteristics of the two types of collaboration partners involved in such projects, i.e., companies on the one and research institutions on the other side, and (2) the two qualitatively different types of innovation, i.e., incremental and radical innovation. This notion is supported by Atuahene-Gima (2005), who finds that competence exploitation has a differing effect on incremental and radical innovation. Consequently, we differentiate between incremental and radical innovation when establishing our hypotheses based on the previous considerations regarding absorptive capacity and innovation competencies.

With regard to the direct influence of UIC on both types of innovation performance, we expect to confirm the findings of previous research on this relationship (Aschhoff and Schmidt 2008; Belderbos et al.2004a; b). Specifically, we propose the following hypotheses:

H1a UIC is positively related to incremental innovation performance.

H1b UIC is positively related to radical innovation performance.

2.2 Absorptive capacity and UIC

Prior research describes absorptive capacity, i.e., "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends" (Cohen and Levinthal 1990, p. 128) as typically being embodied within a company's R&D spending and the presence of internal R&D departments (R&D-related components of absorptive capacity) as well as employees' qualification level and training (employee-related components of absorptive capacity) (Cassiman and Veugelers 2002; Cohen and Levinthal 1990; Keller 1996; Veugelers 1997). It associates absorptive capacity with the search for, as well as with the absorption and transformation of, external knowledge (Zahra and George 2002). Specifically, absorptive capacity improves the ability of companies to search for and identify the relevant areas of knowledge as well as the relevant sources and providers of knowledge within the identified areas (Fabrizio 2009; Tu et al. 2006). In doing so, it also enables companies to reduce the risk for over-searching external knowledge (Katila and Ahuja 2002), which has been shown to deter innovation performance (Laursen and Salter 2006). Moreover, absorptive capacity expands the geographical reach of companies' for their collaboration partners, thus extending the field of potential partners (de Jong and Freel 2010). Furthermore, absorptive capacity improves the ability of companies to manage external knowledge flows (Escribano et al. 2009) as well as their ability to assimilate incoming knowledge (Lane et al. 2001; Tu et al. 2006). Following existing research, the importance of absorptive capacity for knowledge transfer is inversely related to the ease of learning, i.e., the lower the ease of learning, the more important absorptive capacity becomes in the transfer process (Cohen and Levinthal 1990; Lane et al. 2006). In this context, the ease of learning is directly associated with the knowledge content, i.e., common skills, shared culture and cognitive structures and the complexity, tacitness, and proximity of the underlying knowledge stocks (Lane et al. 2006; Woerter 2012). Since skills, cognitive structures, and culture vary between companies and universities (Agrawal 2001), and the knowledge to be transferred is likely to be complex (Perkmann et al. 2011), one might argue that absorptive capacity is especially important in the context of UICs and has the potential to reduce barriers to knowledge exchange (Bruneel et al. 2010). Moreover, Zahra and George (2002) and Todorova and Durisin (2007) describe the transformation of external knowledge within the organization as a core function of absorptive capacity. In summary, absorptive capacity is associated with several knowledge-related processes and activities generally regarded as crucial for the successful creation of innovations within UICs.

Second, absorptive capacity might improve the management and control of UICs. UIC relationships go beyond the mere absorption of external knowledge since they constitute a formalized collaboration relationship with the clear goal of creating specified innovation outcomes (Agrawal 2001; Perkmann et al. 2013). Consequently, to increase companies' innovation performance, such collaborations require guidance and management toward the creation of innovations with a clear economic market perspective. Previous research proposes that an additional function of absorptive capacity "is that it permits the firm to evaluate better the import of current technological developments for future developments, and consequently permits the firm to predict more accurately the nature of future technological advances and their commercial applications" (Cohen and Levinthal 1994, p. 229); this notion is also supported by Grimpe and Sofka (2009). As such, one might argue that absorptive capacity has the potential to not only improve the transfer of knowledge within UICs. Moreover, absorptive capacity could also enhance firms' ability to manage collaborations towards developments that match future technological and customer demands. Thereby, it could increase the likelihood of creating economically viable innovations and consequently increase innovation performance. In summary, prior studies point toward the potential of absorptive capacity to promote both knowledge absorption and transformation as well as the management of UICs, thus potentially improving the ability of companies to increase the innovation performance within UICs.

Given that UIC takes place at the interface of two qualitatively different types of organizations, we expect that the employee-related components of absorptive capacity generally benefit the relationship between UICs and innovation performance. While previous research points out considerably different cultures, norms, and know-how between company employees and academic scientists (Bozeman et al. 2013; D'Este and Patel 2007), we argue that these differences will be less prevalent for company employees having received higher education degrees and better training. We consequently argue that the employee-related components will have a positive moderating effect on the relationship between UIC and incremental innovation performance due to the more aligned level of skills, know-how and culture between those employees of the company with a higher education background and better training, and academic scientists at the university side (Agrawal 2001; Cohen and Levinthal 1990; Lane et al. 2006). We expect this dimension of absorptive capacity to be beneficial to the collaboration regardless of the innovation type (incremental and radical) in the focus of the collaboration. These considerations suggest the following hypotheses:

H2a A higher share of employees with a higher degree has a positive moderating effect on the relationship between UIC and incremental innovation performance.

H2b Higher employee training intensity has a positive moderating effect on the relationship between UIC and incremental innovation performance.

H2c A higher share of employees with a higher degree has a positive moderating effect on the relationship between UIC and radical innovation performance.

H2d Higher employee training intensity has a positive moderating effect on the relationship between UIC and radical innovation performance.

However, previous research also offers findings that point toward a potentially negative effect of absorptive capacity on the relationship between UICs and companies' innovation performance. This potentially negative effect is primarily rooted within organizational path dependence as well as within issues of secretiveness and reduced incentives for collaboration. First, absorptive capacity in terms of efforts in internal R&D and more knowledge residing within the company could lead to path dependence and inertia within the firm (Atuahene-Gima 2005). Leonard-Barton (1992) showed that capabilities are positively related to rigidities that could induce such a path dependence in innovation efforts. Other research attributes absorptive capacity to the "not-invented-here" syndrome and path dependence (Cohen and Levinthal 1990; Lichtenthaler and Lichtenthaler 2009; Schmidt 2010). Consequently, one might argue that greater absorptive capacity leads to a lower acceptance of external ideas, thus reducing the impact of UIC on innovation performance. Second, Ritala and Hurmelinna-Laukkanen (2013) suggest that high levels of absorptive capacity can be perceived as threatening by the other partner, thus evoking concern about benefitting equally from the collaboration, ultimately reducing the willingness for knowledge sharing and transfer. Last, higher absorptive capacity might reduce the incentive to collaborate. A large absorptive capacity is usually characterized by a large stock of internal knowledge and strong internal R&D. If a company perceives its internal R&D as strong, the benefits of collaboration might be perceived as small. Indeed, existing research shows that companies attribute more importance to collaborative R&D when internal R&D is obstructed and when knowledge spillovers are perceived as valuable (Belderbos et al. 2004a; Laursen and Salter 2006). A high priority attributed to collaborative innovation activities by the company is, however, critical for their success (Barbolla and Corredera 2009). Consequently, higher absorptive capacity could hamper the positive effect of UIC on companies' innovation performance. Recently, West and Bogers (2014) coined this potentially negative effect of absorptive capacity on open innovation and collaboration with external knowledge partners "substitution effect" (West and Bogers 2014, p. 822), i.e., a reduced interest in and value of innovation from external sources, and called for further research on this effect.

Taking into consideration that incremental innovation is closely related to the existing knowledge and competencies of an organization (Ettlie et al. 1984), the need to assimilate and transform complex external knowledge that differs qualitatively from existing knowledge (Agrawal 2001; Perkmann et al. 2011) and to engage in competence exploration might be less pronounced than internal path dependence and rigidity in the case of incremental innovation, thus rendering absorptive capacity and innovation competencies to be more of a barrier than support for UIC. Consequently, we propose that with regard to absorptive capacity, a higher internal R&D intensity and a continuously staffed internal R&D department will have a negative effect on the relationship between UIC and incremental innovation performance due to considerations related to a substitution effect (West and Bogers 2014), specifically the prevalence of path dependence, inertia and lower incentives with regard to UIC (Atuahene-Gima 2005; Leonard-Barton 1992; Schmidt 2010). Consequently, we pose the following hypotheses:

H3a R&D intensity has a negative moderating effect on the relationship between UIC and incremental innovation performance.

H3b The continuity of internal R&D has a negative moderating effect on the relationship between UIC and incremental innovation performance.

However, in the case of radical innovation, the specific knowledge of a company will be comparatively smaller. Especially when cutting edge findings from basic research are included in the innovation project, the overlap of the knowledge bases of companies and universities will be smaller. As a consequence, the positive function of absorptive capacity as a base for learning, knowledge sharing and transformation (Cohen and Levinthal 1990; Escribano et al. 2009; Zahra and George 2002) will be more important than in the case of incremental innovation (Cohen and Levinthal 1990; Zahra and George 2002). At the same time, the company is likely to have a comparatively lower path dependence and a smaller specific knowledge base, thus leading the company to value potential external knowledge inflows and competencies more highly. Consequently, we expect all dimensions of absorptive capacity to have a positive moderating effect on the relationship between UIC and radical innovation performance. Specifically, we pose the following hypotheses:

H3c R&D intensity has a positive moderating effect on the relationship between UIC and radical innovation performance.

H3d The continuity of internal R&D has a positive moderating effect on the relationship between UIC and radical innovation performance.

2.3 Innovation competencies and UIC

Following the understanding of Pavitt (1991), Leonard-Barton (1992), and Ko and Lu (2010), innovation competencies are the subset of core competencies of a company that directly relate to the company's ability to innovate. While core competencies in general are defined as "the knowledge set that distinguishes and provides a competitive advantage" (Leonard-Barton 1992, p. 113), the term innovation competencies has not been thoroughly defined by the literature. They are, however, best described as "specific competencies that determine a firm's ability to innovate"(Ko and Lu 2010, p. 165). Previous research introduced several components used to describe innovation competencies. Leonard-Barton (1992) adopts a knowledge-based view of innovation competencies and suggests that there are four dimensions of innovation-related core competencies, namely, employee skills, technical systems, managerial systems, as well as values and norms. Other research identifies innovation competencies as technological, organizational, market, human resource, product, process and communicating competencies, time-to-market competencies, or external resource usage competencies (Ko and Lu 2010; Ritter 2006; Souitaris 2002a; Tidd 2006). Following previous research, the factors constituting innovation competencies can be subsumed in five dimensions: (1) The innovation speed dimension, which captures the ability to quickly grasp market trends and generate first-mover advantages (Caird 1994; Ko and Lu 2010; Stock et al. 2002) (2) the entrepreneurial employees dimension, which captures the ability to build and maintain employee creativity (Baumol 2002; Drucker and Noel 1986) and employee enthusiasm for innovation (Caird 1994; Ko and Lu 2010; Lindman 2002) as well as management commitment and responsibility (Hoffman et al. 1998), (3) the innovation competition and incentives dimension, which captures incentives for innovation (Souitaris 2002a, b) and ways to stimulate innovation (Handfield et al. 1999; Ko and Lu 2010), (4) the product development dimension, which describes companies' ability to develop practical innovative products (Ko and Lu 2010) and the ability to become familiar with customer needs (Keizer et al. 2002), and (5) and the cooperation and collaboration dimension, which describes how well a company is able to use external sources (Martinich 2005), to cooperate (Souitaris 2002b) and to communicate efficiently (Brown and Duguid 1991; Ko and Lu 2010).

Innovation competencies inherently describe firms' competencies pertaining to the entire innovation process. The collaborative innovation process between universities and companies encompasses steps beyond the mere exchange and transformation of knowledge. Especially with regard to market orientation, (human) resource management and the overall management of the innovation process, the industry partner of the UIC project will likely assume a managing (leading) role within the project (Agrawal 2001; Perkmann et al. 2013; Perkmann and Walsh 2009). Moreover, independent of the result of the collaborative effort, it is ultimately the responsibility of the industry partner to have the innovation permeate through the organization and to market it successfully. Consequently, it appears to be highly reasonable to assume that greater innovation competencies have the potential to positively influence the relationship between UIC and innovation performance. We expect that competencies related to innovation speed and competencies related to cooperation and collaboration will have a positive effect on the relationship between UIC and incremental innovation performance. We propose that these specific competencies provide benefits that are beneficial to the relationship between UIC and innovation performance, regardless of the type of innovation in the focus. Specifically, we propose the following hypotheses:

H4a Innovation speed competence has a positive moderating effect on the relationship between UIC and incremental innovation performance.

H4b Innovation cooperation and collaboration competence has a positive moderating effect on the relationship between UIC and incremental innovation performance.

H4c Innovation speed competence has a positive moderating effect on the relationship between UIC and radical innovation performance.

H4d Innovation cooperation and collaboration competence has a positive moderating effect on the relationship between UIC and radical innovation performance.

On the other hand, in line with our reasoning regarding absorptive capacity and following research on the capability-rigidity paradox (Leonard-Barton 1992), "competence exploitation tends to crowd out competence exploration" (Atuahene-Gima 2005, p. 61). Consequently, one might argue that a company that scores high on innovation competencies can exhibit a tendency to undervalue the competencies of the collaboration partner and to over-rely on existing internal competencies, thus closing itself to the benefits of mutual learning and a truly collaborative development. Thus, similar to absorptive capacity, we expect the effect of some innovation competencies on the relationship between UIC and innovation performance to be contingent on the innovation type in the focus as they could have a detrimental effect due to the crowding-out of incentives and due to a substitution effect and the capability-rigidity paradox (Leonard-Barton 1992; West and Bogers 2014). We expect that with regard to the entrepreneurial employees competence, which embodies the individual responsibility for innovation and the creativity of employees, a higher level of competence will go hand in hand with greater path dependence and a strong interest in pushing forward proprietary ideas, thus reducing the incentive to benefit from and perform their best within UIC. Similarly, greater innovation competition and incentives could emphasize not only internal competition between ideas but also concurrence of internal and external ideas in the case of incremental innovation. Greater product development competencies could, in the same vein as greater absorptive capacity, suffer from a substitution effect with regard to UIC and incremental innovation performance. Consequently, we expect a negative moderating effect of these competencies on the relationship between UIC and incremental innovation performance. These arguments result in the following hypotheses:

H5a Entrepreneurial employees competence has a negative moderating effect on the relationship between UIC and incremental innovation performance.

H5b Innovation competition and incentives competence has a negative moderating effect on the relationship between UIC and incremental innovation performance.

H5c Product development competence has a negative moderating effect on the relationship between UIC and incremental innovation performance.

However, in the case of radical innovation, the same innovation competencies could be beneficial to successfully managing more complex innovation activities and more extensive innovation processes within the firm associated with radical innovation. At the same time, the potential drawback of internal competencies with regard to path dependence, substitution, and incentives within the collaboration are expected to play a lesser role than in the context of incremental innovation. Specifically, the incentives created by internal innovation competition in conjunction with the potential to enhance own radical innovation projects through collaboration are likely to positively influence the relationship between UIC and radical innovation performance. Similarly, a stronger product development competence will enhance the ability of a firm to develop products within the UIC, thus positively influencing the relationship between UIC and radical innovation performance. We thus suggest the following hypotheses:

H6a Innovation competition and incentives competence has a positive moderating effect on the relationship between UIC and radical innovation performance.

H6b Product development competence has a positive moderating effect on the relationship between UIC and radical innovation performance.

Yet, we assume that with regard to the entrepreneurialism of employees, strong incentives to push forward internal, proprietary ideas and the consecutive reluctance toward external ideas and lower incentives for best effort within UIC will prevail independent of the innovation type in the focus, thus being detrimental to the relationship between UIC and innovation performance in the case of radical innovation. Consequently, we pose the following hypothesis:

H6c Entrepreneurial employees competence has a negative moderating effect on the relationship between UIC and radical innovation performance.

3 Method

3.1 Sample

To conduct our analysis, we used data available from the *Zentrum für Europäische Wirtschafsforschung* (ZEW), which was compiled as part of the biyearly *Mannheimer Innovationspanel* (MIP). The MIP is the German contribution to the *Community Innovation Survey* (CIS) and commissioned by the *German Federal Ministry of Education and*

Research. CIS data are gathered through an EU-wide, harmonized survey created in accordance with the guidelines of the third revision of the OECD Oslo Manual (OECD 2005) and widely used in the existing literature to answer questions pertaining to the innovation ecosystem and innovation collaboration based on large datasets (e.g., Belderbos et al. (2004b), de Faria et al. (2010); van Beers and Zand (2014), Cricelli et al. (2016)). According to Laursen and Salter (2006), more than 60 peer-reviewed papers use one of the several national editions of these data in their analysis. In our study, we combined data from the 2009 and 2011 waves of the MIP (corresponding to the 2008 and 2010 waves of the CIS). We chose these two waves of the survey for our analyses because they represent the most recent data available that include all variables under investigation. Questionnaires were sent to 35,197 companies for the 2009 wave (2011: 35,530). Liquidation and discontinuation of companies led to a neutral corrected total sample of 29,807 companies (2011: 26.850). The survey was conducted between March and August of 2009 and 2011, respectively. Questionnaires were returned from 7657 companies, resulting in a response rate of 26% (2011: 7388; 28%). To control for potential non-respondent bias, an additional 4829 companies were surveyed by phone (2011: 8.407), resulting in the data available for 42% of the total sample (2011: 59%). Our dataset that is based on this data contains data from 2574 German firms for which the survey was completed for both waves used in our analysis. To provide a clear focus on product innovation, we excluded companies from several sectors prior to our analyses because a clear association with product innovation was not apparent. These sectors are (1) wholesale trade ($n = 104$), (2) banking and insurance ($n = 98$), (3) firm-related services ($n = 112$), (4) other services ($n = 196$), and (5) real estate ($n = 3$). Our final sample consisted of 2061 companies from a total of 18 industry sectors, namely, (1) motor vehicle trade and repair ($n = 7$), (2) mining and quarrying ($n = 57$), (3) glass and mineral products ($n = 61$), (4) furniture ($n = 63$), (5) transport equipment ($n = 77$), (6) information technology and communication ($n = 88$), (7) textile and clothing products ($n = 88$), (8) chemical industry ($n = 89$), (9) plastics ($n = 93$), (10) medical and precision optical equipment ($n = 114$), (11) electrical equipment ($n = 119$), (12) energy and water supply ($n = 123$), (13) manufacturing of food and tobacco products ($n = 125$), (14) machinery equipment ($n = 155$), (15) wood, paper, and printing ($n = 174$), (16) metal and metal product manufacturing ($n = 207$), (17) transportation and communication ($n = 207$), and (18) technical, physical, and chemical services ($n = 214$).

3.2 Measures

3.2.1 Dependent variable

To measure the dependent variable, innovation performance, we differentiated between incremental innovation performance and radical innovation performance. Furthermore, following our definition of innovation and innovation performance, we sought to capture the degree to which companies are able to commercialize novel products rather than focusing on their ability to generate technological inventions or patents.

To operationalize radical and incremental innovation performance based on CIS data, we followed Spithoven et al. (2010), Laursen and Salter (2006), and Frenz and Ietto-Gillies (2009) and measured the share of revenue created by products representing an incremental or radical innovation. Specifically, to measure *Incremental Innovation Performance*, we used the turnover share of new or significantly improved products ($M = 2.20$, $SD = 2.64$). We measured *Radical Innovation Performance* by the turnover share of introduced product innovations which were new to the market ($M = .69$, $SD = 1.57$), i.e., such innovations for which the company was the first one to market the products. For both variables, response options ranged from 0 (= *0% turnover share*) to 8 (= *100% turnover share*) and referred to the 3 years preceding the 2011 wave of the survey (i.e., 2008–2010).

3.2.2 Explanatory variables

First, to operationalize the independent variable *UIC,* we measured whether the companies in our sample participated in collaborative innovation projects with universities or public research institutions. To do so, we formed the dummy variable *UIC* (*0 = company that did not participate in a UIC; 1 = company that at least once participated in a UIC*) ($M = .14$, $SD = .34$). Data for this variable were obtained from the 2009 edition of the MIP, thus capturing the presence of UICs in the years 2006 through 2008. Academic engagement with industry takes many forms, such as the informal exchange of information, outsourced contractual research, or shared research projects (Perkmann et al. 2013). The questionnaire inquiring the data that serves as the basis for our explanatory variable *UIC* adopts and communicates to participants a very narrow definition of UICs, in which UICs are defined as the active collaboration between both partners in joint innovation and research projects. As such, it specifically excludes the informal exchange of information as well as the mere outsourcing of R&D by companies to universities.

With regard to the moderating variable *absorptive capacity*, we used a set of multiple measures because previous research also used several measures to operationalize absorptive capacity. For example, previous research measures absorptive capacity by R&D intensity (Cohen and Levinthal 1990) or by considering whether the company under investigation has a continuously staffed R&D department (Cassiman and Veugelers 2002). Other studies focus on the employee skills component of absorptive capacity and measure absorptive capacity by the investment in employee training (Keller 1996) or the share of employees with a higher education degree (Veugelers 1997). Additionally, there are studies that combine several of the aforementioned factors (Escribano et al. 2009). To allow differentiated inferences regarding the moderating effect of absorptive capacity, we measured absorptive capacity by the four most common measures used in previous studies.

To operationalize the variable *Absorptive Capacity_I* (*AC_I*) ($M = .01$, $SD = .03$), we measured R&D intensity as the share of R&D expenditure of total turnover. To operationalize *AC_II* ($M = .76$, $SD = .89$), we measured the continuity of firm internal R&D activities (*0 = the company has no internal R&D; 1 = the company irregularly conducts internal R&D; 2 = the company has a continuously staffed internal R&D department*). To operationalize the third variable, *AC_III* ($M = .01$, $SD = .01$), we measured the degree of personnel training as the proportion of personnel expenditure invested in employee training and continued education. Lastly, we operationalized *AC_IV* ($M = 3.20$, $SD = 2.39$) by measuring the share of employees holding a university diploma or other higher education degree. We measured the share of employees holding a university diploma or other higher education degree based on a scale ranging from 0 (= *0% employee share*) to 8 (= *100% employee share*).

Regarding *innovation competencies*, previous research used several measures (Ko and Lu 2010): the creativity of employees and incentives for innovation (human resource competencies), the ability to develop new products on the existing knowledge base (technological competencies), the ability to quickly recognize innovation and to speed up the commercialization process of innovations (time-to-market competencies), the responsibility for innovation and a high risk acceptance by management (managerial competencies), and the capabilities to use external resources and to cooperate with external parties (external resource usage competencies). The survey data from the MIP that we used contained multiple items that are likely to capture the dimensions of innovation competencies. Each of the original items measured how pronounced the companies evaluated their innovation competencies on a scale from *1 (= hardly)* to *5 (= very strong)*. The specific competencies rated by the companies were (1) the identification of new consumer needs, (2) the development of new technological solutions, (3) the granting of freedom for trial and error to employees, (4) the high responsibility of employees for innovation, (5) the creativity of employees, (6) incentive systems for employees to develop new ideas, (7) the promotion of internal concurrence among product ideas, (8) the internal cooperation between divisions, (9) the inclusion of external partners in innovation projects, (10) the quick implementation of ideas into market-ready products, and (11) the quick up-take of innovations of other companies. We conducted a factor analysis on these 11 items, resulting in a five-factor solution, with items loading on one factor producing negligible loadings on other factors ($KMO = .863$). We consecutively proceeded by using the resulting factor loadings as moderating variables to operationalize the different dimensions of innovation competencies in our analysis. The five dimensions of innovation competencies extracted as variables can be described as relating to (1) the speed of innovation (*IC_speed*, $M = .02$, $SD = .86$), (2) the entrepreneurialism of employees (*IC_empl*, $M = -.01$, $SD = .87$), (3) product development competencies (*IC_pdev*, $M = .01$, $SD = .84$), (4) innovation competition and incentives (*IC_comp*, $M = .07$, $SD = .85$), and (5) communication and cooperation competencies (*IC_coop*, $M = .02$, $SD = .75$).

3.2.3 Control variables

Based on a thorough literature review, we introduced several control variables to our analyses. First, we controlled for the profitability of the company measured by the return on sales *(ROS*), as previous research showed that profitability issues and financial distress can interfere with companies' ability to innovate. Second, as previous studies showed labor productivity to be related to a company's innovation performance (Belderbos et al. 2004b), we controlled for labor productivity (*LPROD*). Third, following the WZ 93/NACE classification, we introduced 17 industry dummies to control for variances across the 18 industrial sectors included in our sample. Fourth, we controlled for the average innovation intensity (*IIavrg*) of the company. Innovation intensity represents the total expenditure for innovation of the company as a percentage share of total revenue (Belderbos et al. 2015). Last, we controlled for the companies' export status, as exporting companies have been shown to be subject to more innovation inflows from foreign markets and as such can have a higher innovation performance compared to non-exporting companies (Kafouros et al. 2008). The dummy variable *EXP* controlled for the export status of the firm by assuming the value 0 if the company did not indicate that it was exporting, and the value 1 if it indicated doing so.

3.3 Data and data analyses

Data for the independent variable *UIC* were calculated based on the 2009 survey data, thus measuring the presence of UIC in the period from 2006 to 2008. Data for the moderator and control variables were calculated as the average of both waves of the survey, thus representing the average of the years 2006 through 2010. Data for the dependent variable were taken from the wave of 2011 and capture data for the years 2008 through 2010. As such, in choosing the timing of our study we made the following assumption: We assumed that the effect of UIC projects conducted during the first period will be visible in the form of innovative products in the market in the second period and thus, on average, after a 3-year period. That is why, following previous work (e.g., Aschhoff and Schmidt 2008; Belderbos et al. 2004b, 2015; Huang and Yu 2011), we intentionally introduced the time lag between the times of measurement for the independent vs. dependent variables. We measured the independent and dependent variables once and rely on average values for moderating and control variables, which have been measured twice. Thus, following previous work (e.g., Belderbos et al. 2004b; Huang and Yu 2011), we do not use panel regressions but rather rely on moderated OLS regression because our data does not bear the risk of correlations between error terms of variables that are repeatedly measured (Maddala 2009; Wooldridge 2010).

Specifically, we first conducted an OLS regression analysis on the relationship between UIC and incremental innovation performance under consideration of the control variables. In a second step, we modelled the moderating effects of absorptive capacity and innovation competencies on the relationship between UIC and (incremental and radical) innovation performance, respectively, using moderated multiple regression (Cohen et al. 2013; Hayes 2013). One separate moderation analysis was conducted for each of the variables constituting absorptive capacity and innovation competencies. To address potential multicollinearity issues, all variables were mean centered in the moderation analyses. In each analysis, only firms for which data for all variables under investigation in the individual analysis was available were included, leading to varying sample sizes for the individual analyses.

4 Results

4.1 Descriptive statistics

Table 1 displays the descriptive statistics for the variables used in our analyses. Table 2 shows the correlations among these variables.

4.2 Results for regression and moderation analyses

To first analyze the primary relationship between UIC and incremental innovation performance and radical innovation performance, we conducted a regression analysis. We found a positive relationship between both UIC and incremental innovation performance ($\beta = 1.064$, $t(746) = 5.050$, $p < .001$) and UIC and radical innovation performance ($\beta = .371$, $t(741) = 2.377$, $p < .05$), supporting hypotheses H1a and H1b.

We then continued to analyze the moderating effect of absorptive capacity and innovation competencies. First, analyzing the moderating effect of absorptive capacity on the relationship between UIC and incremental innovation performance, we found the following results: The moderating effects of the share of employees with a higher degree ($\beta = -.057$, $t(701) = -.587$, *ns*) and of employee training intensity ($\beta = -8.837$, $t(521) = -.669$, *ns*) were not significant, and thus H2a and H2b were not confirmed. We found a negative moderating effect of both R&D intensity ($\beta = -22.006$, $t(688) = -4.710$, $p < .001$) and continuity of internal R&D ($\beta = -.850$, $t(726) = -1.942$, $p < .10$), thus confirming H3a and H3b. Second, regarding radical

Table 1 Descriptive statistics of relevant variables

Variable	M	SD	Min	Max	Range	Observations
UIC[a]	.13	.34	.00	1.00	1.00	2061
Incremental innovation performance[b]	2.21	2.65	.00	8.00	8.00	1521
Radical innovation performance[b]	.69	1.57	.00	8.00	8.00	1522
AC_I (R&D intensity)	.01	.03	.00	.15	.15	1629
AC_II (continuity of internal R&D)	.76	.89	.00	2.00	2.00	1847
AC_III (employee training intensity)[b]	.01	.01	.00	.10	.10	1135
AC_IV (share of employees with higher degree)	3.20	2.39	.00	8.00	8.00	1821
IC_speed	.02	.86	−2.09	2.20	4.29	2061
IC_empl	−.02	.87	−1.93	2.75	4.68	2061
IC_pdev	.02	.84	−1.53	3.08	4.61	2061
IC_comp	.07	.85	−2.32	1.92	4.23	2061
IC_coop	.03	.75	−2.02	2.29	4.30	2061
ROS	3.84	1.81	1.00	7.00	6.00	1588
LPROD	.28	.17	.03	.60	.57	1756
IIavrg	.04	.07	.00	.35	.35	1399
EXP	.21	.26	.00	.85	.85	1327

N = 2061

[a] 0 = no UIC conducted, 1 = UIC conducted

[b] Revenue share on a scale where 0 = 0% revenue share and 8 = 100% revenue share

innovation performance, we found the following results: We observed a positive moderating effect of the share of employees with a higher degree ($\beta = .123$, $t(696) = 1.683$, $p < .10$), supporting our H2c. The moderating effects of R&D intensity ($\beta = -.140$, $t(685) = -.041$, *ns*), of the continuity of internal R&D ($\beta = .294$, $t(720) = .824$, *ns*), and of employee training intensity ($\beta = -5.070$, $t(515) = -.500$, *ns*) were not significant, thus supporting neither H2d, H3b, nor H3c.

We continued to investigate the moderating effect of the single innovation competencies on the relationship between UIC and incremental innovation performance. We did not find a significant effect for innovation speed competence ($\beta = -.303$, $t(746) = -.949$, *ns*), entrepreneurial employees competence ($\beta = .133$, $t(746) = .467$, *ns*), innovation competition and incentives competence ($\beta = -.403$, $t(746) = -1.252$, *ns*), product development competence ($\beta = -.246$, $t(746) = -.954$, *ns*), or innovation cooperation and collaboration competence ($\beta = -.478$, $t(746) = -1.224$, *ns*). Consequently, H4a, H4b, and H5a through H5c were not confirmed. Second, we investigated the moderating effect of innovation competencies on the relationship between UIC and radical innovation performance. We observed a positive moderating effect of innovation competition and incentives competence ($\beta = .526$, $t(741) = 2.190$, $p < .05$), and innovation cooperation and collaboration competence ($\beta = .679$, $t(741) = 2.412$, $p < .05$), supporting H6a and H4d. Furthermore, we found a negative moderating effect of the entrepreneurial employees competence ($\beta = -.709$, $t(741) = -3.383$, $p < .001$), thus supporting H6c. Last, we found no significant moderating effect of the product development competence ($\beta = .218$, $t(741) = 1.135$, *ns*) and the innovation speed competence ($\beta = .360$, $t(892) = 1.680$, *ns*)

Table 2 Correlations between relevant variables

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(1) UIC[a]	1.00	.35**	.27**	.48**	.51**	.08**	.26**	.16**	−.14**	.12**	.27**	.24**	.06*	.05*	.40**	.21**
(2) Incremental innovation performance[b]		1.00	.56**	.54**	.67**	.12**	.26**	.38**	−.29**	.27**	.46**	.35**	.08**	.06*	.55**	.28**
(3) Radical innovation performance[b]			1.00	.46**	.49**	.10**	.22**	.24**	−.21**	.19**	.32**	.24**	−.00	.05	.44**	.21**
(4) AC_I (R&D intensity)				1.00	.60**	.17**	.42**	.17**	−.19**	.10**	.31**	.23**	−.01	−.11**	.87**	.21**
(5) AC_II (Continuity of internal R&D)					1.00	.10**	.32**	.30**	−.28**	.24**	.48**	.37**	.10**	.12**	.48**	.42**
(6) AC_III (Employee training intensity)[b]						1.00	.24**	.12**	−.11**	.13**	.12**	.07*	.10**	−.11**	.18**	−.13**
(7) AC_IV (Share of employees with higher degree)							1.00	.10**	−.22**	.08**	.23**	.22**	.10**	−.00	.39**	.09**
(8) IC_speed								1.00	−.53**	.55**	.66**	.74**	.08**	.06*	.19**	.14**
(9) IC_empl									1.00	−.52**	−.62**	−.52**	−.11**	−.03	−.23**	−.12**
(10) IC_pdev										1.00	.51**	.64**	.08**	.05*	.12**	.12**
(11) IC_comp											1.00	.70**	.14**	.06**	.33**	.26**
(12) IC_coop												1.00	.08**	.10**	.25**	.18**
(13) ROS													1.00	.04	.02	.02
(14) LPROD														1.00	−.11**	.39**

Table 2 continued

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
(15) IIavrg															1.00	.15**
(16) EXP																1.00

N = 2061

[a] 0 = no UIC conducted, 1 = UIC conducted

[b] Revenue share on a scale where 0 = 0% revenue share and 8 = 100% revenue share

Table 3 Results of moderated multiple regression for Incremental Innovation Performance

Incremental innovation performance	Model 1 (R^2 = .46)	Model 2 (R^2 = .49)	Model 3 (R^2 = .58)	Model 4 (R^2 = .47)	Model 5 (R^2 = .46)	Model 6 (R^2 = .48)	Model 7 (R^2 = .47)	Model 8 (R^2 = .46)	Model 9 (R^2 = .49)	Model 10 (R^2 = .47)
Constant	.51 (.31)*	1.03 (.33)***	1.55 (.23)***	1.04 (.38)**	.97 (.33)**	.95 (.31)**	.85 (.31)**	.80 (.31)**	.99 (.31)***	.85 (.31)***
UIC[a]	1.06 (.21)***	1.49 (.25)***	.83 (.47)	1.01 (.24)***	1.09 (.23)***	1.04 (.23)***	1.06 (.22)***	1.09 (.22)***	1.03 (.26)***	1.10 (.26)***
AC_I		13.96 (.50)**								
AC_II			1.31 (.12)***							
AC_III[b]				7.70 (6.35)						
AC_IV					.04 (.05)					
IC_speed						.48 (.10)***				
IC_empl							−.32 (.10)**			
IC_pdev								.24 (.09)***		
IC_comp									.60 (.11)***	
IC_coop										.41 (.12)***
ROS	.07 (.04)	.04 (.04)	.05 (.04)	.05 (.05)	.04 (.04)	.05 (.04)	.05 (.04)	.06 (.04)	.04 (.04)	.06 (.04)
LPROD	1.30 (.55)*	1.52 (.56)**	.60 (.45)	1.28 (.67)*	1.19 (.57)**	1.01 (.55)*	1.15 (.55)**	1.18 (.55)**	1.06 (.54)*	1.07 (.55)**
IIAVRG	18.45 (1.12)***	15.31 (2.29)***	12.16 (1.09)***	17.59 (1.32)***	17.93 (1.30)***	17.30 (1.18)***	17.72 (1.20)***	18.04 (1.19)***	16.70 (1.20)***	17.66 (1.20)***
EXP	.94 (.34)**	.64 (.36)	.19 (.31)	.56 (.42)	.97 (.36)**	.93 (.34)**	.89 (.35)**	.92 (.35)***	.73 (.34)**	.84 (.35)**
UIC × AC_I		−22.01 (4.67)***								
UIC × AC_II			−.85 (.44)*							
UIC × AC_III				−8.84 (13.21)						
UIC × AC_IV					−.06 (.10)					
UIC × IC_speed						−.30 (.32)				
UIC × IC_empl							.13 (.29)			
UIC × IC_pdev								−.25 (.26)		
UIC × IC_comp									−.40 (.32)	

Table 3 continued

Incremental innovation performance	Model 1 (R^2 = .46)	Model 2 (R^2 = .49)	Model 3 (R^2 = .58)	Model 4 (R^2 = .47)	Model 5 (R^2 = .46)	Model 6 (R^2 = .48)	Model 7 (R^2 = .47)	Model 8 (R^2 = .46)	Model 9 (R^2 = .49)	Model 10 (R^2 = .47)
UIC × IC_coop										−.48 (.39)

N = 2061. *, **, and *** denote significance at the 10, 5, and 1% levels, respectively. Results for the 18 industry dummy variables are included in each analysis but not reported in this table for reasons of clarity

[a] 0 = no UIC conducted, 1 = UIC conducted

[b] Revenue share on a scale where 0 = 0% revenue share and 8 = 100% revenue share

Table 4 Results of moderated multiple regression for radical innovation performance

Radical innovation performance	Model 1 (R^2 = .28)	Model 2 (R^2 = .30)	Model 3 (R^2 = .34)	Model 4 (R^2 = .28)	Model 5 (R^2 = .28)	Model 6 (R^2 = .29)	Model 7 (R^2 = .30)	Model 8 (R^2 = .29)	Model 9 (R^2 = .30)	Model 10 (R^2 = .30)
Constant	.08 (.23)	.35 (.24)	.34 (.24)	.14 (.29)	.16 (.25)	.20 (.23)	.14 (.23)	.19 (.23)	.26 (.23)	.17 (.23)
UIC[a]	.37 (.16)**	.42 (.18)**	−.35 (.38)	.22 (.18)	.24 (.18)	.21 (.18)	.17 (.16)	.31 (.16)*	.01 (.19)	.06 (.19)
AC_I		6.42 (3.69)*								
AC_II			.61 (.10)***							
AC_III[b]				7.61 (1.58)						
AC_IV					.02 (.04)					
IC_speed						.21 (.07)***				
IC_empl							−.25 (.07)***			
IC_pdev								.21 (.07)***		
IC_comp									.39 (.08)***	
IC_coop										.31 (.09)***
ROS	−.06 (.03)*	−.08 (.03)**	−.06 (.03)**	−.07 (.04)*	−.06 (.03)*	−.07 (.03)**	−.06 (.03)**	−.07 (.03)**	−.08 (.03)**	−.07 (.03)**
LPROD	.90 (.41)**	1.05 (.42)**	.71 (.40)*	1.12 (.53)**	.88 (.43)**	.78 (.41)*	.81 (.41)**	.82 (.41)**	.80 (.40)**	.78 (.41)*
IIavrg	10.74 (.88)***	7.90 (1.70)***	8.59 (.91)***	9.99 (1.03)***	9.92 (.98)***	10.39 (.89)***	10.27 (.89)***	10.44 (.88)***	9.64 (.90)***	10.20 (.89)***
EXP	.30 (.26)	.20 (.27)	−.07 (.26)	.49 (.33)	.41 (.27)	.31 (.26)	.27 (.26)	.28 (.26)	.16 (.27)	.27 (.26)
UIC × AC_I		−.14 (3.41)								
UIC × AC_II			.29 (.36)							
UIC × AC_III				−5.07 (10.13)						
UIC × AC_IV					.12 (.07)*					
UIC × IC_speed						.33 (.24)				
UIC × IC_empl							−.71 (.21)***			
UIC × IC_pdev								.22 (.19)		

Table 4 continued

Radical innovation performance	Model 1 ($R^2 = .28$)	Model 2 ($R^2 = .30$)	Model 3 ($R^2 = .34$)	Model 4 ($R^2 = .28$)	Model 5 ($R^2 = .28$)	Model 6 ($R^2 = .29$)	Model 7 ($R^2 = .30$)	Model 8 ($R^2 = .29$)	Model 9 ($R^2 = .30$)	Model 10 ($R^2 = .30$)
UIC × IC_comp									.53 (.24)**	
UIC × IC_coop										.68 (.28)**

N = 2061. *, **, and *** denote significance at the 10, 5, and 1% levels, respectively. Results for the 18 industry dummy variables are included in each analysis but not reported in this table for reasons of clarity

[a] 0 = no UIC conducted, 1 = UIC conducted

[b] Revenue share on a scale where 0 = 0% revenue share and 8 = 100% revenue share

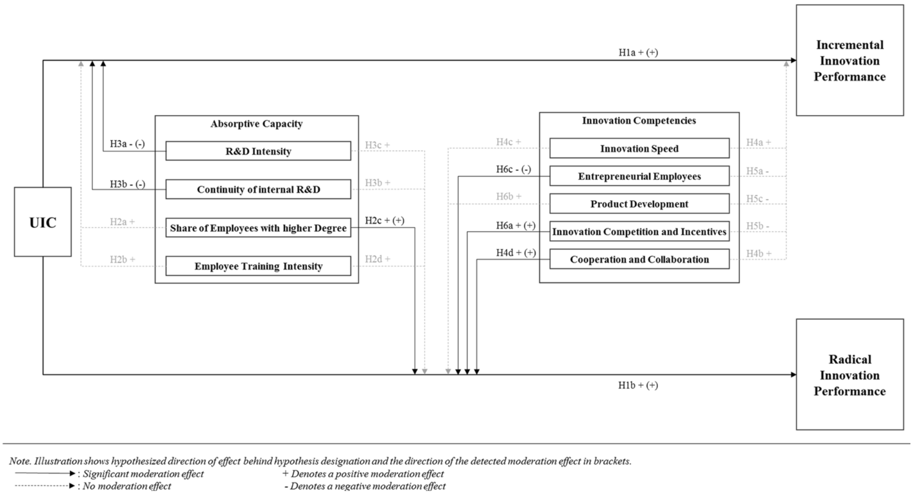

Fig. 1 Illustration of detected moderating effects

and consequently no support for H6b and H4c. Tables 3 and 4 present the results of our moderation analyses. Figure 1 summarizes our hypotheses and findings.

5 Discussion and conclusions

5.1 Summary and discussion of our results

This study set out to answer the question of whether and to what extent absorptive capacity and innovation competencies influence the relationship between UICs and firms' innovation performance. That is, we investigated the moderating effects of absorptive capacity and innovation competencies on the relationship between UIC and (radical and incremental) innovation performance.

First, with regard to absorptive capacity and innovation competencies, our findings are in part counterintuitive. Specifically, regarding absorptive capacity, R&D intensity and continuity of internal R&D negatively moderated the relationship between UIC and incremental innovation performance. While our study does not investigate the specific reasons for this negative effect, based on the literature, one might argue that this detrimental effect is caused by the predominantly negative aspects of these components in incremental innovation settings, namely, the substitution effect (West and Bogers 2014), path dependence (Atuahene-Gima 2005; Leonard-Barton 1992), and the 'not-invented-here' phenomenon (Cohen and Levinthal 1990; Lichtenthaler and Lichtenthaler 2009; Schmidt 2010). Moreover, the root of this negative effect could reside within lower incentives for a full effort within the collaboration because of perceived strong internal R&D (Belderbos et al. 2004a) or by the absorptive capacity of the industry partner being perceived as too high by the university partner, thus causing secretiveness and barriers to collaboration (Ritala and Hurmelinna-Laukkanen 2013).

At the same time, incremental innovation settings are likely characterized by a comparatively large ease of learning, i.e., in the presence of a lower complexity of knowledge and greater shared knowledge base (Cohen and Levinthal 1990; Lane et al. 2006), consequently rendering the positive aspects of absorptive capacity less important. When the focus of the UIC turns toward radical innovation, our results support the notion that this negative impact is mitigated. One might argue that this is caused by the greater importance of the positive aspects of absorptive capacity in radical innovation contexts, characterized by a lower ease of learning, while firm-internal resources and path dependencies potentially embodied in absorptive capacity become less pronounced due to the newness of the underlying products and technologies. This general notion is also supported by our findings regarding the employee-related components of absorptive capacity, namely the share of employees with a higher education degree and the employee training intensity. While these factors exert no influence on the relationship between UIC and incremental innovation performance, the share of employees with a higher education background has a positive influence on the relationship between UIC and radical innovation performance. Again, one could argue that in moving to radical innovation, the negative effects of absorptive capacity are rendered comparatively less important due to the decreasing specific knowledge and path dependency within the firm, while at the same time a higher level of know-how and skills of the firms' employees facilitates communication between the UIC partners in the context of higher complexity and reduced ease of learning (Cohen and Levinthal 1990; Lane et al. 2006). Potentially, the differences in culture and shared knowledge between industry employees and academic researchers (Agrawal 2001) are bridged by a larger share of employees with a higher education degree, as these employees are more familiar with processes of academic research and have a better cognitive capacity for absorbing the knowledge created in academic environments (Bruneel et al. 2010; Lane et al. 2006).

Second, with regard to innovation competencies, we found none of the innovation competencies to be a moderator of the relationship between UIC and incremental innovation performance. With respect to radical innovation, we found a positive moderating effect of innovation competition and incentives competence and innovation cooperation and collaboration competence, and a negative moderating effect of entrepreneurial employees competence. These findings are in line with our hypotheses. However, we did not find the expected positive moderating effect of the product development competence. One could attribute the lack of an effect to product development within UIC being conducted at the university side, or to the incentives to benefit from UIC being crowded out by a strong product development competence (Belderbos et al. 2004a). From a more general point of view, taken together our findings suggest that (1) in settings with a focus on incremental innovation, absorptive capacity presents more of a barrier than a benefit to the success of UIC (static effect of absorptive capacity). In settings with a focus on radical innovation, the negative effect of absorptive capacity is reduced, but there is only a limited positive effect on the relationship (dynamic effect of absorptive capacity). Additionally, our findings suggest that (2) innovation competencies generally only play a role in UIC settings with a focus on radical innovation. While their influence is nonexistent in incremental innovation settings, they exert a primarily positive influence on the relationship between UIC and radical innovation settings (with the exception of the entrepreneurial employees and the product development competence).

Third, our results confirmed the previously established, positive relationship between UIC and both incremental and radical innovation performance (Aschhoff and Schmidt 2008; Belderbos et al. 2004a, b).

5.2 Research contributions

Our findings contribute to the literature in several ways. First, through our analysis of the moderating effect of absorptive capacity and innovation competencies on the relationship between incremental and radical innovation performance, we expand the existing literature on UIC by highly relevant firm-internal factors, adding to the existing literature on factors influencing the performance of such collaborations (Anderson et al. 2007; Baba et al. 2009; Bishop et al. 2011) and offering evidence to further explain the potential variance between different individual UICs. Specifically, our findings show that absorptive capacity and innovation competencies should be considered in the context of innovation performance within UICs. However, contrary to the general consensus within the literature, absorptive capacity and innovation competencies cannot be regarded as having an exclusively positive influence within UIC; rather, their influence depends on the scope (incremental vs. radical) of the innovation type at hand. This finding not only extends our knowledge of the dynamics within UIC relationships but could also point toward a fundamentally two-sided effect of absorptive capacity and innovation competencies within collaborative R&D in general.

Second, we expand the literature on the effects of absorptive capacity, as our study additionally offers further evidence for the presence of properties of absorptive capacity that can be summarized under the term substitution effect. In doing so, we address the call that "more research is needed on the substitution effects" (West and Bogers 2014, p. 822) and provide initial empirical evidence under which circumstances such an effect is present in UICs. Moreover, the partially contradictory effect of different dimensions of absorptive capacity supports the notion that a nuanced measurement of absorptive capacity is beneficial to the explanatory potential of studies investigating absorptive capacity.

Third, with regard to the broader innovation literature, our results confirm the qualitative difference between incremental innovation and radical innovation performance and underscore the importance of distinguishing between different types of innovation in research regarding UIC and potentially other collaborative R&D relationships (Laursen and Salter 2006).

Fourth, our study extends the literature on collaborative R&D and open innovation through the examination of absorptive capacity and innovation competencies in a specific collaboration context (UIC). Our findings support the notion that there are substantial differences between various types of collaborations, specifically as Ritala and Hurmelinna-Laukkanen (2013) showed that in collaborations between competitors, absorptive capacity has quite contrasting effects on the performance than what our findings suggest for UIC.

5.3 Managerial implications

Our findings provide insights about firm-internal factors influencing UIC success for all stakeholders of such collaborations. Specifically, firms, universities and researchers, and grant givers for collaborative research can include the factors shown to influence the effect of UIC on innovation performance in their evaluation of the prospects of potential UIC projects. Once a collaborative agreement has been entered, the same parties can use these factors to increase innovation performance within the UIC. Given the many positive aspects of absorptive capacity (e.g., the general association of absorptive capacity with higher innovation performance), a reduction of absorptive capacity with the goal of improving the efficacy of UICs cannot be implicated. However, a key implication to this end for all practitioners is that a high level of absorptive capacity and innovation competencies is not necessarily a prerequisite to capture the benefits of UIC. On the contrary, companies with less pronounced absorptive capacity and innovation competencies could benefit comparatively more from UIC than others, especially in the context of incremental innovation. Moreover, our research implies that the specific innovation goal of the UIC (incremental vs. radical innovation) should be considered when evaluating the potential of UICs in the context of a specific firm's absorptive capacity and innovation competencies. We argue that these insights are highly valuable, especially for innovation managers who consider embedding UICs within future innovation projects. However, the specific interplay of UICs, absorptive capacity and innovation competencies, and innovation performance is likely depending on determinants of any specific UIC, such as the characteristics of underlying technologies, the overlap of knowledge bases between the partners, and the individual partners' prior experience with collaborative research. These specific factors should be considered in the individual managerial decisions regarding UICs.

5.4 Limitations and future research opportunities

Our study has several limitations. First, we follow an established path in evaluating the performance outcomes of innovation collaboration based on CIS data. However, our data do not allow for a direct association between UIC and consecutive innovation performance, as the innovation performance that we measure could also have its origin in activities other than UIC. To alleviate these concerns, following other studies that could have been affected by the same limitation, we controlled for potential confounding effects. Nonetheless, while we find a relationship between UIC and innovation performance, we cannot rule out that this relationship is caused by factors other than the specific UIC; experimental research would be required to rule out confounding effects. Second, and in a similar vein, we measured innovation performance in an economic sense. While this measurement has the clear advantage of relating UIC to the ultimate goal of innovation (i.e., the commercialization of innovative products), this operationalization opens up the possibility that potentially successful UICs are not measured as such. This oversight could occur when corporate decisions of various natures lead to the abandonment or shelving of UIC outcomes. Third, the operationalization of our explanatory variable UIC adopts a narrow definition of UIC as the active, collaborative participation of both partners within innovation and research projects. While this understanding allows for a clear specification of the type of UIC examined in our study, it limits the transferability of our results to UIC contexts shaped by informal exchange of information or the outsourcing of research to universities. Fourth, the timeframes that we chose for measuring the dependent and independent variables could lead to an underestimation of the effects in our findings. In general, an average 3-year period for UIC to create measurable performance outcomes is reasonable and well-founded within the previous literature (e.g., Belderbos et al. (2004b)). However, such a period bears the risk of not detecting the influences of UICs when their innovation performance outcome is not reflected in the data in our second measurement point. This can be the case when a UIC commenced in the beginning of the first timeframe leads to a commercialization within the same timeframe or when a UIC commenced towards the end of the first timeframe and has not yet created a performance outcome before the end of the second timeframe. However, we argue that the effect of most projects will be measurable during the consecutive 3-year timeframe and that this limitation in our study design can, if anything, only lead to an understatement of the effects detected in our analysis. We are thus confident that this limitation does not severely affect the validity of our results.

Future research could build on and extend our findings. In particular, we suggest that an investigation of the reasons for the effects of absorptive capacity and innovation competencies on the relationship between UIC and (incremental and radical) innovation performance as well as a more fine-grained investigation contingent to underlying technologies and the very nature of specific UIC projects is an especially promising avenue for future research. Such an investigation would not only enable a better understanding of our findings but also provide valuable insights for practitioners; for practitioners, a better understanding of the reasons behind the partly negative influence of absorptive capacity would be especially valuable because absorptive capacity is generally considered a tremendously helpful resource of innovating companies. Furthermore, future studies could build upon our finding of a potentially two-sided effect (i.e., depending in the innovation type in the focus) of absorptive capacity and innovation competencies within collaborative R&D settings. Our knowledge of collaborative R&D would benefit largely from studies investigating whether this two-sided effect is also present in collaborative R&D with customers, suppliers, or competitors. Moreover, future research could replicate our study in other geographic areas and industry sectors as well as with respect to service, process, or environmental innovation and could consider absorptive capacity and innovation competencies not only at the company, but also at the university side. In summary, our study should be regarded as providing new and relevant insights on the dynamics within UIC, while at the same time providing implications for important future research in this field.

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