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Competitor Intelligence and Product Innovation: The Role of Open-Mindedness and Inter-Functional Coordination

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Abstract—Drawing on the central theme of open innovation and the inbound flow of knowledge for improving a firm's innovation performance, this research investigates the application of external knowledge (i.e., competitor intelligence) in product innovation through the mediators of inter-functional coordination and open-mindedness. We examine the joint moderating effect of environmental uncertainty on results obtained from survey data involving 284 executives from Chinese IT SMEs. Our results reveal that competitor intelligence has a positive and direct effect on product innovation, and that relationships can be further strengthened by inter-functional coordination and open-mindedness. In testing their interaction with dynamic external environments, we found that the level of environmental uncertainty interacts positively with open-mindedness, but negatively with the effect of inter-functional coordination on product innovation. We conclude that by building openly-innovative and knowledge sharing culture, SME managers can improve their product innovation performance by obtaining and processing external knowledge relating to competitors. This study contributes to the open innovation literature, advancing understanding of the inflow of external knowledge for innovative output and, more importantly, sheds light on the research of open innovation practices in SMEs from emerging economies.

Index Terms—Open Innovation; Competitor Intelligence; Inter-Functional Coordination; Open-Mindedness; Environmental Uncertainty.

Managerial Relevance

This research offers important insights and implications for strategic decision-makers and professionals responsible for collecting market intelligence to evaluate the market competition of SMEs. The results of this research confirm the importance of competitor intelligence on a firm's innovative product development. We encourage SME leaders to pay greater attention to generating and processing competitor-related information. This requires management teams to build effective intelligence systems that can screen and learn more about competitor behaviors and future directions. Such a process should integrate with a learning environment that reflects a firm's vision and mission at an operational level. Building a sharing, inter-functional, and open-minded organizational culture ensures inflows of external knowledge for internal application, but this can also be a challenging task for SMEs. Thus, firms need to provide necessary training to develop beliefs and learning routines to support the collection and processing of externally-sourced knowledge. Our research reveals an interactive effect from the external environment, suggesting that when external markets become increasingly unpredictable, SME managers should promote an open-minded culture to enhance the exploitation of competitor intelligence for product innovation.

I. INTRODUCTION

Open innovation refers to the application of external knowledge, through internal and external pathways, whether pecuniary or non-pecuniary, to enhance innovative output for the market [1], [2]. The process of open innovation involves recognizing and transferring new ideas for potential commercial success, which encompasses a range of practices including innovative product development [3], [4]. Open innovation sheds light on a firm's innovation achievement through managing external knowledge inflows and outflows and encourages firms to explore a variety of external sources for generating novel ideas to supplement innovation development [5].

Previous research has identified several external sources to complement innovation, such as customers, competitors, suppliers and other market participants [4], [6]. In contrast to the well-developed research on customer and market information for product innovation, studies on how a firm generates competitor intelligence for innovative output have largely been neglected [7]. In general, competitor intelligence research is often linked with that centered on competitive intelligence [8] while, over time, research attention has evolved from early environmental scanning to competitive intelligence collection and dissemination for strategic decision optimization [9], [10]. Existing research points out that competitor analysis is a relatively weak business practice requires further enhancement. For instance, according to Gilad [11], approximately 55% of companies disappear from the *Fortune 500* list each year, partially due to failure to assess the role of competitors in the market. Thus, it is vital to obtain competitor knowledge in order to sustain a business in an increasingly competitive market [10]. Existing literature on open innovation and competitive intelligence reveals some gaps for further exploration. Most studies concern information collection techniques of a descriptive nature, followed by case-based research from large, multi-national organizations in advanced markets [12]. Limited research has provided empirical evidence on a large-scale quantitative basis to support the inflow of external knowledge to improve business performance [10], [13], especially from the perspectives of Small and Medium-sized Enterprises (SMEs) in emerging markets [6], [14], [15]. In fact, SMEs are increasingly practicing open innovation activities [15]-[17], and in the face of scarce resources and limited capability, open innovation creates a new learning paradigm for SMEs to innovate [18].

The importance of understanding how firms process external knowledge for innovation development is well-established [19], [20], but little is understood about how specific external knowledge (i.e., competitor intelligence) contributes to their product innovation [21], or whether the unique culture and high levels of environmental uncertainty in an emerging market

affect the process of knowledge implementation [15]. Thus, the overarching research question of ‘how do SMEs from emerging markets exploit competitor intelligence for their innovative performance?’ requires further exploration.

Under the umbrella of open innovation theory, this study examines the application of external knowledge for innovation development by SMEs from the emerging market. Scholars have acknowledged that the implementation of open innovation is accompanied by changes in organizational culture, as the inflow of knowledge requires increased learning and sharing of the internal environment [23]. Although literature has addressed the importance of organizational culture as an antecedent of product innovation [24], studies that explicitly concern the mediating role of internal culture, between competitor intelligence and product innovation are still scarce. This research proposes that competitor intelligence can facilitate product innovation by encouraging an organization to be more open-minded and inter-functionally coordinated. Both open-mindedness and inter-functional coordination reflect an internal learning and sharing ideology and value, which helps develop a foundation to integrate external knowledge, and achieve the creation of new knowledge and output [6], [23]. Our proposed research framework (see Fig. 1) illustrates the transformation of competitor information into product innovation.

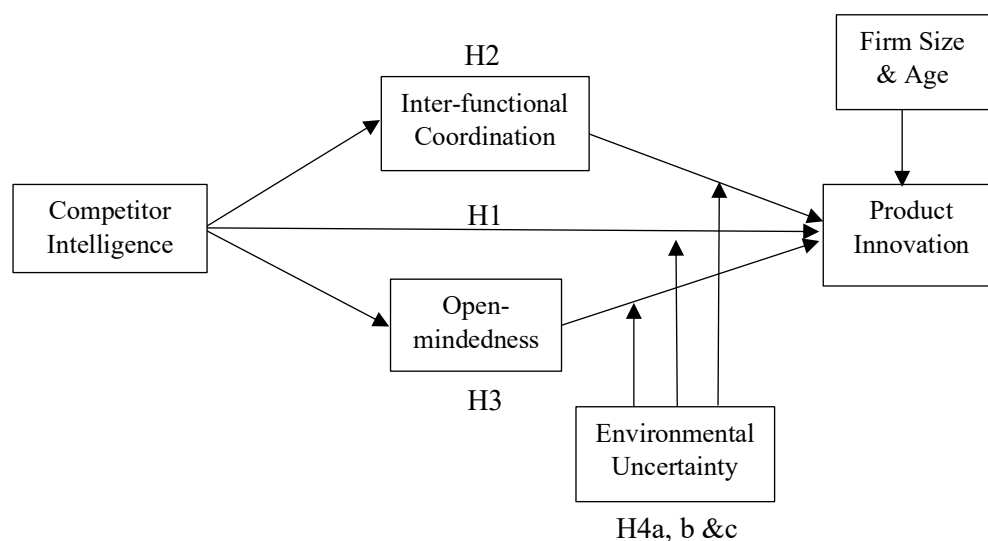


Fig. 1. Proposed Research Framework

The contributions of this research are threefold. First, we develop an integrative framework that outlines a direct effect of generating competitor specific knowledge for innovative product development. This is a field of knowledge that has not been extensively explored in the existing literature [13]. Second, this study enriches open innovation literature by delineating the mediating role of an organization's open-mindedness and inter-functional coordination on the effect of competitor intelligence and product innovation, suggesting that creating and sustaining an open and sharing organizational environment has a significant impact on product innovation. Third, we illustrate how the external market environment interacts with the application of external knowledge on product innovation, responding to the call for more studies on SMEs from emerging markets [15]. These contributions are accomplished through the collection of survey data from Chinese SMEs within the Information Technology (IT) industry. Finally, we provide an interesting and thought-provoking discussion on the intelligence function in businesses and outline a series of managerial implications. Importantly, our findings suggest that organizations should actively engage in generating external knowledge (i.e., competitor information) for innovative product development, along with cultivating a sharing and learning working culture to ensure that maximum advantage is gained through this external knowledge. This research should, therefore, be of interest to management and strategy researchers and professionals, responsible for market intelligence, and others who are concerned with the evaluation of market competition.

II. LITERATURE REVIEW

A. Open innovation

Open innovation is defined as “the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively” [2, p.1]. Existing studies have outlined two modes relating to the flow of ideas: inbound and outbound open innovation [3], [15]. The ‘inbound’ or ‘outside-in’ approach

welcomes external knowledge and ideas to complement and support a firm's innovation process [26], while an 'outbound' or 'inside-out' approach allows internal ideas and knowledge to flow outside the organizational boundaries of a firm and combine with external pathways to innovation exploitation opportunities [3], [4]. Both inbound and outbound open innovation approaches have significant influence on a firm's business performance by broadening knowledge bases and generating business opportunities [25]. Fu et al. [27] found that outbound open innovation has a positive impact whilst inbound open innovation has an inverted U-shaped curvilinear relationship on a firm's long-run performance. Other scholars have pointed out the importance of engaging with external knowledge sources for open innovation activities, such as network embeddedness [28], idea generation from external partners [29], and market engagement with customers [30]. Despite the aforementioned studies, there has been limited research that specifically focuses on how the knowledge captured through inbound open innovation is translated into innovative output.

The inbound open innovation practices allow firms to access and profit from external information, thus to improve firms' innovative outputs and gain competitiveness (Huizingh 2011; Spithoven, Vanhaverbeke, and Roijakkers 2013). It involves the acquisition of cross-boundary knowledge and the utilization of knowledge through the innovation value chain [23], [31]. The acquisition of cross-boundary knowledge concerns knowledge inflows from outside-in, encompassing actions in exploring and acquiring diverse external sources to supplement the internal knowledge pool. The sources of external knowledge that inflows into the firm are well-defined (Hannigan et al., 2018), including market-based sources of customers, suppliers and competitors; science-based sources of specific research organizations, universities; and other upstream and/or downstream contractors to provide progressive technological information, innovative idea and market insights [5], [6], [32]. From a knowledge inflow perspective, competitor information is one of the most essential external sources offering insightful

innovation ideas [19], [33]; however, study on the process of acquiring and assimilating competitor intelligence is often neglected in the literature [7].

The utilization of knowledge can be harnessed in various innovation efforts, such as the innovativeness of a new product and/or service, and the improvement of existing products and productivity [5], [20], [34]. Existing literature reveals a positive effect of inbound open innovation practice on a firm's innovative output, and further research is encouraged to verify such effect within an open context (Hochleitner et al, 2017). Following research focused on innovative output, a contemporary theme in the inbound open innovation literature has been – how the inflows of external knowledge contributes to the innovative performance of a firm [Huizingh, 2011; Hochleitner et al., 2017]. Based on the theory of open innovation, we address product innovation as an aspect of innovative output which shows a firm's ability to produce unique, challenging and innovative products in the market. We decompose the inbound open innovation activities by centering on the inflow of external knowledge (i.e. competitor intelligence) and its impact on product innovation. We aim to relate the inbound open innovation practice with the mediating effect of an open and sharing internal culture, and the interaction with external environments.

B. Competitor intelligence and product innovation

Intelligence terminology originated from the military field, which suggests that firms use a warlike approach to fight for the same or similar resources, occupying the same market territory [36]. Intelligence generation and applications are not new to the business world, but academic interest in the application of business intelligence for competitive analysis has only grown recently [13]. In order to build a business intelligence system, companies must scan the external environment to understand their market rivals' vision and mission, along with their strengths and weaknesses. The pursuit of competitor intelligence was first acknowledged by Porter [37] in his seminal work on emplacing, monitoring and analyzing specific competitor behavior as

part of competitive strategy [22]. The literature studies on competitor intelligence have been immersed in the competitive intelligence realm, which is also linked to the strategy field, to bridge internal strategies and external competition in the marketplace.

In the business domain, competitors are defined as companies that sell similar products in an identical market, have similar objectives in the areas of profit and business growth [9] and are often referred to as direct competitors. A broader concept of competitors includes indirect competitors from different industries with different approaches to business [22], [38]. Competitor intelligence focuses on analyzing a firm's direct and indirect competitors, and is 'the output of a systematic and legal process of the gathering and analyzing of information about the current and potential competitors of a business' [38, p.3]. A competitor-oriented firm has a good scrutiny system to learn its own strengths and weaknesses, and has sufficient resources, capacity and strategies to manage and project current and potential competitors' actions [33], [39].

Literature has addressed the contribution of competitor intelligence to improve business performance [38], [40], and it is clear that competitor knowledge is one of the essential sources for innovative product development. However, empirical studies investigating the contribution of competitor intelligence to product innovation are limited [13], [21]. Competitor intelligence collects various pieces of market information, including competitors' actions, intentions and changing behavior; comparative market information of price, service, advertising and copycat production; market trends, business opportunities and threats; and technological involvement [22], [38]. During the process of product innovation, these information types provide market insight, facilitate the reduction of risk associated with innovation, and feed novel ideas into the creation of new products for existing and new markets [8], [22], [41].

In the application of competitor intelligence in the business world, research has found that the level of awareness is relatively low, as most managers employ competitor intelligence activities

at a tactical level rather than at a strategic level [41]. An effective competitor intelligence system is particularly important for firms, especially SMEs, as it provides innovative ideas, improving financial performance and the likelihood of survival [22]. Given the increasing competition in the industrial environment, it is essential that the SME managers harness their abilities and focus their attention on competitive analysis. Taken together, competitor intelligence helps SMEs address the external sources of knowledge inflow to enrich their knowledge pool for product innovation. We thus propose our first hypothesis:

H1. Generating competitor intelligence has a positive and direct effect on a firm's product innovation development.

C. Indirect links between competitor intelligence and product innovation: open-mindedness and inter-functional coordination

Although competitor intelligence can enhance product innovation by providing valuable innovative ideas about products and technology, such direct effect does not imply an empirically conclusive result. The literature suggests that the intervention of other variables facilitate the transaction of competitor and market information to develop innovative performance [42]. Organizational culture, as an internal context, is regarded as an important variable to apply leverage on the transaction of external knowledge [43] and further aid the implementation of open innovation practice [23], [31]. Developing an appropriate internal culture helps to form successful interaction with the external environment and ensures successful knowledge inflows by applying and transferring appropriate resources for innovation practice [44]. Therefore, an organizational culture potentially acts as a mediator to aid the inflow of external knowledge for innovative output [23].

Existing literature on open innovation has explored the mediating role of organizational culture in terms of organizational learning orientation and knowledge-sharing [23], [26], suggesting that an open-minded and shared vision in the internal learning culture plays a critical role in facilitating the transaction of external knowledge for innovation development [23], [45]. In this study, we propose the mediating roles of a firm's inter-functional coordination and open-mindedness to promote the application of competitor intelligence for product innovation.

1) Mediating role of inter-functional coordination

Inter-functional coordination is a mechanism that is defined as managing, integrating and collaborating activities between different functional units within an organization [33]. It is a process that involves exchanging information, along with linking and aligning a series of departmental activities and actions to achieve a unified goal [46]. Inter-functional coordination is one of the most important factors in the development of a sharing, open and learning internal culture.

The relationship between competitor intelligence and inter-functional coordination is positive and correlated. Competitor intelligence allows two-way interaction between the internal and external environment, enables firms to take the initiative and endeavor to bring different functions together [22]. Coordination between departments has proved to be an invaluable asset in the formation of organizational intelligence [46]. It also ensures a firm's internal collaboration and a cohesive communication network. Inter-functional coordination aims to satisfy the benefits of an organization as a whole, accommodating different interests and conflicting perspectives within departments for the sake of a common goal [47]. Competitor-related information collected from external sources can be varied, and to consume such information effectively is not an easy job; it requires a high level of understanding, coordination and breaking down of barriers to achieve it. It is possible that each functional unit within an organization has developed a different internal system with different goals and

priorities. Hence a high level of coordination is needed to regulate the objectives, overcome impediments to communication and unify communication methods throughout the organization [48]. Thus, competitor intelligence promotes a firm's inter-functional coordination.

Inter-functional coordination, in turn, facilitates the application of product innovation. Previous research emphasizes the importance of inter-functional coordination for new product development processes [49]. For instance, to provide high-quality service and effectively meet customers' needs, different functional units (e.g. marketing, R&D and manufacturing) have to foster inter-functional coordination capability, align operational objectives and build a common language to communicate effectively [48], [49]. Inter-functional coordination helps in the formation of an effective and efficient information-sharing system to ensure intra-organizational knowledge-sharing, allowing firms to reassess past decision strategies and implementation activities [32]. The literature reveals that heightened inter-functional coordination helps to improve a firm's performance [50], but limited studies have explored the application of inter-functional coordination in the relationship of competitor intelligence and product innovation, especially in the context of SMEs. In order to successfully implement the competitor intelligence needed for product innovation, effective coordination across different functions can help to decompose competitor information, and to integrate and develop competitor knowledge for innovative outputs. We thus propose the following hypothesis:

H2. Inter-functional coordination mediates the positive effect of competitor intelligence on product innovation.

2) Mediating role of open-mindedness

Open-mindedness is defined as ‘questioning traditional ways of viewing market information and seeking new ways of looking at market phenomena’ [51, p.92]. It refers to the notion of unlearning, denoting a firm constantly questioning existing values, beliefs and assumptions, and engaging in absorbing new knowledge and ideas [52]. Being open-minded is one of the essential components of learning orientation [53]. A successful learning culture facilitates an organization’s behavioral changes, reflects the ability to absorb external knowledge, and willingness to address and challenge existing norms - to ‘think outside of the box’ [52], [54]. Thus, an open-minded organization encourages employees to be vigorous, open and curious about new knowledge, actively exploiting external sources for the generation of innovative ideas, which, in turn, helps the organization to achieve better performance and greater competitiveness [55].

External knowledge, in the form of competitor intelligence, is expected to motivate firms to have an open mind-set. External knowledge stimulates a firm’s desire to interact with external sources to obtain useful information, and advocates a working environment shaped by a sharing, open and learning oriented mind-set. When an open-minded internal culture is developed, it potentially taps into knowledge that is foreign to the company. Competitor intelligence is the process of recognizing, acquiring and transferring competitor information internally; and knowledge relating to competitors’ behavior, market information and trends, business opportunities, technological development and challenges is collected to supplement the firm’s intelligence system [22], [38]. This process is further enhanced by having an effective learning culture. Competitor intelligence provides opportunities for a firm to exploit different resources, motivating employees to interact with the newly-obtained information, and further advocating a sharing and open-minded working environment. Thus, generating external knowledge such as competitor intelligence inspires a firm to form an open mind-set.

Open mindedness, in turn, can facilitate product innovation. Creating and sustaining an open-minded environment requires the management team to develop a strong learning culture which shares and translates the organization's vision and mission across different functions [56]. Existing literature has proved a positive relationship between learning orientation and a firm's product innovation performance [34], [57], open-mindedness, as one of the key factors in learning orientation, playing an important role in affecting innovation efficiency and efficacy [55]. An open-minded firm tends to take advantage of valuable external information and use it to respond to any underlying challenges. An open-minded learning culture also prompts employees to keep updated with possible opportunities to coordinate resources for innovation. As such, firms with high levels of open-mindedness welcome contradictions and conflict, converting challenges into opportunities for performance development [23]. These attributes help to support innovation development; hence open-mindedness promotes product innovation. The quality of being open-minded is essential in the process of generating external knowledge for internal application, which helps to reinforce a firm's desire and ability to generate external knowledge [54]. An open-minded organization, including SMEs, is more likely to devote resources and support systems to facilitate knowledge acquisition and sharing, develop processes associated with an intelligence system, and further enhance their employees to utilize new knowledge for new product development [34], [57]. Thus, we propose the following hypothesis:

H3. An organization's open-mindedness mediates the positive effect of competitor intelligence on product innovation.

D. Moderating role of environmental uncertainty

The concept of environmental uncertainty remains germane to contemporary market competition, and continuously attracts academics' attention on the firm-environmental interface [58], [59]. Environmental uncertainty describes the external environment changes in '*competition, deregulation, isomorphism, resource scarcity, and customer demands*' [60, p652], and plays a significant role in product innovation development [59]. Rich empirical evidence shows that environmental uncertainty has a major effect on almost any type of managerial planning and control, including management practices, capabilities development, decision-making and innovative performance [59], [61]. Thus, more research is encouraged to explore the moderating role of the dynamic external environment on the effect of certain causal relationships [62], especially in the resource-constrained SME context.

A dynamic external environment reflects fluctuating market demand, an unstable buyer-supplier relationship, variations in customer preference and changing pricing and technologies [63], which ultimately affect a firm's market behavior and business activities. In a stable environment, firms tend to focus on applying the existing knowledge relating to markets and technologies, along with developing existing capabilities to satisfy current customer demands [25]. When the external environment becomes unpredictable and volatile, firms encounter numerous unforeseen changes, and existing technological knowledge and products soon become obsolete [64]. Simultaneously, firms exploit external knowledge and opportunities across boundaries to sustain their competitiveness [65]. Competitor intelligence plays a crucial role for a firm to capture market trends and any behavioral changes among competitors [38]. By acquiring and assimilating competitor information, firms can actively adjust their existing knowledge according to turbulent market conditions and may implement intelligence benefits to pioneer innovative products and satisfy customer needs [8].

The level of external uncertainty determines a firm's purpose in collecting external knowledge [66]. In particular, a dynamic and uncertain market environment significantly influences SME

activities in obtaining and absorbing external knowledge (i.e., competitor intelligence) for product innovation [67]. We propose that the effect of competitor intelligence on product innovation is more likely to be amplified in a high level of environmental uncertainty, thus, we hypothesize that:

H4a. Environmental uncertainty positively moderates the relationship between competitor intelligence and product innovation.

In this research, a high level of inter-functional coordination promotes and transforms a firm's vision and ideas, but also requires more effort in the context of managerial implication by bringing different functional units with different resources and mind-sets together with a common goal [32]. The availability of resources differs across units, making it difficult for firms to find a pathway to implement external knowledge effectively and efficiently. This situation is even more challenging in the SME context. Turbulent and fluctuating market environments lead to a significant amount of changing information, which requires more intense inter-functional coordination, and ultimately means that resources and costs are higher than they would be in a stable market. Such a situation may affect a firm's motivation and willingness to coordinate, with the consequence that the dynamic market may have a negative moderating role on the relationship between inter-functional coordination and innovative output. We therefore propose that:

H4b. Environmental uncertainty negatively moderates the relationship between inter-functional coordination and product innovation.

In turbulent market conditions, firms exposed to the external environment are more likely to be open-minded and to flexibly accommodate external changes to renew their knowledge bases and sustain competitiveness [25]. Thus, an increasing level of environmental uncertainty promotes the adoption and implementation of open-mindedness, and the management team has to actively engage in transforming a firm's vision and beliefs into actions and changes to respond to the environmental turbulence [56], which makes open-mindedness more beneficial for a firm. Firms such as SMEs are more flexible in adjusting their strategic plans and actions according to the level of uncertainty. We therefore hypothesize that a higher level of environmental uncertainty enhances the relationship between open-mindedness and innovative product output.

H4c. Environmental uncertainty positively moderates the relationship between open-mindedness and product innovation.

III. METHOD

A. Sampling and data collection

Chinese SMEs from the IT industry were selected for this research for various reasons. First, compared with advanced economies that have developed relatively mature legal systems to ensure a fair and efficient business environment, the business infrastructures and industrial regulations in most emerging markets are inefficient [63], [68], with firms updating their market intelligence on an *ad hoc* basis, rather than on a regular basis [69]. In the context of China, as the world's largest emerging market, intelligence plays a significant role in the sphere of technology transformation and innovation development by absorbing relevant external knowledge [70]. Nevertheless, the business environment in China is considered to have a high level of uncertainty [63], leading to high risk when establishing long-term relationships and

other business activities [68]. Thus, we consider China to be a good context in which to apply our conceptual framework.

Second, the significance of SMEs' contribution to national economic development is well-documented, but existing studies on open innovation and competitor intelligence show little interest in this context [14]. As industrial latecomers, Chinese SMEs are continuously absorbing advanced knowledge and skills in managerial expertise and firm-level capabilities, but, to date, have been deprived of further resources to advance their innovative activities [71]. Chinese officials provide considerable support for local firms to catch up with their global rivals, but such areas of support are more accessible to large firms [72]. SMEs have limited resources for innovative activities, and the existing studies offer limited knowledge to further our understanding of how Chinese SMEs manage to innovate [73]. Therefore, a study of the SME context contributes to the existing literature on open innovation and competitor intelligence.

Third, the IT industry was chosen as it is one of the most dynamic industries for innovation development. The high level of dynamism requires IT firms to make exceptional efforts to learn about market changes and acquire external knowledge for innovative activities. Hence, the area of Chinese IT SMEs was an appropriate research context within which to investigate the relationship between competitor intelligence and product innovation.

The research sample included senior executive level managers, such as business owners, marketing managers, and departmental directors. We adopted an online self-administrative survey method, due to the samples being geographically dispersed, and due to past research having found no difference in data validity and reliability between online survey and other survey methods, such as the face-to-face method [74], [75]. The survey questionnaire was initially compiled in English with the existing scales and tailored to the research context; it was then translated into Chinese. Each question was carefully validated to ensure an accurate

translation. Five Chinese-origin UK academics were invited to review the translation, and concerns about ambiguous and uncertain questions were addressed. We then refined the unclear questions and a revised questionnaire was constructed. Last, we gave the preliminary questionnaire to four Chinese IT SME managers for clarification. The questionnaire was finalized after re-tuning the questions.

To collect the data, we consulted the largest Chinese online survey firm - WJX.com (previously known as sojump.com), to approach qualified respondents from its B2B database. WJX is a highly credible and trustworthy survey platform in China. It has been employed by a number of studies published in a wide range of respectable academic journals (e.g. [76], [77]). To ensure the quality of data, the survey company used a payment service for every completed questionnaire, either through an internal point accumulation system, or monetary reward. Data were collected from a nationwide internal SMEs database with over 10,000 SMEs listed across different regions in China. Using the internal filtering system to focus on SMEs from the IT industry, the survey generated over 380 replies. We further screened the data to exclude non-executive answers, omitted answers, and questionnaires completed below the time baseline (such as taking less than five minutes to complete). 284 usable questionnaires were finalized for data analysis. Table I shows the profile of respondents.

Table I: Sample description

Size (No of employees)			Age (Year of establishment)			Annual sales performance (Yuan)		
<i>Categori</i>	<i>Count</i>	<i>%</i>	<i>Categori</i>	<i>Count</i>	<i>%</i>	<i>Categor</i>	<i>Count</i>	<i>%</i>
901-	52	18.2	Above	39	13.7	50-400	73	25.7
701-900	5	1.8	16-20	45	15.8	40 - 50	23	8.1
501-700	10	3.5	11-15	54	19.0	30 - 40	16	5.6
301-500	29	10.2	6-10	74	26.1	20 - 30	16	5.6
101-300	58	20.4	2-5	57	20.1	15- 20	18	6.3
21-100	92	13.4	Less	15	5.3	10-15	24	8.5
<20	38	13.4				3 -10	80	28.2
						< 3	34	12.0
Total	284	100%	Total	284	100%	Total	284	100%

B. Measures

Data were collected using a seven-point Likert scale, ranging from ‘1’ = ‘strongly disagree’ to ‘7’ = ‘strongly agree’. A seven-point Likert scale is most appropriate to demonstrate the reliability and validity of scores and performance [78]. We adapted the scales from existing studies to fit the Chinese research context, and all constructs were treated as first-order constructs.

Competitor Intelligence (*CI*) scales concerning how the direct and indirect competitor information was collected and processed were based on Narver and Slater [33] and Navarro-García et al. [79]. This construct revealed Cronbach’s alpha value of 0.837. Product Innovation (*PI*) scales were adapted from Backmann et al. [80] with four items indicating a firm’s product innovation performance, and information about the novelty and creativeness/innovativeness of the product offered by firms in the existing industry. The construct indicated a high reliability with $\alpha = 0.896$.

Inter-Functional Coordination (*IFC*) drew on Narver and Slater [33], indicating how the external information was shared within the organization, with Cronbach’s alpha value of 0.853. Open-Mindedness (*OM*) scales were adopted from Calantone et al. [53], and the reliability result showed $\alpha = 0.766$. Environmental Uncertainty (*EU*) measured the external market uncertainty, and we adapted the scales from Noordewier et al. [81] and Wong et al. [63], comprising items related to the external industrial-market environment, and showing a high level of reliability with $\alpha = 0.804$.

We also included two control variables suggested by prior research [23]: firm size and age. Prior research indicates that a firm’s resources accumulate as the firm grows [82], indicating that the length of operations affects the development of innovative capability [83]. We controlled for a firm’s age – the number of years in operation from establishment to the year 2017. A firm’s size in relation to the number of employees is an important attribute that

determines a firm's decision-making; larger firms tend to have more resources to attract talent for innovative activities [71]. The definition of Chinese SMEs differs from other contexts. In China, a SME is a firm with fewer than 2000 employees, which is relatively large in other contexts, i.e., 250 in Europe, and 500 in the USA. For this study, we selected firms with fewer than 1,000 employees. We applied the interval scales to obtain information on size (from 1= less than 20 to 7= less than 1000).

C. Controlling for nonresponse bias and CMV

Non-response bias was tested by comparing the means revenue of early and late respondents against the key variables [84]. We took 25% of early and late respondents to compare the unpaired *t* test, and found no significant difference, indicating the non-response bias was less of a concern in this study. To ensure the robustness of the result, our sampling covered managerial positions from a wide range of products in the IT industries — i.e., software and website developer, cloud service provider, data processor and e-commercial developer, to name but a few.

We further tested Common Method Variance (CMV) by taking certain steps. Prior to collecting the data, the survey instrument was accompanied with clear guidelines and we provided explanation of the necessary terms. According to Zhang *et al.* [85], potential biases in the survey instrument are more salient at the item level than at the construct level; thus, the multiple items in each construct were randomly ordered to moderate CMV concerns. For the CMV test, we followed the approach taken by Podsakoff and Organ [86] and conducted one-factor analysis [87]. Five factors were generated with unrotated principal component analysis with eigenvalues larger than 1. All factors accounted for 65% of total variance and the first factor took 35% weight of variance, revealing that no single factor explained the majority of the variance, which means that common method bias was less of a concern in this dataset. To further ensure the robustness of the results, we combined Harman's one-factor analysis with

constructs' correlation matrix test [88]. The result of Pearson's correlations test showed that all correlations were below the threshold of 0.9, indicating a low possibility of common method bias [89].

IV. ANALYSIS AND RESULTS

A. Reliability and validity

The statistical package AMOS 23 was applied to run confirmatory factor analysis (CFA) to test the measurement properties of constructs. The model fit indices showed a good model-data fit ($\chi^2 = 238.757$ (142), $p < 0.001$, GFI = 0.922, CFI = 0.963, NFI = 0.915, RMSEA = 0.049 and PCLOSE = 0.543). Table II displays details of factor loadings. All constructs had Cronbach's alpha values ranging from 0.766 to 0.896, satisfying the adequate benchmark of 0.7 [90]. The standardized factor loading met the minimum level of 0.6 [91], ranging from 0.605 to 0.890, to support for convergent validity.

We further examined the inter-construct correlations, composite reliabilities (CR), average variance extracted (AVE), and the square root of AVE for discriminant validity test (see Table III). The results from CR and AVE demonstrated adequate reliability. Composite reliabilities (CR) of constructs varied from 0.770-0.897, and were greater than the usual standard 0.70 [92]; the average variance extracted (AVE) results were from 0.514 to 0.685, exceeding the 0.5 threshold [93]. Results also revealed that the correlations amongst variables were less than 1.0 [89] and the square root of AVE was greater than the correlation between constructs, which indicates that each construct shared more variance with its own measures than with other variables in the framework [94]. Overall, the results supported the reliability, convergent validity and discriminant validity of the tests, and demonstrated adequate reliability and validity.

Table II. Construct and Item Loadings

Variables and items	Loading
Competitor intelligence (CI) (<i>Cronbach's alpha</i> = 0.837)	
CI1 Our people are instructed to monitor and report	0.665
CI2 We respond rapidly to competitors' actions	0.806
CI3 Our top managers discuss competitors'	0.784
CI4 We frequently collect marketing data on our competitors to help direct our marketing plans	0.765
Inter-functional Coordination (IFC) (<i>Cronbach's alpha</i> = 0.853)	
IFC1 We do a good job integrating the activities	0.776
IFC2 We regularly have inter-organizational	0.725
IFC3 The marketing people regularly interact with	0.801
IFC4 Our marketing people regularly discuss	0.783
Open-mindedness (OM) (<i>Cronbach's alpha</i> = 0.766)	
OM1 We are not afraid to reflect critically on the	0.764
OM2 Personnel in this enterprise realise that the very way they perceive the marketplace must be	0.670
OM3 We continually judge the quality of our	0.742
Product innovation (PI) (<i>Cronbach's alpha</i> = 0.896)	
PI1- We produce novel products in our industry	0.797
PI2- Our product is very challenging to existing	0.809
PI3- Our product offers new ideas to our industry	0.890
PI4- Our product is creative	0.812
Environmental uncertainty (EU) (<i>Cronbach's alpha</i> = 0.804)	
EU1- Availability of product in the market is highly	0.770
EU2 - Uncertainties in production and/or	0.760
EU3 - The market in which we buy products is	0.605
EU4 - Supply of major product in the market is not	0.720

Note: The EU construct is negatively indicated, so it has been converted to the reverse order to align with other constructs: '1'='strongly disagree' to '7'='strongly agree'.

Table III. Descriptive Statistics and Correlation Matrix

	Mean	S.D	CR	AVE	1	2	3	4	5
1. PI	5.0797	0.86480	0.897	0.685	0.828				
2. CI	5.2726	0.77489	0.842	0.573	0.457	0.757			
3. IFC	5.4679	0.76876	0.855	0.596	0.576	0.682	0.772		
4. OM	5.3297	0.71217	0.770	0.528	0.625	0.705	0.695	0.726	
5. EU	4.7269	0.93178	0.807	0.514	0.269	0.260	0.259	0.340	0.717

Note: S.D: Standard Deviation; CR: composite reliability; AVE: Average Variance Extracted

B. Results

To test the mediating effects of open-mindedness and inter-functional coordination, we followed the multistep approach by Kenny *et al.* [95]. By using the maximum likelihood

procedure in AMOS 23, a series of structural equation models (SEM) was conducted (see Table IV).

The first step was to establish the direct effect between competitor intelligence and product innovation. The results in model 1 suggest that $\beta = .564$ with p value < 0.001 . The R-squared value of the product innovation variable indicates 27.5% of dependent variable variation explained, supporting a positive relationship between competitor intelligence and product innovation; thus, H1 is accepted.

The second step examined the relationship between independent variables (competitor intelligence and the mediators (inter-functional coordination and open-mindedness)). Model 2 reveals that competitor intelligence strongly influenced the level of inter-functional coordination ($\beta = 0.756$; $p < 0.001$) and open-mindedness ($\beta = 0.734$; $p < 0.001$), reflecting a stronger correlation between competitor intelligence and inter-functional coordination and open-mindedness. R-squared value reveals that a higher reflection of over 58% of inter-functional coordination and 63.8% of open-mindedness variations were illustrated. Third, we intended to demonstrate that the mediators also affected the dependent variable - product innovation - when controlling for the effect of competitor intelligence. The result in Model 3 suggests that inter-functional coordination ($\beta = 0.237$; $p < 0.001$) and open-mindedness ($\beta = 0.645$; $p < 0.001$) influenced product innovation.

To test the indirect effects of competitor intelligence on product innovation through inter-functional coordination and open-mindedness, we conducted bootstrap analysis based on 2000 bootstrap samples and the two-tailed test. Results revealed that competitor intelligence had a positive effect on product innovation ($\beta = 0.585$; $p = 0.001$) indicating a partial mediation effect. The final model fit revealed a good-fit ($\chi^2 = 19.847$ (5), $p = 0.001$, GFI = 0.978, CFI = 0.983, NFI = 0.978, RMSEA = 0.102), and R-square values revealed more than 52% of product innovation variation. Based on the above evidence, we thus accept H2 and H3.

Table IV. Mediation Analysis Result

	Model 1 DV=Product Innovation (PI)	Model 2		Model 3 DV=PI
		DV= IFC	DV= OM	
Firm age	-0.033	-	-	-0.022
Firm size	0.054*	-	-	0.050**
Competitor intelligence (CI)	0.564***	0.756***	0.734***	-
Inter-functional coordination (IFC)	-	-	-	0.237**
Open-mindedness (OM)	-	-	-	0.645***
R-square	0.275	0.581	0.638	0.523

Note: Standardized coefficients are reported. * $p < 0.10$; ** $p < 0.05$; *** $p < 0.001$ (two-way tests of significance)

To test the moderating effect of environmental uncertainty, we used standardized composites for latent variables and multiplied both scores to create the interaction terms [96]. The results in Table V reveal that environmental uncertainty interacted with both inter-functional coordination and open-mindedness on the effects on product innovation with $p = 0.027$ for the interaction with inter-functional coordination, and p value = 0.058 for the interaction with open-mindedness. We did not find an interaction between environmental uncertainty and competitor intelligence, rejecting H4a.

The interaction of environmental uncertainty with inter-functional coordination and open-mindedness on product innovation showed different impacts according to the results in Table V. We plotted these interactions in Fig. 2 and Fig. 3 for further explanation. Fig. 2 reveals a significant but negative relationship between inter-functional coordination on product innovation when moderated by environmental uncertainty (simple slope: $b = -0.144$, $p = 0.027$). Fig. 3 shows a significant positive relationship between open-mindedness and product innovation when moderated by environmental uncertainty (simple slope: $b = 0.116$; $p = 0.058$). In other words, when the market environment is dynamic and fluctuating, being open-minded to changes in the market to gain new information and knowledge for product innovation is more pronounced; conversely, coordination between departments may negatively affect

product innovation when the market becomes more fluid. As a result, we accept the moderating effect of H4b and H4c. Table VI shows the results of hypotheses testing.

Concerning the effects of control variables, the results suggest that a firm's size had statistically significant positive effect on product innovation ($b = 0.053$; $p = 0.007$). A firm's age did not affect product innovation. This provides us with an insight that in the IT industry, a SME's ability to absorb and process external knowledge such as competitor information is positively related to the firm's size. An SME's ability to innovate, nevertheless, is not influenced by age, but by the size of the firm, which aligns with previous literature, indicating that bigger firms have more resources to invest in innovation development [83].

Table V. Estimation Results for Interaction Terms

Independent Variables (IV)	DV= Product innovation (PI) R ² = 0.551	
	Unstandardized regression weight	P-value
Competitor intelligence (CI)	-0.286	< 0.001
Inter-functional coordination	0.308	< 0.001
Open-mindedness (OM)	0.817	< 0.001
Environmental uncertainty (EU)	0.042	0.269
Firm age	-0.016	0.471
Firm size	0.053	0.007
<i>Interaction effects</i>		
IFC x EU	-0.144	0.027
OM x EU	0.116	0.058
CI x EU	0.005	0.927
$\chi^2 = 71.811$ (12), $p=0.000$, $GFI=0.955$, $CFI=0.968$, $NFI=0.962$, $RMSEA=0.133$,		

Note: Standardized coefficients are reported; * $p < 0.10$; ** $p < 0.05$; *** $p < 0.001$ (two-way tests of significance)

Table VI. Hypotheses Testing Results

Hypotheses	S.E	P-value	Result
H1: CI-PI	0.564	0.000	Accept
H2: CI-IFC-PI	0.645	0.000	Accept
H3: CI-OM-PI	0.237	0.000	Accept
H4a: EU→CI-PI	0.005	0.927	Reject
H4b: EU→IFC-PI	-0.144	0.027	Accept
H4c: EU→OM-PI	0.116	0.058	Accept

Note: * $p < 0.10$; ** $p < 0.05$; *** $p < 0.001$

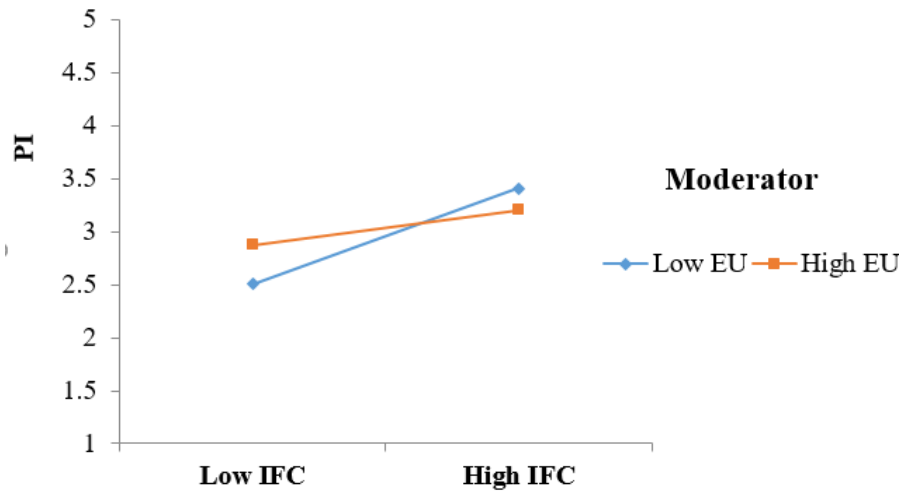


Fig. 2. Interaction of PI & IFC

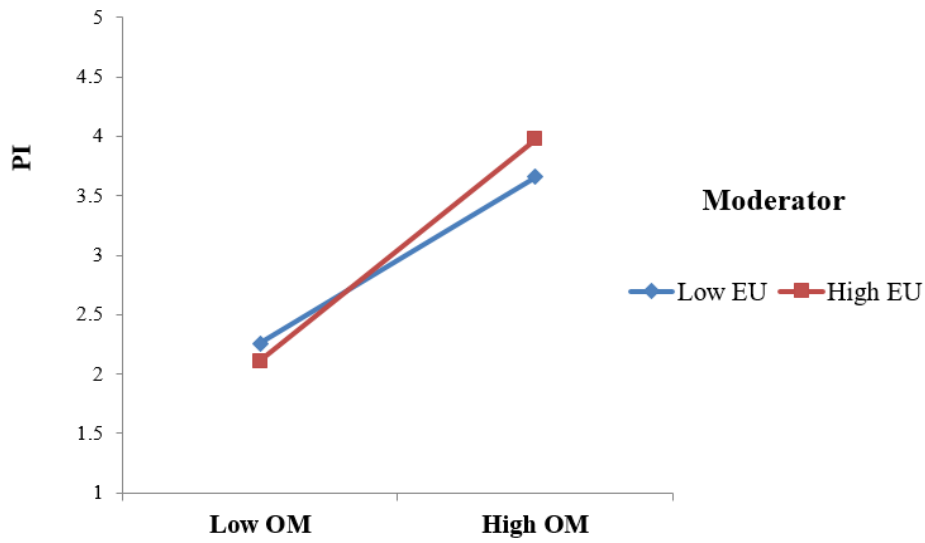


Fig. 3. Interaction of PI & OM

V. DISCUSSION AND CONCLUSION

This paper follows a prevailing topic in the extant open innovation literature concerning the importance of recognizing, transforming and deploying the external sources of knowledge in the context of innovative performance [26], [31]. Our research elucidates the important contribution of competitor intelligence on product innovation. We examined the mediating roles of inter-functional coordination and open-mindedness in generating competitor

intelligence for product innovation, and further investigated their interactions in the presence of environmental uncertainty. By obtaining data from Chinese IT SMEs, our research answers call for open innovation research on small-sized companies and emerging markets settings [20].

A. Contributions

This study offers a number of contributions. First, it provides significant insights to research on decoding the process of open innovation for product innovation. The established value of open innovation makes it vital to recognize the types of external knowledge to acquire [5], and to study what and how this external knowledge contributes to product innovation. Previous studies have explored the contribution of open innovation to a firm's ability to pursue innovation [23], and the relationship between open innovation activities and innovative performance [15] but have yet to unravel the types of external knowledge inflow to contribute to innovative performance. Our findings on the positive linkage of competitor intelligence and product innovation contribute to existing literature on open innovation and enrich the understanding of competitor-specific knowledge as an essential antecedent of a firm's innovative performance [7].

Moreover, this research advances our knowledge of open innovation by stating the importance of establishing an open, sharing and learning organizational culture to achieve the incorporation of external knowledge with product innovation. A certain amount of research has addressed the complementarity role of a firm's internal culture in process successful open innovation; for instance, Lin and McDonough [44] indicated that organizational culture promotes innovation performance; Chen and Liu [23] found that an organization's learning orientation is an essential internal cultural factor in open innovation. Our research is in line with these findings, introducing open-mindedness and inter-functional coordination factors to develop an internal culture, supporting the focal idea of promoting openness with shared norms and a shared organizational vision, which in turn allows the internal culture to stimulate the

process of learning [97]. Overall, our findings respond to the call made by Lichtenthaler [31] to develop more open innovation research on the relationship between open innovation, organizational culture and firm level corporate strategy.

Second, we have made a contextual contribution by extending the open innovation research in the context of emerging markets. Chen *et al.* [15] state that the majority of open innovation research focuses on developed countries, with the assumption that open innovation is under the wing of a well-established institutional environment. Although emerging economies have become crucial hubs for global R&D and innovation, limited research has investigated the extent to which external knowledge influences their innovation performance (Wang and Kafouros, 2009). To address this issue, we collected data from the emerging market of China, where inbound open innovation makes more appearances in serving businesses to catch-up and advance their innovation and technology development (Kafouros and Forans, 2012). Initially considered a home for cheap labor, China has now made a significant contribution to R&D and innovation development, providing a prevailing and appropriate research context for exploring the relationship between external knowledge and innovation development. In line with past research into emerging economies (e.g. [98], [99]), our research highlights the crucial role of open innovation as external knowledge inflows of innovation performance. We provide evidence on how firms open up their boundaries to inflows of knowledge from external sources to benefit their innovative performance. More specifically, this research emphasizes the need for further academic attention to incorporate the country-specificity of external knowledge inflow for innovation performance.

We also considered the interaction of external environment with the process of open innovation activities for innovative output. Previous research has illustrated that market dynamism is an inevitable external factor affecting all types of businesses [59], [61]. The effect is predominantly in emerging economies, as the undeveloped market infrastructure and

inefficient industrial regulation [63] leads to a high level of uncertainty to influence open innovation activities [15]. We found that in a turbulent business environment, being open-minded to external knowledge helps to enhance innovative output, while close collaboration between functional units negatively impacts on innovative performance. This finding confirmed that the level of external uncertainty significantly affects the collection and integration of external knowledge for product innovation [66], [67]. Overall, this study sheds light on the exploration of open innovation from a different research context than that of advanced economies [15] and responds to calls for more research to explore the moderating role of the external environment on business relationships [62].

In addition, we specifically focused on SMEs to address the research needs on understanding how SMEs use external knowledge (more specifically, competitor intelligence) for innovation development [19]-[21]. Historically, studies on open innovation have paid more attention to large and multi-national enterprises (MNEs) [15]. Despite the large number of SMEs contributing to the economy, research on how SMEs apply open innovation strategy has been generally neglected [15]. Our findings revealed that a firm's size is positively related to the ability to innovate products, and that smaller firms face more challenges in innovation due to constraints in resources and opportunities [17], [83]. Thus, SMEs need to actively extend their network to compensate for lack of resources. There is increasing evidence to show that adopting open innovation strategy allows SMEs to overcome the difficulties of size [16], and more SMEs have been practicing open innovation than ever before [17]. By focusing on SMEs, our research echoes earlier research in outlining the importance of open innovation for SMEs (e.g., [15]-[17], [100]), and we have reinforced the argument on the appropriateness of open innovation practice for SMEs [17].

B. Managerial implications

Our research yields a number of managerial implications. First, it reports the positive effect of competitor knowledge on a firm's innovative performance, and this finding gives justified impetus to the practice of competitor intelligence in the emerging marketplace. The results of this research serves to encourage senior managers from SMEs to not only focus on building and maintaining good relations with customers and suppliers, but also to concern themselves with collecting and processing competitor intelligence by regularly screening competitors' movements, behaviors and actions. Our study provides strong evidence that collecting, disseminating and transforming competitor intelligence increases a firm's innovation performance.

Second, our study has explicitly indicated that, in the process of consuming external knowledge for the purpose of developing innovative performance, senior managers should cultivate a learning and sharing organizational culture, which informs employees so that they remain open-minded to the inflow of new and fresh ideas, and thus build a good collaboration system between departments. Nevertheless, open-mindedness is one of the most challenging tasks to handle from an organizational perspective, as Hernández-Mogollon *et al.* [56] state that a number of cultural barriers in terms of deficiencies in training, absence of openness and a discouraging culture of failure can constrain the effect of open-mindedness on organizational innovation. We therefore suggest that SME managers should help develop and transform a firm's vision and mission at the operational level, and fully engage in cultivating an open, active and flexible organizational culture. Providing necessary training for employees from different departments, and proactively building beliefs and routines, enabling them to participate in the collecting and processing of external knowledge effectively leads to internal development.

Third, managers should be aware of the level of turbulence in the external environment. The present research also considers the effects of an emerging market environment in the process

of generating competitor intelligence for product innovation. Our research findings reveal that a high level of market uncertainty has a positive interaction with open-mindedness, contributing to a firm's innovative performance. Nevertheless, under the same environmental circumstances, collaboration between departments may impede the process of integrating external knowledge for product innovation. The research context shows that interaction with the external environment affects the innovative output. We suggest that managers should pay attention to the external environment, and if the level of environmental turbulence increases, a firm should focus more on promoting and cultivating an open-minded culture to explore external knowledge, as well as maintaining awareness that a turbulent environment can cause negative interactions with the collaborations that take place within an organization.

C. Limitations and future research

There are a number of limitations associated with this study. First, the study is primarily focused on a single emerging market — China. The emerging context varies, due to different cultural and political backgrounds. The results of this study provide some valuable implications for Chinese IT SMEs, but its implications for other emerging contexts are also worth exploring and comparing. Future research is encouraged to consider samples from a wider geographical area; as well as the use of longitudinal data to explore the causal effects that concern relevant constructs. Second, although the study shows a limited trace of common method bias, we encourage future research to use objective data to check the framework. Moreover, the design of our questionnaire allowed respondents to note down the different products and services that they offered to the market, providing us with robust information about the industrial sector; however, it constrained us from differentiating between service provider and product producer. Future studies should clearly differentiate between the service and/or product provider, and apply it as a control variable to enhance the results.

We have also pinpointed opportunities for future exploratory research. For instance, our paper focuses on competitor intelligence and product innovation. Future research could explore the relationships between other types of intelligence, such as business intelligence, market intelligence, customer intelligence and different types of firm innovation, such as exploitative innovation, exploratory innovation, incremental innovation, or breakthrough innovation [35]. Also, this study considers inter-functional coordination and open-mindedness as mediating factors, but future research could consider other factors that may also play a mediating role in this process, such as commitment to learning and shared vision. Taking this idea further, we advocate that more studies should be conducted on exploring how SMEs create learning routines that help them translate external knowledge for application, as creating and sustaining an open and sharing organizational culture presents a big challenge. Fourth, our study takes environmental uncertainty as a moderating factor; a more comprehensive list of the moderating effects of market turbulence and technological turbulence could be investigated in future research.

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