Journal of Management & Organization (2023), page 1 of 30
doi:10.1017/jmo.2023.20

RESEARCH ARTICLE

Exploring microfoundations and multilevel mechanisms of absorptive capacity in an emerging economy: empirical evidence from a leading car manufacturer

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(Received 27 May 2022; revised 14 February 2023; accepted 22 March 2023)

Abstract

Purpose. Despite the importance of knowledge processes in building absorptive capacity, we are less clear about the micro-processes of absorptive capacity development and particularly about the role of individuals' knowledge processes.
Design/methodology/approach. This study empirically examined, via an in-depth case study, the microfoundations of absorptive capacity and their influence on building absorptive capacity in an automaker across the course of four product innovation projects.
Findings. Findings suggested that dynamics in a knowledge environment informed individual-level tacit and explicit knowledge processes. In return, knowledge processes at the individual level informed organizational learning processes and the emergence of knowledge processes at organization level for acquisition, assimilation, transformation, and exploitation of new knowledge.
Originality. This study contributes to the literature by revealing individuals' knowledge processes from which absorptive capacity emerges. Practically, managers can use the findings of this study to promote certain knowledge processes to develop intended aspects of absorptive capacity at an individual level.

Keywords: Absorptive capacity; knowledge processes; microfoundations; multilevel mechanisms; product innovation

Introduction

It is well established that innovation is critical to the sustainable development of firms, economic growth (Lundvall, 2016), and social progress (Stiglitz & Greenwald, 2014). The strategic management literature is particularly acute in explaining how innovation allows firms to gain and maintain competitive advantages (Pisano, 2015). We also know that the innovation process is increasingly becoming open due to distributed knowledge sources which have made it difficult and inefficient for a single firm to internally create all the required knowledge for innovation (Chesbrough, 2004). To realize such open innovation frameworks and ensure that firms can make sense of external knowledge, firms need to have absorptive capacity (Torres de Oliveira, Verreynne, Figueira, Indulska, & Steen, 2020), which is 'the ability to recognize the value of new external information, assimilate it and apply it to commercial ends' (Cohen & Levinthal, 1990: 128).

Indeed, over the course of approximately 30 years of research – and due to its critical role in mediating and moderating innovation, adaptation, and performance in firms – absorptive capacity has become the center piece of a firm's adaptation and change in general (Apriliyanti &

Alon, 2017). As a result, the role of absorptive capacity has been explored conceptually and empirically within several fields of research, such as innovation, firm adaptation, knowledge creation, knowledge transfer, and internationalization, as well as across different contexts and levels of analysis (e.g., Hotho, Becker-Ritterspach, & Saka-Helmhout, 2012). Although the importance and the role of absorptive capacity are well elaborated, interestingly, there are fewer insights into the process of developing absorptive capacity (Distel, 2019). This oversight leaves firms unaided and sometimes unguided when they decide to build absorptive capacity to ensure strategic success.

Inadequate insights about the process of absorptive capacity development can be attributed to the overemphasis of the existing research on the organizational-level antecedents and outcomes of absorptive capacity and paying less attention to the lower-level factors and mediation mechanisms underlying the emergence of absorptive capacity in an individual level. This macro-level bias, which is evident in the broader organizational capability research (Barney & Felin, 2013), has also lessened the explanatory power of the absorptive capacity concept and restricted our understanding of its role in the process of organizational learning and knowledge development. To address this issue, the micro-foundation view, aiming to explain macro-level phenomena through micro-level factors and mechanisms (Felin & Foss, 2006), is suggested as a theoretical lens for the investigation of absorptive capacity (Martinkenaite & Breunig, 2016). Felin, Foss, Heimeriks, and Madsen (2012) argued that studies driven by the micro-foundation view undertake multilevel analysis and are able to identify lower-level constitute components of organizational-level routines and capabilities and investigate how the interactions among these components contribute to the aggregation of the collective constructs.

Thus, most of the studies on the micro-foundations of absorptive capacity remain conceptual or focus on the processes which are at the project or even organizational level (Magistretti et al., 2021). It is argued that the actions and interactions of individuals and the organizational context are the building blocks of capability development in general (Barney & Felin, 2013; Foss, 2011). However, there are limited insights, and empirical evidence, about the role of individual-level processes in the development of a specific capability (Barney & Felin, 2013; Felin et al., 2012), like absorptive capacity. The abstracting of the impact of individuals undermines a fundamental part of Cohen and Levinthal's (1990) argument that the development of absorptive capacity depends heavily on individuals' cognitions and behaviors. In addition, due to the role of absorptive capacity in organizational learning, revealing the micro-mechanisms underlying absorptive capacity may create additional insights into the process of organizational knowledge development and the interplay between absorptive capacity and organizational learning (Distel, 2019; Martinkenaite & Breunig, 2016).

To address this problem in absorptive capacity research and the broader 'knowledge movement' context (Foss, Husted, & Michailova, 2010) in the strategic management literature, this study aimed to examine the individual-level knowledge and learning process and the multilevel mechanisms embedded in the emergence of organizational absorptive capacity. Thus, we asked: What are the individual-level knowledge and learning processes and the multilevel mechanisms embedded in the emergence of organizational absorptive capacity in the context of an emerging economy?

Following this broad research aim, we focused on the context of an emerging economy. We argue that the trajectory of absorptive capacity development in firms in an emerging economy is specific to the context of emerging economies and could differ from their counterparts in advanced economies. While prior knowledge is argued to be a major constituent of absorptive capacity (Cohen & Levinthal, 1990), the level of prior knowledge is found to be different between firms from emerging economies and those from advanced economies, once exposed to external knowledge (Scaringella & Burtschell, 2017). Emerging economy firms suffer from a technological knowledge disadvantage when competing with firms from advanced economies, and seek the acquisition of knowledge (Ponomariov & Toivanen, 2014) when engaged in international business exchange (Kogut & Zander, 1992). However, considerable research on knowledge flows in

https://doi.org/10.1017/jmo.2023.20 Published online by Cambridge University Press

emerging economy firms highlights the difficulties of knowledge transfer from external sources, among which lack of absorptive capacity and prior knowledge was found to be critical (Ponomariov & Toivanen, 2014; Scaringella & Burtschell, 2017). This indicates that the dynamics between absorptive capacity and the process of knowledge development within emerging economy firms can be different from those within firms from developed countries. Thus, this study focuses on the interplay between absorptive capacity and organizational learning in the context of emerging economy firms (Argote, McEvily, & Reagans, 2003) and the development of absorptive capacity in these firms, considering their technological knowledge and the obstacles to technological progress.

Because the research question required a fine-grained and in-depth analysis, we chose a qualitative, longitudinal single case study. To develop an understanding of the multilevel interactions between micro-level processes and organizational-level absorptive capacity development, and to draw a picture of how absorptive capacity microfoundations at the micro level can drive absorptive capacity emergence at the organization level, we needed to capture the process through which absorptive capacity unfolded in an organization and then identify the micro-processes which contributed to this process and analyze their role. For this purpose, after a careful evaluation of multiple alternatives, we selected a case and made an initial investigation and pilot study to make sure that it qualified as an exemplar case. We focused on the Iran Khodro Company (IKCO) as a single, deep case study and investigated the process of knowledge development in this company over 12 years. During a period of technological knowledge development, IKCO was transformed from a car assembler, into the leading carmaker in the Middle East, Central Asia, and North Africa. The special situation of this company made it an excellent 'case of' (Stake, 2008) absorptive capacity development over a period of technological knowledge development. In the pilot study, we identified four product innovation projects which had become turning points for the process of knowledge development. We selected these as embedded cases to dive deeper and investigate the role of micro-processes in the projects, which were the major steps in absorbing external knowledge and advancing IKCO's knowledge.

This study makes three contributions to our understanding of the process of absorptive capacity development and the role of individual-level knowledge processes (microfoundations) in the context of emerging economies. First, as a rare longitudinal study of absorptive capacity development, it contributes to a process view of absorptive capacity and reveals the sequential stages through which absorptive capacity may unfold in organizations. We found that different routines of absorptive capacity develop in a sequential way by acquisition, then assimilation, then transformation, and, finally, exploitation. We took a further step by explicitly uncovering the mechanisms and triggers that underlie and link the different stages. By identifying the microfoundations and unpacking the underlying mechanism for the formation and sustainability of absorptive capacity, we started to uncover how some firms can use absorptive capacity as a sustainable competitive advantage. This talks to the core of the strategic management literature and advances our understanding of how micro-processes and interactions at the micro level can drive the emergence of strategic outcomes at the organization level. Second, this study enhanced our understanding of the interplay between absorptive capacity and the process of knowledge development by identifying the reciprocal relationship between the evolution of a knowledge base and the development of absorptive capacity, in the context of emerging economies. We found that knowledge processes vary as the level of tacitness of the new knowledge and the characteristics of the knowledge environment change, leading to the development of different absorptive capacity knowledge processes. We also showed how prior knowledge coevolves with characteristics of the knowledge environment and impacts the development of different absorptive capacity knowledge processes through the introduction of a new mediator and moderators (individual-level knowledge processes). Finally, it advances the innovation literature by providing a clear, holistic, and systematic guide for developing different knowledge processes of absorptive capacity (knowledge acquisition, assimilation, transformation, and exploitation) at an

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organizational level through the deliberate manipulation of knowledge processes at the individual level during innovation projects. In this regard, using insights from the microfoundations view, this study identified the underlying mechanism of absorptive capacity development, which links the individual-level knowledge processes to the emergence of different absorptive capacity knowledge processes at the organizational level and helps to explain the role of absorptive capacity in new innovation frameworks, such as open innovation.

Theoretical background

Since its introduction by Cohen and Levinthal (1990), the concept of absorptive capacity has been used in different areas such as organization theory, strategic management, organizational learning, and innovation. Inspired by the resource-based view of the firm (Barney, 1991), the knowledge-based view of the firm considers knowledge as the firm's most important resource (Grant, 1996). Absorptive capacity is known as a critical enabler for firms seeking to develop their knowledge base to gain or evolve a competitive advantage (Zhang, Han, & Chen, 2022). Absorptive capacity is the 'ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends' and has been used as a mediator of the speed, frequency, and magnitude of innovation (Cohen & Levinthal, 1990: 128). The same authors also refer to the role of prior knowledge in building absorptive capacity, arguing that absorptive capacity evolves based on strong path dependency and prior investments in research and development (R&D) activities and that the knowledge base accumulates over time.

In Cohen and Levinthal's (1990) theorization, the role of individuals is central, and they argue that a firm's absorptive capacity develops based on the cognitive abilities and intensity of effort of its individual members. Firms' learning evolves over time by absorbing new external knowledge; however, the capacity for recognizing the value of new knowledge, assimilating it, and exploiting the assimilated external knowledge is a function of individuals' prior related knowledge and the diversity of experience. Interestingly, while the roles of individuals and their knowledge were highlighted by Cohen and Levinthal (1990), successive research has overlooked these micro-level processes and focused on macro-level relationships and mechanisms (Apriliyanti & Alon, 2017).

This oversight of individuals behind the macro-level relationships (Cabrera & Cabrera, 2005) is unfortunate because an important aspect of firms' competitive advantage is undeniably rooted in knowledge assets which are developed through processes of creating, integrating, and sharing knowledge (Cohen & Levinthal, 1990). To highlight the role of knowledge processes in absorptive capacity building, Zahra and George (2002) suggest adopting an organizational-routine view, proposing that different organizational routines for acquisition, assimilation, transformation, and exploitation of knowledge underpin absorptive capacity. Their conceptual effort was later adapted or extended by other researchers (e.g., Lane, Koka, & Pathak, 2006; Todorova & Durisin, 2007). Despite these conceptual developments in using routines to better capture absorptive capacity, empirical examination of the absorptive capacity construct is still challenging because routines themselves are hard to measure due to their inherent intangibility (Becker & Gassmann, 2006). To address this problem, a few studies have used case studies or survey instruments to explore absorptive capacity routines in more detail (e.g., Lane & Lubatkin, 1998; Lane, Salk, & Lyles, 2001).

However, prior contributions are still at an abstract level, and we know little about the micro-processes that constitute absorptive capacity. This has resulted in the claims raised by scholars in the field about absorptive capacity being a black box (Martinkenaite & Breunig, 2016) or an exogenous variable (Distel, 2019). There is a lack of direct observation or measurement of the routines that make up absorptive capacity and, therefore, there is a need for better understanding and operationalization of the absorptive capacity concept (Zahra & George, 2002). For this purpose, first, we looked at the relevant literature on absorptive capacity at the micro level and then presented a conceptualization of macro–micro dynamics.

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Knowledge-based view and learning processes

Based on the knowledge-based view of the firm (Kogut & Zander, 1992), knowledge is seen as the critical asset of organizations and the major source of competitive advantage. While individuals in organizations contribute to learning through recognizing knowledge and sharing it, emergence of a shared knowledge and learning throughout the organization requires organizational-level processes, routines, and skills that engage synergies among individuals (Matusik & Heeley, 2005). A stock-and-flow metaphor is useful for understanding learning processes and capabilities (Jansen, Van Den Bosch, & Volberda, 2005). Knowledge stocks can be found within individuals, projects, functions, or organizations (Bontis, Crossan, & Hulland, 2002). However, learning requires the flow of the knowledge among individuals, projects, and functions and between different levels to integrate the stocks of knowledge and create and internalize the new knowledge (Vera & Crossan, 2005).

However, past research (e.g., Distel, 2019; Martinkenaite & Breunig, 2016) refers to the limited examination of the multilevel perspective, which covers both the stock of knowledge and the flow of knowledge incorporating the individual and organization levels. Stocks and flows of knowledge coevolve as prior knowledge is needed before the learning process begins, and prior knowledge accumulates based on the learning process (Cohen & Levinthal, 1990). However, the flow of tacit knowledge (which is context-specific, embedded in actions, and difficult to transfer) is challenging, while explicit knowledge (which is transferable through simple communication means such as words and symbols) flows easily (Polanyi, 1966).

Huber (1991) identified four learning processes associated with organizational learning including knowledge acquisition, information distribution, information interpretation, and organizational memory. Later, focusing on the internalization of external knowledge, Zahra and George (2002) suggested a new set of four learning processes which they referred to as dimensions of absorptive capacity. Firstly, new knowledge is acquired using exploratory learning processes to identify external knowledge with a potential value for the organization (March, 1991). Contrary to previous R&D approaches, external knowledge acquisition does not require the recruitment of new employees. Instead, firms need to promote critical assessment of existing knowledge and alternative knowledge seeking among their employees. The second dimension is related to the newly acquired knowledge which must be embedded in the individuals as well as in organizational routines. Hence, cross functional learning processes become critical for assimilating externally sourced knowledge. Knowledge assimilation includes sharing and communicating the valuable external knowledge with other individuals across the organization using social interactions and interpretations (Tidd & Bessant, 2020). This dimension refers to development of a shared knowledge among individuals and groups by lowering the cognitive distance between them (Nemanich, Keller, Vera, & Chin, 2010).

The learning processes associated with the third dimension support the development and refinement of the organizational routines which enable the integration of the acquired and assimilated knowledge with knowledge already existing in the organization. Transformational learning related to this dimension can add to, or remove from, the existing knowledge or configure and interpret it in a new way (Camisón & Forés, 2010). The final dimension is related to the application of the transformed knowledge. The exploitation learning processes apply the newly reconfigured knowledge to the organizational outputs and commercial ends (March, 1991). Hence, the nature and underlying mechanisms of absorptive capacity are dynamic and change through the process of organizational learning (Todorova & Durisin, 2007).

Knowledge and absorptive capacity development in emerging market firms

Referring to the ability of a firm to identify, absorb, and utilize new knowledge from external sources, the existence and development of absorptive capacity depends on the firm's prior knowledge (Zahra & George, 2002). A large gap in technological knowledge between the source firm

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and the recipient firm may lower the chance of realizing the benefits of external knowledge (Chen et al., 2021). This puts firms with different levels of prior knowledge on different trajectories for absorptive capacity development, which is the case when comparing knowledge development processes between firms from advanced countries and those from emerging markets (Cuervo-Cazurra & Rui, 2017).

Despite their considerable performance, firms from emerging markets are perceived as latecomers and technological laggards, compared with their counterparts in the more advanced economies (Harzing, 2000), suffering from technological disadvantages due to weak innovation systems, undeveloped supporting institutions, and poor protection of intellectual property rights in the countries in which they are located (Khanna & Palepu, 2010; Zhao, 2006). As a result, emerging market firms are perceived to lack sophisticated firm-specific advantages, and compete mainly based on their national comparative advantage and economy of scale (Rugman, 2010), with a focus on the lower value-added parts of global value chains (Mudambi, 2008). To cover the gap in technological knowledge, emerging market firms endeavor to incorporate technologies from firms coming from more advanced countries through copying their innovation (Luo, Sun, & Wang, 2011), establishing alliances (Kumaraswamy, Mudambi, Saranga, & Tripathy, 2012), or acquiring firms in the advanced economies (Madhok & Keyhani, 2012). While firms from advanced economies develop knowledge at technological frontiers (Hobday, Rush, & Bessant, 2004), firms from emerging markets are a step behind technology frontiers, trying to 'catch-up' or 'leapfrog' (Lee & Lim, 2001). Emerging market firms may also access knowledge embedded in returnees, products, parts and components, and foreign patent files, or transfer it from advanced counterparts in exchange for access to their home market (Hennart, 2012). However, while being highly motivated to incorporate the knowledge from external sources, emerging market firms are less likely to do so, due to lack of absorptive capacity and ability to establish and benefit from connection with foreign knowledge centers (Cantwell & Mudambi, 2011). To benefit from the sophisticated knowledge transferred across borders (Pérez-Nordtvedt, Kedia, Datta, & Rasheed, 2008), emerging market firms need to be able to integrate and use the technology, based on a level of absorptive capacity (Awate, Larsen, & Mudambi, 2012). Therefore, absorptive capacity, via social integration mechanisms (such as learned social relationships inside the organization), affects the knowledge-seeking behavior of these firms (Todorova & Durisin, 2007).

The lack or endowment of absorptive capacity is frequently reported as one of the reasons for failure or success in knowledge transfer and innovation processes of emerging market firms (Scaringella & Burtschell, 2017). However, and surprisingly, there are few detailed analyses of absorptive capacity in the context of emerging market firms (e.g., Mehreen, Rammal, Pereira, & Del Giudice, 2022; Scaringella & Burtschell, 2017). Particularly, there are very limited insights about the process of developing absorptive capacity in the emerging market firms. Considering the different knowledge positions of emerging market firms and advanced economy firms, the research findings from such processes in the advanced economies can hardly be applied to the context of emerging markets. Kim (1998) provided evidence that the knowledge processes are different in developed and developing countries, and while firms in developing countries start with product innovation and then move into process innovation, firms in the developing countries start from process innovation and imitation to learn and 'catch up' before moving to product innovation. Such difference can be reflected in the absorptive capacity trajectories taken by these firms.

Social interactions as drivers of absorptive capacity

To conceptualize the relationships between micro–macro levels of absorptive capacity, the existing literature suggests that absorptive capacity can be developed at the organizational level as a result of the development of prior knowledge among individuals who engage with learning processes (Cohen & Levinthal, 1990) and the social interaction patterns among them (Van Den Bosch, Volberda, & De Boer, 1999). While employees' prior knowledge is an essential part of

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individuals' absorptive capacity, collecting the knowledge of these individuals does not represent absorptive capacity at the organizational level. Also, although individuals' prior knowledge is important for acquiring external information (Inkpen & Tsang, 2005), it does not contribute as much to the process of internal knowledge transformation and application.

In the traditional approach to absorptive capacity research, prior knowledge is mainly used to represent absorptive capacity which is then measured using R&D investments (Apriliyanti & Alon, 2017). With the existing emphasis of literature on narrowing research on absorptive capacity to prior knowledge, a good understanding has not yet been developed of the mechanisms underlying knowledge acquisition, assimilation, transformation, and application and how individuals' learning processes can contribute to these organizational learning processes (Ali, Musawir, & Ali, 2018).

Individuals' knowledge leads to the development of organizational absorptive capacity only if the mechanisms underlying knowledge acquisition, transformation, and application, as well as the type of social interaction patterns among employees, allow them to be involved with the process of integrating new and existing organizational knowledge. The type of dialogue among individuals and the speed and efficiency in the development of shared understanding depend on the patterns of social interactions promoted by the organization (Martinkenaite & Breunig, 2016). Thus, the depth of knowledge transformation and applications depends on the pattern of social interactions among employees. The mechanisms in firms that promote suitable social interactions, required for internal transfer of tacit or explicit knowledge, are referred to as combinative capabilities (Van Den Bosch, Volberda, & De Boer, 1999).

Firms may manage knowledge coordination, socialization, and systemization through the development of relevant combinative capabilities that promote different learning processes (Zollo & Winter, 2002). In accordance with different knowledge process requirements, Van Den Bosch, Volberda, and De Boer (1999) argue that firms may develop different combinative capabilities including socialization, systems, and coordination capabilities. They refer to coordination capabilities as the mechanisms for cross-functional coordination, employees' engagement with decision processes, and coordination of lateral interactions. The extent of documentation, instructions, guidelines, and systematic mechanisms for storage, retrieval, and sharing of explicit knowledge represents systems capabilities. Socialization capabilities provide mechanisms which help individuals engage and interact with each other for the purpose of tacit knowledge transfer and development of shared interpretation and mental models (Van Den Bosch, Volberda, & De Boer, 1999). Each of these combinative capabilities can promote a particular pattern of social interaction (Distel, 2019). We argue that different patterns of social interactions are required at different stages of absorptive capacity development, which will be promoted by the firm's application of the relevant combinative capabilities.

Despite the importance of social interactions in linking individuals' behavior to organizations' absorptive capacity, there is a limited understanding of the interrelationships between different social interaction patterns among individuals and different organizational outcomes, and whether and how specific social interaction patterns can generate a desired learning outcome for the organization (e.g., Todorova & Durisin, 2007).

Microfoundations view of absorptive capacity

To conceptualize the relationships between micro-level activities and organization-level processes in the context of knowledge processes, we adopted the microfoundations view in strategy (Felin, Foss, & Ployhart, 2015). This view is relevant because it uses micro-level factors to explain the emergence of organizational-level phenomena. A microfoundations approach aims to explain collective phenomena, particularly the processes for capability generation, renewal, and management (Foss, 2011). Like parallel work in the contemporary strategy research on lower-level sources of organizational capabilities (Teece, 2007), the basic motive for investigating the microfoundations

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of organizational capabilities is to explain differences in firms' capabilities. The enhanced understanding gained using this view about the micro-level factors and the interactions among them may help researchers explain the dynamics of organizational-level capability development based on the dynamics in micro-level behavior.

Having roots in sociology and institutionalism (e.g., Coleman, 1986), this view focuses on the role of individuals and their interactions with processes and structures at the micro level. Since individuals play a critical role in creating, storing, sharing, and integrating knowledge, the microfoundations view, with its focus on the role of individuals, provides an advantage for research aimed at understanding the process of knowledge development and the mechanisms underlying absorptive capacity (Foss, 2011). Emphasizing the critical role of individuals in organizational-level knowledge development, Argote and Ingram (2000) highlight that 'it has been at the level of identifying consistencies in organizations' knowledge development paths and almost never at the level of human interactions that are the primary source of knowledge and knowledge transfer' (p. 156).

Sjödin, Frishammar, and Thorgren (2019) identified some of the individual-level activities and practices which contribute to the knowledge processes and the process of developing absorptive capacity but did not unpack the multilevel interaction mechanisms involved in the process. Aligned with Martinkenaite and Breunig (2016) and Distel (2019), we suggest that elaborating the interactions between individual-level knowledge processes and firm-level macro routines of absorptive capacity may provide more explanatory power over the complex relationships between absorptive capacity and its antecedents. This approach builds upon Felin et al.'s (2012) and Foss's (2011) suggestion to find the linkages between individual-level behavior and higher-level outcomes and understand how higher-level variables (like environmental dynamism and absorptive capacity routines) can be the antecedents and outcomes of individuals' behavior (Coleman, 1990).

Investigation of the microfoundations and multilevel mechanisms embedded in the emergence of organizational absorptive capacity (this study's research question) requires an enhanced understanding of the interactions between macro-level antecedents and micro-level mechanisms in influencing the development of absorptive capacity. To conceptualize such multilevel interactions, we referred to the model suggested by Coleman (1990) for micro–macro relations in explanation of social science phenomenon, which was used for the same purpose in other microfoundational studies (see e.g., Abell, Felin, & Foss, 2008; De Massis & Foss, 2018; Felin, Foss, & Ployhart, 2015). Coleman (1990) conceptualized multilevel casual mechanisms through which a macro-level phenomenon can be explained by both a macro-level antecedent and micro-level processes which underlie the casual relationship between the antecedent and the phenomenon at the macro level. In the suggested model, the macro-level antecedent influences the conditions faced by individuals; the conditions influencing the individuals (i.e., the opportunities and constraints he or she faces) will influence their actions; and finally the individuals' actions aggregate to the explanandum phenomenon. Abell, Felin, and Foss (2008) argue that this general conceptualization can be adopted when using different theoretical lenses to explain different social phenomena based on macro–micro interactions. For the purpose of this research, we used the co-evolutionary mechanism of absorptive capacity suggested by Van Den Bosch, Volberda, and De Boer (1999) and knowledge integration requirements suggested by Grant (1996). Van Den Bosch, Volberda, and De Boer (1999) argue that the type of knowledge environment (the extent to which the new knowledge is tacit versus explicit/codifiable) informs the type of organizational form and patterns of social interactions promoted in the organization to absorb that knowledge. Depending on the type of knowledge, the organizational forms and patterns of social interactions promoted can enhance explorative or exploitative learning. As illustrated in Figure 1, we suggest that the level of knowledge tacitness provides a certain condition for individuals requiring certain knowledge processing among them. To promote such knowledge processes of individuals, specific social interactions and

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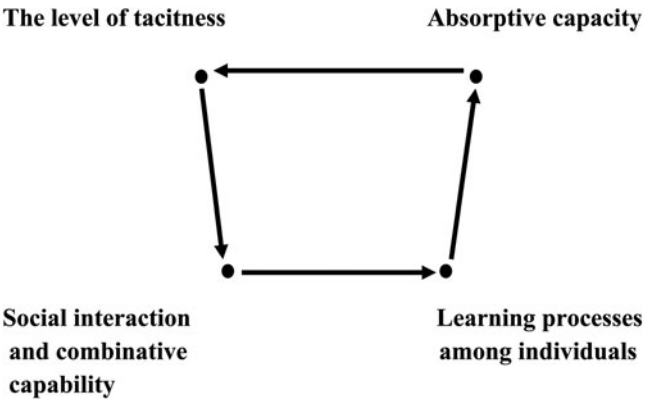

Figure 1. Conceptualization model of micro-macro dynamics. AC, absorptive capacity. *Source*: Own elaboration.

organizational forms need to be promoted in the organization which will in turn shape the learning process.

The dynamics in the learning process can promote different aspects of absorptive capacity at the organizational level. This multi-level conceptualization includes reciprocal relationships between micros and macros. Following Gupta et al. (2007), we believe that it is dependent on the researcher to reveal how absorptive capacity routines at higher levels emerge from interaction with lower-level micro processes.

Research method and analysis

To investigate the research question, we undertook an in-depth investigation of the interrelationships between knowledge processes and knowledge development in the process of absorptive capacity development in an exemplar case of technological knowledge development. Aligned with this approach, the case study method was adopted as the research strategy. This approach is suitable for studying complex social phenomena, and allows researchers to gain a holistic knowledge of real-life events (Yin, 1994) and reveal the underlying processes, including multiple causal chains (Pettigrew, 1992).

Research context

This study investigated our research question in the context of Iran. As an emerging economy, Iran has progressed significantly in science and technology development through knowledge transfer, best practices imitation, learning from partners, and innovating in different sectors, with the aim of bridging the technological gaps between it and advanced economies (Ghazinoory, Bitaab, & Lohrasbi, 2014). Based on a 'national technology strategy' integrating both 'national technology policy' and 'firm technology strategy' (Ghazinoory, Divsalar, & Soofi, 2009), Iran intends to transform its traditional economy into a knowledge-based economy. There is a limited, but increasing, interest in the empirical research in technology development in an Iranian context (Scaringella & Burtschell, 2017).

As several studies in emerging economies have shown (Mathews, 2002; Park & Lee, 2014), new technology and knowledge are not developed internally within R&D departments but sourced mainly externally and from companies in advanced countries through knowledge transfer and different forms of partnerships. These studies show that, while being beneficial, knowledge transfer has proven to be challenging in many cases (Kogut & Zander, 1992; Ponomariov & Toivanen, 2014). This makes the exploration of barriers and enablers of knowledge transfer in emerging economies a topic of interest for research (Argote, McEvily, & Reagans, 2003) and a good setting to study our problem. A lack of absorptive capacity has been emphasized as a reason behind

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unsuccessful knowledge transfers (Scaringella & Burtschell, 2017). To address the above purpose with an in-depth investigation, a single case study was conducted in one organization, IKCO, as an exemplar of absorptive capacity development during a period of technological knowledge development.

More specifically, the Iranian Government, as an emerging economy, has planned for economic transformation toward liberalization (Ghazinoory, Bitaab, & Lohrasbi, 2014). Therefore, policy-making has been aimed at enabling firms to enter global markets and compete using free-market-based mechanisms (Ghazinoory, Divsalar, & Soofi, 2009). At the center of this policy lies the triggering and supporting of the process of knowledge development in the key players in the strategic industries for the purpose of transforming and developing those industries. The auto industry was selected as one of the target industries for transformation (in terms of creating substantial job opportunities and having a high, but achievable, technology base).

Accordingly, unique attention was placed on IKCO as the major car maker within the Iranian auto industry (having between 65% and 90% of market share over the history of the industry) to develop the competitive technological knowledge and lead the process of industry transformation. The government imposed tariffs on car imports which provided IKCO with a protected local market prior to this company developing the necessary competitive capabilities and helped in the development of a local network of suppliers. During a period of technological knowledge development, IKCO was transformed from a car assembler, into the leading carmaker in the Middle East, Central Asia, and North Africa.

The special situation of IKCO made this company an excellent 'case of' (Stake, 2008) absorptive capacity development over a period of technological knowledge development, and an extreme case where the phenomenon under study is 'closer to the surface' and easier to observe (Eisenhardt, 1989; Pettigrew, 1990). As opposed to 'intrinsic' case studies (for better understanding cases), we adopted an 'instrumental' case study approach to examine a particular instance to provide insights into an issue or refinement of a theory (Stake, 2008). Eisenhardt (1989: 547) states that 'it makes sense to choose cases such as extreme situations and polar types in which the process of interest is "transparently observable".' Due to availability of rich data in this company, the authors decided to gain in-depth understanding of this single case and emphasize the 'analytic generalizability' of findings (Yin, 2003) rather than their external validity. Dyer and Wilkins (1991: 615) argued that 'theory that is born of such deep insights [from a single "deep case study"] will be both more accurate and appropriately tentative because the researcher must take into account the intricacies of a particular context.' While the process of knowledge transfer and development at IKCO slowed down and even stopped over time due to political conflicts and global economic sanctions on Iran, this company did experience a 12-year golden period of technological knowledge development which was covered in this study.

A number of critical product innovation projects commenced during the 12-year technological knowledge development period. This allowed us to examine the product innovation projects that promoted the development of absorptive capacity as they progressed, instead of presuming which actors, technologies, and events might be critical (Czarniawska, 2004). The initial investigation showed that IKCO had developed its knowledge over the course of four major product innovation projects, namely the *Pars*, *Samand*, *Soren*, and *Dena* projects.

Data collection

Data were mainly collected using semi-structured interviews. Secondary sources of information included company websites, annual reports, newsletters, and news websites, other related websites, and the company archive. Snowball sampling (Patton, 2002) was used to make sure that the most suitable participants were identified for interviews. The aim was to identify the key informants from functional areas of the company who were actively involved, influential, and who could provide insights into each case project.

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Because IKCO has a high strategic value and high secrecy levels are maintained, it is extremely difficult for researchers to gain access. Approval was gained from the Deputy Minister of Industry only after lengthy negotiations. The first author and a dedicated liaison were assigned to our project. The benefit of taking this top-down approach in getting approval was gaining high-level access to all necessary informants, including ex-employees. The head of the Technology Strategy department acted as the dedicated liaison, and because he was instructed by the top management to facilitate access to the best informants, we could select high caliber interviewees who had the relevant experience, high level of engagement with the case projects, direct interaction with foreign and local suppliers, good overview of the technology transfer process at IKCO, and insights related to our investigation. The selection was made after a few sessions between the first author and the liaison person during which the first author discussed the nature of the research project, the main aspects of investigation, and the type of data required, and the liaison person explained the technology transfer at IKCO and the role of case projects. These sessions helped the development of a common understanding between the researchers and the liaison person to ensure a fully informed selection of interviewees.

As indicated in Table 1, interviewees were drawn from multiple functional areas (e.g., R&D, marketing, and manufacturing), and from various organizational levels. Interviewees had at least 6 years of experience in the case company and a high level of engagement with case projects. Some of them were involved with a particular project and some had participated in different projects. According to their information and the stage of data collection, interviewees were asked about one or more projects. There were two waves of interviews. The first round of interviews was conducted at IKCO's site in Tehran (at the R&D department) between October and November 2011 including a total of 37 interviews with senior managers and senior engineers. The interviews were conducted during 22 site visits. In the second round, which occurred 1 year after the primary round of data collection, we interviewed nine informants in IKCO's site in Tehran (at R&D department) during October 2012. The second round of interviews were mostly of a confirmatory nature. The interviews were in Persian and were recorded and translated and transcribed by one of the researchers. The interviewers were then coded by two of the researchers and notes were compared.

Data analysis

A highly iterative approach (particularly between data and literature) was used to analyze the data, including two separate phases of analysis with distinct analytic characteristics.

Phase one. This phase commenced with open coding of the interview transcripts and the related organizational documents and evidence. The transcripts and documents were carefully read to identify themes and patterns (Miles & Huberman, 1994). Two of the authors conducted multiple reviews of the data, and constantly searched for critical passages, highlighted them and created memos as their understanding of the phenomenon of study progressed in the context of the research (Strauss, 1987). This continuous process of reviewing data, revisiting our interpretations, relabeling codes, and fine-tuning our memos (Eisenhardt, 1989) supported the grouping of codes into conceptual clusters (Berg, 2004). While addressing the data and empirical evidence, the emerging conceptual clusters pointed to the relevant literature, leading to further elaboration in the second phase of analysis.

Phase two. An abductive approach, including moving back and forth between data and the literature (Behfar & Okhuysen, 2018), was taken for the second round of coding, once the initial categories had emerged in the first round of coding. We looked at the extant literature on absorptive capacity to find associations between the evidence from the first round of coding and the existing theoretical constructs and factors, to see how our empirical findings might add to the categories existing in the literature. As a result, we used current operationalizations and definitions of absorptive capacity and the related factors to understand and illustrate what had

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Table 1. Summary of interviewees' details

Interviews and the departments involved in the interview process		
	Number of interviewees and positions	
Informants work unit	First round interviewees, number and positions (October and November 2011)	Second round interviewees, number and positions October (2012)
	Total interviews: 22	**Total interviews: 3**
	Head of NPD department	Samanad project manager
	Pars project manager	Soren project manager
	Samand project manager	Dena project manager
	Soren project manager	
	Dena project manager	
NPD (New Product Development) department	Head of exterior body	
	Head of braking system	
	Head of power train	
	Head of electric systems	
	Head of suspension system	
	Senior engineer in electric systems (2)	
	Senior engineer in power train (4)	
	Senior engineer in braking systems (2)	
	Senior engineer in suspension system (3)	
	Senior engineer in exterior body (2)	
	Total interviews: 5	**Total interviews: 2**
	Head of the department	Head of technology
Strategic planning and studies department	Head of technology	Head of marketing
	Senior research officers (2)	
	Total interviews: 4	**Total interviews: 1**
Production engineering department	Senior engineer in control systems	
	Senior engineer in automation	Site manager
	Site manager	
	Plant manager	
Quality control department	**Total interviews: 1**	
	Head of department	
	Total interviews: 5	**Total interviews: 3**
	Implementation manager	Implementation manager
Informants from SAPCO*	Head of knowledge management group	Head of knowledge management group

(*Continued*)

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Table 1. (*Continued.*)

Interviews and the departments involved in the interview process		
	Number of interviewees and positions	
Informants work unit	First round interviewees, number and positions (October and November 2011)	Second round interviewees, number and positions October (2012)
	Senior officer in exteriors	Project coordinator officer
	Senior officer in interiors	
	Project coordinator officer	

Source: Own elaboration.

happened at IKCO. Although our empirical evidence was inclined to reveal alternative, concrete, and perhaps more coherent indicators of absorptive capacity, all our data did fall into current categories within the broad absorptive capacity literature. Such interrelationships between the first and second rounds of coding followed Gioia, Corley, and Hamilton's (2013) multi-layer approach, using first- and second-order codes to organize and outline themes and aggregate dimensions while analyzing and comparing key events and ideas pointed out by the participants. Accordingly, following the first round of open coding (first-order coding), axial coding (Gioia, Corley, & Hamilton, 2013) was then used in the second round of coding, to search for interrelationships between and among the emergent clusters, and gather them into higher-order categories. Finally, related themes were combined into multiple overarching concepts of absorptive capacity, which formed the basis for the emerging processes. This process is presented in Figure 2, showing how this approach was used to link the knowledge process measures to the development of routines of absorptive capacity. A number of knowledge processes emerged in relation to different knowledge processes of absorptive capacity, including acquisition, assimilation, transformation, and exploitation.

Knowledge and learning processes used at individual and firm levels across four product innovation projects

This section details the findings of the study to illustrate how IKCO used knowledge processes in the course of new knowledge development across different product innovation projects to build absorptive capacity at the firm level. The projects were sequential and IKCO developed absorptive capacity across different maturity levels over the course of the four projects.

Pars project

Prior to the Pars project, IKCO was focused on assembly at the firm level and did not have even basic car design knowledge; in other words, knowledge of how different parts interact with each other and how that interaction influences performance. During the Pars project, based on a policy of self-sufficiency, IKCO made significant use of its strategic alliance with Peugeot to have all parts produced by local suppliers and also to have their assembly carried out in IKCO.

Through the process of aligning the production of all car parts and their assembly with a world-class standard, IKCO identified where strategic knowledge could be obtained for designing the components required to assemble the whole product. In fact, during the localization process, IKCO developed the capacity to acquire new knowledge, which, as defined by the literature, is 'a firm's ability to locate, identify, value, and acquire external knowledge that is critical to its operations' (Camisón & Forés, 2010: 709).

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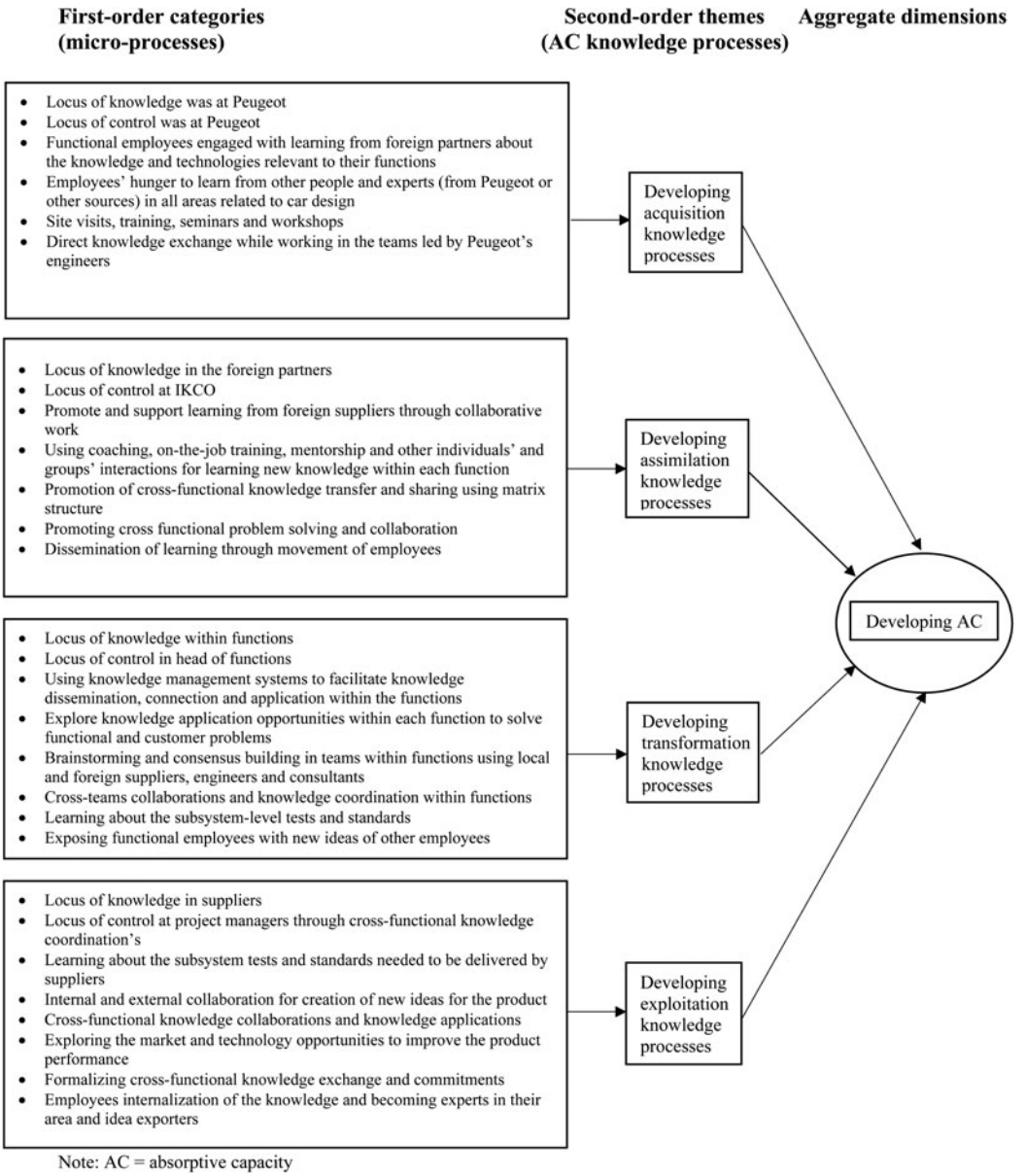

Figure 2. Data structure. AC, absorptive capacity.
Source: Own elaboration.

At the individual level, and based on the nature of the project, employees were encouraged to gain new knowledge from engineers in Peugeot in their particular area of work. Multiple methods were applied to exchange tacit knowledge with teams of engineers from Peugeot. IKCO's engineers in different sections like power train, suspension, electrical systems, interior design, exterior design, and others received specialized training from their counterparts in Peugeot. Such training took place either at IKCO, where Peugeot's engineers could involve a larger number of IKCO's employees, or at Peugeot, where IKCO's lead engineers had the chance to visit different sites and operations. As a senior engineer commented: 'Sometimes they [Peugeot engineers] came

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over here and joined us and completed the work and sometimes we went there and worked with them on our projects.' In some cases, such as exterior design, some lead engineers stayed longer at Peugeot and collaborated with engineers in the labs to receive first-hand experience of how new knowledge or technologies were applied at Peugeot.

This stage required employees to be engaged with different types of searches for information (desktop searches and fieldwork) about the new technology relevant to their functions. The head of electric systems provided an example of such situations:

> Sometimes the foreign suppliers offered a presentation to introduce their parts. We did some preparation by pre-studying, reviewing, and doing some internet searches before attending the presentations or meetings. With the general information that we had, we could ask about more details within the discussions. We also had some information from local suppliers because they were also concerned with that part and were connected to the foreign partner and had collected some information. We exchanged our information to have a better learning.

Regular meetings with Peugeot's engineers were in place in different functions. There was a hunger to learn in all areas, and, on some occasions, the best experts in the world (e.g., a lead exterior designer from BMW) were invited to provide feedback on Peugeot and their work, bringing new insights. Employees seeking to master new areas of knowledge were promoted. In the R&D department, employees were engaged with research projects in collaboration with Peugeot's engineers to adjust technologies with local requirements in terms of market, environment, and safety regulations.

Samand project

While, in the Pars project, Peugeot was the single source of knowledge as the key foreign partner leading the project, during the Samand project (when there was a national determination to develop a new national product), IKCO replaced Peugeot and led the project. In this project, the locus of knowledge transfer (from foreign partners) moved into individual functions.

Within each function, the required knowledge identified during collaboration with Peugeot in the Pars project was transferred from different functional suppliers. As a result, the single source of knowledge during the Pars project was broken down into multiple sources of knowledge within functions, and staff in functions could develop components (as a set of parts) of their functions, tailored to the specific needs of IKCO's local market (in a newly designed car, not a copy).

During the Samand project, IKCO was able to assimilate the new knowledge and develop a shared understanding of the new knowledge among employees in each function. Assimilation capacity is defined as 'the processes and routines that allow new information or knowledge acquired to be analyzed, processed, interpreted, understood, internalized, and classified' (Camisón & Forés, 2010: 709).

During this project, IKCO had clear instructions in all the collaborative projects with different foreign partners to transfer the knowledge to IKCO's engineers and local suppliers who were immediately involved with each project. IKCO applied a different means of codification to transform and communicate tacit knowledge gained to others. For example, it used collaborative work between IKCO's employees and foreign suppliers, as noted by a senior suspension systems engineer:

> The good thing with designing our work with foreign partners was the joint nature of the work. For example, in a team of four people for handling a job, two people were foreigners. If any questions came up with the task in hand, the foreign partner could reply; otherwise, he referred to his parent company to find an answer for that problem.

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This also helped individuals to understand their newly acquired knowledge from foreign partners. Employees likewise were engaged with on-the-job training, coaching, and mentorship by foreign partners' lead engineers to gain hands-on skills and explore ways in which they could apply the new technology or knowledge, as explained by a senior engineer in the exterior body system: 'The relationships between us and the Korean experts was sort of a teacher and student relationship where the Korean experts did the job, and we observed and then we did the next samples under Korean supervision.' Many seminars and workshops were organized to introduce the new areas of knowledge and discuss the implications for each function.

Employees, particularly the lead engineers, were engaged mainly with transferring learnings from the Pars project to others in their functional unit and also to other functions. A senior engineer in braking systems described one way of doing this: 'In our organizational structure, you were located within one function, but your function could serve three different projects. I was representing the braking system in all our cross-functional meeting[s] for designing the Samand.' In addition, collaborative and cross-functional problem solving was encouraged and facilitated at times through employee transfers. This helped IKCO's employees learn more through knowledge sharing combined with intuition. The Technology Strategy Unit promoted activities for sharing new developments, achievements, and problems in each function with other relevant functions through seminars, reports, newsletters, and other publications to help them create mental maps, establishing new connections among stored related patterns.

The sources of information were known to employees; if they wanted to learn or solve a particular problem, they knew what the reference was, as described by a senior engineer:

> We had to be smart enough to get the most of their knowledge. From this viewpoint, we had different performance in our different knowledge transferring projects. In some of them we did great but in some others not. It depends on our engineers' willingness to ask.

In most functions, particularly the power train or suspension functions, foreign partners were still engaged on-site to assist. Compared with interactions in the Pars project, however, individuals were able to understand and interpret the partners' knowledge better.

Soren project

While the Samand project focused on designing new components, the Soren project concentrated on changing and integrating new components and designing new subsystems. Each function had to face a higher level of complexity in designing new subsystems, which required integrating new components with other components in the existing subsystems. While employees in each function were engaged with a new subsystem which was basically designed by the foreign partners during the Samand project (leaving no opportunity to use their own ideas and previous experience), during the Soren project, employees had the chance to include their own insights and knowledge of the local market into the new design of subsystems. At the same time, IKCO was determined to use new subsystem-level technologies which could either resolve the issues raised in the market or improve the subsystem performance. As a result, IKCO's engineers found the opportunity to apply their knowledge in the local context and learn about new technologies, thus formalizing their knowledge through continuous learning and deepening their experience.

IKCO established an education center to systematically engage employees with knowledge improvement to help them transform old approaches into new ones based on new technologies and knowledge. Employees with learning capabilities were promoted by the company. This helped them to master how to manipulate knowledge they had learned in the way they wanted. To support such knowledge dissemination and accumulation, and connect the knowledge of different experts, IKCO established knowledge management systems to facilitate storing new

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knowledge developments and provide access to relevant employees to apply those developments in their areas or let others use their developments. The knowledge management systems facilitated sharing and combining employees' knowledge with each other to better integrate different components in each function. Soren's project manager gave an example of such knowledge management systems:

> An English consultant helped us to set some organizational procedures. For example, we designed a form called DMR [design modification request], which is used when any function is intended to change something. It shows who sent this form and to whom, when it should be released and how it should be archived.

As a result, employees were exposed to the ideas and knowledge of other employees or experts through the exchange of documents and codified information.

During this project, employees learned about the system-level tests and standards that were needed to deliver components from the parties to which IKCO had outsourced the knowledge of a component or the knowledge together with the task. As a result, foreign and local suppliers were also involved, and their knowledge and ideas were integrated into the project. The knowledge management systems were used across IKCO, SAPCO (Supplier of Automotive Parts Company), and its foreign partners. The information flow was established from marketing to functions to foreign and local suppliers to collect information to identify and assess the problems and develop solutions.

IKCO organized different teams in each function to use these knowledge processes and solve the problems related to each function and benefit from new technologies available. Each team within the function was responsible for a small project, usually targeted at solving customer or production problems, and, subsequently, the team monitored and sought feedback on their solutions for further improvements. Different functional teams had to integrate their design decisions and approaches to address the issues, as reflected in the comments of a senior engineer in the suspension system: 'The team leaders were not independent in decision-making, and we had members working across different teams. The final decisions needed approval of the head of function which had a coordinating role among different teams.' In addition, during the team discussions, diverse views from foreign partners and local engineers were presented, and employees had to resolve conflicts and communicate a collective view, as described in an example provided by a senior engineer in the power train system:

> For example, we had a control project team and parallel to it we had a team from our foreign partner; however, they were mixed together. Whenever we had meetings, all the members of both sides had to participate and discuss their ideas which were sometimes conflicting, but the outcome was a unified report.

Developing the new subsystems for the Soren included integrating components into each system (like the braking system) based on the principles of new knowledge. During this project, the knowledge about the existing components, which already existed in codified format, was combined with the new knowledge for car design, which was codified during the Samand project, and with new pieces of technology. In fact, during this project, IKCO applied the knowledge assimilated during the previous project (Samand) within functions to reconfigure the components in a new way (based on new knowledge) and, through that, develop new subsystems. This included transforming the already existing knowledge within functions through reintegration and combining it with new knowledge and technologies. This aligns with transformation learning as described by Camisón and Forés (2010: 709) as 'developing and refining the internal routines that facilitate the transference and combination of previous knowledge with newly acquired or assimilated knowledge.'

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Dena project

While IKCO made subsystem changes to address the issues with functionalities and features in each function in the Soren project, in the Dena project IKCO took another step forward and decided to provide a new architectural design reflecting IKCO's differentiating strengths. By this time, IKCO understood the knowledge of car design at the functional level, but the overall product looked the same as those existing in the market.

However, over the previous three projects, IKCO had developed its own specific ideas in some areas. Accordingly, in the Dena project, IKCO endeavored to shape its car design competences and establish a brand based on a realistic picture of its own strengths and weaknesses. The Dena project provided an opportunity for employees in each function to apply the subsystem knowledge developed during the Soren project to a new product architecture. While IKCO was more focused on the new architectural design for Dena based on its own signature and competence, the subsystem design within functions was delegated to local suppliers, which had grown along with IKCO during the past projects and had become experts. In fact, the locus of functional/subsystem knowledge that used to be in IKCO's functions during the Soren project was moved to local suppliers in the Dena project. This helped IKCO quickly apply its existing knowledge within each function in new ways by incorporating the new technologies offered by suppliers working with each function. This enabled IKCO to quickly adopt new technologies, such as automatic lights, wiper blades, environment-friendly engine designs, safety features, computerized engine and electronic systems, and improved panel and navigation, among others, that could add competitive features and meet a range of customer expectations.

Since the new subsystems were developed in collaboration with local suppliers, IKCO focused on integrating the new subsystems into a new product system that reflected the firm's specific car design competence. In this project, it had the opportunity to learn about interactions among different functions as a result of the new technologies used in the subsystems. At the firm level, IKCO learned more about how a subsystem can work with other subsystems so that the product achieves proper performance. In other words, IKCO learned more about the tests and standards that were needed to deliver subsystems produced by suppliers to which they had outsourced the subsystem knowledge or knowledge together with the subsystem task.

IKCO had tried to find product issues and deal with them within functions in the Soren project, whereas during the Dena project it formalized cross-functional processes to find issues and market requirements for new features and technologies and address them in its new design, as indicated by the Dena project manager: 'Engineers working in each function continuously traced technology and collected feedback from customers, where they found room for improvement, they sent through the company-wide forms for other functions to adjust their design with the changes made.' Employees in the functions were less focused on functional tasks and were more engaged with cross-functional commitments. The locus of control moved from the head of functions (which was the case in Soren) into the project managers dealing with designing different aspects of the new product architecture. While applying their functional knowledge to the new product system, IKCO's employees had to create their own ideas and new knowledge while working with others. The head of the exterior body system function gave an example of this:

> We had six months travel to Italy and joined Porsche for car style design; we worked in their team to design style for our product. Our designs were put on the wall mixed with designs of their designers, and all the designs were voted on by a higher manager blindly and without knowing which design belonged to whom.

This helped employees internalize the knowledge and become experts in their area, ready to export their expertise to other companies – particularly in areas like safety, LNG-based engines, and equipment design, among others.

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Such application of knowledge within functions occurred during the integration of newly transformed knowledge within each function with knowledge of other functions to create a new car design (changing the whole system architecture). This process is aligned with the knowledge application component of absorptive capacity, which is defined by Camisón and Forés (2010: 709) as

> routines that enable firms to incorporate acquired, assimilated, and transformed knowledge into their operations and routines not only to refine, perfect, expand, and leverage existing routines, processes, competencies, and knowledge, but also to create new operations, competences, routines, goods, and organizational forms.

Discussion

This study unpacked the micro-level processes, mechanisms, and triggers underlying absorptive capacity. Zahra and George (2002) argue that at a micro level, absorptive capacity has four major knowledge processes: acquisition, assimilation, transformation, and exploitation. However, we were interested in the micro-level knowledge processes underlying each of these micro-level components of absorptive capacity. To understand the role of these micro-level processes in building absorptive capacity knowledge processes at the macro level, we investigated a mechanism for building absorptive capacity that was based on the interactions between micro-level and macro-level processes.

We found that individuals' information processing and the forms of knowledge exchange used by them were informed by characteristics of the knowledge environment and knowledge tacitness at the macro level, and, in turn, they informed the formation of absorptive capacity knowledge processes. Because an increase in organizational knowledge decreases 'inherent uncertainty' about causal connections between actions and outcomes (Lippman & Rumelt, 2003), increases in prior knowledge change the uncertainty level and the knowledge environment. The change in the characteristics of knowledge environment and knowledge tacitness affects the subsequent information processing and transfer of tacit or explicit knowledge required (Daft & Lengel, 1986; Nonaka, 1994) (see Figure 3).

We found that the underlying mechanism shown in Figure 3 may explain the dynamics in the information flow and knowledge processes at the individual level, their reciprocal relationship with the characteristics of knowledge environment, and the emergence of absorptive capacity at the organizational level across the four case projects. Individuals' processing of different combinations of tacit and explicit knowledge across the Pars, Samand, Soren, and Dena projects led to the development of different knowledge processes of absorptive capacity at IKCO, which is explained in the following sections. Based on our empirical work, Figure 4 conceptualizes and illustrates how the micro–macro interactions evolved over the course of the four projects leading to the development of acquisition, assimilation, transformation, and exploitation knowledge processes in IKCO. Figure 4 also shows what mechanisms, triggers, and variables are in place in the different absorptive capacity processes in the organization and explores how these can be used to internalize new knowledge.

Knowledge acquisition

Initially, during the Pars project, IKCO had no idea about developing radical new car designs, did not understand the potential benefits, and could not evaluate different new technology options, creating a knowledge environment characterized by 'equivocality' due to a lack of clear goals and knowledge of the potential disruptions (Sakka, Barki, & Côté, 2016).

In response, as the findings show, IKCO facilitated a flow of 'rich information' (Daft & Lengel, 1986) at the micro level among individuals throughout IKCO to help the acquisition of car design

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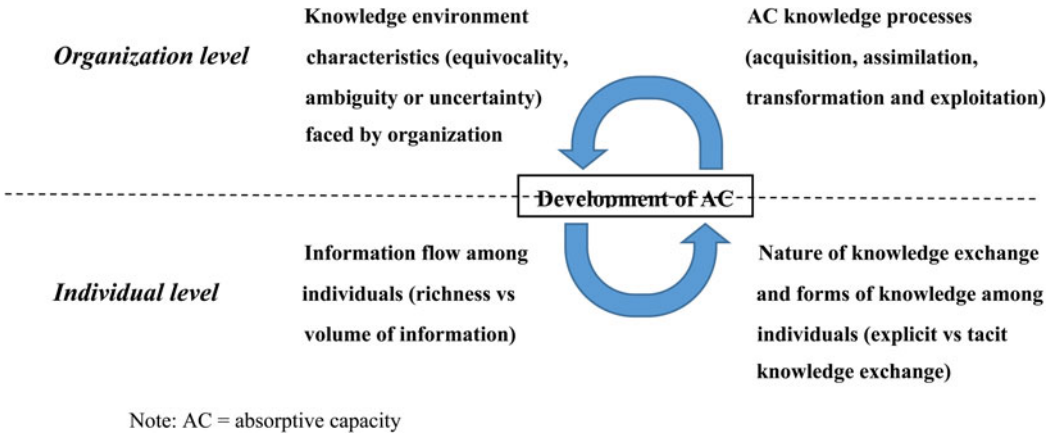

Figure 3. The interconnection between the individual and organization levels in absorptive capacity. Legend: small dashes rectangle – individual-level learning mechanisms in place. Larger dashes rectangle – individual-level knowledge processes. Solid rectangle – organizational-level triggers and outcomes.
Source: Own elaboration.

knowledge and understanding of new technological advancements. Pars was already designed by Peugeot, and the design was implemented in collaboration with IKCO. Peugeot was the main technology partner in this project, supervising the project and directly engaging with IKCO's employees through its staff sent over to IKCO's sites. IKCO provided conditions for exchanging

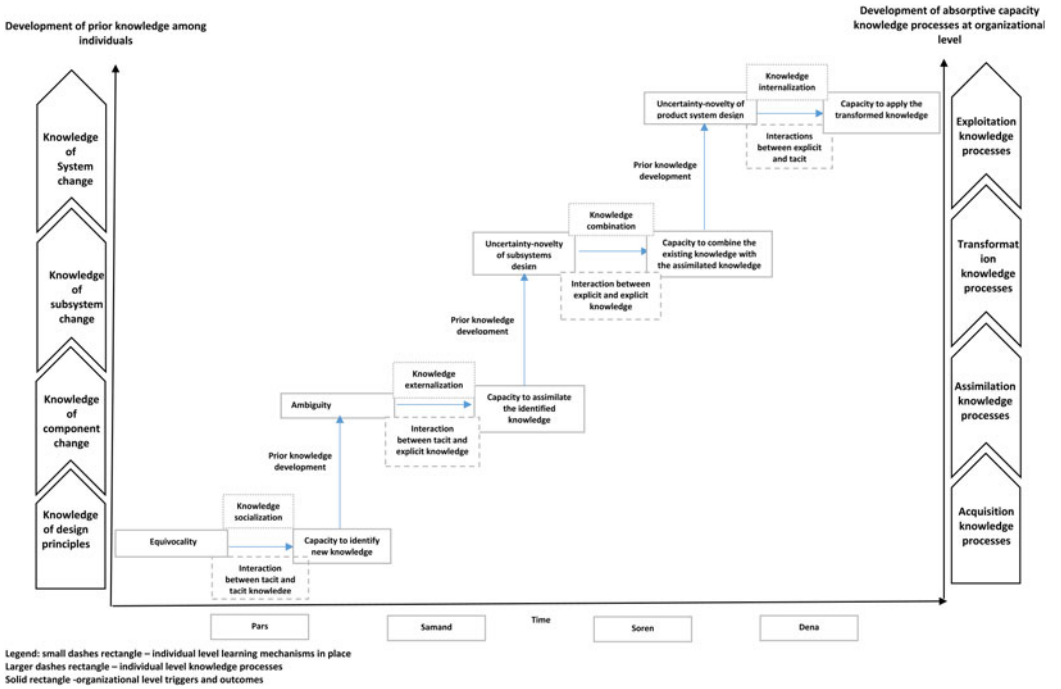

Figure 4. Process model of absorptive capacity development across the four case projects based on individual-level knowledge processes.
Sources: Own elaboration.

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and transferring tacit forms of knowledge between Peugeot's engineers and IKCO's employees to facilitate the flow of rich information. The rich information flow facilitated knowledge transfer at the individual level (Nonaka, 1994), showing that learning happens by walking around observing and by direct interactions inside and outside the firm – albeit subject to common experience – and leads to acquisition of skills and development of shared mental models.

In addition, to engage with Peugeot's engineers, IKCO encouraged employees to engage in activities such as investigating customers' needs and market research/analysis, participation in industry conferences, connecting with university researchers, attending courses, co-development activities with other foreign partners, and hands-on training with leading technology companies. These knowledge processes are examples of the transfer of tacit knowledge to people 'who do not have it' from people 'who do have it' – a process Nonaka (1994) named 'socialization.'

The tacit-to-tacit knowledge processes among individuals promote the knowledge explorative learning process (Martinkenaite & Breunig, 2016). The interactions between different tacit forms of knowledge during the Pars project became part of the creation and evolution of prior knowledge at the individual level and subsequent recognition of its cognitive value (Cohen & Levinthal, 1990). IKCO's employees became familiarized with the process of car design (not just assembly) and developed an understanding of the new knowledge of car design and the underlying technology. At the organizational level, IKCO learned about the relevance of opportunities created by this car design knowledge in terms of the functionalities of each subsystem (suspension, braking, body, and others). The development of employees' prior knowledge was shaped by individuals' learning processes and tacit-to-tacit interactions.

With the increase in prior knowledge, the equivocality level was reduced, and the subsequent learning processes (occurring in the Samand project) were affected. Tacit-to-tacit social interactions, knowledge socialization (Nonaka, 1994), and explorative learning processes (Martinkenaite & Breunig, 2016) helped the establishment of the 'knowledge acquisition' process of absorptive capacity (Zahra & George, 2002) at IKCO and identified valuable knowledge relevant to its strategic context (Lane, Koka, & Pathak, 2006). These knowledge processes were routinized through repeated use and further developed at IKCO across the following projects. Two propositions address the micro–macro level interactions mentioned above:

Proposition 1. Equivocality around new technology and alternative options leads to an increase in the flow of 'rich information' at the micro level and among individuals, which promotes tacit-to-tacit knowledge processes.

Proposition 2. The exchange of tacit knowledge among individuals and their engagement with knowledge socialization leads to emergence of acquisition routines and the capacity to identify new knowledge.

Knowledge assimilation

During the Samand project, IKCO dealt with multiple foreign suppliers (instead of mainly Peugeot) in relation to individual components and, therefore, there were different views and interpretations about how a component could be designed (based on ideas generated through interactions with different foreign partners). Due to the development of prior knowledge of car design (understanding the process of car design and what technology to use and how) among employees during the Pars project, in the Samand project, at the organizational level, IKCO had fewer issues with 'equivocality' around the technology. Instead, it faced 'ambiguity' about how to use the new technology in each function due to dealing with multiple ideas from different foreign partners engaged with functions caused by different interpretations of the potential applications of the external technology/knowledge (Sakka, Barki, & Côté, 2016).

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In response to new knowledge environment, as the findings show, IKCO provided conditions for the flow of rich information (Daft & Lengel, 1986) at the micro level and among individuals. At the organizational level, because IKCO had made an earlier phase of general resolution across all the functions (developing a base understanding of the new technology) during the Pars project, the level of equivocality related to the new technology was lower during the Samand project. However, the new knowledge of car design remained tacit after the Pars project (despite the development of a general understanding of car design) in terms of explicit implications of this knowledge within individual functions. With prior knowledge developed in the Pars project, the resolutions only needed to be made around the complexities involved with designing the individual components within each function. 'Rich information' flowed by facilitating tacit and explicit knowledge interactions where tacit forms of knowledge (sourced from external partners) were converted to explicit forms. Assessing competing ideas and interpretations needed tacit ideas to be codified and converted into explicit ideas (e.g., through prototyping, sketches, pilot plans, and others) to facilitate comparison and evaluation of different design options for individual components. Tacit-to-explicit conversion requires articulation – ideas or images in words, metaphors, analogies (Nonaka, 1994). This can happen through dialogue, feedback, and reflection, including conversion of the foreign partner's tacit knowledge to explicit forms.

In turn, this facilitated the 'knowledge externalization' stage of the knowledge creation process (Nonaka, 1994) and supported the establishment of the 'knowledge assimilation' processes of absorptive capacity (Zahra & George, 2002). It promoted knowledge sharing about the newly gained knowledge among different functions and across 'synthetic,' 'semantic,' and 'pragmatic' boundaries (Carlile, 2004). These knowledge processes were routinized through repeated use and further developed at IKCO across the following projects. IKCO's employees could develop their level of prior knowledge by engaging with component design within each function. However, they did not change the existing components and just learned the principles underlying the design of a component in the function. At the organizational level, the new car design knowledge was codified in terms of specific applications in different functions (power train, body, suspension system, and others). Thus, we offer two propositions for further examination:

Proposition 3. Ambiguity around how to use the new technology and relate it to operations leads to an increase in the flow of 'rich information' at the micro level and among individuals which promotes tacit-to-explicit knowledge processes.

Proposition 4. The knowledge processes among individuals which convert tacit knowledge to explicit knowledge, and their engagement in knowledge externalization, leads to emergence of assimilation routines and the capacity to assimilate new knowledge.

Knowledge transformation

Based on the prior knowledge developed across the Pars and Samand projects, during the Soren project, IKCO had no more issues with equivocality around the disruptive changes and technological options and their potential benefits, nor was ambiguity around the right strategy to use the new technology identified; instead, IKCO faced 'uncertainty' around integrating newly developed components and old components resulting in new 'subsystem design' (Sakka, Barki, & Côté, 2016). Our data showed that IKCO facilitated the flow of a 'high volume of information' (Daft & Lengel, 1986; Galbraith, 1973) within each function based on exchanging explicit knowledge related to different components and transforming it into a usable form (Nonaka, 1994) of functional knowledge. These knowledge processes helped IKCO further develop its prior knowledge in car design up to the level of designing a new subsystem, such as a new braking system (using ABS technology) or exterior body. IKCO's success in transforming functional knowledge depended on how well the systems and structures enabled individuals to share knowledge

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(Foss, 2011). These explicit-to-explicit knowledge processes among individuals promoted the knowledge transformation learning process (Martinkenaite & Breunig, 2016).

Within each function, the level of social cohesion of individuals, the level of their interconnections, and the diversity of their backgrounds explain the effectiveness of combining new and existing knowledge in that unit (Hotho, Becker-Ritterspach, & Saka-Helmhout, 2012). Therefore, social interactions and within-unit document-sharing systems and software were emphasized during the Soren project, contributing to the 'knowledge combination' stage of the new knowledge creation process (Nonaka, 1994). Knowledge combination is the process of 'systematizing concepts into a knowledge system.' This happens when people synthesize different sources of explicit knowledge into, for example, a report, or 'through … meetings and telephone conversations' and exchange of documents (Nonaka, 1994: 19; Nonaka & Takeuchi, 1995: 67). Knowledge combination led to development of 'knowledge transformation' processes of absorptive capacity (Zahra & George, 2002) at IKCO, which were routinized through repeated use and further developed across the following projects in this company. The practice of explicit-to-explicit knowledge processes among the individuals within each function and knowledge combination content of the social interactions led to further development of a level of prior knowledge among the individuals engaged with the Soren project.

Since the same employees who engaged with Samand were engaged with Soren, the level of prior knowledge developed further during the Soren project, and employees could engage in designing new subsystems based on changing multiple components of the existing subsystems (like adding airbags and changing the face design in the body subsystem or using sensors in lights and window wipers in the electric subsystem).

To explicate these micro–macro level interactions, this study proposes the propositions below:

Proposition 5. Uncertainty related to integration of novel and old parts in the subsystems leads to an increase in the flow of 'high volume of information' at the micro level and among individuals which promotes explicit-to-explicit knowledge processes.

Proposition 6. The exchange of explicit knowledge with explicit knowledge among individuals and their engagement in knowledge combination leads to emergence of transformation routines and the capacity for transformation of existing knowledge and integration of new knowledge.

Knowledge exploitation

With the prior knowledge developed during the Soren project (IKCO had learned about designing new systems within functions), there was less uncertainty around subsystems' novelty. Instead, during the Dena project, while integrating new subsystems and reconfiguring the overall architecture of the product to introduce new 'product system design,' at the organizational level, IKCO faced 'uncertainty' around integration of new and old subsystems in a novel 'product system design,' in terms of the number of people involved in the project, the number of functions affected by the new product system, and the number of subsystems linked to the new product system and how they were linked (Davila, 2000).

For uncertainty resolution, our data showed that IKCO facilitated a flow of 'high volume of information' (Daft & Lengel, 1986; Galbraith, 1973) across different functions at the individual level. At the organizational level, different organizational function knowledge areas were coordinated and applied to create a radically new product design. The flow of information at the individual level was based on the exchange of explicit and tacit forms of knowledge among staff from different functions. At the organization level, new organizational knowledge in each function developed during the Soren project was replicated at the system level and internalized within that function. Applying the explicit knowledge within individual functions to the shared product system required complex mechanisms for coordination and integration of different knowledge to

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achieve the shared goal of developing new product architecture. IKCO's employees across different functions developed tacit knowledge of integrating and coordinating different functional knowledge. According to Nonaka (1994), this conversion of explicit to tacit knowledge is largely experiential based on replications to actualize concepts and methods, either through doing or through simulations. In this project, the flow of information was from each function to multiple functions.

At this stage of knowledge processing, the functional knowledge created in units was applied across functions. Because the knowledge created within functions was tacit, situated, and distributed (Brown & Duguid, 2001), integrating it across functions was a challenging task. Here, the combining and recombining of the complementary knowledge of individuals across different functions determined the extent, scope, and speed of knowledge exploitation.

The explicit-to-tacit knowledge processes among individuals promote the knowledge exploitation learning process (Martinkenaite & Breunig, 2016), leading to establishment of 'knowledge exploitation' processes of absorptive capacity (Zahra & George, 2002) which were routinized through repeated use and further developed at IKCO across following projects. This stage of knowledge processing and the interaction between explicit and tacit forms of knowledge represents the 'knowledge internalization' stage in new knowledge creation. Nonaka (1994) describes 'knowledge internalization' as 'a process of embodying explicit knowledge into tacit knowledge.' It is 'closely related' to 'the traditional notion of learning' and to 'learning by doing' (Nonaka, 1994: 340–341).

The practice of explicit-to-tacit knowledge processes among individuals within and across functions and the knowledge internalization content of the social interactions led to further extension of the level of prior knowledge among the individuals engaged with the Dena project. Since the same employees engaged with the Soren, Samand, and Pars projects were engaged with the Dena project, the level of their prior knowledge further extended during the Dena project because employees could engage with changing multiple subsystems to create a new product architecture. Using new engine subsystems, electric subsystems, suspension subsystems, and others created a radical new product with completely new features and safety levels. Thus, and following the discussions on micro–macro interactions, this paper offers the following propositions:

Proposition 7. Uncertainty related to integration of new subsystems leads to an increase in the flow of 'high volume of information' at the micro level and among individuals which promotes explicit-to-tacit knowledge processes.

Proposition 8. The knowledge processes among individuals which convert the explicit knowledge within functions to tacit knowledge and their engagement in knowledge internalization leads to emergence of exploitation routines and the capacity for new knowledge exploitation.

Theoretical and practical implications

Overall, the findings of this study from the four product innovation projects at IKCO identified the mechanisms, processes, and triggers for building absorptive capacity at a firm level. Our data suggested a sequential four-stage process for building absorptive capacity. This process included a reciprocal relationship between individuals' knowledge processes and the development of knowledge processes of absorptive capacity. It suggested that the micro-level and individual-level knowledge and learning processes coevolve with acquisition, assimilation, transformation, and exploitation of the new knowledge at the organizational level.

Our model also showed that absorptive capacity is built through the sequence of knowledge processes associated with acquisition, then assimilation, then transformation, and, finally, exploitation of new knowledge. It went even further by explicitly uncovering the mechanisms and

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triggers that underlie and link the different stages. Findings also showed that once an absorptive capacity knowledge process was developed in a project, the development of that knowledge process continued across subsequent projects. For example, the knowledge acquisition began to develop within the Pars project but continued across the other projects. Similarly, knowledge assimilation was first established within the Samand project but continued across subsequent projects. The reason for the absence of knowledge processes like transformation and exploitation in the earlier projects (Pars and Samand) was due to the fact that IKCO had not established absorptive capacity knowledge processes before these projects.

This finding conflicts with existing literature (e.g., Camisón & Forés, 2010; Todorova & Durisin, 2007; Zahra & George, 2002), which assumes the coexistence of all knowledge processes of absorptive capacity in companies, independently of their stage of absorptive capacity. We added to the absorptive capacity literature by arguing that building absorptive capacity knowledge processes in companies with no existing absorptive capacity happens in a sequential way and is not a given. Our case showed that this sequence followed from the development of knowledge acquisition routines up to assimilation, then transformation, and finally exploitation knowledge processes; we also explained how this happened. IKCO developed knowledge processes as they were required in the process of developing knowledge which was radically new for this company. Therefore, it did not make sense for IKCO to develop knowledge processes for the assimilation of knowledge before it was acquired. As the company progressed with processing new knowledge and facilitating the required flow of tacit and explicit knowledge, it established different knowledge processes of absorptive capacity. This argument also strengthens the findings of Scaringella and Burtschell (2017), who attribute the unsuccessful transfer of tacit and explicit knowledge to the lack of absorptive capacity in case organizations. Therefore, external agents need to understand the level at which the focal firm is in terms of absorptive capacity to align their knowledge transfer accordingly.

Further, the refined conceptualization that emerged from the empirical work identified the reciprocal relationship between the development of absorptive capacity and the development of new knowledge (or adoption of new technology). This reciprocal relationship showed that, on the one hand, absorptive capacity knowledge processes in the organizations can be used to internalize new knowledge or technology. Organizations may use different knowledge processes of absorptive capacity for different stages of the process of integrating external competitive knowledge with their internal knowledge base. The outcome model, on the other hand, shows that different knowledge processes of absorptive capacity can be developed as needed for different stages of knowledge convergence. Therefore, the development of new technology must be an antecedent for the development of absorptive capacity.

A higher resolution picture of this reciprocal relationship was provided through our empirical work, which found that the organizational knowledge processes of absorptive capacity could be developed based on the dynamics at the level of knowledge tacitness and the associated knowledge processes among individuals. Our results showed that the dynamics in the characteristics of the knowledge environment (uncertainty, ambiguity, and equivocality around knowledge transfer projects) and the level of tacitness of new knowledge acted as opportunity sets for individual learning behavior and the way in which tacit and explicit knowledge interacted. Individuals were directed to specific knowledge conversion interactions required for different stages of their knowledge creation process and cumulative knowledge building. Different capacities and knowledge processes for learning (capacities for acquisition, assimilation, transformation, and exploitation of external knowledge) emerged at the firm level according to the specific learning behavior and knowledge creation processes (socialization, externalization, combination, and internalization) at the individual and organizational levels.

Therefore, this research developed an explanation of how different stages of evolution of prior knowledge set the direction, efficiency, and flexibility required for individuals to identify external knowledge that is strategic for the firm, share that knowledge among the functions, combine it

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with functional knowledge, and apply it for the firm's commercial purposes across functions. This finding particularly added to Cohen and Levinthal's (1990) work, where the role of prior knowledge was emphasized as the major predictor of absorptive capacity in organizations. Therefore, this study not only highlighted the role of knowledge development at both individual and firm levels but also clarified their differentiated roles.

Our results identified the underlying explanatory mechanism based on interactions between firm-level knowledge development and individual-level knowledge processes. We showed the processes for identifying strategic knowledge, sharing that knowledge within functions, combining new knowledge with knowledge existing within functions, applying the combined knowledge across functions, and how that was influenced by actions and interactions among individuals. In doing so, we uncovered what organizations – particularly the ones that want to upgrade – need to do both at an individual and organizational level. With that, we advanced the absorptive capacity framework by opening the black box of multilevel interactions and showing what mechanisms need to be in place to enhance the development of absorptive capacity within an organization.

Martinkenaite and Breunig (2016) suggest that different organizational-level knowledge processes of absorptive capacity can have different underlying mechanisms at the individual level. Their conceptual model shows that different organizational forms and combinative capabilities shape different motivational and ability conditions for individuals, promoting different learning processes and leading to the development of different knowledge processes of absorptive capacity. Extending this conceptual work and using empirical data, we identified the specific macro-level factors, mechanisms, and triggers that promoted certain individual-level knowledge processes leading to the development of different absorptive capacity knowledge processes.

Our study found that there were relationships between the dynamics in the knowledge tacitness and characteristics of the knowledge environment at the organization level and specific knowledge processes at the individual level, leading to different learning processes (such as explorative, transformative, and exploitative as suggested by Martinkenaite and Breunig (2016)). These findings explain the emergence of different knowledge processes of absorptive capacity. In this regard, we showed how tacit-to-tacit knowledge processes can scale up to form acquisition knowledge processes, how tacit-to-explicit knowledge processes collectively form assimilation knowledge processes, how explicit-to-tacit knowledge processes lead to the emergence of transformation knowledge processes, and how explicit-to-explicit knowledge processes scale up to create exploitation knowledge processes. We showed that different absorptive capacity knowledge processes could have different antecedents, moderators, mediators, and outcomes.

Practically, the findings of this study showed how managers in emerging economies like Iran can plan for the development of absorptive capacity across different product innovation projects in collaboration with external partners. By dynamically managing knowledge processes and facilitating the different learning behaviors of individuals across major product innovation projects, firms can facilitate knowledge transfer from external partners and develop different knowledge processes of absorptive capacity across a series of product innovation projects to support the emergence of absorptive capacity at the firm level. What our research showed is that there are different and subsequent stages, and, in each one of them, there are different requirements. Furthermore, this research indicated that absorptive capacity could be used for transferring and integrating new knowledge, which could be a source of competitive advantage. The step-by-step development of different knowledge processes of absorptive capacity suggested in this research may reassure organizations that the type of absorptive capacity being developed will contribute to their competitive advantage by identifying and internalizing the competitive knowledge and technology.

Limitations and future research

Like other qualitative studies, the findings from this study have limitations in terms of generalizability. This study was done in the auto industry and the findings may be informed by the

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highly integrated structure of the auto industry and the specific relationships between automakers and suppliers in this industry. Our conceptualization may also reflect operations in the manufacturing sectors where the final outcome is mainly a product with a clear product structure and different levels. Future studies can compare the findings of this study with other industries with different industry structures, manufacturing operations, and outcomes (like continued production in oil and gas or power generation). Alternatively, future studies may examine our conceptual framework in the service sectors, which have different processes and outcomes. The findings of this study may also be influenced by the national context of Iran, and its political system, as a developing country seeking technology development. Future studies can be made in other emerging markets and in developed economies.

Comparisons of findings across different economies, industries, and operational processes can provide additional insights into the process of absorptive capacity development and the role of micro-processes and individuals. Despite these limitations, the insights generated in this in-depth case study, as expected from applying a microfoundations view, provide an explanatory mechanism for developing absorptive capacity. We refer to the point raised by Felin et al. (2012: 9), who suggest that:

> …the pursuit of the microfoundations of routines and capabilities will usually bear fruit if the research agenda is rigorously defined. Importantly, this includes specifying the underlying components, or parts, of routines and capabilities, and their interactions, the mechanisms connecting the parts to the collective constructs in time and space, and the boundary conditions for this line of inquiry.

Aligned with this suggestion, our research conceptualized the mechanism underlying absorptive capacity and interactions among different components at the micro level with organizational-level outcomes. This conceptualization provides a foundation for further qualitative and quantitative investigation about the construct of absorptive capacity, its emergence and interactions with other external and internal variables. Future investigation in this line of research may contribute to the core questions in the area of strategic management and advance our understanding of the real roots of competitive advantage. In this regard, the conceptual framework suggested in this study can be verified through quantitative and large-sample studies to be fine-tuned into generalizable suggestions.

The single case study design is another limitation. However, the case was particularly appropriate to uncover the mechanisms, triggers, and processes of the interaction between individual and organizational absorptive capacity development because it had different projects that allowed us to study such dimensions in fine detail. Future research should try to identify other firms that have followed similar metamorphoses or follow a multiple case study approach when only parts of the absorptive capacity development are present.

We suggest in this paper that different knowledge tacitness indicators can be antecedents for different knowledge processes. Future studies may explore other knowledge attributes or knowledge-related antecedents which predict the development of absorptive capacity knowledge processes. Also, revealing the multilevel antecedents, moderators, mediators, and outcomes will provide a useful tool for academics as well as practitioners to deliberately control the process of developing absorptive capacity in organizations. Management interventions can be designed based on the relevant signals from the antecedents and using the relevant moderator and mediator to achieve the desired consequence. Future studies are needed at the individual level to explore the psychological (e.g., emotional factors), cultural (e.g., goal-frame approach [Kruglanski & Kopetz, 2009]), and cognitive factors influencing the development of each absorptive capacity routine. Other than individuals, other micro-level components (e.g., structure and processes) influencing individual routines can be explored.

https://doi.org/10.1017/jmo.2023.20 Published online by Cambridge University Press

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Cite this article: Kashan AJ, Mohannak K, Torres de Oliveira R (2023). Exploring microfoundations and multilevel mechanisms of absorptive capacity in an emerging economy: empirical evidence from a leading car manufacturer. *Journal of Management & Organization* 1–30. https://doi.org/10.1017/jmo.2023.20