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Connections count: How relational embeddedness and relational empowerment foster absorptive capacity

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ABSTRACT

While research has produced ample evidence showing that absorptive capacity affects innovation and organizational performance outcomes, we still know little about why some organizations possess greater absorptive capacity than others. This study extends previous research by showing how absorptive capacity emerges as an unintended consequence from organizational boundary spanners' external and internal relational embeddedness and their relational empowerment. Drawing upon survey data from 218 inter-organizational projects in the German engineering industry, we propose and find empirically that potential and realized absorptive capacity have partially distinct antecedents. Moreover, we show that the two components of absorptive capacity unfold not only separate but also complementary effects on innovation, implying that the whole of absorptive capacity is greater than its parts. In examining how different components of absorptive capacity emerge and unfold their effects, this study addresses critical limitations of the literature on absorptive capacity.

1. Introduction

Research has shown that an organization's ability to acquire and exploit external knowledge in alliances, joint ventures, R&D collaborations, and supply chains – i.e. its absorptive capacity (Cohen and Levinthal, 1990) – has direct positive effects on firm performance outcomes, especially innovation in terms of new products, technologies or processes (Bierly et al., 2009; Gilsing et al., 2008; Jiang and Li, 2009; Lichtenthaler, 2009). While the management literature has widely invoked the notion of absorptive capacity as an important driver of competitive advantage (see Lane et al., 2006), our understanding of how absorptive capacity contributes to performance outcomes is still limited. One reason is that most empirical studies have considered absorptive capacity as an independent variable (Volberda et al., 2010). However, if variations in organizations' absorptive capacity can help explain differences in performance outcomes, it seems important to understand how organizations develop greater or lesser absorptive capacity. Nevertheless, research to date has mainly neglected to study the micro-foundations of organizations' absorptive capacity so that we still know little about how an organization's absorptive capacity arises from the actions and interactions of lower-level actors, such as individuals, teams, or organization units (Lane et al., 2006; Volberda et al., 2010).

The present paper addresses this gap in the literature. We theorize and demonstrate empirically that absorptive capacity emerges as the unintended consequence of organizational boundary spanners' external and internal relational embeddedness (Granovetter, 1985) as well as their relational empowerment (Spreitzer, 2008). An analysis of a large sample of inter-organizational projects managed by German mechanical engineering and plant engineering firms shows that both project members' external relational embeddedness (measured via project members' inter-organizational tie strength and trust with external project partners) and the amount of training they receive enhance the capacity of these organizational boundary spanners to acquire and assimilate external knowledge, that is potential absorptive capacity (Zahra and George, 2002). Whereas the capacity to transform and exploit the externally acquired knowledge, that is realized absorptive capacity (Zahra and George, 2002), positively depends on project members' internal relational embeddedness (measured via project members' intra-organizational tie strength and trust with colleagues inside their home organization) and their relational empowerment in terms of the amount of training they receive and the discretion they have over project-level decision-making. Results further reveal that project members' external and internal relational embeddedness are positively associated exerting mutual indirect effects on realized and potential absorptive capacity, respectively. This

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finding suggests that project members can develop social skills and relational capabilities that transcend their internal and external relationships and may thus be important micro-factors from which absorptive capacity emerges.

As its main contribution to the literature, this study argues theoretically and shows empirically how boundary spanners' external and internal relational embeddedness and relational empowerment affect their capacity to acquire, assimilate, transform, and exploit external knowledge and thus enhance their organizations' absorptive capacity. Furthermore, by focusing on cases where innovation is not a main goal, the study also demonstrates that an organization's ability to integrate and exploit external knowledge for innovative outcomes can be the unintended consequence of social micro-processes at inter- and intra-organizational interfaces. Finally, this study adds to the extant literature by showing that potential and realized absorptive capacities emerge from partially distinct antecedents and unfold not only separate but also complementary effects on innovation, implying that the whole of absorptive capacity is greater than its parts. Together, these findings contribute to mitigating the reification of the absorptive capacity construct (Lane et al., 2006).

2. Theory and hypotheses

Research has suggested slightly different conceptualizations of absorptive capacity. The classic article by Cohen and Levinthal (1990: p. 128) defines absorptive capacity as "an organization's ability to recognize the value of new, external information, assimilate it, and apply it to commercial ends". Zahra and George (2002) refine this conceptualization by differentiating between an organization's potential and realized absorptive capacity. Potential absorptive capacity refers to an organization's capability to acquire (i.e. access and import) and assimilate external knowledge (i.e. interpret and understand it). Realized absorptive capacity reflects an organization's capacity to transform the knowledge (i.e. combine the newly acquired with the existing knowledge) and exploit it (i.e. apply it to the organization's operations). In their discussion of Zahra and George's (2002) model, Todorova and Durisin (2007) suggest to enhance it by adding as a fifth component of absorptive capacity the ability to recognize the value of external knowledge. As capabilities are not directly observable, a number of researchers have conceptualized absorptive capacity by means of the underlying processes that constitute the capability. Lane et al. (2006) suggest and Lichtenthaler (2009) empirically corroborates such a process-based view, where absorptive capacity is conceptualized as an organization's ability to utilize external knowledge through the sequential processes of exploratory, transformative, and exploitative learning. Similarly, Lewin et al. (2011) suggest a taxonomy of internal and external meta-routines expressed in the form of practiced routines that underlie an organization's absorptive capacity. The internal meta-routines comprise facilitating variation; managing internal selection regimes; sharing knowledge and superior practices across the organization; reflecting, updating and replicating; managing adaptive tension. Whereas the external meta-routines encompass identifying and recognizing value of externally generated knowledge; learning from and with partners, suppliers, customers, competitors, and consultants; and transferring knowledge back to the organization.

While some overlap exists among the various conceptualizations of absorptive capacity offered in the literature, a common dimensionalization has not emerged. One reason is that the concept has widely been reified in research, as Lane et al. (2006) note in their extensive review of the literature. One indication of this reification is that very few empirical studies actually examined the set of capabilities, learning processes or routines constituting an organizations absorptive capacity (e.g. Jansen et al., 2005; Lane et al., 2001; Lichtenthaler, 2009). Instead, the majority of empirical studies have used overall proxies (such as R&D expenditures, the number of scientists working in R&D departments or patents) to measure absorptive capacity. This not only raises serious concerns with regard to construct, internal and external validity (Lane et al., 2006) but also implies an important first gap in the literature that we seek to address in this study: We still know very little about how the different proposed components of absorptive capacity individually, together and through their interactions affect relevant outcomes. In a bibliometric analysis of 1213 publications on absorptive capacity that appeared between 1992 and 2005, Volberda et al. (2010) find that studies on knowledge recognition and to a lesser extent assimilation, i.e. on potential absorptive capacity, dominate the field, whereas studies on realized absorptive capacity and innovation outcomes are underrepresented and still receive only limited attention. It is important that research acknowledges the different components of absorptive capacity not only in order to establish the constructs' validity, but also because there is first evidence that the different components do not have uniform effects on innovation outcomes (Lichtenthaler, 2009) and may have different antecedents (Jansen et al., 2005).

As it is the most widely cited conceptualization and captures the dimensions of absorptive capacity that are commonly highlighted in the pertinent literature, for the purposes of the present study we rely on the process-based conceptualization of absorptive capacity suggested by Zahra and George (2002). They define absorptive capacity as "a set of organizational routines and processes by which firms acquire, assimilate, transform, and exploit knowledge to produce a dynamic organizational capability." (Zahra and George, 2002: p. 186) They further posit that "acquisition and assimilation ... are dimensions of 'potential' [absorptive] capacity and that transformation and exploitation ... are dimensions of 'realized' [absorptive] capacity." (Zahra and George, 2002: p. 190) On the basis of this conceptualization, we seek to contribute to providing a more complete understanding of how the processes that underlie potential and realized absorptive capacity unfold their effects. Specifically, we study Zahra and George's (2002) claim that these dimensions of absorptive capacity play different but complementary roles in explaining how absorptive capacity influences performance outcomes by examining how absorptive capacity affects product and process innovation.

A second important gap in the literature exists with regard to the factors that drive the development of absorptive capacity, as most empirical studies have considered absorptive capacity as an independent variable (Volberda et al., 2010). However, if variations in organizations' absorptive capacity can help explain differences in performance outcomes, it seems important to understand when and how organizations develop greater absorptive capacity. While a number of possible industry- and firm-level influence factors on absorptive capacity have been suggested in the literature (see Cohen and Levinthal, 1989, 1990; Zahra and George, 2002), there has been fairly little empirical research that has examined these or other possible antecedents of absorptive capacity (Volberda et al., 2010). In their seminal article, Cohen and Levinthal (1990) indicate that prior related knowledge could be an important antecedent of absorptive capacity. Later empirical research has confirmed this notion. For instance, Lane et al. (2001) in their study of Hungarian international joint ventures uncover that the extent to which an international joint venture learns from its foreign parent depends on the amount of prior knowledge it received from the parent, its relatedness with the parent, and the amount of training it received from the parent. Lenox and King (2004) show that the information provided by managers to potential knowledge users can augment the application of external knowledge. Van den

Bosch et al. (1999), on the basis of case studies in the multimedia industry, highlight how organization forms and combinative capabilities affect organizations' absorptive capacity. Furthermore, Yli-Renko et al. (2001) reveal that a firm's repeated interactions with other firms enhance its ability to evaluate and acquire external knowledge.

Only few studies have asked and examined empirically whether the different constituent elements of absorptive capacity have distinct antecedents. A study by Jansen et al. (2005) shows that an organization's coordination capabilities (cross-functional interfaces, participation, and job rotation) primarily enhance potential absorptive capacity, while its socialization capabilities (connectedness and socialization tactics) primarily strengthen realized absorptive capacity. In their study of more than 2000 Spanish firms, Fosfuri and Tribó (2008) find evidence that R&D cooperation, external knowledge acquisition and experience with knowledge search are key antecedents of an organization's potential absorptive capacity.

The present paper extends previous research on the antecedents of absorptive capacity in two main ways. First, it explicitly separates the processes underlying potential and realized absorptive capacity, as each of these components of absorptive capacity may be influenced by a different set of antecedents. Second, it focuses on a set of hitherto neglected potential influence factors. While earlier research has mainly highlighted features of the knowledge exchanging organizations, we examine to what extent absorptive capacity is also a function of the personal capacities of and relationships among individual organization members. At the inception of the concept, Cohen and Levinthal (1990: p. 132) already suggested that "the firm's absorptive capacity depends on the individuals who stand at the interface of either the firm and the external environment or at the interface between subunits within the firm." However, 20 years later Volberda et al. (2010: p. 945) still note that "current research never truly shows how organization level AC is related to . . . the interaction of individuals . . .". We therefore propose and examine empirically how the capacities of organizational boundary spanners who stand at the interface between potential external knowledge providers, on the one hand, and colleagues within the organization, on the other, impact organizations' potential and realized absorptive capacity. As absorptive capacity refers to the ability to acquire and assimilate external knowledge, and then to transform and exploit it within the organization, the capacities and actions of organizational boundary spanners who link external knowledge providers with internal knowledge exploiters should be crucial for an organization's absorptive capacity. As organizational boundary spanners work with external partners, they are exposed to the latters' knowledge and practices. Their organizations will only be able to capitalize on the acquired knowledge, however, to the extent that it is transformed and exploited by organization. Thus, absorptive capacity also depends on boundary spanners' capacity to interact with other colleagues in their organization, who might be quite removed from the original point of knowledge acquisition but are crucial for applying newly acquired knowledge toward organizational ends (Bakker et al., 2011).

We submit that two heretofore understudied potential influence factors, both concerning the capacities of organizational boundary spanners to fulfill their outward and inward-looking role, are critical for an organization's absorptive capacity: boundary spanners' relational embeddedness and relational empowerment.

2.1. Relational embeddedness as an influence factor on absorptive capacity

Based on Granovetter's (1985) pioneering work on the structural and relational embeddedness of economic exchange, the beneficial effects of actors' network ties – sometimes referred to as their social capital (Adler and Kwon, 2002) – have mainly been studied in two dimensions (Moran, 2005). The structural dimension refers to the configuration of linkages between actors, e.g. to the number and density of relations. The relational dimension describes the kind of relations that exist between and among actors, such as the strength of ties and the level of trust. Organizational research has theorized and examined why and how structural and relational features of individual, group and organizational actors' network relations affect their opportunity, motivation and ability to access resources in their network in general (Lee, 2009; Payne et al., 2011). It has revealed that relational features of actors' network relations are especially conducive to processing difficult to transfer knowledge (Uzzi and Lancaster, 2003) that then is conducive to generating innovation (Maurer et al., 2011; Moran, 2005).

In the context of this study we therefore focus on the relational dimension of actors' network ties. In line with earlier literature, we highlight the two main defining dimensions of relational embeddedness (Uzzi, 1996): the strength and trustfulness of actors' ties. We posit that different subsets of boundary spanners' ties affect different dimensions of absorptive capacity. Specifically, we propose that potential absorptive capacity is a function of boundary spanners' external relational embeddedness with potential external providers of new knowledge, while realized absorptive capacity depends on boundary spanners' internal relational embeddedness with their colleagues inside the organization.

Organizational boundary spanners entertain strong ties with potential external knowledge providers to the extent that they engage in frequent interaction, a high level of emotional closeness, reciprocity, and intimacy (Granovetter, 1973). Frequent interactions enhance boundary spanners' opportunities for acquiring knowledge from their external partners and should thus be positively related to potential absorptive capacity. With a higher frequency of interactions, boundary spanners can also ask more questions and receive more, and more accurate, explanations. Moreover, frequent interactions help them to build routines over time that support the effective processing of knowledge (Uzzi, 1997) which should aid the assimilation of knowledge and further enhance potential absorptive capacity. Closeness and reciprocity motivate boundary spanners' and their external partners to invest time and effort in the knowledge transfer process as well as to reveal knowledge (Hansen et al., 2001). A strong emotional attachment and intimacy broaden the range of topics discussed and thus positively affect potential absorptive capacity by increasing both opportunities for knowledge acquisition and the likelihood that the acquired knowledge will be assimilated.

Trust encompasses positive expectations regarding the competence or goodwill of exchange partners (Das and Teng, 2001; Schoorman et al., 2007). When organizational boundary spanners trust potential external knowledge providers, this increases their openness in acquiring and assimilating knowledge, thus enhancing potential absorptive capacity. Actors will be more inclined to share knowledge with, and to acquire knowledge from, trusted sources (Tsai and Ghoshal, 1998; Wu, 2008). While the sender believes the recipient to handle the knowledge carefully and in adequate form (Nooteboom, 1996), the recipient is more likely to acquire and assimilate the knowledge because s/he assumes a high level of knowledge quality and reliability (Fischer et al., 2002). As Uzzi and Lancaster (2003: p. 384) note, "actors typically share private knowledge with others they trust to accept it at face value and guard it from misuse." As trusted relations reduce the need for formal monitoring and bargaining, they also free capacities of the potential recipient for the acquisition of knowledge (Dyer and Singh, 1998).

Based on these lines of reasoning, we propose:

Hypothesis 1. Organizational boundary spanners' external relational embeddedness is positively associated with their organization's potential absorptive capacity.

The transformation of knowledge that was externally acquired by organizational boundary spanners requires their sharing relevant knowledge with other members of the organization (Spender, 1996). Strong ties provide rich communication channels through which actors from different parts of an organization can inform one another about the existence and value of novel knowledge (Smith et al., 2005). Besides enabling the recognition of novel knowledge, such ties also provide rich conduits for the exchange of knowledge identified as useful (Levin and Cross, 2004). Moreover, strong ties over time engender common understandings (Reagans and McEvily, 2003) and provide feedback loops that help actors to understand the knowledge received, transform and exploit it (Leonard-Barton and Sinha, 1993). Because strong ties facilitate joint problem-solving (McEvily and Marcus, 2005), they enhance the effectiveness with which knowledge recipients can transform and exploit novel knowledge received. Trust among organization members enhances the likelihood that they will incorporate newly assimilated knowledge into their knowledge base, thus transforming it (Tsai and Ghoshal, 1998; Wu, 2008). In a relationship based on trust, organizational boundary spanners are more open and motivated to advise their colleagues of knowledge and to accept such advice (Nooteboom, 1996). At the same time, the recipients of the knowledge are more likely to transform and use it as they will assume a high level of both reliability and quality of the novel knowledge when it is provided by a trusted source (Schoorman et al., 2007). Finally, it has been argued that internal network relations establish social capital enhancing organization members' opportunity, motivation and ability to share knowledge across intra-organizational boundaries (Bartsch et al., 2013), thus thus fostering knowledge transfer within an organization (Maurer et al., 2011). Based on these arguments, we expect that internal relational embeddedness facilitates organizational boundary spanners to engage in the intra-organizational processes of knowledge transformation and exploitation and thus enhances an organization's realized absorptive capacity. Accordingly, we propose:

Hypothesis 2. Organizational boundary spanners' internal relational embeddedness is positively associated with their organization's realized absorptive capacity.

While we proposed above that the two constituent components of an organization's absorptive capacity have distinct antecedents, there is reason to believe that the levels of organization members' external and internal relational embeddedness may be related. Specifically, we suggest that organizational boundary spanners' external relational embeddedness exerts an indirect effect on the organization's realized absorptive capacity by influencing boundary spanners' internal relational embeddedness, and that, conversely, boundary spanners' internal relational embeddedness exerts an indirect effect on the organization's potential absorptive capacity by influencing boundary spanners' external relational embeddedness.

These indirect effects result for a number of reasons. First, individuals will only be able to develop strong and trusted external or internal ties, if they have the requisite social skills. Mead (1934) maintains that some social actors are better than others at inducing cooperation because they are socially skilled. Social skill has accordingly been defined as the ability to induce cooperation (Fligstein, 2001). If organizational boundary spanners possess the social skills to induce cooperation with external partners, the same social skill will also be conducive to producing cooperation with internal partners, and vice versa. Second, individuals entertaining strong and trusted relationships build up cooperative routines that also allow them to manage other ties effectively and efficiently (Ariño and de la Torre, 1998; Gulati, 1999). Due to such learning effects, organizational boundary spanners with strong and trusted external ties will also be better able to establish such ties internally, and vice versa. Finally, when organizational boundary spanners entertain strong and trusted relations with external or internal partners, they will establish specific norms of cooperation (Hillebrand and Biemans, 2003). These cooperative norms will be reflected in other relationships as well, as they transcend specific relationships and collaborators expect comparable treatment (Campbell, 1998). We therefore propose:

Hypothesis 3. Organizational boundary spanners' internal (external) relational embeddedness positively indirectly affects their organization's potential (realized) absorptive capacity.

2.2. Relational empowerment as an influence factor on absorptive capacity

Empowerment occurs when managers at higher levels within the organizational hierarchy delegate decision-making power to employees at lower levels with a view toward enhancing the employees' motivation and investment in their work (Conger and Kanungo, 1988; Thomas and Velthouse, 1990). The management literature on empowerment has developed two main perspectives. The relational (also called social-structural) empowerment perspective focuses on the structures, policies, and practices that empower individuals, whereas the psychological empowerment perspective focuses on individuals' perceptions of empowerment (Spreitzer, 2008). While distinct, the two approaches are substantively linked, as the organizational implementation of empowering structures, policies, and practices is positively associated with levels of psychological empowerment reported by the affected employees (Konczak et al., 2000; Seibert et al., 2004; Zhang and Bartol, 2010). Considering twenty years of research on empowerment, Spreitzer (2008) identifies five main facets of relational empowerment: participative decision-making; skill/knowledge-based pay; open flow of information; flat organizational structures; and training. Research has shown that each of these practices contributes to employee empowerment by increasing access to opportunity, information, support, or resources (Spreitzer, 2008).

In the following, we focus on how two facets contributing to project members' empowerment, discretion in decision-making and training, may affect an organization's potential absorptive capacity. When project members enjoy greater discretion in decision-making, this broadens the range of "receptors" who have the authority to acquire and assimilate new external knowledge (Cohen and Levinthal, 1990) thus facilitating the organization's capacity to acquire new external knowledge. Moreover, it increases project members' motivation to assimilate new external knowledge, since better information improves the quality of decision-making and work groups will be held responsible for their decisions. Greater discretion in decision-making therefore increases actors' ability and motivation to acquire and assimilate external knowledge and as a result fosters the potential absorptive capacity of their organization (Jansen et al., 2005). Training and other investments into the skill set of employees enhances their expertise to spot relevant external information that may be valuable to their team or the organization. Training will also make actors more adept at processing relevant external knowledge. In sum, greater discretion in decision-making and enhanced skills through better training motivate and enable individuals and teams to scan their environment for opportunities, to show initiative, lead to more proactive and productive behavior (Kirkman and Benson, 1999), and will thus enhance their ability to acquire and assimilate external information. We therefore propose:

Hypothesis 4. Organizational boundary spanners' relational empowerment (in terms of discretion in decision-making and training) is positively associated with their organization's potential absorptive capacity.

We expect that discretion in project-level decision-making will improve organization members' capacity to transform and exploit newly acquired external knowledge for the same reasons that it positively influences their organization's potential absorptive capacity. In particular, greater discretion in decision-making allows both inter-organizational project members and their colleagues in the project leading organization to engage in deeper exchange and collaboration, similar to how decentralization within a multi-unit company enhances the level of subsidiary absorptive capacity for marketing strategy absorption (Schleimer and Pedersen, 2013). Participation in decision-making might have negative effects on realized absorptive capacity to the extent that it hampers information-processing efficiency and slows down decision-making processes (Jansen et al., 2005). Yet Jansen et al.'s (2005) findings suggest that the positive effects of employees' empowerment to initiate new ideas, insights, and opportunities outweigh any negative ones that may be associated with greater discretion in decision-making.

We further posit that training too positively affects an organization's realized absorptive capacity. Cohen and Levinthal (1990: p. 132) argue that "organizational absorptive capacity is not only a function of the gatekeeper's capabilities but also of the expertise of those individuals to whom the gatekeeper is transmitting the information." Investment into training should therefore increase the ability of employees in the wider organization, who may be quite removed from the boundary spanners acquiring the new information, to transform and exploit new external information transmitted to them by the boundary spanners. Finally, it has been shown that relational empowerment in terms of greater discretion in decision-making and training increases employees' commitment (Kirkman and Benson, 1999; Konczak et al., 2000). More committed employees will invest greater effort to transform and exploit relevant knowledge. Therefore, we posit:

Hypothesis 5. Organizational boundary spanners' relational empowerment (in terms of discretion in decision-making and training) is positively associated with their organization's realized absorptive capacity.

2.3. Innovation as an outcome of absorptive capacity

We noted above that absorptive capacity is difficult to measure directly, because it is an unobservable capability. In order to establish measurement validity, it thus seems important not only validly to gauge the different processes underlying absorptive capacity but also to ascertain the predictive validity of the conceptualization. Absorptive capacity has gained such scholarly attention, because it is considered to be an important driver of performance in general (Lane et al., 2001), and of innovation in particular (Cohen and Levinthal, 1990). A number of studies produced empirical evidence that absorptive capacity indeed enhances firm performance (e.g. Chang et al., 2012; Dushnitsky and Lenox, 2005; Wales et al., 2012) and increases the amount, speed, and frequency of innovation (Benner and Tushman, 2002; Fosfuri and Tribó, 2008; Helfat, 1997; Kim and Inkpen, 2005).

However, as we mentioned above, there has been little empirical research to date examining how the different components of absorptive capacity individually and together affect innovation outcomes (Volberda et al., 2010). Zahra and George (2002) contend that an organization's potential and realized absorptive capacity have separate but complementary roles. Complementarity exists when two activities have a positive association (Cassiman and Veugelers, 2006) and/or reinforce each other in such a way that doing more of one thing increases the value of doing more of the other (Milgrom et al., 1991). Accordingly, one would expect that for any given level of potential absorptive capacity, organizations with stronger realized absorptive capacity will show greater innovativeness than organizations with weaker realized absorptive capacity. The reason is that organizations with stronger realized absorptive capacity will be able to transform more of the knowledge they acquire and will apply more of this transformed knowledge to its product development, thus generating more innovation outcomes. Conversely, it seems equally plausible to expect that, for any level of realized absorptive capacity, greater potential absorptive capacity will enhance an organization's innovativeness. Yet we still lack empirical tests of these propositions. As one of the few studies on absorptive capacity components and their complementarities, a study by Lichtenthaler (2009) has shown that different learning processes as constitutive components of absorptive capacity have complementary effects on performance and innovation.

In order to gauge the predictive validity of our conceptualization of absorptive capacity and to add to the emerging research on the separate but possibly complementary effects of potential and realized absorptive capacity, we examine the following hypothesis:

Hypothesis 6. Potential absorptive capacity and realized absorptive capacity complement one another in enhancing innovation.

3. Methods

3.1. Sample and data collection

We test our hypotheses using data from 218 projects in 144 firms in the German mechanical engineering and plant engineering industries. Such project-based organizations to some extent need to develop absorptive capacity in order to mitigate the unique and discontinuous nature of projects (Gann and Salter, 2000) and the resulting fragmentation of project knowledge (Schwab, 2009). They therefore provide a particularly fruitful context for studying how absorptive capacity develops and unfolds its effects. Moreover, innovation plays a key role for German engineering firms, as they need to differentiate their product offerings from international competitors that are able to produce at lower cost levels. Industry reports demonstrate that in 2009, as in earlier years, almost one third of the overall industry turnover was earned with innovative products (ZEW, 2011) and the average share of R&D spending in turnover was approximately 5% (Krebs, 2011).

Work in the engineering industry is typically managed in inter-organizational projects (Fong and Lung, 2007; Hobday, 1998), usually as unique, one-off projects that provide built-to-order machinery (Gann and Salter, 2000). The projects in our sample cover the four main sectors of the engineering industry as established on the basis of the international standard NACE code and reflect the full range of tasks in this industry: the design and production across all types of machinery and equipment, from single components to highly complex equipment such as production lines and entire factories. We focused on projects that had been completed within one to three years prior to the study. The average project volume was 42 million €.

Members of the organization leading a project collaborate with members from other organizations that provide selected inputs to the project, be it particular knowledge or pieces of hardware or software, which cannot be provided by the project-leading firm. The project-leading firm coordinates and integrates the different contributions of the partner firms (Brusoni et al., 2001). We describe the quality of these external ties linking members of the organization leading the focal project with the outside project partners in terms of organizational boundary spanner's external relational

embeddedness. Project team members have to coordinate and collaborate not only with their external project partners but also to some extent with their colleagues within their respective organizations in order to fulfill the project goals. They thus not only span the boundary between the project leading organization and its external project partners but also between the inter-organizational project and line or project functions within the project leading organization supporting or feeding off the inter-organizational project. Due to different project tasks and team compositions, the quality of these latter relations in terms of strength of ties and trust, i.e. project team members' internal relational embeddedness, will vary from project to project. Moreover, the quality of the relations cannot be fully organizationally prescribed in a project context but will to a large extent emerge and develop informally (Bresnen et al., 2003). Informal social processes such as those highlighted in the present research thus play an important part in knowledge acquisition and transfer in the studied industry context.

Although innovation plays a key role in the German engineering industry, many projects involve external partner firms mainly for purposes of gaining access to complementary resources or pooling similar resources, rather than for learning or jointly creating innovations. Accordingly, only 15% of the firms in our sample indicated that learning from the project was one of the reasons for collaborating with the external project partners, while 92% emphasized the need for complementary competencies and 47% the pooling of resources. Still, inter-organizational projects nevertheless can (and often do) provide a source of innovation, as external partners in this innovation-driven industry bring in new ideas, insights and knowledge which may trigger future innovations as a side effect of a joint project (White and Fortune, 2002). Thus, the industry context of our study provides high potential for the absorption of external knowledge and rewards for being able to develop absorptive capacity. The industry context of the present study thus seems particularly appropriate for studying the emergence of absorptive capacity and its implications for innovation as unintended by-products of ongoing external collaborations.

In line with earlier research (e.g. Lui and Ngo, 2005), we used project managers as key informants. Project managers are experienced and often long-term organization members and thus well informed about the level of relational empowerment in the project. Moreover, as boundary spanning is one of their key tasks, they are best positioned to report about both the relations of project members with external project partners and with colleagues within the project leading organization. For data collection we used a standardized questionnaire. The overall response rate was 25%. We checked for possible response biases by comparing responding and non-responding firms with regard to company size, industry sector, and number of employees. As we found no significant differences, response bias does not seem to be a serious concern. The questionnaire was thoroughly pretested and distributed to the project managers responsible for the studied inter-organizational projects.

3.2. Measures

For all independent and dependent variables, we employed measures based on previously validated measures wherever possible. With the exception of some control variables, items were measured statement-style on a scale from 1 (fully disagree) to 5 (fully agree). Appendix A shows a list of the items used to measure the independent and dependent constructs of this study.

3.2.1. Relational embeddedness

Following Uzzi and Lancaster (2003), we measured boundary spanners' *external and internal relational embeddedness* as latent reflective constructs each composed of two different facets: tie strength and trust (corresponding to a type I measurement model as defined by Jarvis et al., 2003). To measure tie strength, we used three items. However, as Cronbach's α was well below the usual cut-off point of 0.7, we followed earlier well established conceptualizations (Hansen et al., 2001) and built a two item scale for both inter- and intra-organizational tie strength. Specifically, we measured *inter-organizational tie strength* on the basis of the closeness and communication frequency between project team members and their colleagues at the external project partner firms (Cronbach's $\alpha = .72$). To measure *intra-organizational tie strength* we applied the same items, however, referring to relations between project team members and their colleagues within their own organization, i.e. within the project-leading firm (Cronbach's $\alpha = .82$).

Following Tsai and Ghoshal (1998) as well as Tsai (2000), we measured *inter-organizational trust* on the basis of three items: the degree to which project team members and their external colleagues could trust each other to decide and act professionally and competently, to receive all necessary and reliable information, and to keep their promises (Cronbach's $\alpha = .78$). The variable *intra-organizational trust* applied similar items to project team members' relationships with colleagues of their own organization (Cronbach's $\alpha = .78$).

3.2.2. Relational empowerment

We measure relational empowerment by two facets: discretion in project-related decision-making and training (Spreitzer, 2008). We measured *discretion in project-level* decision-making by two items capturing the degree to which project team members could influence task related decisions (Batt, 2002) (Cronbach's $\alpha = .73$). To measure *training*, we used two items adopted from MacDuffie (1995). These items refer to the level of ongoing training provided to project team members and project managers (Cronbach's $\alpha = .84$).

3.2.3. Absorptive capacity

It is notoriously difficult directly to measure capabilities per se, as they are intangible. As a potential remedy, recent literature conceptualizes absorptive capacity and its components as a set of processes and routines related to an organization's knowledge stocks and flows (Lane et al., 2006; Lewin et al., 2011; Zahra and George, 2002). We follow earlier empirical studies which have adopted this process-based approach (Jansen et al., 2005; Lichtenthaler, 2009) and measure absorptive capacity on the basis of the manifestations of external knowledge acquisition processes as indicators for potential absorptive capacity (cf. Maurer, 2010) and internal knowledge transfer processes as indicators for realized absorptive capacity (cf. Maurer et al., 2011). Moreover, following Volberda et al.'s (2010) call that research should be explicit about the kind of knowledge being absorbed, we consider two important knowledge contents that figure prominently in earlier research (e.g. Sidhu et al., 2007): supply side knowledge absorption (in terms of new technologies) and demand side knowledge absorption (in terms of new markets). Though both kinds of knowledge capture different contents, they are closely intertwined in affecting firm innovativeness and thus can be combined in one construct.

Potential absorptive capacity refers to knowledge processes regarding the acquisition and assimilation of external knowledge (Zahra and George, 2002). We measured this construct on the basis of three items adopted from Gupta and Govindarajan (2000) and Yli-Renko et al. (2001). Respondents indicated whether project team members received from their colleagues at the external project partners a lot of stimuli and suggestions, ideas for new products and product enhancements, and new information on market trends, customer needs, and competitors (Cronbach's $\alpha = .70$).

To measure *realized absorptive capacity*, we used four items capturing the processes of knowledge transformation and exploitation (Lane et al., 2006; Zahra and George, 2002). In line with measures from Jansen et al. (2005) and Yli-Renko et al. (2001), we asked

respondents about the extent to which they discussed with their colleagues inside the organization about market-, technology- and product-related ideas received through the inter-organizational project, the extent to which their colleagues inside the organization through the project obtained new knowledge about the market, competitors and possible customers, and the extent to which through the project many new projects were initiated to newly develop and enhance products and/or technologies (Cronbach's $\alpha = .72$).

To test whether potential and realized absorptive capacity actually constitute two components of absorptive capacity, we model absorptive capacity as a second-order construct formed by two indicators – potential and realized absorptive capacity – that are themselves measured by several reflective indicators (corresponding to Jarvis et al.'s (2003) type II measurement model). We based the decision to model absorptive capacity as a formative construct on the four decision criteria put forward by Jarvis et al. (2003). First, for formative constructs the direction of causality flows from the indicators to the second-order construct so that the measures all impact a single construct (Bollen and Lennox, 1991). Definitions of absorptive capacity indicate that potential and realized absorptive capacity together constitute overall absorptive capacity (Todorova and Durisin, 2007; Zahra and George, 2002); the direction of causality is thus said to flow from the indicators to the second-order construct. Second, reflective constructs measure the same construct in slightly different ways so that the indicators are mutually exchangeable. This need not necessarily be the case for formative constructs, as here the indicators represent different facets forming one second-order construct. If one would drop one indicator of absorptive capacity – potential or realized absorptive capacity – this would considerably alter the conceptual domain of the overall absorptive capacity construct. Therefore, the two indicators cannot be viewed as interchangeable. Third and relatedly, in contrast to reflective indicators, formative ones need not necessarily correlate. Bollen and Lennox (1991) nevertheless recommend that models should allow for inter-correlations among formative indicators, yet need not theorize any specific relationship. Fourth, in reflective models indicators possess the same antecedents and consequences, because they all reflect the same underlying construct. In formative models, however, indicators may have different antecedents and/or consequences. Prior work has shown this to be the case for the components of absorptive capacity (Jansen et al., 2005; Lichtenthaler, 2009). On the basis of these four criteria, the conceptualization of absorptive capacity as a formative construct seems justified.

3.2.4. Innovation outcomes

While innovation has attracted plenty of research, the term remains ambiguous (see the reviews by e.g. Anderson et al., 2004; Crossan and Apaydin, 2010; Garcia and Calantone, 2002). It has been defined as a process (from the generation to the application and diffusion of novel ideas, or as exploration and exploitation processes) and as an outcome (e.g. in terms of technological, product, process, or social innovations) of different magnitudes (e.g. incremental and radical). The absorptive capacity literature focusing on innovation has been mainly concerned with innovation outcomes, mostly at the organizational level. Since we require two independent dependent variables to identify the formative model of absorptive capacity, we focus on product innovation and process innovation as two innovation outcomes that the project-leading organizations realize as a result of the focal inter-organizational projects. To measure *product innovation*, we followed Yli-Renko et al. (2001) and asked respondents to indicate to what extent the project-leading organization was able to develop a tremendous amount of new or better products and/or to improve their products/technologies as a result of participating in the focal inter-organizational project (Cronbach's $\alpha = .82$). Inter-organizational projects also present a source of learning about project management tools and methods resulting in improvements of an organization's internal operations and work processes (Bartsch et al., 2013; van Donk and Riezebos, 2005). We measured *process innovation* by four items: improvements in project management skills, in project management tools (such as handbooks), in internal processes as well as better goal attainment in subsequent projects in terms of schedule, budget, and quality (cf. Human and Provan, 1997) (Cronbach's $\alpha = .88$).

We examine how absorptive capacity affects these two types of innovation at the level of the project-based organization. Note that our measures of innovation outcomes link the level of inter-organizational projects within project-based organizations and the level of the project-based organization as a whole by gauging to what extent the ideas generated within the focal inter-organizational projects led to firm-level innovation outcomes. We need to introduce this link of levels, and cannot stay at the project level alone, because all projects within project-based organizations are terminated after completion. Product and process innovations that flow from newly absorbed external knowledge will thus mainly be exploited in future projects that are conducted within the project-based organization, yet not in the focal project that generated the learnings or novel ideas.

3.2.5. Control variables

We acknowledge possible other influences on the dependent innovation variables and, therefore, included the following firm and project level control variables in the model. *Firm age* (measured by the number of years from the founding date until 2006) can influence the ability to produce innovations, as older firms are supposed to be more resistant toward new and innovative ideas (Dirks and Ferrin, 2001). *Firm size* (measured by the natural logarithm of the number of firm employees as well as the natural logarithm of firm turnover) may affect firm innovation as larger firms have the opportunity to provide slack resources (Damanpour, 1991). *R&D spending* is often used as a proxy for an organization's capacity to absorb outside knowledge and to innovate (Cohen and Levinthal, 1990), yet has been found to be unrelated to the processes associated with absorptive capacity (Lichtenthaler, 2009). However, R&D spending might impact an organization's innovativeness. We measured R&D spending in percent of firm turnover. We also controlled for the extent to which firms applied *standardized knowledge management systems*, because. knowledge management systems might encourage employees to exploit knowledge for innovative outcomes (Argote et al., 2003). We further controlled for *learning intent* as a sub-goal of the project, since projects that aspire to learning are more likely to entail knowledge transfer (Child, 2001) and thus innovation. We measured learning intent in form of a dummy variable that indicates whether or not learning from the project was a goal for the project. Similarly, *project success* may result in firm innovation, as people outside the project are more willing to learn from successful projects (Smith-Doerr et al., 2004). We measured project success by a dummy variable indicating whether or not the project was deemed successful in terms of having met its schedule, budget, and quality goals.

3.3. Reliability and validity

Several research steps helped to ensure the reliability and validity of the data. We thoroughly pre-tested and revised the questionnaire on the basis of interviews with 24 industry experts (managing directors, project managers, and industry consultants). Additionally, the questionnaire includes measures validated by previous research wherever possible. To check for possible informant bias and cross-validate data on both control and our

dependent variables, we used additional data sources. For about 25% of the sample we gathered data from written documents (firm reports) as well as second informants (higher-level project coordinators). Data triangulation revealed no significant differences between responses from the three different sources. We further used multiple-item constructs for the variables of the theoretical model to enhance content coverage. Cronbach's α for the multiple-item constructs indicates construct reliability, as it is above the usual cut-off point of 0.7 (Nunnally, 1978). Principal component factor analyses indicate convergent validity of all multi-item constructs. Standardized factor loadings for all items are above the recommended minimum of 0.4 (Ford et al., 1986). Average variance extracted by the factors is above the recommended minimum of 0.5 (Fornell and Larcker, 1981). The squared correlation between the constructs is less than the average variance extracted revealing the distinctiveness of each of the constructs and, thus, discriminant validity.

Due to conceptual heterogeneity in absorptive capacity research, we additionally applied confirmatory factor analysis to test the convergent and discriminant validity as well as the dimensionality of the absorptive capacity construct. Following prior research, we compared three alternative measurement models to this end (Lichtenthaler, 2009; Tanriverdi and Venkatraman, 2005). In Model 1 a unidimensional first-order factor accounts for the variance among all 7 items. Model 2 lets the items load on two uncorrelated first-order factors (potential and realized absorptive capacity). Model 3 allows the two first-order factors to correlate. An alternative model which has the items load on three first-order factors was excluded from the analysis, as the two factor solutions proved superior. Model comparisons reveal that model 3 ($\chi^2 = 59$; df = 13) with its two freely correlated first-order factors is superior to models 1 ($\chi^2 = 110$; df = 14) and 2 ($\chi^2 = 113$; df = 14), as it shows a lower ratio between χ^2 and degrees of freedom. Moreover, in model 3 the standardized loadings of the measurement items on their respective factor are all highly significant and above 0.55 indicating convergent validity (Santos and Ledur Brito, 2012). The correlations between the two factors are significantly different from zero. Yet, they are well below 0.9, indicating that the theoretical content captured by the individual first-order factors is distinct from each other (Bagozzi et al., 1991). This further provides support for the constructs' discriminant validity (Bagozzi and Phillips, 1982). Together, comparisons between the different models support the two-dimensionality of the first-order constructs as well as their interrelationship.

For the second-order formative absorptive capacity constructs classical test theory and methods do not apply. Instead, validation relates to the strength and significance of the path from the first-order indicators – potential and realized absorptive capacity – to the construct (MacKenzie et al., 2005). As formative constructs require at least two paths to be identified, the final model tests the impact of absorptive capacity on the two dependent variables we observed, product innovation and process innovation. To avoid estimation difficulties in the formative model, we also applied a multicollinearity check for the formative indicators using the commonly accepted cut-off value of a variance inflation factor (VIF) > 10 and a condition index (CI) > 30 (Belsley, 1991; Hair et al., 1995). While high correlation among the first-order constructs is consistent with complementarity (Milgrom and Roberts, 1995), multicollinearity may cause estimation difficulties and therefore is an undesirable property of formative models. Neither the VIF nor the CI exceeds the cut-off value indicating that multicollinearity does not present a severe problem.

Finally, we controlled for common method variance with Harman's one-factor test (Podsakoff and Organ, 1986). Common method variance is unlikely to be a problem, as an exploratory principal component factor analysis of all items in the hypothesized model resulted in 10 factors explaining 66% of the variance (16% was the largest variance explained by one factor).

3.4. Data analysis

We tested the research hypotheses by means of structural equation modeling using maximum likelihood estimation. We conducted principal component factor analyses to extract factors for the constructs, yet for construct measurement relied on additive indices of the items. For the structural equation analysis, we included them in a path model and added all control variables. For the final presentation of results below, we omitted the control variables that had no significant effect on the dependent variables. We allowed the independent variables to correlate freely and omitted non-significant paths in the course of post hoc analyses. While enhancing model fit, these specifications did not alter the significance and direction of hypothesized paths.

We complemented the structural equation analysis by regression analyses to test for the indirect effects of internal (external) relational embeddedness on potential (realized) absorptive capacity proposed in hypothesis 3. In order to determine indirect effects, we followed the recommendations of Preacher and Hayes (2004). An indirect effect differs from a mediation effect in that the former, in contrast to the latter, need not imply a direct effect of an independent variable X on an outcome variable Y. Rather, it suffices to show that (1) the independent variable X significantly affects a third variable M which then significantly effects an outcome variable Y, controlling for the effects of the independent variable X; and (2) that the indirect effect of X on Y through M is significantly different from 0. In order to test for such indirect effects, we conduct normal theory tests for indirect effects (Sobel test) and complement them with bootstrap analyses with 1000 resamples to establish a 95% a bias corrected confidence interval for the size of the indirect effects (see Preacher and Hayes, 2004).

For examining hypothesis 6 that proposes complementarities between potential and realized absorptive capacity in affecting innovation, we compared two structural equation models (c.f. Lichtenthaler, 2009; Tanriverdi and Venkatraman, 2005).[2] Model I suggests that potential and realized absorptive capacity unfold direct effects on product innovation and process innovation. Model II includes absorptive capacity as a second-order factor being manifested by the two first-order factors as its formative indicators. A second-order construct models the complementarity of its first-order indicators by presenting the main source of covariance among them; that is absorptive capacity as a second-order factor explains why the first-order factors coexist and covary with each other. The explanatory contribution of the second-order factor captures complementarities between the first-order factors, as it represents the incremental explanatory power of the relatedness between potential and realized absorptive capacity (Rindskopf and Rose, 1988). According to recommendations by Jarvis et al.

[2] For several reasons, and in line with prior research, we did not use a pair-wise interaction test to examine complementarities between potential and realized absorptive capacity (Tanriverdi and Venkatraman, 2005; Whittington et al., 1999). First, we find considerable correlation among potential and realized absorptive capacity as the two components of the absorptive capacity construct. While this is consistent with the theory of complementarities (Milgrom et al., 1991) and can be accounted for in formative higher-order factor modeling (Bollen and Lennox, 1991), it may lead to biased estimates when applying a pair-wise interaction test approach. Second, the significance of a pair-wise interaction test can also indicate other theoretical relationships than complementarity, for instance a fit relationship or moderation effect (Drazin and Van de Ven, 1985). An interaction analysis thus does not offer an unambiguous test of a complementarity relationship (Tanriverdi and Venkatraman, 2005). Third, structural equation modeling is parsimonious, as it allows us simultaneously to examine the antecedents, outcomes and complementarity of the two postulated components of absorptive capacity.

(2003) and MacCallum and Browne (1993) and in line with our measurement model, we followed standard practice and allowed for covariances among the formative indicators. A comparison with this model and one which does not free covariances among the formative indicators reveals that all significant paths remain significant within the more parsimonious model, while goodness of fit indices degrade.

4. Results

Table 1 presents means, standard deviations, and correlations for all model constructs.

Table 2 shows the values and levels of significance of the path coefficients and control variables as well as goodness of fit indices for the specified structural equation models: Model I, the direct effects model, tests the direct effects of potential and realized absorptive capacity on product innovation and process innovation, respectively. Model II, the complementarity model, includes a second-order factor accounting for complementarities among potential and realized absorptive capacity in affecting product and process innovation.

Hypotheses 1 and 2 concerned the relation between external and internal relational embeddedness and potential and realized absorptive capacity, respectively. In line with Hypothesis 1, we find that the external relational embeddedness of boundary spanners' ties, measured as a latent variable reflected by inter-organizational tie strength and trust between project team members and their colleagues in the external project partner firms, is positively associated with potential absorptive capacity. As proposed in Hypothesis 2, results also indicate a positive relationship between the internal relational embeddedness of boundary spanners' ties (measured as a latent variable reflected by intra-organizational tie strength and trust) and realized absorptive capacity, though only at a 10% level of significance.

Hypothesis 3 postulated that boundary spanners' external (internal) relational embeddedness indirectly positively affects realized (potential) absorptive capacity. Table 3 shows the results of the pertinent regression analyses, the Sobel tests, and the bootstrap analyses. Results largely support our hypothesis. They indicate a significant, albeit small positive indirect effect of boundary spanners' internal relational embeddedness through their external relational embeddedness on project leading organization's potential absorptive capacity. The total effect of boundary spanners' internal relational embeddedness on their organization's potential absorptive capacity, i.e. the sum of the direct and indirect effects, however, is not significant. We further find a marginally significant, even smaller positive indirect effect of boundary spanners' external relational embeddedness through their internal relational embeddedness on their organization's realized absorptive capacity. Here, however, results indicate a positive and significant total effect of boundary spanners' external relational embeddedness on their organization's realized absorptive capacity.

Hypotheses 4 and 5 refer to relational empowerment as a further antecedent for the two components of absorptive capacity. Hypothesis 4 stated that relational empowerment (in terms of greater discretion in decision-making and training) positively affects an organization's potential absorptive capacity. Data show partial support for this hypothesis. While organization members' training is positively associated with potential absorptive capacity, discretion in project-level decision-making shows no significant relation. Hypothesis 5 submitted that relational empowerment (in terms of greater discretion in decision-making and training) is positively associated with an organization's realized absorptive capacity. This hypothesis is fully supported by the data.

Table 1
Means, standard deviations, and correlations for all constructs in the model.

		Mean	S.D.	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.
1.	External embeddedness: Tie strength	3.33	0.90																
2.	External embeddedness: Trust	3.65	0.82	.313***															
3.	Internal embeddedness: Tie strength	3.36	0.93	.156*	.110														
4.	Internal embeddedness: Trust	3.96	0.60	.162*	.295***	.371***													
5.	Relational empowerment: Discretion	3.73	0.91	.013	.000	.207**	.255***												
6.	Relational empowerment: Training	4.22	2.58	.049	.065	.069	−.028	.007											
7.	Potential absorptive capacity	2.65	0.89	.144*	.140*	.175**	−.021	.060	.179*										
8.	Realized absorptive capacity	2.84	0.85	.207**	.059	.193**	.080	.241***	.217*	.444***									
9.	Product innovation	2.61	1.11	.203**	.141*	.175**	.064	.144*	.198*	.415***	.574***								
10.	Process innovation	2.60	0.93	.105	−.097	.088	−.044	.090	.084	.124	.305***	.336***							
11.	Firm age	67.88	57.36	−.074	−.016	−.055	.090	−.036	−.013	−.152*	−.129	−.058	−.092						
12.	Firm size (employees)	5.88	1.90	.060	−.047	−.203**	.024	−.027	.067	.046	−.019	−.057	−.093	.277***					
13.	Firm size (turnover)	18.96	2.57	.098	−.041	−.259***	.033	−.121	.159*	.080	.006	−.051	−.037	.254***	.745***				
14.	R&D spending (in % turnover)	5.92	8.40	−.055	.136*	.047	.008	−.106	.192**	.108	.098	.200**	−.073	−.061	.054	−.048			
15.	Standardized knowledge management	2.59	1.21	−.023	−.072	−.106	.133*	.203**	.144*	−.128	.011	−.015	.076	.110	.203**	.188*	−.031		
16.	Learning is a project goal	0.15	0.36	.138*	.043	.062	.066	.095	−.056	.149*	.200**	.105	.105	−.056	−.085	−.118	−.014	−.096	
17.	Project Success	0.89	0.31	.159*	.153*	.109	.100	−.012	.131	.072	.194**	.108	.055	.030	.123	.098	.052	−.104	.016

$N = 218$, for firm size and firm age, natural logarithms are used in correlations.
*** $p \leq .001$ (two-way significance).
** $p \leq .01$ (two-way significance).
* $p \leq .05$ (two-way significance).

Table 2
Structural equation modeling results for model I (direct effects model) and model II (complementarity model).

	Coefficient (model I)	Coefficient (model II)
Description of path		
Potential absorptive capacity → Product innovation	.189**	–
Potential absorptive capacity → Process innovation	n.s.	–
Potential absorptive capacity → Absorptive capacity	–	.204**
Realized absorptive capacity → Product innovation	.482***	–
Realized absorptive capacity → Process innovation	.311***	–
Realized absorptive capacity → Absorptive capacity	–	.584***
External embeddedness → Potential absorptive capacity	.169*	.169*
Internal embeddedness → Realized absorptive capacity	.141+	.141+
Discretion → Potential absorptive capacity	n.s.	n.s.
Discretion → Realized absorptive capacity	.188**	.188**
Training → Potential absorptive capacity	.171**	.171**
Training → Realized absorptive capacity	.214***	.214*
External embeddedness → Inter-organizational tie strength	.457***	.457***
External embeddedness → Inter-organizational trust	.693***	.693***
Internal embeddedness → Intra-organizational tie strength	.508***	.508***
Internal embeddedness → Intra-organizational trust	.723***	.273***
Absorptive capacity → Product innovation	–	.841***
Absorptive capacity → Process innovation	–	.416***
Potential absorptive capacity ↔ Realized absorptive capacity	.416***	.416***
External embeddedness ↔ Internal embeddedness	.524***	.524***
Discretion ↔ Internal embeddedness	.364***	.364***
Control variables		
Firm age → Product innovation	n.s.	n.s.
Firm age → Process innovation	n.s.	n.s.
Firm size (employees) → Product innovation	n.s.	n.s.
Firm size (employees) → Process innovation	n.s.	n.s.
Firm size (turnover) → Product innovation	n.s.	n.s.
Firm size (turnover) → Process innovation	n.s.	n.s.
R&D spending → Product innovation	.134*	.155**
R&D spending → Process innovation	n.s.	n.s.
Standardized knowledge management → Product innovation	n.s.	n.s.
Standardized knowledge management → Process innovation	n.s.	n.s.
Learning intent → Product innovation	n.s.	n.s.
Learning intent → Process innovation	n.s.	n.s.
Project success → Product innovation	n.s.	n.s.
Project success → Process innovation	n.s.	n.s.
Model fit statistics		
CMIN/DF	1.87	1.60
GFI	.95	.95
AGFI	.91	.92
CFI	.90	.93
RMSEA	.06	.05

n.s.: not significant.
*** $p \leq .001$.
** $p \leq .010$.
* $p \leq .05$.
+ $p \leq .10$.

The final Hypothesis 6 stated that potential absorptive capacity and realized absorptive capacity complement one another in enhancing innovation. Comparisons between model I and model II support this conjecture. In model II, the structural links from the second-order construct of absorptive capacity to both product innovation and process innovation are strong, positive, and highly significant. In model I, the direct effect of potential absorptive capacity on product innovation is only weak; the direct effect of potential absorptive capacity on process innovation is not significant. Moreover, the complementarity model II shows better fit indices than the direct effects model I (Hair et al., 1995; Jöreskog, 1993). In sum, these results support Zahra and George's (2002) notion that absorptive capacity is composed of two components, potential and realized absorptive capacity, that have separate but complementary roles in enhancing innovation and performance.

5. Discussion and conclusion

While the concept of absorptive capacity has promise to provide a valuable inroad for better understanding why organizations vary in their innovativeness, pertinent research has not yet realized the concept's full potential (Lane et al., 2006; Volberda et al., 2010). A first reason is that only few empirical studies have opened the black box of absorptive capacity and actually examined the organizational routines and processes that constitute an organization's absorptive capacity (see Jansen et al., 2005; Lane et al., 2001; Lichtenthaler, 2009; Schleimer and Pedersen, 2013). Instead, the majority of empirical studies have used overall proxies (such as R&D expenditures, the number of scientists working in R&D departments or patents) to measure absorptive capacity. These proxies, however, provide less accurate representations of the concept and preclude more nuanced analyses of its conceptual foundations. Second, as a consequence, research has rarely examined empirically the possibly distinct ramifications of the different processes underlying an organization's absorptive capacity and their combined effects. Third, we therefore also still know little about the micro-processes from which the different components of absorptive capacity emerge (Foss et al., 2010).

This study has sought to contribute to overcoming these critical limitations of the literature on absorptive capacity. First,

Table 3a
Tests for indirect effects of internal relational embeddedness on absorptive capacity.

	Coeff.	SE	*t*	*p*
Internal to external relational embeddedness	.2714	.0655	4.1445	.0000
External relational social capital to potential absorptive capacity	.1600	.0697	2.2961	.0226
Total Effect of internal relational embeddedness on potential absorptive capacity	.0947	.0677	1.3983	.1634
Direct effect of internal relational social capital on potential absorptive capacity	.0513	.0697	.7359	.4626

Model summary for dependent variable model

R-sq	Adj. *R*-sq	*F*	df1	df2	*p*
.0327	.0237	3.6330	2.0000	215.0000	.0281

Normal theory test (Sobel test) for indirect effects
Indirect effects of internal relational embeddedness on potential absorptive capacity through external relational embeddedness

	Effect	SE	*Z*	*p*
External relational embeddedness	.0434	.0215	2.0167	.0437

Bootstrap results for indirect effects
Indirect Effects of internal relational embeddedness on potential absorptive capacity through external relational embeddedness

	Data	Boot	Bias	SE
External relational embeddedness	.0434	.0412	−.0022	.0215

Bias corrected confidence intervals

	Lower	Upper
External relational embeddedness	.0097	.1011

Level of confidence for confidence intervals: 95%. Number of bootstrap resamples: 1000.

Table 3b
Tests for indirect effects of external relational embeddedness on absorptive capacity.

	Coeff.	SE	*t*	*p*
External to internal relational embeddedness	.2714	.0655	4.1445	.0000
Internal relational embeddedness to realized absorptive capacity	.1361	.0695	1.9593	.0514
Total effect of external relational embeddedness on realized absorptive capacity	.1486	.0673	2.2078	.0283
Direct effect of external relational embeddedness on realized absorptive capacity	.1116	.0695	1.6071	.1095

Model summary for dependent variable model

R-sq	Adj. *R*-sq	*F*	df1	df2	*p*
.0392	.0303	4.3886	2.0000	215.0000	.0135

Normal theory test (Sobel test) for indirect effects
Indirect effects of external relational embeddedness on realized absorptive capacity through internal relational embeddedness

	Effect	SE	*Z*	*p*
Internal relational embeddedness	.0369	.0208	1.7788	.0753

Bootstrap results for indirect effects
Indirect effects of external relational embeddedness on realized absorptive capacity through internal relational embeddedness

	Data	Boot	Bias	SE
Internal relational embeddedness	.0369	.0376	.0006	.0238

Bias corrected confidence intervals

	Lower	Upper
Internal relational embeddedness	.0011	.0973

Level of confidence for confidence intervals: 95%. Number of bootstrap resamples: 1000.

our results provide confirming evidence for the fruitfulness of Zahra and George's (2002) conceptualization of absorptive capacity. Our empirical results corroborate that the processes underlying potential and realized absorptive capacity form two constituent components of the overall absorptive capacity construct. The finding that potential and realized absorptive capacity form a second-order construct strengthens confidence in the robustness of a process-based conceptualization of the absorptive capacity construct, because it confirms pertinent earlier results by Schleimer and Pedersen (2013) and Lichtenthaler (2009) that were based on slightly different operationalizations of the underlying constructs. Furthermore, our results corroborate the fruitfulness of distinguishing different components of absorptive capacity, because they indicate that potential and realized absorptive capacity have partially distinct antecedents and complement one another in affecting innovation outcomes. While other conceptualizations of the processes underlying absorptive capacity (Cohen and Levinthal, 1990; Lewin et al., 2011; Todorova and

Durisin, 2007) may prove to be equally fruitful, our findings suggest that it is productive to apply a refined conceptualization of absorptive capacity that distinguishes different components, rather than overall (proxy) measures. This conclusion is further supported by the fact that a frequently used proxy for absorptive capacity, R&D expenditures, in our data (as in Lichtenthaler's, 2009) does not correlate significantly with our measure of absorptive capacity.

Second, our study responds to Todorova and Durisin (2007) call to study the antecedents of the different components of absorptive capacity. While the few studies that have examined antecedents of absorptive capacity have mainly emphasized organizational factors, the present research has turned its attention to the possible impact of the personal capacities and relationships among individual organization members. Complementing earlier research on the drivers of absorptive capacity (Jansen et al., 2005; Schleimer and Pedersen, 2013), our results indicate that absorptive capacity emerges from the external and internal relational embeddedness of relationally empowered members of inter-organizational projects who operate at the interface both with external project partners and colleagues within the project leading organization. As we control for learning intent, our findings reveal how absorptive capacity emerges as an unintended consequence of boundary spanners' external and internal ties and relational empowerment.

Our findings partially confirm Todorova and Durisin (2007) notion and Jansen et al.'s (2005) finding that the components of absorptive capacity are influenced by different sets of antecedents. Specifically, we find that strong and trusted relations of inter-organizational project members with external project partners increase potential absorptive capacity. While the strong and trusted internal relations of project members with their colleagues inside the organization augments realized absorptive capacity. These findings reveal that the relational embeddedness of boundary spanners' internal and external network ties play an important, yet distinct role in explaining absorptive capacity.

In addition, we argued and indeed found empirically that organization members' relational empowerment in terms of discretion in project-level decision-making and training also contribute to an organization's absorptive capacity. In particular, our research underscores the important impact that discretion in project-level decision-making exerts on realized absorptive capacity. We did not find the expected positive association with potential absorptive capacity, however. It thus seems that the empowerment granted by greater discretion enables and motivates organization members to try and realize potential gains from new external knowledge but less so to seek out new, potentially fruitful possibilities. Our mixed finding echoes the mixed result of the study by Jansen et al. (2005), who find a positive impact of participation in decision-making on the acquisition and transformation of new knowledge but not on its assimilation and exploitation. While not analyzing the selective influence of discretion in project-level decision-making on the different components of absorptive capacity, Schleimer and Pedersen (2013) report a related, significant positive effect of MNC decentralization on subsidiary absorptive capacity. In all, these findings establish that discretion in project-level decision-making is an important driver of absorptive capacity, yet at the same time call for more research that further illuminates whether, and if so why, discretion has distinct implications for the different components of absorptive capacity. Relational empowerment by training, on the other hand, according to our results clearly enhances both potential and realized absorptive capacity, as it augments organization members' capacity to acquire, assimilate, transform, and exploit potentially useful new external knowledge. Together, these results suggest that some factors may drive both potential and realized absorptive capacity, while others selectively influence the two components of absorptive capacity.

Third, our results further indicate that external and internal relational embeddedness mutually influence one another, implying that these dimensions of embeddedness have both direct and indirect effects on the two components of absorptive capacity. While we could not examine the learning and routinization processes that, we argued, underlie the influence relationships between internal and external embeddedness, we suspect that they give rise to social skills and a relational capability that are conducive, both directly and indirectly, to the development of potential and realized absorptive capacity, respectively. It seems a potentially fruitful avenue for future research further to scrutinize these arguments.

Our findings to some extent contrast with those of Hansen et al. (2005) who studied knowledge seeking and transfer among product development team members in various subsidiaries of one organization. They found that strong within-ties of product development teams lead to fewer knowledge-seeking attempts across organizational boundaries and, thus, less external knowledge acquisition because team members channel their time and energy toward the team. The test for indirect effects we conducted to test for this possibility indicates no such effect of the embeddedness of project members' internal ties on the acquisition and assimilation of external knowledge in our sample (see Table 3a). This may be due to the fact that our study focused on established external ties within a given inter-organizational project with external partners, while Hansen et al. (2005) looked at inter-subsidiary ties with potentially competing project development teams that had to be specifically activated. In this latter context, organization members will have to invest comparatively greater effort to search for and access potential external providers of new knowledge than in the context of inter-organizational projects we studied. Moreover, prior knowledge may be more similar among the members of an inter-organizational project team than across rival subsidiaries working on different kinds of products. Here too the implication would be that knowledge acquisition and assimilation would be easier in our study context.

Fourth, our results further contribute to the emerging research investigating Zahra and George's (2002) claim that the components of absorptive capacity have separate but also complementary effects on organizational innovation and performance (Lichtenthaler, 2009). While we do find separate effects of potential and realized absorptive capacity on organizational innovation outcomes, the model including the effects of the second-order factor of absorptive capacity shows better fit, corroborating findings of earlier studies by Schleimer and Pedersen (2013) and Lichtenthaler (2009). This indicates that the combined effect of potential and realized absorptive capacity is greater than the effects of its components. However, in their case study of a large financial firm Jansen et al. (2005) find that base-line levels of realized and high levels of potential absorptive capacity show relatively better performance outcomes in organizational units operating in dynamic environments. It thus remains an open question which level of balance between firms' potential and realized absorptive capacity is most beneficial for performance under which circumstances.

Finally, a number of limitations of this study suggest further fruitful avenues for future research. First, while the key informant approach might be viewed as a limitation of the study, through triangulation, procedural and statistical remedies we could secure reasonable reliability and validity of the data. Second, while the present study identified boundary spanners' relational embeddedness and relational empowerment as significant individual- and team-level antecedents of absorptive capacity, future research could seek to determine how important relational embeddedness and relational empowerment are compared to other antecedents, e.g. organization structural factors (Jansen et al., 2005) or prior knowledge (Lane et al., 2001). Building on Rost (2011), research could furthermore examine how the interplay of

relational embeddedness and different positions of organization members' within their external and internal networks affect their organizations' potential and realized absorptive capacity, respectively. Third, we focused on a particular, though important group of organizational boundary spanners, namely members of inter-organizational projects. Future research might examine to what extent our findings also apply to other groups of boundary spanners, such as sales people, organizational delegates to industry associations, and others. Finally, it would also be important better to understand the conditions that affect the extent to which an organization's realized absorptive capacity translates into more or less radical innovation. In all, the links between the different components of absorptive capacity, their drivers and outcomes remain important ones that invite future research.

Appendix A. Measurement of constructs

External relational embeddedness
Inter-organizational tie strength (Cronbach's $\alpha = .72$)

- Our project team members and their colleagues at the external project partners were very close to each other.
- Our project team members and their colleagues at the external project partners communicated very often with each other.

Inter-organizational trust (Cronbach's $\alpha = .78$)

- Our project team members and their colleagues at the external project partners could always trust that each other would decide and act professionally and competently.
- Our project team members and their colleagues at the external project partners could always trust that each would receive necessary and reliable information and service.
- Our project team members and their colleagues at the external project partners could always trust each other without any fear that one will take advantage of the other even if the opportunity arises.

Internal relational embeddedness
Intra-organizational tie strength (Cronbach's $\alpha = .82$)

- Our project team members and their colleagues in our company were very close to each other.
- Our project team members and their colleagues in our company communicated very often with each other.

Intra-organizational trust (Cronbach's $\alpha = .78$)

- Our project team members and their colleagues in our company could always trust that each other would decide and act professionally and competently.
- Our project team members and their colleagues in our company could always trust that each would receive necessary and reliable information and service.
- Our project team members and their colleagues at the external project partners could always trust that each would keep the promises they make.

Relational empowerment
Discretion in project-level decision-making (Cronbach's $\alpha = .73$)

- In general, project team members have a high degree of influence over the tasks of the project.
- In general, project team members are allowed to make many decisions (e.g. with regard to task fulfillment, rules, exceptions).

Training (Cronbach's $\alpha = .84$)

- How many days per year will project team members normally go through training programs?
- How many days per year will project managers go through training programs?

Absorptive capacity
Potential absorptive capacity (Cronbach's $\alpha = .70$)
Introductory sentence: In the following questions, please state how many ideas were generated in this project.

- From our project partners we obtained a tremendous amount of stimuli and suggestions.
- From our project partners we obtained a lot of new ideas to develop new products or to further develop existing products.
- From our project partners we obtained a lot of new information on market trends, customer needs and competitors.

Realized absorptive capacity (Cronbach's $\alpha = .72$)
Introductory sentence: In the following questions, please state how many ideas were forwarded from the project into your organization.

- With our colleagues outside the project (i.e. in the company or in other projects), we discussed a lot about our market.
- With our colleagues outside the project (i.e. in the company or in other projects), we discussed a lot about technologies and products.
- Through this project, colleagues outside the project (i.e. in the company or in other projects) obtained a tremendous amount of market knowledge (i.e. about the market, competitors, and possible customers).
- Through this project, many new projects to (further) develop products and/or technologies have been initiated.

Product innovation (Cronbach's $\alpha = .82$)

- As a result of this project, our organization could develop new products and enhance existing products considerably.
- As a result of this project, our organization could improve our products/technologies tremendously.

Process innovation (Cronbach's $\alpha = .88$)

- As a result of this project, our organization could improve our project management skills tremendously.
- As a result of this project, our organization could improve our project management tools (e.g. handbooks, project plans, project controlling) tremendously.
- As a result of this project, our organization could improve our internal processes tremendously.
- As a result of this project, our organization could much better achieve our project goals (in terms of schedule, budget and quality) in subsequent projects.

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