R&D MANAGEMENT

Developing organizational agility in product innovation: the roles of IT capability, KM capability, and innovative climate

Zhao Cai[1], Hefu Liu[1], Qian Huang[1] and Liang Liang[2]

[1]School of Management, University of Science and Technology of China, Hefei, China. caizhao@mail.ustc.edu.cn; liuhf@ustc.edu.cn; huangq@ustc.edu.cn
[2]School of Management, Hefei University of Technology, Hefei, China. lliang@hfut.edu.cn

This study investigates how to leverage information technology (IT) capability to build organizational agility in the context of product innovation. A moderated mediating model is proposed from the capability-building processes perspective. The data collected from 194 senior executives of firms in China show that knowledge management capability partially mediates the relationship between IT capability and organizational agility. Innovative climate also positively moderates the indirect relationship between IT capability and organizational agility in the context of product innovation. Discussion, implications, and direction for future research are offered at the end of this paper.

1. Introduction

The product innovations of firms are suffering from a high failure rate of approximately 40% (Castellion and Markham, 2013). An increasing number of practitioners and scholars have attributed such failures to the lack of focus on the continuous changes in the marketplace (Jalonen, 2011; Gaubinger et al., 2015). Berends et al. (2014), for example, suggested that firms should constantly monitor the marketplace and adjust their product innovation based on current market trends. Accordingly, *organizational agility*, which reflects a firm's ability to sense and respond to market changes, has been widely regarded as the key capability for quickly and appropriately adjusting product innovation activities to seize emerging opportunities (Pavlou and El Sawy, 2006; Lu and Ramamurthy, 2011). This agility not only makes firms sensitive to the timely and valuable market information for decision making regarding product innovation (Sambamurthy et al., 2003; Najafi Tavani et al., 2013) but also facilitates their efficient execution of new innovation plans (Cooper and Kleinschmidt, 2007; Chakravarty et al., 2013). For example, Apple quickly invested in the smartwatch when it sensed the potential of the wearable devices market and released the Apple Watch in 2 years, thereby obtaining 75.5% of the global smartwatch market share (Rawassizadeh et al., 2015). However, attaining such agility is difficult for most firms (Lu and Ramamurthy, 2011; Lee et al., 2015). Meanwhile, extant understanding on how to develop organizational agility in product innovation remains limited (Pavlou and El Sawy, 2006; Chakravarty et al., 2013).

Existing literature has widely identified *information technology (IT) capability* as an indispensable enabler of organizational agility (Overby et al., 2006; Tallon, 2008; Lee et al., 2015). IT capability refers to a firm's ability to leverage IT resources to support business strategies and work processes (Tippins and Sohi, 2003; Lu and Ramamurthy, 2011). Scholars have reported various benefits provided by IT capability to agility, such as speeding up information processing, controlling business processes, and creating digital options (Sambamurthy et al., 2003; Chakravarty et al., 2013; Chen et al., 2014). Similarly, the importance of IT capability is recognized by product innovation research (Nambisan, 2003; Durmuşoğlu and Barczak, 2011). They demonstrate the supportive role of IT capability in managing knowledge resources, which improves the speediness and market performance of new products (Pavlou and El Sawy, 2006; Barczak et al., 2007).

Despite the aforementioned merits, IT capability has recently been suspected as the trigger of rigidity and unexpected barriers to agility (Lu and Ramamurthy, 2011; Chakravarty et al., 2013). For example, although IT capability could improve the information processing capacity of a firm, it may lead to information overload for decision makers, thus resulting in failure of firms to respond in a timely manner (Seo et al., 2014). Meanwhile, integrated enterprise systems generated by IT capability are claimed as the biggest barrier to the reengineering initiatives of business processes to address market changes (Rettig, 2007; Lu and Ramamurthy, 2011). Owing to these inconclusive findings, scholars began to question the simplistic relationship between IT capability and agility, thereby calling for studies to investigate the underlying intermediating mechanisms and boundary conditions in such relationship (Bi et al., 2013; Lee et al., 2015). Moreover, it is suggested that agility studies should be based on a specific context (e.g., supply chain management, new product development, and strategic management) to generate insightful findings (Roberts and Grover, 2012; Bi et al., 2013; Shin et al., 2015). Hence, the goal of the current study is to address this issue by identifying and testing the mediator and moderator in the relationship between IT capability and agility based on the context of product innovation.

Product innovation is a knowledge-intensive activity that requires effective knowledge integration from many disparate specialists (Grant, 1996b; Luca and Atuahene-Gima, 2007). Developing agility in this context thus needs the effective deployment of a wide range of knowledge resources, such as market knowledge on customer preference and technical knowledge on product engineering (Mao et al., 2015; Cegarra-Navarro et al., 2016). Accordingly, *knowledge management (KM) capability* is claimed to directly address such need in developing agility in product innovation because it represents the ability of a firm to create, transfer, integrate, and leverage related knowledge (Tanriverdi, 2005; Pitt and MacVaugh, 2008; Chang et al., 2014). Meanwhile, the literature indicates that KM capability may bridge the gap between IT capability and agility by transforming raw information to knowledge resources that can be readily used to develop new products for market changes (Tanriverdi, 2005; Song et al., 2006; Mao et al., 2016). Although KM capability is not a new concept, it is scarcely mentioned in the research on the contradictory relationship between IT capability and agility in product innovation (Mao et al., 2015). The current study examines the mediating role of KM capability in the link between IT capability and agility to advance the understanding of the intermediating mechanism of such relationship. Therefore, the first research question is as follows:

RQ1. How does KM capability mediate the relationship between IT capability and organizational agility in the context of product innovation?

However, the extent to which KM capability mediates the relationship between IT capability and agility may depend on the climate of the firm in supporting innovation. *Innovative climate*, an organizational context promoting creative ideas and behaviors, is widely acknowledged as an important factor in product innovation (Cooper and Kleinschmidt, 2007; Parry et al., 2009; Oke, 2013). This climate encourages employees to engage in knowledge-related works not only by creatively utilizing advanced IT tools to support KM but also by proactively participating in various KM activities to develop agility (Acur et al., 2010; Roberts et al., 2012; Mao et al., 2015). Hence, an innovative climate may motivate employees to actively apply the IT functionalities in KM practices (Jasperson et al., 2005; Hsieh and Wang, 2007; Ke et al., 2012). This climate could also prompt employees to apply various KM tools to share new ideas and voice out different opinions when innovating products to address market changes, which is conducive to the positive link between KM capability and agility (Bock et al., 2005; Chen et al., 2010). Thus, in firms with a high innovative climate, KM capability may be effective in transmitting the benefits of IT capability to agility due to the involvement of employees in KM activities (Chen and Huang, 2007; Kang et al., 2015). Notwithstanding the facilitating role of an innovative climate, most firms do not have a specific focus on cultivating such climate for product innovation (Kahn et al., 2012). Furthermore, the existing literature has not provided any empirical evidence on the role of innovative climate in developing agility. Hence, the current study aims to address the second research question below:

RQ2. How does innovative climate moderate the relationship among IT capability, KM capability, and organizational agility?

To untangle the above research questions, a moderated mediating model is proposed based on the capability-building processes perspective. This theoretical perspective provides guidance on how to develop higher-order capabilities (e.g., organizational agility) in the support of fundamental and process-based capabilities (e.g., IT and KM capability) (Grant, 1996a; Rai et al., 2006). The model also incorporates the context of developing capabilities (e.g., innovative climate) as the contingency (Lee et al., 2015). Data were collected from the senior executives in 194 firms in China who lead product innovation to examine this research model. This study attempts to elucidate how KM capability mediates the IT–agility relationship and how such a mediating effect is contingent on the presence of an innovative climate in the context of product innovation. This research is expected to enrich the existing literature in three aspects. First, this research addresses an important but overlooked topic – building agility in the context of product innovation – which focuses on rapidly and creatively developing new products to respond to market changes. Second, this research investigates the mediating role of KM capability to clarify mixed findings on the link between IT capability and agility, thereby highlighting the importance of deploying knowledge resources in developing agility. Third, this study offers a nuanced understanding of this topic by investigating the moderating role of innovative climate, which aims to show that the mediating role of KM capability is contingent on the climate that encourages the explorative behavior and creative thoughts of employees.

2. Theoretical background and literature review

2.1. Organizational agility in product innovation

Organizational agility, defined as a firm's ability to address unexpected changes via rapid and innovative responses, is widely recognized as the critical capability that helps firms adjust production innovation to current market trends (Cooper and Kleinschmidt, 2007; Lu and Ramamurthy, 2011; Chakravarty et al., 2013). Prior studies have identified two dimensions of agility according to their different focuses (Lu and Ramamurthy, 2011). *Market capitalizing agility* reflects the ability to take advantage of market changes and focuses on the up-front planning of product innovation to effectively target customer preference (Ledwith and O'Dwyer, 2009; Chakravarty et al., 2013). *Operational adjustment agility* refers to the ability to cope with market changes physically and rapidly with internal business processes, and concerns the execution of a product innovation plan to materialize new product design (Pavlou and El Sawy, 2011).

In the context of product innovation, organizational agility generates benefits to firms in terms of sensing and responding to market changes. Specifically, agile firms have a solid market knowledge base and awareness of the current market trend (Overby et al., 2006; Roberts and Grover, 2012). Firms thrive and improve when creative thoughts on product innovation are aligned to the current market changes (Richtnér and Löfsten, 2014). Agility also represents the prompt responding ability which helps firms adjust its internal operations to perform actions based on market changes (Sambamurthy et al., 2003; Tallon, 2008). With this ability, firms effectively adjust their product innovation processes to create and commercialize new products to address disruptions or specific market demands (Hock et al., 2016). Although the benefits are salient, it is reported that firms still fail to be sufficiently agile when encountering market changes (Huang et al., 2012; Wang et al., 2014). The investigation of agility remains scarce in product innovation literature. This research aims to bridge this gap by examining the development of organizational agility in the context of product innovation.

2.2. Development of organizational agility in product innovation

Owing to the benefits and difficulties of developing agility, extant studies have placed considerable efforts in investigating its antecedents (e.g., Wang et al., 2014; Mao et al., 2015; Cegarra-Navarro et al., 2016). Scholars suggest the capability-building processes perspective as a theoretical framework to analyze the development of agility (Chakravarty et al., 2013; Lee et al., 2015). This perspective considers organizational agility as a higher-order capability that requires the support of fundamental capabilities (Teece et al., 1997; Rai et al., 2006; Lee et al., 2015). Numerous agility studies posit that *IT capability* is a fundamental capability that enables organizational agility (Lu and Ramamurthy, 2011; Chakravarty et al., 2013). IT capability refers to a firm's ability to effectively utilize IT resources to support business strategies and work processes (Tippins and Sohi, 2003). Such capability provides technical support for agility in terms of information acquisition, collaborative communication, and process adjustment (Roberts and Grover, 2012; Chen et al., 2014; Lee et al., 2015). For example, with Internet-based CAD/CAE applications, product innovators can concurrently design new products regardless of their geographical positions, which ensures the efficient exchange of diverse ideas to keep up with market changes (Durmuşoğlu and Barczak, 2011).

While empirical research postulates the positive role of IT capability in agility development, an increasing number of studies present opposing arguments that question their direct relationship (Rai et al., 2006; Seo and La Paz, 2008) (See Supporting Information Appendix A for an illustrative review). For example, Lu and Ramamurthy (2011) demonstrate that a globally integrated IT infrastructure may lead to rigidity in addressing local changes. Chakravarty et al. (2013) report that IT capability has a negative effect on entrepreneurial agility in highly dynamic environments. Based on these controversies, scholars recently called for a better understanding of the intermediating mechanism that explains how IT capability promotes organizational agility (Drnevich and Croson, 2013; Chae et al., 2014). Moreover, initial evidence indicates that the relationship between IT capability and organizational agility might be more complex than previously depicted. For example, Huang et al. (2012) report that the effect of IT capability on operational agility is mediated by information processing efficiency and effectiveness. Bi et al. (2013) propose the mediating role of supply chain capability in the IT–agility relationship. Lee et al. (2015) find that IT capability supports agility through the development of operational capabilities. However, the role of IT capability in developing organizational agility still remains unclear, especially in the context of product innovation (Pavlou and El Sawy, 2006; Lee et al., 2015).

As suggested by the capability-building processes perspective, the higher-order capability is embedded in the organizational processes and requires process-based capabilities to transmit the benefits of fundamental capabilities (Grant, 1996a; Lee et al., 2015; Rai et al., 2006). *KM capability* is proposed as an ideal process-based capability to transfer the technical support provided by IT capability to the development of agility in the context of product innovation (Rai et al., 2006). KM capability reflects a firm's ability to mobilize and deploy knowledge resources to achieve goals and gain business values (Tanriverdi, 2005; Mao et al., 2016). This capability includes multiple processes that complement and support each other and help firms efficiently create, transfer, integrate, and leverage knowledge (Tanriverdi, 2005; Miranda et al., 2011).

Extant literature offer some clues which indicate the possible mediating role of KM capability in the relationship between IT capability and organizational agility. For example, a few scholars propose that IT capability supports KM capability by providing real-time external information, facilitating cross-department communication, and offering efficient knowledge storage and retrieval (Song et al., 2006; Mabey et al., 2015). Others argue that given a high level of knowledge quality, richness, and complexity, firms can modify their product innovation process according to the current marketplace and develop new products that address market changes (Pitt and MacVaugh, 2008; Durmuşoğlu, 2013; Kim et al., 2013). Therefore, further investigation is necessary with regard to how KM capability mediates the relationship between IT capability and agility in the context of product innovation.

Finally, the capability-building processes perspective contends that the building process of higher-order capability could be leveraged by a firm's environmental context (Chakravarty et al., 2013; Lee et al., 2015). The literature further indicates that although KM capability is conducive to the development of organizational agility, how to fully leverage its benefit is still under discussion (Mao et al., 2016). As Alexander et al. (2003) claim, the major problem in utilizing KM capability is the participation of employees. Scholars further contend the *innovative climate* is the chief environmental factor encouraging employees to engage in knowledge exchange activities (Chen et al., 2010). Innovative climate reflects the shared perceptions of employees regarding the practices, procedures, and behaviors that promote the generation of new ideas, the experimentation with creative thoughts, and the acceptance of changes (Bock et al., 2005; van der Vegt et al., 2005; Acur et al., 2010). Such climate offers a collective understanding of what is socially acceptable, thus regulating the attitude and behavior of employees (Chen and Huang, 2007; Bertels et al., 2011).

Existing product innovation literature suggests the moderating role of innovative climate by claiming that KM capability is better supported by IT capability and in turn more effective in improving agility in such climate. On one hand, it is argued that employees working within an innovative climate tend to search for and experiment with new, sophisticated, and possibly risky IT tools to accomplish tasks, thereby significantly improving KM capability (Barczak et al., 2007). On the other hand, scholars claim that innovative climate increases the engagement and enthusiasm of employees and motivates them to use KM

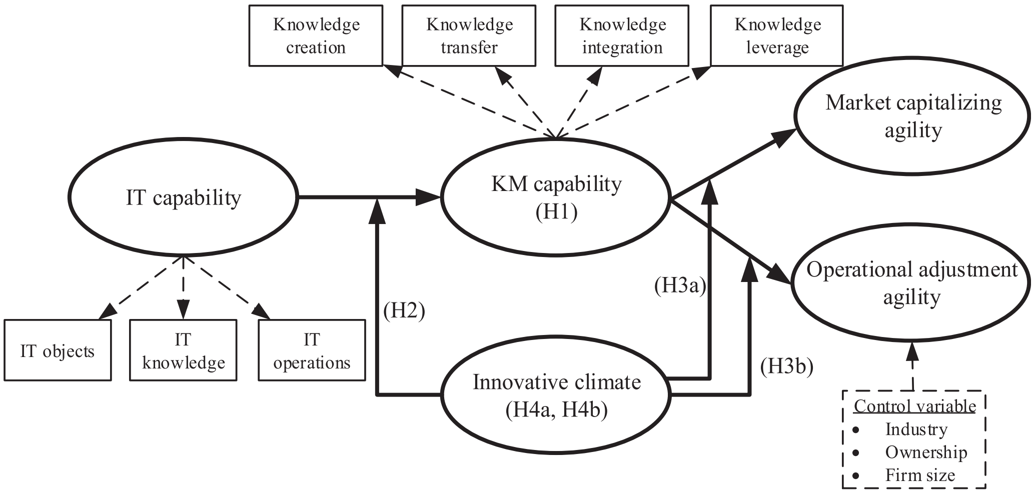

Figure 1. Conceptual model with hypotheses.

mechanisms to share and embody creative thoughts for product innovation (Parry et al., 2009; Acur et al., 2010; Chen et al., 2010). Accordingly, the moderating role of innovative climate requires theoretical reasoning and empirical testing.

3. Hypothesis development

The current study proposes a moderated mediating model to explain the development of agility in the context of product innovation. Specifically, this research posits that KM capability serves as a mediator in the relationship between IT capability and organizational agility. Meanwhile, innovative climate is proposed to moderate the relationship among IT capability, KM capability, and organizational agility. Figure 1 displays the conceptual model with hypotheses.

3.1. Mediating role of KM capability

The literature indicates that IT can enhance the reach and richness of a firm's knowledge, thereby allowing the firm to rapidly react to market changes (Overby et al., 2006; Tallon, 2008; Lee et al., 2015). Accordingly, we propose that KM capability mediates the relationship between IT capability and organizational agility in the context of product innovation. On one hand, KM capability is supported by the digitalized and integrated platforms provided by IT capability, thereby achieving high efficiency in deploying and mobilizing knowledge resources (Lee and Choi, 2003; Tanriverdi, 2005; Mehta et al., 2014). For example, KM systems are capable of coding and storing the best practices of product innovation, which are useful as the knowledge base for future business activities (Alavi and Leidner, 2001). In addition, IT-enabled transactive memory systems support firms in building knowledge maps, through which employees can locate the relevant expertise required for a specific product innovation task (Huang et al., 2013; Dai et al., 2016). Social media tools, such as enterprise social network services and enterprise wikis, contribute to the sharing of innovative ideas by operating knowledge communities (von Krogh, 2012). According to recent studies, digital tools for KM are still emerging, along with the development of IT (Sultan, 2013; Pedro and Juan-Gabriel, 2016), which manifests a strong support of IT capability toward KM capability.

On the other hand, KM capability is beneficial to organizational agility. For market capitalizing agility, KM capability assists firms in assimilating market knowledge as the intellectual base of developing market-oriented products (Gold et al., 2001). With such intellectual base, creative ideas are generated and applied in product innovation through knowledge flow and refinement (Lee and Choi, 2003; Swink and Song, 2007). For operational adjustment agility, KM capability is conducive to the development and implementation of operation schedules (Sher and Lee, 2004; Aboelmaged, 2014). When developing schedules, the domain knowledge from different departments can be integrated by KM activities to create flexible and robust schedules (Inkpen and Tsang, 2005; Tanriverdi, 2005). Meanwhile, when implementing schedules, unexpected problems can be solved by effective idea exchange and cross-unit collaboration, which ensures the prompt execution of operation schedule even in unpredictable environments (Huber, 1991; Darroch, 2005). Based on the preceding discussion, we propose the mediating role of KM capability.

Hypothesis 1 (H1): *KM capability mediates the relationship between IT capability and (a) market capitalizing agility and (b) operational adjustment agility.*

3.2. Moderating role of innovative climate

Product innovation is a dynamic field where an increasing number of new technologies, ideas, and processes emerge (Durmuşoğlu and Barczak, 2011). Product innovation requires a high level of innovative climate to help employees overcome their concerns regarding learning efforts and unpredictable changes, thereby facilitating the development of agility (Chen and Huang, 2007; Oke et al., 2013; Sung and Choi, 2014). We first propose that innovative climate can amplify the positive relationship between IT capability and KM capability. Specifically, an innovative climate promotes creative ideas and thoughts in the workplace, which enables employees to seek novel ways of utilizing IT to support knowledge-related business processes (van der Vegt et al., 2005; Acur et al., 2010; Liang et al., 2015). KM processes and activities are reconfigured by innovative IT usage, which leads to concerns regarding potential risks generated by such changes (Ke et al., 2012; von Krogh, 2012). The innovative climate bestows employees with a positive attitude to treat changes as opportunities, which is helpful for fully leveraging IT to improve KM capability (Kim and Kankanhalli, 2009).

Hypothesis 2 (H2): *An innovative climate positively moderates the relationship between IT capability and KM capability, such that this relationship is stronger under a high innovative climate and is weaker under a low innovative climate.*

We also propose that an innovative climate may strengthen the positive relationship between KM capability and market capitalizing agility. As market capitalizing agility requires KM capability to provide market and product knowledge to develop market-oriented products, an innovative climate satisfies this requirement by encouraging employees to engage in generating and applying relevant knowledge for product innovation (Chen and Huang, 2007; Bertels et al., 2011). Specifically, this climate enhances the willingness of employees to adopt KM tools to communicate with others to absorb new ideas and thoughts (Sandhawalia and Dalcher, 2011; Liu and Deng, 2015). By integrating a wide range of knowledge from multiple sources, they can develop innovative mindsets and systematic market cognitions, which enable the formulation of creative and market-oriented ideas on product innovation (Smith et al., 2005; Luca and Atuahene-Gima, 2007; Bianchi et al., 2015). Such ideas can be fully utilized by employees to develop new products which satisfy the marketplace, because an innovative climate alleviates their concern regarding the possible failure of innovation (Choi, 2007; Sung and Choi, 2014). Based on the preceding discussion, an innovative climate facilitates the use of KM capability in terms of idea generation and application to support product innovation in response to market changes.

Hypothesis 3a (H3a): *An innovative climate positively moderates the relationship between KM capability and market capitalizing agility, such that this relationship is stronger under a high innovative climate and is weaker under a low innovative climate.*

We further hypothesize that an innovative climate could serve as a catalyst in the relationship between KM capability and operational adjustment agility. Given that operational adjustment agility requires the support of KM capability in terms of cross-unit coordination to develop and execute operation schedules, an innovative climate can facilitate such process by motivating employees to leverage KM initiatives for learning and collaboration (van der Vegt et al., 2005; Wong and Wong, 2011; Kandemir and Acur, 2012). When developing operation schedules, product designers and line managers learn from each other and reach a consensus in terms of quality and cost control, which leads to a balance of product quality and manufacturing efficiency (Chen and Huang, 2007). In implementing schedules, accuracy and punctuality can be ensured against disruptions, because employees are willing to leverage KM tools to jointly seek for solutions to accidents (Barczak et al., 2007; Cooper and Kleinschmidt, 2007; Oke et al., 2013). By encouraging learning and collaboration across units, an innovative climate enables employees to better leverage KM capability for designing and executing operation schedules to adjust internal operations for materializing new product design.

Hypothesis 3b (H3b): *An innovative climate positively moderates the relationship between KM capability and operational adjustment agility, such that this relationship is stronger under a high innovative climate and weaker under a low innovative climate.*

Based on the preceding hypotheses, we further assume the contingent role of an innovative climate in the agility building process, which leads to a moderated mediating model. An innovative climate strengthens the mediating role of KM capability by motivating employees to participate in KM activities with the support of IT tools to develop new products

Table 1. Sample demographic information

	N	Percentage		*N*	Percentage
Industry			Ownership		
Manufacturing industry	111	57.22	State-owned	87	44.85
Service industry	83	42.78	Privately owned	90	46.39
Number of employees			Foreign-controlled	17	8.76
Less than 100	51	26.29	Firm history		
100–299	50	25.77	1–5 years	31	15.98
300–499	14	7.22	6–10 years	47	24.23
500–999	20	10.31	11–25 years	73	37.63
1,000–1,999	18	9.28	26–50 years	21	10.82
More than 1,999	41	21.13	More than 50 years	22	11.34

to serve the market (Chen and Huang, 2007; van der Vegt et al., 2005). Specifically, an innovative climate encourages employees to propose new ideas and thoughts in achieving agility (Acur et al., 2010). To put forward creative ideas, employees need to absorb and integrate knowledge from various sources with the assistance of IT tools provided by firms (Nonaka and Toyama, 2003; Smith et al., 2005). Moreover, an innovative climate is task-oriented and aims to guide employees to leverage new ideas to solve problems and complete tasks, thereby highlighting the role of KM activities, including knowledge integration, transfer, and application (Anderson and West, 1998; Alavi and Leidner, 2001; Wang and Rode, 2010). Essentially, the intermediating role of KM capability is salient in an innovative climate, because employees are willing to perform knowledge-related activities to realize the benefits offered by IT capability in achieving agility. Based on the preceding arguments, we propose the moderated mediating effect as follows.

Hypothesis 4a/b (H4a/b): *An innovative climate positively moderates the mediating effect of KM capability in the relationship between IT capability and (a) market capitalizing agility and (b) operational adjustment agility, such that this mediating effect is stronger under a high innovative climate and is weaker under a low innovative climate.*

4. Research method

4.1. Sample and data collection

We conducted a questionnaire survey in China for this research. China recently emerged as a valuable global player in product innovation, and many international firms operate R&D centers in the country. To obtain valid and reliable responses, we collaborated with an educational institution that is well known for its executive training programs, including those in the field of innovation management, information systems, and KM. A sample pool of 300 eligible firms was identified. These firms belong to a number of industries, including machinery and equipment manufacturing, electronic and optical product manufacturing, financial and insurance services, wholesale and retail trade, and information services industry.

We identified one senior executive responsible for product innovation from each firm to serve as a key informant. These senior executives were selected because they are knowledgeable in product innovation, IT, and KM, which is helpful in understanding the questionnaire items. As active product innovation executives, these executives have a significant responsibility for shaping the scope and direction of IT, KM, agility, and product innovation in their firms. Although the use of a single respondent may not be ideal for firm-level studies, the method is acceptable in recent studies (e.g., Mehta et al., 2014).

We distributed questionnaires with the assistance of the educational institution. We made follow-up phone calls and sent reminder emails to encourage responses. We received 228 questionnaires, of which 34 were incomplete and thus discarded. Finally, 194 valid questionnaires were used for the analysis, with a response rate of approximately 64.67%. Following Armstrong and Overton (1977), we evaluated the non-response bias by comparing the first 25% and the final 25% of the responses on all variables using the chi-squares. The results indicated no significant differences, thereby suggesting that the non-response bias is not a critical issue in this study. Table 1 presents the demographic information of the sample.

4.2. Measures

A Chinese questionnaire was required because the study was conducted in China. We developed an English questionnaire based on existing validated

Table 2. Standardized loadings, Cronbach's alphas, composite reliability, and AVEs

Construct	Items	Loading	Cronbach's alpha	Composite reliability	AVE[a]
IT object	4	0.64–0.91	0.82	0.88	0.66
IT knowledge	4	0.86–0.93	0.93	0.95	0.82
IT operations	6	0.78–0.87	0.91	0.93	0.69
Knowledge creation	3	0.77–0.83	0.70	0.84	0.64
Knowledge transfer	3	0.72–0.81	0.63	0.80	0.57
Knowledge integration	3	0.79–0.84	0.76	0.86	0.68
Knowledge leverage	3	0.80–0.89	0.80	0.88	0.72
Market capitalizing agility	3	0.87–0.89	0.86	0.92	0.79
Operational adjustment agility	3	0.87–0.92	0.89	0.93	0.82
Innovative climate[b]	2	0.89–0.89	0.73	0.88	0.79

AVE, average variance extracted.
[a]Loading, standardized loading
[b]One item was dropped because of low reliability.

measures and then translated it into Chinese with the aid of a team of three researchers from different fields (Van de Vijver and Leung, 1997). A professional translator who has no knowledge regarding this study was then employed to translate the Chinese questionnaire back to English. We carefully compared the translated English version with the original and found no semantic discrepancy between the versions. Consequently, we were able to use the Chinese questionnaire to represent the original English one. All items in the questionnaire were measured in the context of product innovation based on five-point Likert scales ranging from 'strongly disagree' to 'strongly agree'.

The questionnaire provided an instruction for respondents to rate the items based on the conditions of product innovation in their firms. Respondents were notified that all the measurement items in this questionnaire were embedded in the context of product innovation. Supporting Information Appendix B displays the scale of each construct. Specifically, IT capability was operationalized as a reflective second-order construct with the dimensions of IT objects, IT knowledge, and IT operations. The measures for these dimensions were adopted from Tippins and Sohi (2003). We also adopted measures from Tanriverdi (2005) to test the KM capability. Based on the existing studies and the fitness of the measurement model, we took a process-based view to measure KM capability, which was treated as a second-order construct with the dimensions of knowledge creation, transfer, integration, and leverage. We adopted the scale from Lu and Ramamurthy (2011) to measure market capitalizing agility and operational adjustment agility. Innovative climate was measured using the scale adopted from Bock et al. (2005).

Industry and ownership types and firm size were considered to be control variables. We categorized the industries into manufacturing and service industries based on whether a firm provides physical goods. According to these criteria, machinery and equipment manufacturing, electronic and optical product manufacturing, textile mill, chemical, automotive, and food industries were included in the manufacturing industry. The service industry included financial and insurance services, wholesale and retail trade, and information services industry. We utilized a dummy variable to represent the industry type. The ownership type includes state-owned, privately owned, and foreign-controlled firms. Two dummy variables were employed to identify the ownership type. The number of full-time employees was regarded as the representation of firm size.

5. Analysis and results

Common method bias posed a threat to the validity of this study because all data were simultaneously collected from a single source. We conducted Harman's post hoc single-factor analysis and marker variable analysis to test this bias. The results of both methods indicated that common method bias is not a serious issue in the current dataset. Supporting Information Appendix C contains the details.

5.1. Measure validation

We evaluated the construct reliability and validity of the measurement. Specifically, we assessed the reliability using Cronbach's alpha as suggested by Fornell and Larcker (1981). One item of innovative climate was dropped due to low reliability. The Cronbach's alpha of most constructs was finally higher than the recommended value of 0.70, thereby indicating good reliability. Although the Cronbach's

Table 3. Assessment of discriminant validity

	Mean	SD	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. IT objects	3.23	1.06	**0.81**													
2. IT knowledge	2.94	1.12	0.73	**0.91**												
3. IT operations	3.30	0.96	0.57	0.63	**0.83**											
4. Knowledge creation	3.90	0.76	0.11	0.14	0.12	**0.80**										
5. Knowledge transfer	3.66	0.77	0.22	0.21	0.32	0.56	**0.76**									
6. Knowledge integration	3.95	0.78	0.16	0.24	0.29	0.54	0.59	**0.82**								
7. Knowledge leverage	3.86	0.74	0.11	0.17	0.25	0.57	0.48	0.62	**0.85**							
8. Market capitalizing agility	3.56	0.83	0.29	0.36	0.40	0.30	0.29	0.41	0.32	**0.90**						
9. Operational adjustment agility	3.72	0.81	0.25	0.38	0.55	0.30	0.37	0.43	0.32	0.61	**0.87**					
10. Innovative climate	3.50	0.73	0.24	0.33	0.35	0.24	0.19	0.28	0.16	0.40	0.41	**0.75**				
11. Industry dummy	–	–	−0.18	−0.17	−0.17	0.14	0.05	0.08	0.04	−0.06	−0.13	−0.11	–			
12. Ownership dummy 1	–	–	0.23	0.08	−0.04	0.00	0.00	−0.04	−0.05	−0.14	−0.21	−0.07	−0.06	–		
13. Ownership dummy 2	–	–	−0.26	−0.15	0.01	0.04	0.02	0.05	0.08	0.16	0.17	0.06	0.01	−0.84	–	
14. Firm size	–	–	0.31	0.21	0.04	0.01	0.06	0.03	0.04	0.08	0.01	−0.10	0.16	0.32	−0.34	–

Diagonal elements are the square roots of AVEs.

alpha of knowledge transfer is 0.63, it is also acceptable because the recommended threshold for the contextualized construct is 0.60 as suggested by innovation management scholars (Li et al., 2011; Marion et al., 2012). We further tested the convergent validity with the loadings of each item and the average variance extracted (AVE) from each construct. Table 2 shows that the loadings ranged from 0.64 to 0.93 at a significance level of 0.001, which were higher than the threshold of 0.60. The AVE scores varied from 0.57 to 0.82, which were above the suggested benchmark of 0.50 (Fornell and Larcker, 1981). The overall fit of the measurement model is acceptable according to the result of LISREL 8.70 ($\chi^2 = 1043$ on 470 d.f., RMSEA = 0.079, CFI = 0.95, IFI = 0.95, NFI = 0.92, NNFI = 0.94).

We used a second-order confirmatory factor analysis with LISREL 8.70 because IT and KM capability are second-order constructs. The results indicated an acceptable fit ($\chi^2 = 135$ on 64 d.f., RMSEA = 0.076, CFI = 0.99, IFI = 0.99, NFI = 0.98, NNFI = 0.98 for IT capability; $\chi^2 = 68$ on 34 d.f., RMSEA = 0.072, CFI = 0.99, IFI = 0.99, NFI = 0.97, NNFI = 0.97 for KM capability). The loadings of each dimension on IT and KM capability were positive and significant, ranging from 0.60 to 0.94. Thus, these dimensions converged on the corresponding second-order construct.

We also evaluated discriminant validity by comparing the correlations among the constructs and the corresponding square root of AVEs (Paulraj et al., 2008). As shown in Table 3, none of the correlations between constructs were higher than the square roots of AVE, thereby satisfying the requirement of discriminant validity. We performed a multicollinearity test because several inter-construct correlations in Table 3 were higher than 0.60. The results showed that the highest VIF was 2.60, which is below the threshold of 10.00; the lowest tolerance value was 0.39, which is above the benchmark of 0.10 (Dormann et al., 2013). Thus, multicollinearity was not a significant problem in this dataset.

5.2. Hypotheses testing

We applied the bootstrapping sampling method (bootstrap sample size = 5000) recommended by MacKinnon et al. (2004) to test the mediating effect using IBM SPSS Statistics 19. Asymmetric confidence intervals (CIs) were generated for the indirect relationship. The estimation accuracy provided by the bootstrapped approach of CIs was higher than that by the other methods because the former could correct the non-normality of the sampling distribution (Gong et al., 2013). Table 4 demonstrates that the relationships between IT and KM capability

Table 4. Results of bootstrapping method for mediation

IV	M	DV	Effect of IV on M (a)	Effect of M on DV (b)	Direct effect (c’)	Indirect effect (a × b)	Total effects (c)	95% CI
IT capability	KM capability	Market capitalizing agility	0.19**	0.45**	0.50**	0.08**	0.32**	0.03–0.15
IT capability	KM capability	Operational adjustment agility	0.19**	0.42**	0.35**	0.08**	0.27**	0.03–0.14

*$P < 0.05$.
**$P < 0.01$.

($\beta = 0.19$, $p < 0.01$), KM capability and market capitalizing agility ($\beta = 0.45$, $p < 0.01$), and KM capability and operational adjustment agility ($\beta = 0.42$, $p < 0.01$) were significant. The indirect relationship between IT capability and market capitalizing agility was 0.08 with 95% CI of (0.03, 0.15), excluding zero, while, the indirect relationship between IT capability and operational adjustment agility was 0.08 with 95% CI of (0.03, 0.14). Thus, the mediating role of KM capability proposed by H1a/b was supported. Furthermore, the mediating effect of KM capability was partial in both relationships because the direct relationships between IT capability and market capitalizing agility ($\beta = 0.50$, $p < 0.01$) and operational adjustment agility ($\beta = 0.35$, $p < 0.01$) were significant.

We used hierarchical regression analysis to test Hypotheses 2 and 3 using IBM SPSS Statistics 19. Table 5 indicates that the relationship between IT capability and KM capability was positively moderated by innovative climate ($\beta = 0.19$, $p < 0.01$), which supported Hypothesis 2. Furthermore, the positive relationship between KM capability and market capitalizing agility was positively moderated by innovative climate ($\beta = 0.20$, $p < 0.01$), thereby supporting Hypothesis 3a. However, the relationship between KM capability and operational adjustment agility was not significantly moderated by innovative climate

Table 5. Results of hierarchical regression analysis for moderation

	KM capability			Market capitalizing agility			Operational adjustment agility		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
Control variables									
Dummy_ Manufacturing	0.17*	0.17*	0.14*	−0.21**	−0.17*	−0.17**	−0.13	−0.09	−0.09
Dummy_ State-owned	0.14	0.14	0.14	−0.31*	−0.28*	−0.26*	−0.11	−0.08	−0.07
Dummy_ Privately owned	0.21	0.20	0.21	−0.08	−0.06	−0.04	0.09	0.11	0.12
Firm Size	−0.03	0.00	0.01	0.10	0.12	0.12	0.15*	0.17*	0.17*
Independent variable									
IT capability	0.33**	0.25**	0.26**						
KM capability				0.44**	0.36**	0.36**	0.40**	0.32**	0.32**
Moderator									
Innovative climate		0.19**	0.20**		0.29**	0.30**		0.31**	0.31**
Interaction terms									
IT capability × innovative climate			0.19**						
KM capability × innovative climate						0.20**			0.04
R^2	0.11	0.15	0.18	0.27	0.35	0.39	0.21	0.30	0.30
Adjusted R^2	0.09	0.12	0.15	0.25	0.32	0.36	0.19	0.27	0.27
F change	4.83**	6.97**	7.58**	13.95**	21.28**	12.45**	10.11**	22.43**	0.46

*$P < 0.05$.
**$P < 0.01$.

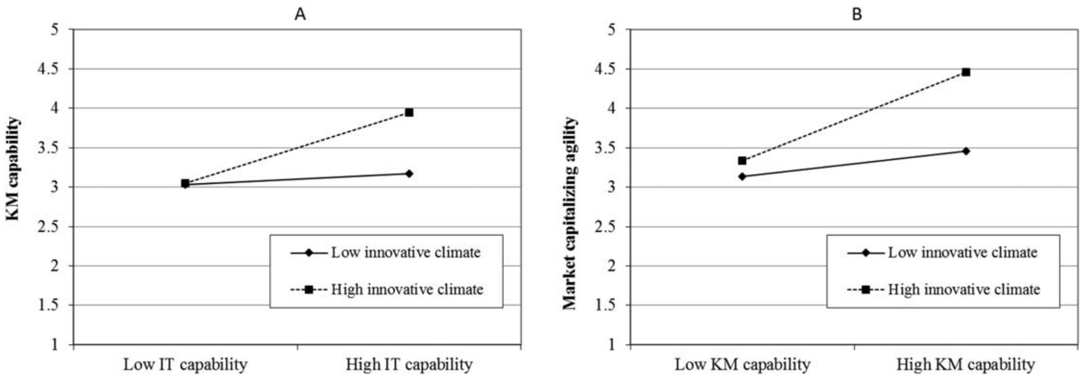

Figure 2. Regression plots of moderating effects of innovative climate.

($\beta = 0.04$, p = 0.50). Hence, Hypothesis 3b was not supported. We also performed the robustness check for hierarchical regression analysis as shown in Supporting Information Appendix D.

In addition, we analyzed the moderating effects using a graphical procedure (Aiken and Stephen, 1991). Specifically, we assigned values of one standard deviation above and below the means to the construct of innovative climate and plotted the corresponding effects. Figure 2A shows that the relationship between IT capability and KM capability in a high innovative climate was significantly positive ($\beta = 0.43$, $P < 0.01$). However, this relationship became insignificant in a low innovative climate ($\beta = 0.09$, $P = 0.39$). The slope regression line in Figure 2B suggests that the effect of KM capability on market capitalizing agility was significant when innovative climate was high ($\beta = 0.55$, $P < 0.01$). Although weakened, this effect remained significant in a low innovative climate ($\beta = 0.18$, $P < 0.05$).

To test Hypothesis 4, we followed the technique recommended by Preacher et al. (2007) and generated the results in Table 6. The indirect effects were calculated at three different levels of innovative climate. As shown in Table 6, the indirect relationship between IT capability and the market capitalizing and operational adjustment agilities shared a common trend. In the low innovative climate, the indirect relationships were insignificant. However, both indirect relationships became significant in the medium innovative climate and were strengthened in the high innovative climate. Accordingly, the moderated mediating effects proposed in Hypotheses 4a and 4b were supported. Table 7 summarizes the results of the data analysis.

6. Discussion

The results of this study revealed the partial mediating role of KM capability, which indicates that IT capability could be associated with agility via two approaches. One approach is consistent with the hypothesis which claims that IT capability contributes to agility through the provision of fundamental

Table 6. Results of bootstrapping method for moderated mediation

Value	Indirect effect	SE	Z	$P > \|Z\|$	Lower	Upper
Conditional indirect effect on market capitalizing agility at range of values of innovative climate						
−1 SD	0.00	0.01	0.23	0.82	−0.03	0.06
−0.5 SD	0.02	0.02	1.37	0.17	−0.01	0.08
M	0.06	0.02	2.50	0.01	0.01	0.13
+0.5 SD	0.11	0.03	3.09	0.00	0.03	0.20
+1 SD	0.16	0.05	3.19	0.00	0.06	0.33
Conditional indirect effect on operational adjustment agility at range of values of innovative climate						
−1 SD	0.01	0.02	0.25	0.81	−0.05	0.07
−0.5 SD	0.03	0.02	1.41	0.16	−0.01	0.09
M	0.05	0.02	2.36	0.02	0.01	0.11
+0.5 SD	0.07	0.03	2.58	0.01	0.03	0.15
+1 SD	0.09	0.04	2.30	0.02	0.03	0.21

Table 7. Summary of hypothesis testing

No.	Hypothesis	Result
H1a	KM capability mediates the relationship between IT capability and market capitalizing agility.	Support
H1b	KM capability mediates the relationship between IT capability and operational adjustment agility.	Support
H2	Innovative climate positively moderates the relationship between IT capability and KM capability, such that this relationship is stronger under high innovative climate and weaker under low innovative climate.	Support
H3a	Innovative climate positively moderates the relationship between KM capability and market capitalizing agility, such that this relationship is stronger under high innovative climate and weaker under low innovative climate.	Support
H3b	Innovative climate positively moderates the relationship between KM capability and operational adjustment agility, such that this relationship is stronger under high innovative climate and weaker under low innovative climate.	Unsupported
H4a	Innovative climate positively moderates the mediating effect of KM capability in the relationship between IT capability and market capitalizing agility, such that this mediating effect is stronger under high innovative climate and weaker under low innovative climate.	Support
H4b	Innovative climate positively moderates the mediating effect of KM capability in the relationship between IT capability and operational adjustment agility, such that this mediating effect is stronger under high innovative climate and weaker under low innovative climate.	Support

technical support for the effective deployment of knowledge resources (Sher and Lee, 2004; Tanriverdi, 2005). The other approach demonstrates that IT capability remains valuable in directly improving agility by creating digital options (Sambamurthy et al., 2003; Huang et al., 2012). These findings complement previous arguments on either non-mediated (Lu and Ramamurthy, 2011) or mediated relationships (Lee et al., 2015) between IT and agility.

It was shown that innovative climate facilitates the agility building process by amplifying the positive effect of IT and KM capability. In particular, IT capability can better support KM capability in a highly innovative climate, which echoes the argument that the innovative use and application of technology are necessary to materialize the value of IT (Ke et al., 2012). Moreover, the positive relationship between KM capability and market capitalizing agility is strengthened by innovative climate, which validates the viewpoint that realizing the value of KM activities requires an appropriate climate to motivate employees to contribute their embedded knowledge for firms (Chen et al., 2010).

Interestingly, we did not find evidence for the proposed moderating effect of an innovative climate on the relationship between KM capability and operational adjustment agility. A plausible explanation for such finding is that an innovative climate encourages employees to leverage KM mechanisms to propose disruptive ideas to enhance operations, because creative ideas and open thoughts are appreciated in such a climate (van der Vegt et al., 2005; Chen et al., 2010). However, the disruptive ideas generated in an innovative climate are hardly applied (Oke et al., 2013), because operational adjustment agility focuses on the refinement and incremental improvement of existing business processes (Lu and Ramamurthy, 2011). Therefore, this moderating effect is unsupported.

The results further validated the proposed moderated mediating model, which suggests that the mediating role of KM capability is strengthened by an innovative climate. In a low innovative climate, IT capability is related to agility through the direct approach, as Sambamurthy et al. (2003) suggested. The mediating role of KM capability is significant when the innovative climate is high, which is consistent with the argument of Lee et al. (2015). The finding indicates that KM capability should be jointly developed with innovative climate. The finding also verifies the argument that without an appropriate climate, knowledge resources cannot be effectively leveraged to support organizational processes to create value (Chen et al., 2010).

7. Implications, limitations, and future research

7.1. Theoretical implications

The current study has three theoretical implications for the existing research. First, this study enriches product innovation literature by discussing an important but overlooked topic on how to develop agility to make new products suitable to the current market demand. Although scholars have highlighted the necessity to adjust product innovation to market changes, few have directly presented and investigated the concept of agility in such a context (Richtnér and Löfsten, 2014; Hock et al., 2016). We introduce this concept into product innovation research and describe its role in the up-front planning and execution (Ledwith and O'Dwyer, 2009; Pavlou and El Sawy, 2011). Based on the knowledge-intensive feature of product innovation (Pitt and MacVaugh, 2008), this study identifies and validates the mediating role of KM capability and the moderating role of innovative climate to offer guidance for agile product innovation.

Second, embedded in the context of product innovation, this study contributes to agility research by validating the mediating role of KM capability to solve the inconsistent findings on the relationship between IT capability and agility. IT capability has long been identified as a key influencing factor of agility (Sambamurthy et al., 2003; Tallon and Pinsonneault, 2011), but its effect was recently undermined and questioned by scholars addressing the rigidity and inflexibility created by IT (Lu and Ramamurthy, 2011; Chakravarty et al., 2013; Chae et al., 2014). Based on previous research which highlight the role of knowledge not only in product innovation but also in building agility (Pitt and MacVaugh, 2008; Mao et al., 2016), we incorporate KM capability as the mediating mechanism to offer additional insights to this contradiction. Our study opens up the 'black box' of associating IT capability with organizational agility in the context of product innovation by validating the intermediating role of KM capability (Pavlou and El Sawy, 2006; Luca and Atuahene-Gima, 2007).

Third, this study provides evidence on the contingent role of innovative climate, thereby generating nuanced findings on developing agility in the context of product innovation. Our investigation addresses the climate inside an organization, which affects the effectiveness of the employee's use of IT tools and KM mechanisms (Acur et al., 2010; Ke et al., 2012). Our study compensates the extant literature considering IT flexibility (Tallon and Pinsonneault, 2011), spending (Lu and Ramamurthy, 2011), and environmental dynamism (Chakravarty et al., 2013) as contingencies in the IT–agility relationship. Therefore, we can contribute to the increasing number of evidence in product innovation research regarding the facilitating role of innovative climate (Sung and Choi, 2014). By validating the role of innovative climate, this research further highlights the importance of creative thoughts and behaviors of employees in developing agility. This interplay between IT and KM capability and innovative climate also emphasizes the critical role of employees in effectuating technology usage and knowledge strategy in product innovation (Pitt and MacVaugh, 2008; Acur et al., 2010). Our study reinforces existing assertions on the importance of an innovative climate among employees to achieve the desired outcomes for product innovation success (Oke, 2013).

7.2. Practical implications

Our findings have several major implications for management. First, the results of this study suggest that managers should realize that justifying IT investments based only on the immediate relationship between IT capability and organizational agility is inappropriate. Except for the immediate effect, IT investment may produce high agility if firms leverage their IT capability to achieve superior process-based KM capability.

Second, managers are advised to focus on KM initiatives when building agility as regards product innovation. Currently, a set of IT artifacts and operational processes was established to ensure the speed of developing new products. However, managers still encounter difficulties in determining the appropriate development of products even with efficient responsive mechanisms. KM capability serves as the intellectual pillar for product innovation by providing the content of new products. With a solid knowledge base, firms could respond in an appropriate and innovative way, thereby capturing the opportunities generated by market changes.

Third, the current study cautions product innovation managers to note the critical role of innovative climate in the relationships among IT capability, KM capability, and organizational agility. Managers should adapt their capability deployment to reflect the internal innovative climate. When innovative climate is low, IT capability does not necessarily support KM capability. We also remind managers of the various moderating roles of innovative climate. That is, in the context of product innovation, although encouraging innovative climate effectively transfers KM capability into market capitalizing agility, it is less useful for transferring KM capability into operational adjustment agility.

7.3. Limitations and future research

This study has several limitations that can be addressed in future research. First, we only considered KM capability and innovative climate as the mediator and moderator, respectively. Future studies can extend our model by exploring other mediators or moderators, such as other capabilities, leadership styles, and environmental factors, in the context of product innovation.

Second, we utilized a single respondent as the source of the survey data. Although all the informants were senior executives for product innovation, their perception of the firm's IT capability, KM capability, and organizational agility might not fully reflect reality. Meanwhile, employees and managers may have various understandings of innovative climate. Thus, collecting data from multiple informants could provide strong empirical evidence for the relationships and help reduce the common method bias.

Third, we collected subjective data in the current research. Although subjective perceptual measures are widely validated and have been found to strongly correlate with objective measures, collecting objective data can contribute to a better alignment of perception and reality (Tanriverdi, 2005; Lu and Ramamurthy, 2011; Liu et al., 2016). Therefore, we suggest that future research improve the research design and collect both subjective and objective data to measure IT capability, KM capability, and organizational agility.

Finally, the respondent demographics of this study may limit the generalizability of the findings because the informants were from firms in China. Although China is an ideal representative of an emerging economy, its unique features may cause bias in the result. Hence, future studies should be conducted with samples from more countries and informants with more diverse backgrounds.

Acknowledgements

This work was supported by the National Natural Science Foundation of China (NSFC: 71622009, 71571169, and 71571177); Anhui Natural Science Foundation (1608085MG155).

References

Aboelmaged, M.G. (2014) Linking operations performance to knowledge management capability: the mediating role of innovation performance. *Production Planning and Control*, **25**, 44–58.

Acur, N., Kandemir, D., De Weerd-Nederhof, P.C., and Song, M. (2010) Exploring the impact of technological competence development on speed and NPD program performance. *Journal of Product Innovation Management*, **27**, 915–929.

Aiken, L.S. and Stephen, G. (1991) *Multiple Regression: Testing and Interpreting Interactions*: Newbury Park, CA: Sage.

Alavi, M. and Leidner, D.E. (2001) Review: knowledge management and knowledge management systems: conceptual foundations and research issues. *MIS Quarterly*, **25**, 107–136.

Alexander, A., Vaughn, P., and Tim, W. (2003) Motivation and barriers to participation in virtual knowledge-sharing communities of practice. *Journal of Knowledge Management*, **7**, 64–77.

Anderson, N.R. and West, M.A. (1998) Measuring climate for work group innovation: development and validation of the team climate inventory. *Journal of Organizational Behavior*, **19**, 235–258.

Armstrong, J. and Overton, T. (1977) Estimating nonresponse bias in mail surveys. *Journal of Marketing Research*, **14**, 396–402.

Barczak, G., Sultan, F., and Hultink, E.J. (2007) Determinants of IT usage and new product performance. *Journal of Product Innovation Management*, **24**, 600–613.

Berends, H., Jelinek, M., Reymen, I., and Stultiëns, R. (2014) Product innovation processes in small firms: combining entrepreneurial effectuation and managerial causation. *Journal of Product Innovation Management*, **31**, 616–635.

Bertels, H.M.J., Kleinschmidt, E.J., and Koen, P.A. (2011) Communities of practice versus organizational climate: which one matters more to dispersed collaboration in the front end of innovation? *Journal of Product Innovation Management*, **28**, 757–772.

Bi, R., Davidson, R., Kam, B., and Smyrnios, K. (2013) Developing organizational agility through IT and supply chain capability. *Journal of Global Information Management*, **21**, 38–55.

Bianchi, M., Croce, A., Dell'Era, C., Benedetto, D.C.A., and Frattini, F. (2015) Organizing for inbound open innovation: how external consultants and a dedicated R&D unit influence product innovation performance. *Journal of Product Innovation Management*, **33**, 492–510.

Bock, G.W., Zmud, R.W., Kim, Y.G., and Lee, J.N. (2005) Behavioral intention formation in knowledge sharing: examining the roles of extrinsic motivators, social-psychological forces, and organizational climate. *MIS Quarterly*, **29**, 87–111.

Castellion, G. and Markham, S.K. (2013) Perspective: new product failure rates: influence of argumentum ad populum and self-interest. *Journal of Product Innovation Management*, **30**, 976–979.

Cegarra-Navarro, J.-G., Soto-Acosta, P., and Wensley, A.K.P. (2016) Structured knowledge processes and firm performance: the role of organizational agility. *Journal of Business Research*, **69**, 1544–1549.

Chae, H.-C., Koh, C.E., and Prybutok, V.R. (2014) Information technology capability and firm performance: contradictory findings and their possible causes. *MIS Quarterly*, **38**, 305–326.

Chakravarty, A., Grewal, R., and Sambamurthy, V. (2013) Information technology competencies, organizational agility, and firm performance: enabling and facilitating roles. *Information Systems Research*, **24**, 976–997.

Chang, J.J., Hung, K.P., and Lin, M.J.J. (2014) Knowledge creation and new product performance: the role of creativity. *R&D Management*, **44**, 107–123.

Chen, C.J. and Huang, J.W. (2007) How organizational climate and structure affect knowledge management - the social interaction perspective. *International Journal of Information Management*, **27**, 104–118.
Chen, C.J., Huang, J.W., and Hsiao, Y.C. (2010) Knowledge management and innovativeness: the role of organizational climate and structure. *International Journal of Manpower*, **31**, 848–870.
Chen, Y., Wang, Y., Nevo, S., Jin, J., Wang, L., and Chow, W.S. (2014) IT capability and organizational performance: the roles of business process agility and environmental factors. *European Journal of Information Systems*, **23**, 326–342.
Choi, J.N. (2007) Change-oriented organizational citizenship behavior: effects of work environment characteristics and intervening psychological processes. *Journal of Organizational Behavior*, **28**, 467–484.
Cooper, R.G. and Kleinschmidt, E.J. (2007) Winning businesses in product development: the critical success factors. *Research Technology Management*, **50**, 52–66.
Dai, Y., Roundy, P.T., Chok, J.I., Ding, F., and Byun, G. (2016) 'Who knows what?' In new venture teams: transactive memory systems as a micro-foundation of entrepreneurial orientation. *Journal of Management Studies*, **53**, 1320–1347.
Darroch, J. (2005) Knowledge management, innovation and firm performance. *Journal of Knowledge Management*, **9**, 101–115.
Dormann, C.F., Elith, J., Bacher, S., Buchmann, C., Carl, G., Carré, G., Marquéz, J.R.G., Gruber, B., Lafourcade, B., and Leitão, P.J. (2013) Collinearity: a review of methods to deal with it and a simulation study evaluating their performance. *Ecography*, **36**, 27–46.
Drnevich, P.L. and Croson, D.C. (2013) Information technology and business-level strategy: toward an integrated theoretical perspective. *MIS Quarterly*, **37**, 483–509.
Durmuşoğlu, S.S. (2013) Merits of task advice during new product development: network centrality antecedents and new product outcomes of knowledge richness and knowledge quality. *Journal of Product Innovation Management*, **30**, 487–499.
Durmuşoğlu, S.S. and Barczak, G. (2011) The use of information technology tools in new product development phases: analysis of effects on new product innovativeness, quality, and market performance. *Industrial Marketing Management*, **40**, 321–330.
Fornell, C. and Larcker, D.F. (1981) Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, **18**, 38–50.
Gaubinger, K., Rabl, M., Swan, S., and Werani, T. (2015) Corporate success through market driven innovation. In *Innovation and Product Management*. Berlin Heidelberg: Springer. pp. 3–25. Available from http://www.springer.com/gp/book/9783642543753?wt_mc=ThirdParty.SpringerLink.3.EPR653.About_eBook
Gold, A.H., Malhotra, A., and Segars, A.H. (2001) Knowledge management: an organizational capabilities perspective. *Journal of Management Information Systems*, **18**, 185–214.
Gong, Y., Kim, T.-Y., Zhu, J., and Lee, D.R. (2013) A multilevel model of team goal orientation, information exchange, and creativity. *Academy of Management Journal*, **56**, 827–851.
Grant, R.M. (1996a) Prospering in dynamically-competitive environments: organizational capability as knowledge integration. *Organization Science*, **7**, 375–387.
Grant, R.M. (1996b) Toward a knowledge-based theory of the firm. *Strategic Management Journal*, **17**, 109–122.
Hock, M., Clauss, T., and Schulz, E. (2016) The impact of organizational culture on a firm's capability to innovate the business model. *R&D Management*, **46**, 433–450.
Hsieh, J.P.-A. and Wang, W. (2007) Explaining employees' extended use of complex information systems. *European Journal of Information Systems*, **16**, 216–227.
Huang, P.Y., Ouyang, T.H., Pan, S.L., and Chou, T.C. (2012) The role of IT in achieving operational agility: a case study of Haier, China. *International Journal of Information Management*, **32**, 294–298.
Huang, Q., Liu, H., and Zhong, X. (2013) The impact of transactive memory systems on team performance. *Information Technology & People*, **26**, 191–212.
Huber, G.P. (1991) Organizational learning: the contributing processes and the literatures. *Organization Science*, **2**, 88–115.
Inkpen, A.C. and Tsang, E.W.K. (2005) Social capital, networks, and knowledge transfer. *Academy of Management Review*, **30**, 146–165.
Jalonen, H. (2011) The uncertainty of innovation: a systematic review of the literature. *Journal of Management Research*, **4**, E12.
Jasperson, J.S., Carter, P.E., and Zmud, R.W. (2005) A comprehensive conceptualization of post-adoptive behaviors associated with information technology enabled work systems. *MIS Quarterly*, **29**, 525–557.
Kahn, K.B., Barczak, G., Nicholas, J., Ledwith, A., and Perks, H. (2012) An examination of new product development best practice. *Journal of Product Innovation Management*, **29**, 180–192.
Kandemir, D. and Acur, N. (2012) Examining proactive strategic decision-making flexibility in new product development. *Journal of Product Innovation Management*, **29**, 608–622.
Kang, J.H., Solomon, G.T., and Choi, D.Y. (2015) CEOs' Leadership styles and managers' Innovative behaviour: investigation of intervening effects in an entrepreneurial context. *Journal of Management Studies*, **52**, 531–554.
Ke, W., Tan, C.-H., Sia, C.-L., and Wei, K.-K. (2012) Inducing intrinsic motivation to explore the enterprise system: the supremacy of organizational levers. *Journal of Management Information Systems*, **29**, 257–290.
Kim, H.-W. and Kankanhalli, A. (2009) Investigating user resistance to information systems implementation: a status quo bias perspective. *MIS Quarterly*, **33**, 567–582.
Kim, N., Im, S., and Slater, S.F. (2013) Impact of knowledge type and strategic orientation on new product

creativity and advantage in high-technology firms. *Journal of Product Innovation Management*, **30**, 136–153.

von Krogh, G. (2012) How does social software change knowledge management? Toward a strategic research agenda. *The Journal of Strategic Information Systems*, **21**, 154–164.

Ledwith, A. and O'Dwyer, M. (2009) Market orientation, NPD performance, and organizational performance in small firms. *Journal of Product Innovation Management*, **26**, 652–661.

Lee, H. and Choi, B. (2003) Knowledge management enablers, processes, and organizational performance: an integrative view and empirical examination. *Journal of Management Information Systems*, **20**, 179–228.

Lee, O.-K., Sambamurthy, V., Lim, K.H., and Wei, K.K. (2015) How does IT ambidexterity impact organizational agility?. *Information Systems Research*, **26**, 398–417.

Li, Y., Li, X., Liu, Y., and Barnes, B.R. (2011) Knowledge communication, exploitation and endogenous innovation: the moderating effects of internal controls in SMEs. *R&D Management*, **41**, 156–172.

Liang, H., Peng, Z., Xue, Y., Guo, X., and Wang, N. (2015) Employees' exploration of complex systems: an integrative view. *Journal of Management Information Systems*, **32**, 322–357.

Liu, H., Wei, S., Ke, W., Wei, K.K., and Hua, Z. (2016) The configuration between supply chain integration and information technology competency: a resource orchestration perspective. *Journal of Operations Management*, **44**, 13–29.

Liu, S. and Deng, Z. (2015) Understanding knowledge management capability in business process outsourcing: a cluster analysis. *Management Decision*, **53**, 124–138.

Lu, Y. and Ramamurthy, K. (2011) Understanding the link between information technology capability and organizational agility: an empirical examination. *MIS Quarterly*, **35**, 931–954.

Luca, L.M.D. and Atuahene-Gima, K. (2007) Market knowledge dimensions and cross-functional collaboration: examining the different routes to product innovation performance. *Journal of Marketing*, **71**, 95–112.

Mabey, C., Wong, A.L.Y., and Hsieh, L. (2015) Knowledge exchange in networked organizations: does place matter?. *R&D Management*, **45**, 487–500.

MacKinnon, D.P., Lockwood, C.M., and Williams, J. (2004) Confidence limits for the indirect effect: distribution of the product and resampling methods. *Multivariate Behavioral Research*, **39**, 99–128.

Mao, H., Liu, S., and Zhang, J. (2015) How the effects of IT and knowledge capability on organizational agility are contingent on environmental uncertainty and information intensity. *Information Development*, **31**, 358–382.

Mao, H., Liu, S., Zhang, J., and Deng, Z. (2016) Information technology resource, knowledge management capability, and competitive advantage: the moderating role of resource commitment. *International Journal of Information Management*, **36**, 1062–1074.

Marion, T.J., Dunlap, D.R., and Friar, J.H. (2012) The university entrepreneur: a census and survey of attributes and outcomes. *R&D Management*, **42**, 401–419.

Mehta, N., Hall, D., and Byrd, T. (2014) Information technology and knowledge in software development teams: the role of project uncertainty. *Information & Management*, **51**, 417–429.

Miranda, S.M., Lee, J.-N., and Lee, J.-H. (2011) Stocks and flows underlying organizations' knowledge management capability: synergistic versus contingent complementarities over time. *Information & Management*, **48**, 382–392.

Najafi Tavani, S., Sharifi, H., and S. Ismail, H. (2013) A study of contingency relationships between supplier involvement, absorptive capacity and agile product innovation. *International Journal of Operations & Production Management*, **34**, 65–92.

Nambisan, S. (2003) Information systems as a reference discipline for new product development. *MIS Quarterly*, **27**, 1–18.

Nonaka, I. and Toyama, R. (2003) The knowledge-creating theory revisited: knowledge creation as a synthesizing process. *Knowledge Management Research & Practice*, **1**, 2–10.

Oke, A. (2013) Linking manufacturing flexibility to innovation performance in manufacturing plants. *International Journal of Production Economics*, **143**, 242–247.

Oke, A., Prajogo, D.I., and Jayaram, J. (2013) Strengthening the innovation chain: the role of internal innovation climate and strategic relationships with supply chain partners. *Journal of Supply Chain Management*, **49**, 43–58.

Overby, E., Bharadwaj, A., and Sambamurthy, V. (2006) Enterprise agility and the enabling role of information technology. *European Journal of Information Systems*, **15**, 120–131.

Parry, M.E., Song, M., Weerd-Nederhof, D., Petra, C., and Visscher, K. (2009) The impact of NPD strategy, product strategy, and NPD processes on perceived cycle time. *Journal of Product Innovation Management*, **26**, 627–639.

Paulraj, A., Lado, A.A., and Chen, I.J. (2008) Inter-organizational communication as a relational competency: antecedents and performance outcomes in collaborative buyer-supplier relationships. *Journal of Operations Management*, **26**, 45–64.

Pavlou, P.A. and El Sawy, O.A. (2006) From IT leveraging competence to competitive advantage in turbulent environments: the case of new product development. *Information Systems Research*, **17**, 198–227.

Pavlou, P.A. and El Sawy, O.A. (2011) Understanding the elusive black box of dynamic capabilities. *Decision Sciences*, **42**, 239–273.

Pedro, S.-A. and Juan-Gabriel, C.-N. (2016) New ICTs for knowledge management in organizations. *Journal of Knowledge Management*, **20**, 417–422.

Pitt, M. and MacVaugh, J. (2008) Knowledge management for new product development. *Journal of Knowledge Management*, **12**, 101–116.

Preacher, K.J., Rucker, D.D., and Hayes, A.F. (2007) Addressing moderated mediation hypotheses: theory, methods, and prescriptions. *Multivariate Behavioral Research*, **42**, 185–227.

Rai, A., Patnayakuni, R., and Seth, N. (2006) Firm performance impacts of digitally enabled supply chain integration capabilities. *MIS Quarterly*, **30**, 225–246.

Rawassizadeh, R., Price, B.A., and Petre, M. (2015) Wearables: has the age of smartwatches finally arrived? *Communications of the ACM*, **58**, 45–47.

Rettig, C. (2007) The trouble with enterprise software. *MIT Sloan Management Review*, **49**, 21–27.

Richtnér, A. and Löfsten, H. (2014) Managing in turbulence: how the capacity for resilience influences creativity. *R&D Management*, **44**, 137–151.

Roberts, N., Galluch, P.S., Dinger, M., and Grover, V. (2012) Absorptive capacity and information systems research: review, synthesis, and directions for future research. *MIS Quarterly*, **36**, 625–648.

Roberts, N. and Grover, V. (2012) Leveraging information technology infrastructure to facilitate a firm's customer agility and competitive activity: an empirical investigation. *Journal of Management Information Systems*, **28**, 231–269.

Sambamurthy, V., Bharadwaj, A., and Grover, V. (2003) Shaping agility through digital options: reconceptualizing the role of information technology in contemporary firms. *MIS Quarterly*, **27**, 237–263.

Sandhawalia, B.S. and Dalcher, D. (2011) Developing knowledge management capabilities: a structured approach. *Journal of Knowledge Management*, **15**, 313–328.

Seo, D. and La Paz, A.I. (2008) Exploring the dark side of IS in achieving organizational agility. *Communications of the ACM*, **51**, 136–139.

Seo, D.B., La Paz, A.I., and Miranda, J. (2014) Information systems for organizational agility: action research on resource scheduling at the Universidad de Chile. *Asia Pacific Journal of Information Systems*, **24**, 417–441.

Sher, P.J. and Lee, V.C. (2004) Information technology as a facilitator for enhancing dynamic capabilities through knowledge management. *Information & Management*, **41**, 933–945.

Shin, H., Lee, J.N., Kim, D., and Rhim, H. (2015) Strategic agility of Korean small and medium enterprises and its influence on operational and firm performance. *International Journal of Production Economics*, **168**, 181–196.

Smith, K.G., Collins, C.J., and Clark, K.D. (2005) Existing knowledge, knowledge creation capability, and the rate of new product introduction in high-technology firms. *Academy of Management Journal*, **48**, 346–357.

Song, M., Bij, H., and Weggeman, M. (2006) Factors for improving the level of knowledge generation in new product development. *R&D Management*, **36**, 173–187.

Sultan, N. (2013) Knowledge management in the age of cloud computing and Web 2.0: experiencing the power of disruptive innovations. *International Journal of Information Management*, **33**, 160–165.

Sung, S.Y. and Choi, J.N. (2014) Do organizations spend wisely on employees? Effects of training and development investments on learning and innovation in organizations. *Journal of Organizational Behavior*, **35**, 393–412.

Swink, M. and Song, M. (2007) Effects of marketing-manufacturing integration on new product development time and competitive advantage. *Journal of Operations Management*, **25**, 203–217.

Tallon, P.P. (2008) Inside the adaptive enterprise: an information technology capabilities perspective on business process agility. *Information Technology & Management*, **9**, 21–36.

Tallon, P.P. and Pinsonneault, A. (2011) Competing perspectives on the link between strategic information technology alignment and organizational agility: insights from a mediation model. *MIS Quarterly*, **35**, 463–486.

Tanriverdi, H. (2005) Information technology relatedness, knowledge management capability, and performance of multibusiness firms. *MIS Quarterly*, **29**, 311–334.

Teece, D.J., Pisano, G., and Shuen, A. (1997) Dynamic capabilities and strategic management. *Strategic Management Journal*, **18**, 509–533.

Tippins, M.J. and Sohi, R.S. (2003) IT competency and firm performance: is organizational learning a missing link?. *Strategic Management Journal*, **24**, 745–761.

van der Vegt, G.S., Van de, V., E., and Huang, X. (2005) Location-level links between diversity and innovative climate depend on national power distance. *Academy of Management Journal*, **48**, 1171–1182.

Van de Vijver, F.J. and Leung, K. (1997) *Methods and Data Analysis for Cross-Cultural Research*. Volume **1**. Sage.

Wang, P. and Rode, J.C. (2010) Transformational leadership and follower creativity: the moderating effects of identification with leader and organizational climate. *Human Relations*, **63**, 1105–1128.

Wang, Z., Pan, S.L., Ouyang, T.H., and Chou, T.C. (2014) Achieving IT-enabled enterprise agility in China: an IT organizational identity perspective. *IEEE Transactions on Engineering Management*, **61**, 182–195.

Wong, W.P. and Wong, K.Y. (2011) Supply chain management, knowledge management capability, and their linkages towards firm performance. *Business Process Management Journal*, **17**, 940–964.

Zhao Cai is a Post-Doctoral Fellow in the School of Management at University of Science and Technology of China. His interest covers organizational agility, IT value creation, and interfirm relationships. He has published papers in International Journal of Operations and Production Management, International Journal of Information Management, Information Technology for Development, and in some academic conferences such as ICIS, PACIS, and HICSS.

Hefu Liu is a Professor in the School of Management at University of Science and Technology of China. He earned his PhD degree with the University of Science and Technology of China and City University of Hong Kong. He has published in Journal of

Operations Management, Decision Support Systems, International Journal of Productions Research, International Journal of Operations and Production Management, Information Technology and People, and in the academic conference ICIS, PACIS and AMCIS.

Qian Huang is an Associate Professor in the School of Management at University of Science and Technology of China. She obtained her PhD from USTC and City University of Hong Kong. Her research focuses on knowledge management and E-commerce. She has published papers in the Information Systems Journal, Asia Pacific Journal of Management, and Journal of Global Information Management.

Liang Liang is a Professor in the School of Management at Hefei University of Technology. He earned his PhD degree from Southeast University. His research focuses on decision analysis and supply chain management. He has published in Operations Research, Journal of Operations Management, IEEE Tran. On SMC, OMEGA, IIE Transactions, and Naval Research Logistics.

Supporting information

Additional Supporting Information may be found online version of this article at the publisher's website.

Appendix A. Illustrative literature review of research concerning the relationship between IT capability and organizational agility.
Appendix B. Items in the questionnaire.
Appendix C. Common method bias test.
Appendix D. Robustness check.

