Open innovation and sustainable competitive advantage: The role of organizational learning

Xiaobin Zhang [a], Zhaofang Chu [b,*], Lei Ren [a], Jianguo Xing [a]

[a] *Dongwu Business School, Soochow University, 215021 Suzhou, China*
[b] *School of Business, Anhui University, 230039 Hefei, China*

ARTICLE INFO

ABSTRACT

With intensifying competition and increasing dependence on external partners, open innovation has been becoming an inevitable and prevalent strategy to achieve long-term competitive advantage. Considerable research has investigated the benefit of open innovation, the mechanism through which open innovation translates into sustainable competitive advantage have yet been well examined. Drawing on the strategy-competence-competitive advantage framework and the knowledge-based view, this study examines the role of ambidextrous organizational learning in mediating the relationship between open innovation and sustainable competitive advantage as well as the moderating role of knowledge management capability. Based on data collected from 269 Chinese high-tech enterprises in 2021, we found that open innovation contributes to sustainable competitive advantage through enhancing organizational learning including both exploratory and exploitative learning as well as their balance. Moreover, knowledge management capability positively moderates the relationships of open innovation to exploration and exploitation as well as their combination. Research and practical implications are discussed.

1. Introduction

As a result of globalization, technological complexity, increased competition and resource scarcity, organizations are changing and adopting a more open, cooperative approach to building their competitive advantage (Barrett et al., 2021; Lewis et al., 2010). Hence, open innovation has been becoming an important concept in both academic research and industrial practice; it refers to "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (Chesbrough, 2006). Compared with closed innovation, open innovation permits firms to explore outside knowledge and to externally exploit existing internal resources to gain a competitive edge (Drechsler and Natter, 2012; Popa et al., 2017). The more a business interacts with other organizations, the higher its chances of acquiring external ideas, capabilities, knowledge, technology and other intangibles, and the greater its chances of successful innovation (Greco et al., 2016). Moreover, the complementarity and collaboration of internal and external innovation resources will gradually improve enterprises' innate innovation capability, helping them to ultimately form their own core competitiveness (Lichtenthaler, 2011).

Despite such prospective benefits, empirical evidence suggests that the impact of open innovation on performance is unclear (Carmona-Lavadoa et al., 2021; Greco et al., 2017). For example, several studies have found a positive impact of an open innovation strategy on organizational performance (Caputo et al., 2016; Cheng and Huizingh, 2014) and innovation performance (Chen et al., 2011; Greco et al., 2017). However, some scholars believe it is difficult to measure the impact of internal innovation openness on innovation and economic measures, and findings show that its impact is limited (Kratzer et al., 2017), leading to diminishing marginal returns on innovation performance or even a negative impact on it (Greco et al., 2017; Lin, 2014). These inconsistent findings may be due to our limited understanding of the mechanism through which open innovation positively contributes to competitive advantage and the conditions under which firms can benefit from open innovation (Greco et al., 2017; Lazzarotti et al., 2017; Carmona-Lavadoa et al., 2021). To fill this void, this research examines how and when open innovation can be turned into competitive advantage.

Drawing on the strategy-competence-competitive (SCC) framework (Teece et al., 1997; March, 1991; Grant, 1996) and the knowledge-based view (KBV), this research argues that firms can leverage open innovation for competitive advantage by enhancing organizational learning.

According to the SCC standpoint, as a strategy, open innovation brings competitive advantage by building competence (Carmona-Lavadoa et al., 2021). The KBV suggests that knowledge is a key determinant of competitive advantage, and importantly, knowledge is generally refined and/or created in the process of organizational learning (Valentim et al., 2016; Mueller et al., 2012; Chalikias et al., 2014). Integrating the SCC perspective and KBV, open innovation contributes to competitive advantage via organizational learning. In fact, firms can benefit from the information and knowledge acquired from the outside environment due to open innovation only when such knowledge is processed and utilized to develop new knowledge that is necessary for generating competitive advantage (Carmona-Lavadoa et al., 2021). In line with this thinking, organizational learning is necessary, as it enables firms to refine and improve existing knowledge (exploitative learning) and create new knowledge (exploratory learning). In other words, organizational learning is a necessary mediating mechanism through which open innovation can turn into competitive advantage. Moreover, the KBV suggests that the efficacy of organizational learning is contingent upon the capability of knowledge management. In sum, this research advances and tests a model that proposes the mediating role of organizational learning (i.e., exploration, exploitation, and ambidexterity) on the relationship between open innovation and sustainable competitive advantage and the moderating effect of knowledge management capability.

The findings, based on data collected from 269 Chinese enterprises, contribute to the literature in three ways. First, they shed light on how the open innovation strategy serves as a catalyst for firms' competitive advantage, as we found the significant mediating role of organizational learning (i.e., exploration, exploitation, and ambidexterity). Second, the findings reveal a contingent condition that affects the translation of open innovation into competitive advantage, as we confirmed the significant moderating effect of knowledge management capability, indicating that knowledge management capability can vary the role of organizational learning in turning open innovation into competitive advantage. Furthermore, the use of polynomial regression with response surface analysis is another contribution, as it helps scrutinize the role of organizational ambidexterity in terms of organizational learning.

The remainder of this paper is organized as follows. In the next section, this study outlines the theoretical background and reviews the literature. Then, this study develops the underlying hypotheses of the direct and indirect effects, followed by the methodology and results. Finally, we conclude with the discussion and limitations and offer potential avenues for future research.

2. Theoretical background

2.1. Open innovation

With intensifying competition and increasing dependence on external partners, the open innovation paradigm has attracted increasing attention from academics and practitioners (Popa et al., 2017; Stanko et al., 2014; Bogers et al., 2018). Despite rising interest in the "openness" construct in academia, the existing literature has not unified the definition of open innovation. From the perspective of a paradigm, open innovation refers to a distributed innovation strategy based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with each organization's business model (Chesbrough, 2006; Chesbrough and Bogers, 2014). From the perspective of process, the open innovation process has three core processes: outside-in, inside-out, and coupled (Gassmann and Enkel, 2004). Sometimes, these processes complement one another, although the outside-in process usually dominates. From the perspective of outcomes, open innovation means that good technical solutions can be obtained from outside and inside the enterprise, and innovative ideas from inside and outside are treated equally to present innovation to consumers in the shortest time and at the lowest cost

(Yang, 2006). In this paper, we focus on the problem of how to transform an open innovation strategy into sustained competitive advantage. Therefore, Chesbrough's (2006) paradigm view of open innovation is followed. Open innovation refers to an innovation paradigm that consciously integrates enterprise capabilities and resources with externally acquired resources, and develops market opportunities through various channels.

Over the years, open innovation has been widely examined from various perspectives. One stream of the literature focuses on the developing open innovation by examining its enablers and antecedents, such as citizenship behaviors (Naqshbandi, 2016), organizational culture (Naqshbandi et al., 2015), human asset specificity (Hsieh et al., 2016), informal ties (Zhu et al., 2019), and business models (Hung and Chiang, 2010).

The other stream of the research focuses on the value of open innovation through investigating its impact on firm performance (Greco et al., 2016; Lopes and De Carvalho, 2018) in terms of economic performance (such as sales growth, market share, profitability, financial indicators, customer performance, and turnover) and innovation performance (such as new product, R&D, and intellectual property). Some authors advocate for a positive influence of open innovation strategies on a firm's performance, whereas some authors contend that the open innovation approach may have diminishing marginal returns or even a negative effect on a firm's performance (Duysters and Lokshin, 2011; Kang and Kang, 2009; Lin, 2014). Moreover, Carmona-Lavadoa et al. (2021) even assert that openness per se may not be a determinant of performance unless it is supported by complementary assets (e.g., coordination and learning capabilities). In sum, although open innovation has been mainly believed to bring benefits, the findings of extant research on the relationship between open innovation and performance remain mixed. Such a lack of a consistent conclusion suggests the need of further investigations on this relationship and especially the necessity to examine the mediating mechanisms through which open innovation contributes to performance and the contingencies that affect the value of open innovation.

2.2. Organizational learning

According to March (1991), learning is generally divided into two categories: exploitative and exploratory learning. Exploration is an organizational activity characterized by seeking, discovering, and creating new knowledge and trying new opportunities. Exploitation activities involve selecting, implementing, improving, and refining existing knowledge. These two types of learning distinguish each other and play different roles (Andriopoulos and Lewis, 2010). Exploitive learning is an in-depth investigation of existing knowledge to refine overall strategic planning into specific tasks, to be executed by specific departments to improve employees' understanding of organizational strategies. In contrast, the purpose of exploratory learning is to promote the absorption and transformation of new knowledge and ideas, and enhance the response to market demand and the external environment to promote the implementation of innovation strategies. However, they are both important. Enterprises not only need exploratory learning to seize and respond to new market opportunities and demands, but also need ensure existing competitive advantage and capabilities through exploitative learning (March, 1991).

To better leverage the advantages of these two types of organizational learning, researchers have suggested the need to pursue the combination and balance of them as the term "organizational ambidexterity" (Lee et al., 2017). In line with these researchers, this study examines the organizational ambidexterity of learning. Following Cao et al. (2009) and Junni et al. (2013), this study conceptualizes organizational ambidexterity from a balanced aspect (hereinafter, OAB) and a combined aspect (hereinafter, OAC). OAB means that the distribution of exploration and exploitation activities should be relatively close, while OAC represents the overall synergy of the two activities (Cao et al.,

2009; Lee et al., 2017). In fact, most prior studies have examined these two aspects of organizational ambidexterity affecting firm performance separately. The combined view highlights the need to pursue exploitation and exploration simultaneously (Koryak et al., 2018) and argues that the exploration of new knowledge is organically integrated with the refinement of existing knowledge, thus the combination of exploration and exploitation can spawn innovative results (Cao et al., 2009; Jin et al., 2016) and superior performance (Junni et al., 2013). The balanced view emphasizes the need to avoid risks associated with the exclusive pursuit of either exploitation or exploration and argues that the imbalance between exploitation and exploration leads to performance deterioration due to a higher level of unstructured control over performance risk (Lewis et al., 2010; Atuahene-Gima and Murray, 2007).

With a brief review of literature, the findings on the relationship between exploration and exploitation and performance are ambiguous, ranging from positive (Cao et al., 2009) to an inverted U-shaped influence (Li et al., 2013). These various findings may suggest that exploration and exploitation need to be configured properly (Lee et al., 2017; Junni et al., 2013). Therefore, this study examines organizational ambidexterity aiming to identify the optimal configuration of exploration and exploitation in translating open innovation into performance.

2.3. Integrating the SCC framework and the KBV

This study builds on the SCC framework (Teece et al., 1997; March, 1991; Grant, 1996), which argues that business strategies can be effectively implemented and ultimately transformed into competitive advantage by building capabilities (Teece et al., 1997). However, based on the KBV, knowledge is a key determinant of competitive advantage, which is difficult to obtain through the market, but it can be refined and/or created in the process of organizational learning (Grant, 1996). Therefore, as a means of integrating resources and creating new knowledge, organizational learning is critical for enterprises to implement business strategies and obtain sustainable competitive advantage. In sum, in integrating the SCC framework and KBV, this study proposes that firms on the basis of their open innovation need to engage in learning activities to increase competitive advantage, and knowledge management capability can promote adaptive learning activities (See Fig. 1).

3. Hypotheses

3.1. Open innovation and sustainable competitive advantage

Since open innovation strategies represent enterprises breaking through closed boundaries and taking advantage of knowledge resources flowing in and out in a planned way (Chesbrough and Crowther,

2006), it contributes to the long-term competitive advantage in the following aspects. First, the KBV holds that a company's core task is to acquire, integrate, and use knowledge. Knowledge is an essential resource in enterprises' long-term competitiveness (Grant, 1996). Through the inward or outward flow of knowledge, technology and resources, innovation elements can be differentiated and integrated to accelerate the pace of innovation and reduce the cost and risk of innovation (West, 2006). Second, the effective integration of knowledge, information, and capital in the external environment can compensate for a company's own shortcomings, enrich the resource base for innovation (Rigby and Zook, 2002), expand innovation output, and open new markets (Chesbrough and Schwartz, 2007). Finally, from the perspective of an organization's external network, enterprises can obtain valuable social capital from the outside innovation network, seeking more development opportunities and living space by searching through the resources of the network's members (Wang et al., 2014). External networks can bring enterprises opportunities and technological advantages to break through their own technological bottlenecks and to help enterprises occupy a favorable market position (Rass et al., 2013). Therefore, we suggested that:

H1. Open innovation has a positive association with sustainable competitive advantage.

3.2. The mediating role of exploration and exploitation

While openness has been proposed as a new paradigm for innovation management (Chesbrough, 2003; Gassmann, 2006; Gassmann et al., 2010), it seems difficult to adopt an open innovation model and benefit from it. The resource-based view (RBV) has illustrated the advantages of open innovation in accumulating material and cognitive resources. However, possession of resources does not necessarily imply efficient use, especially for non-material resources such as knowledge. Tu and Wu (2021) argue that "how to refine abstract strategies into concrete practices is also an urgent problem faced by enterprises." Based on the KBV, knowledge is an indispensable, intangible resource in fierce market competition. Thus, as the main means of knowledge discovery and creation (Mueller et al., 2012), organizational learning has a vital impact on the implementation of a company's strategy and the returns of innovation activities (Gerschewski et al., 2015), which eventually affects competitiveness.

While researchers have acknowledged the importance of these two learning approaches, they have also identified their different roles. Lichtenthaler and Lichtenthaler (2009) combine two different organizational learning modes with the open innovation practice of enterprises, confirming the significant position of exploratory learning in companies' acquisition of external knowledge and the decisive role of
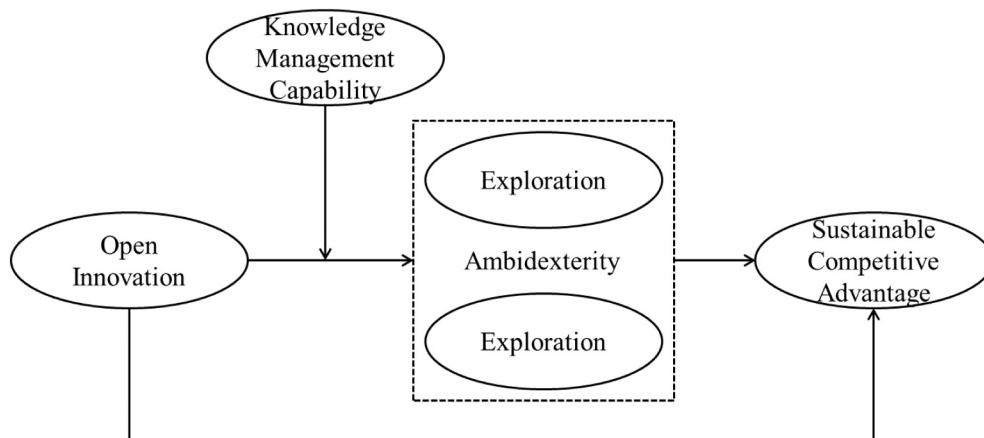

Fig. 1. Theoretical model.

exploitative learning in the process of externalizing their own research and development results. Similarly, Bianchi et al. (2011) point out that open innovation input mainly serves to improve companies' "exploration" capabilities, while open innovation output is closely related to the "exploitation" of their basic knowledge and technology. To obtain and apply the knowledge beneficial to innovation activities from the strategic action of improving openness, enterprises must increase their investments in exploratory and exploitative efforts (Hull and Covin, 2011; Tu and Wu, 2021). We therefore posited that:

H2a. Exploitative learning positively mediates the relationship between open innovation and sustainable competitive advantage.

H2b. Exploratory learning positively mediates the relationship between open innovation and sustainable competitive advantage.

3.3. The mediating role of organizational ambidexterity

As discussed above, companies can benefit from open innovation when they have the capabilities to connect closed and open approaches to innovation (Prud'homme Van Reine, 2015). Researchers generally recognize the importance of dual capabilities in implementing innovation strategies and stress the role of organizational context in facilitating and balancing exploitation and exploration for better development (Cao et al., 2009; Gibson and Birkinshaw, 2004). They also affirm that organizational ambidexterity is a meta-capability that should be gradually developed and institutionalized within an organization. Hence, this study argues that organizational ambidexterity, as a form of learning, plays an important role in strengthening the relationship between the open innovation strategy and competitive advantage. Specifically, with regard to OAC, although open innovation can help build up exploitation and exploration, firms need to possess organizational capabilities to create synergistic effects between the two (Lee et al., 2017). Similarly, Lichtenthaler (2009) identifies that firms need to understand the complementarity of the exploratory and exploitative learning processes. With regard to OAB, based on their competitive edge, firms need to build capacities to manage the structural risks arising from exploitation and exploration, to advisably mix the two activities, and to properly allocate resources between the two (Grant, 1996). Hence, although open innovation may influence competitive advantage, ambidexterity plays a vital role in effectively channeling and utilizing it for competitive advantage enhancement. New information from external networks—such as customers, suppliers, scientific research institutions, and other external partners—is important for both the exploitation of current resources and the capabilities required for exploitation and the development of new resources and the capabilities required for exploration (Kiss et al., 2020); this leads to a higher level of organizational ambidexterity to enjoy sustainable competitive advantage and thrive (Cao et al., 2009; He and Wong, 2004). On the other hand, open innovation aims to generate more new products and technologies through external cooperation (Kyriakopoulos et al., 2019). With the help of a relatively balanced distribution of exploration and exploitation, enterprises' innovation strategy can be prevented from falling into the "success trap" caused by an excessive focus on exploitation and the "failure trap," which is caused by an excessive focus on exploration (Chakma et al., 2021). As such, we posited that:

H3a. OAC positively mediates the relationship between open innovation and sustainable competitive advantage.

H3b. OAB positively mediates the relationship between open innovation and sustainable competitive advantage.

3.4. The moderating role of knowledge management capability

Knowledge has become the main source of a company's competitive advantage (March, 1991; Grant, 1996). Effective knowledge management is a prerequisite for enterprises to use knowledge effectively (Chen and Huang, 2009). Knowledge management capability is the ability of a business to coordinate and integrate various knowledge resources and to continuously use and create knowledge resources. Its central purpose is to enhance a company's management and use of resources to carry out research and development (R&D) activities or innovative activities (Tanriverdi and Venkatraman, 2005). In a fiercely competitive environment, it is difficult for enterprises to have all the resources needed for R&D. With the promotion of open innovation activities, companies can acquire new technologies and knowledge from the outside. However, without the management capability of internal and external knowledge, the open innovation process will be disordered or even fail.

The improvement of knowledge management capability encourages enterprises to acquire, select, disseminate and utilize external, heterogeneous knowledge from open innovation activities (Castro, 2015). At the same time, the literature have acknowledged knowledge management capability as a driving factor of organizational ambidexterity by showing positive effects of knowledge management capability on exploration and exploitation (Santoro et al., 2021; Soto-Acosta et al., 2018). Hence, this study postulates that the level of a company's knowledge management capability would determine the influence of its interaction with open innovation on organizational learning activities. The improvement of the openness level of innovation activities will bring more abundant, complex external information and knowledge to enterprises; it has become a precondition for enterprises to conduct exploration and exploitation to extract truly valuable knowledge from information, or to select potential R&D objects from many potential business partners (Fidel et al., 2015). In addition, more information and business knowledge from outside leads to a larger set of potential (re) combinations of different information that is beneficial for both exploitation and exploration with the help of knowledge management capability (Yu et al., 2005). In sum, when an enterprise gradually improves the openness of its innovation activities, the knowledge existing inside and outside the organization leads to more extensive communication and collision. In this process, knowledge management capability can help enterprises effectively identify valuable heterogeneous knowledge, integrate it with their own knowledge base, and promote the balance and interaction between exploration and exploitation to improve overall learning capabilities. Hence, we proposed the following hypotheses:

H4a. Knowledge management capability positively moderates the relationship between open innovation and exploitative learning.

H4b. Knowledge management capability positively moderates the relationship between open innovation and exploratory learning.

H4c. Knowledge management capability positively moderates the relationship between open innovation and OAC.

H4d. Knowledge management capability positively moderates the relationship between open innovation and OAB.

4. Methods

4.1. Data collection

The sample is selected from the list of high-tech firms that registered in the Yangtze River Delta region where the economy is highly developed and tends to be open. The sample collection process is as follows: First, we excluded companies that have been established for less than three years and have an annual revenue of <10 million. Then we randomly selected 1000 companies from this list. Second, we contacted with the selected companies to obtain their agreement on participating our research. Third, a two-stage survey was conducted to collect data from the agreed companies, so as to reduce the impact of common method bias (Meier and Spector, 2013). The first stage took place in March 2021, in which senior executives answered questions about their personal backgrounds and their perceptions of open innovation and

knowledge management capability. The second stage took place in May 2021, and the above respondents reported on exploitative learning, exploratory learning, and sustainable competitive advantage. Finally, a total of 408 questionnaires were sent out; and 312 completed questionnaires were received. After eliminating unqualified questionnaires, 269 was valid and used in our data analysis.

The average age of the sample firms was 17.81. Among them, 17 (6.3 %) had been open for 3 to 5 years; 24 (8.9 %) had been open for 6 to 10 years; 67 (24.9 %) had been open for 11 to 15 years; 73 (27.1 %) had been open for 16 to 25 years; and 88 (32.7 %) had been open for 25 years or longer. The firms represented various sectors such as software, information technology and telecommunications (115); electronic and communication equipment manufacturing (44); new materials and new energy (20); energy conservation, environmental protection, biology and pharmaceutical industries (25); chemical, textiles and other traditional manufacturing enterprises (54); and others. The sample industry is widely distributed to meet the basic requirements of the study. Table 1 describes the profile of the respondent firms.

4.2. Measures

We took the scales in this paper from previously validated studies. Before the survey, we invited eight domain experts and entrepreneurs in the field to evaluate and modify the questionnaire, and adjusted the measurement items appropriately according to the Chinese context. All items and responses were scored on a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). Appendix I summarizes the measurement items used in the survey.

4.2.1. Exploitative and exploratory learning

We adapted the scale of exploration and exploitation from Atuahene-Gima and Murray (2007) and Zhao et al. (2016). Exploitative learning consists of 5 items that measure the competence, efficiency, and reliability of searching for intellectual capital within an organization based on existing knowledge of products and market areas with which the business is familiar. Exploratory learning comprises 4 items that capture an organization's efforts to search for entirely new intellectual capital

outside of its current experience. In addition, we followed the approach of Mom et al. (2007) to measure organizational ambidexterity. OAC was measured by multiplying exploration and exploitation, and OAB was measured by the absolute value of the difference between the two.

4.2.2. Open innovation

We adapted the scale developed by Naqshbandi (2016) to measure open innovation. It comprises 6 items that capture a firm's degree and philosophy of openness in all aspects.

4.2.3. Knowledge management capability

The scale we adapted to measure knowledge management capability is from Pérez-López and Alegre (2012), which consists of 7 items.

4.2.4. Sustainable competitive advantage

We employed a subjective scale to measure sustainable competitive advantage because of data privacy issues and the context of this study. This scale, consisting of 6 items, was adopted from Chang (2011), which have repeatedly used and validated by several scholars (Camisón and Villar-López, 2011; Chen et al., 2009; Ali, 2021).

Additionally, we controlled for five contextual variables that might have a potential influence on sustainable competitive advantage: firm size, age, revenue, ownership, and industry type. These variables have been confirmed to have an impact on a firm's sustainable competitive advantage in previous studies (Ali, 2021).

5. Analysis

5.1. Reliability and validity

We used Cronbach's alpha to assess reliability (Nunnally, 1978). As Table 2 shows, the values for Cronbach's alpha of all measures were greater than the threshold of 0.7, suggesting adequate reliability (Fornell and Larcker, 1981). In terms of convergent validity, the standardized factor loadings were significant and above the suggested value of 0.6 excepting one of knowledge management capability was 0.55; the values of average variance extracted (AVE) surpassed the minimum threshold of 0.5 (Fornell and Larcker, 1981) excepting that of exploitative learning was 0.474; and thus the convergent validity was acceptable. Furthermore, it can be seen from Table 3 that the proposed five-factor model (e.g., exploitative learning, exploratory learning, open innovation, knowledge management capability, and sustainable competitive advantage) had a better fit than alternative models (χ^2/df = 1.95, CFI = 0.92, TLI = 0.91, and RMSEA = 0.06), indicating that the main variables concerned in this study had good discriminant validity (Bentler and Bonett, 1980).

5.2. Common method bias (CMB) assessment

Several approaches were conducted to test CMB. First, the analysis of Harman's single-factor test indicated that no single factor accounted for >50 % of the variance, suggesting no evidence of CMB (Podsakoff and Organ, 1986). Second, the fit of the single-factor model was very unsatisfactory (as shown in Table 3), indicating no serious CMB in the sample (Podsakoff et al., 2012). Finally, the unmeasured latent method

Table 1
Demographic profile of the respondent firms.

Characteristics	Classifications	Frequency	Percentage
Firm age (year of establishment)	3–5	17	6.3
	6–10	24	8.9
	11–15	67	24.9
	16–25	73	27.1
	Above 25	88	32.7
Firm size (no. of employees)	100–600	148	55.0
	600–1000	16	5.9
	1000–2000	22	8.2
	Above 2000	83	30.9
Firm ownership	Public enterprise	72	26.8
	Private enterprise	91	33.8
	Joint company	15	5.6
	Foreign capital firm	91	33.9
Industry type	Software, information technology and telecommunications	115	42.8
	Electronic and communication equipment manufacturing	44	16.4
	New materials and new energy	20	7.4
	Environmental protection, biology and pharmaceutical	25	9.3
	Chemical, textiles and other traditional manufacturing	54	20.1
	Others	11	4.1
Annual revenue	RMB 10–50 million	65	24.2
	RMB 50–1000 million	89	33.1
	RMB 1000–2000 million	35	13.0
	Above RMB 2000 million	80	29.7

Table 2
Reliability and validity of variables.

Constructs	Factor loadings	α value	CR	AVE
Open innovation	0.67–0.88	0.89	0.894	0.586
Exploitative learning	0.62–0.75	0.82	0.818	0.474
Exploratory learning	0.64–0.84	0.83	0.832	0.556
Knowledge management capability	0.55–0.80	0.89	0.887	0.533
Sustainable competitive advantage	0.65–0.76	0.86	0.859	0.504

Table 3
Confirmatory factor analysis results.

Model	χ^2	df	χ^2/df	CFI	TLI	RMSEA
Five-factor model[a]	661.73	340	1.95	0.92	0.91	0.06
Four-factor model[b]	738.04	344	2.15	0.90	0.89	0.07
Three-factor model[c]	1248.89	347	3.60	0.78	0.77	0.10
Two-factor model[d]	1418.66	349	4.07	0.73	0.71	0.11
One-factor model[e]	1573.71	350	4.50	0.70	0.67	0.11

Note: a hypothesis model; b exploitative learning and exploratory learning were combined into one factor; c open innovation, exploitative learning and exploratory learning were combined into one factor; d open innovation, exploitative learning, exploratory learning and knowledge management capability were combined into one factor; e all variables were combined into one factor.

construct (ULMC) approach which can shut out half of the studies heavily influenced by CMB (Podsakoff et al., 2012) was conducted. The results showed no significant improvement in simulation fitting after the addition of the method construct, in which RMSEA decreased by 0.006 (<0.05) and CFI and TLI increased by 0.018 and 0.015 (<0.1), respectively, eliminating concerns about CMB.

6. Results

6.1. Hypothesis testing

Table 4 shows the descriptive statistics and correlation analysis on all variables.

Before the regression analysis, we mean-centered all variables to minimize multicollinearity. After centering, the results revealed that the VIF values of each model ranged from 1.029 to 3.579, and the tolerance was >0.100, implying no serious multicollinearity problem (Kock, 2015). We also analyzed the sample proportion; the sample proportion of balanced learning was 47.584 %, and the sample proportions of "high exploration-low exploitation" and "low exploration-high exploitation" of imbalanced learning were 26.022 % and 26.394 %, respectively, which met the requirements of polynomial regression (Shanock et al., 2010). The empirical regression results of this paper were depicted in Tables 5 and 6. Table 5 showed that open innovation had a significant, positive effect on sustainable competitive advantage (Model 9, $\beta = 0.49$, $p < 0.001$), supporting H1. In addition, open innovation had a significant, positive effect on exploratory learning (Model 1, $\beta = 0.34$, $p < 0.001$), exploitative learning (Model 3, $\beta = 0.47$, $p < 0.001$), OAB (Model 5, $\beta = 0.25$, $p < 0.001$), and OAC (Model 6, $\beta = 0.17$, $p < 0.05$) respectively. It can be seen from Table 6 that exploratory learning (Model 10, $\beta = 0.51$, $p < 0.001$), exploitative learning (Model 11, $\beta = 0.64$, $p < 0.001$), OAB (Model 14, $\beta = 0.22$, $p < 0.001$), and OAC (Model 13, $\beta = 0.10$, $p < 0.05$) had significant, positive effects on sustainable

competitive advantage. Thus, we further tested the mediating effect via the SPSS Process V3.3 plugin performing Bootstrap 5000 repeated sampling to test whether the confidence interval at the 95 % level contains 0 (Hayes, 2017). The mediating effect value of exploitative learning was 0.25, and the confidence interval was [0.17, 0.32], thereby supporting H2a. The mediating effect value of exploratory learning was 0.13, and the confidence interval was [0.07, 0.19], thus supporting H2b. The mediating effect value of OAC was 0.01, and the confidence interval was [−0.01, 0.05], which did not support H3a. The mediating effect value of OAB was 0.02, and the confidence interval was [0.01, 0.05], supporting H3b.

As Table 5 indicated, the interaction terms of open innovation and knowledge management capability had a significant, positive correlation with exploratory learning (Model 2, $\beta = 0.11$, $p < 0.01$), exploitative learning (Model 4, $\beta = 0.10$, $p < 0.01$), and OAC (Model 8, $\beta = 0.32$, $p < 0.001$). Therefore, H4a, H4b and H4c were supported, but not H4d. Simple slope testing was presented in Figs. 3, 4 and 5. Open innovation had a positive effect on exploratory learning and OAC, but only under a high level of knowledge management capability. Compared with a low level of knowledge management capability, open innovation had a stronger positive impact on exploitative learning under a high level of knowledge management capability.

6.2. Post hoc analysis

According to the attention allocation theory, the attention of enterprises in learning and acquiring resources is limited, so how to allocate the attention in exploratory learning and exploitative learning, as well as discuss the different effects of the matching modes of the two on sustainable competitive advantage, has important practical significance for enterprises. Moreover, the relationship of organizational ambidexterity with competitive advantage has failed to produce consistent results (Li et al., 2013; Cao et al., 2009). To scrutinize the relationship of exploitation and exploration with competitive advantage in greater depth, we conducted polynomial regression with response surface analysis (Edwards and Parry, 1993) to identify which configuration of exploration and exploitation is more conducive to promoting competitive advantage. Table 6 showed that the slope value was significant and positive ($Slope^1 = 0.49$, $p < 0.001$). After further checking the response surface (Fig. 2), we found that sustainable competitive advantage at the rear corner (where ERL = EIL = 3) was higher than that at the front corner (where ERL = EIL = −3). The above results indicated that sustainable competitive advantage was higher when exploratory and exploitative learning were aligned at a high level than at a low level. Moreover, Fig. 2 demonstrated that sustainable competitive advantage in the right corner (ERL = −3 and EIL = 3) was higher than that in the left corner (ERL = 3 and EIL = −3), and was significant and negative

Table 4
Descriptive statistics and correlation analysis.

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. Firm age	1											
2. Firm size	0.55**	1										
3. Firm ownership	0.07	0.01	1									
4. Industry type	−0.14*	−0.15*	−0.20**	1								
5. Firm revenue	0.52**	0.80**	0.10	−0.21**	1							
6. OI	−0.04	0.06	0.03	0.08	−0.01	1						
7. ERL	0.02	0.04	0.03	−0.10	0.03	0.32**	1					
8. EIL	0.09	0.15*	0.10	−0.06	0.03	0.48**	0.67**	1				
9. OAB	−0.07	0.01	0.04	0.10	−0.06	0.27**	0.11	0.43**	1			
10. OAC	0.06	0.07	0.07	−0.08	0.07	0.13*	0.05	0.09	0.17**	1		
11. KMC	−0.02	0.04	0.15*	0.00	0.00	0.54**	0.58**	0.65**	0.25**	0.06	1	
12. SCA	0.09	0.06	0.16**	0.03	0.01	0.49**	0.50**	0.64**	0.23**	0.14*	0.64**	1
M	17.81	3.48	2.53	2.76	2.48	3.16	3.75	3.59	0.95	13.71	3.67	3.62
SD	1.19	2.03	1.31	1.97	1.15	0.82	0.54	0.65	0.05	4.07	0.63	0.63

** $p < 0.01$.
* $p < 0.05$.

Table 5
Regression results for mediators.

Variables	Exploratory learning		Exploitative learning		OAB		OAC	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Firm age	0.02	0.03	0.06	0.07	−0.05	−0.05	0.03	0.04
Firm size	−0.02	−0.03	0.11*	0.11**	0.07	0.07	0.01	0.01
Firm ownership	−0.01	−0.06	0.06	0.02	0.05	0.03	0.05	0.07
Industry type	−0.07*	−0.06*	−0.04	−0.03	0.04	0.04	−0.05	−0.04
Firm revenue	0.02	0.04	−0.18*	−0.17*	−0.11	−0.11	0.03	0.03
OI	0.34***	0.01	0.47***	0.17**	0.25***	0.17*	0.17*	0.14
KMC		0.61***		0.56***		0.15*		0.04
OI × KMC		0.11**		0.10**		−0.01		0.32***
R^2	0.12	0.37	0.28	0.49	0.09	0.11	0.03	0.14
F	6.10***	19.14***	16.57***	31.24***	4.30***	3.81***	1.50	5.40***

*** $p < 0.001$.
** $p < 0.01$.
* $p < 0.05$.

Table 6
Regression results for sustainable competitive advantage.

Variables	Sustainable competitive advantage								
	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14	Model 15	Model 16	Model 17
Firm age	0.12*	0.08	0.06	0.09	0.08	0.10	0.12*	0.07	0.06
Firm size	0.02	0.07	−0.03	−0.02	0.08	0.06	0.01	−0.01	−0.01
Firm ownership	0.12**	0.14***	0.09*	0.09**	0.13**	0.13**	0.11**	0.09*	0.09*
Industry type	0.01	0.06*	0.05†	0.04	0.04	0.02	0.01	0.05*	0.06*
Firm revenue	−0.09	−0.14†	0.00	−0.02	−0.15†	−0.12	−0.08	−0.02	−0.02
OI	0.49***			0.24***			0.46***		
ERL		0.51***		0.15*				0.15*	0.16*
EIL			0.64***	0.42***				0.53***	0.52***
OAC					0.10*		0.04		
OAB						0.22***	0.09†		
ERL^2									0.05
ERL × EIL									0.02
EIL^2									0.01
R^2	0.28	0.30	0.43	0.49	0.07	0.10	0.29	0.45	0.45
F	17.03***	18.85***	33.39***	30.95***	3.06**	4.56***	13.41***	29.88***	21.33***
Balance									
$Slope^1$									0.49***
$Curvature^1$									0.06
Imbalance									
$Slope^2$									−0.29*
$Curvature^2$									0.04

*** $p < 0.001$.
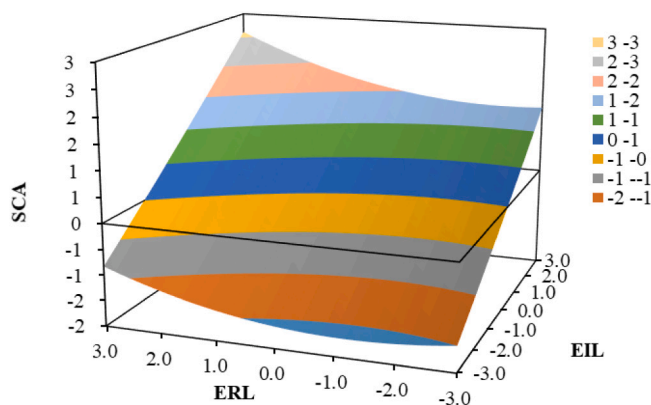** $p < 0.01$.
* $p < 0.05$.
† $p < 0.1$.

Fig. 2. Response surface analysis.

($Slope^2 = -0.29$, $p < 0.05$) (Table 6). Therefore, when enterprises highlighted an imbalanced pursuit of exploration and exploitation, "high exploitation-low exploration" had a greater promoting effect on a
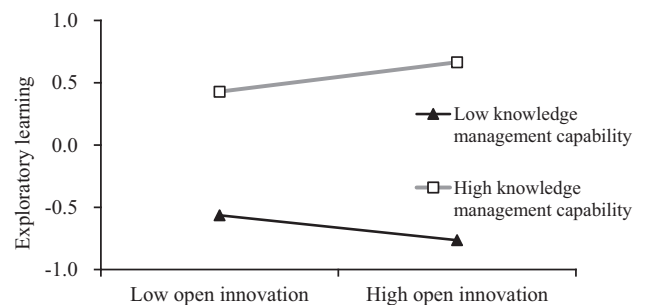

Fig. 3. The moderating effect of knowledge management capability on open innovation and exploratory learning.

firm's sustainable competitive advantage than "high exploration-low exploitation."

6.3. Robustness test

To further ensure the robustness of this study, we conducted a robustness test. We didn't distinct the exploratory and exploitative learning but enveloped them into one construct (i.e., organizational learning), which was used to examine the mediating effect on the relationship between open innovation and sustainable competitive advantage. The results showed that open innovation had a significant, positive, direct impact on sustainable competitive advantage ($\beta = 0.27$, $p < 0.001$) and a significantly indirect effect ($\beta = 0.17$, $p < 0.05$) through organization learning, confirming the mediating role of organizational learning in translating open innovation into competitive advantage. Moreover, we also examined the moderating effect of knowledge management capability on the relationship between open innovation and organizational learning. The interaction term of open innovation and knowledge management capability had a significant, positive effect on organizational learning ($\beta = 0.15$, $p < 0.01$), confirming the support of the moderation effect of knowledge management capability. Hence, the main findings of this study were robust.

7. Discussion

Focusing on the relationship between open innovation and sustainable competitive advantage, this study finds that open innovation contributes to sustainable competitive advantage through enhancing explorative and exploitative learning as well as their ambidexterity, and that such mediating mechanisms are moderated by knowledge management capability. These findings are robust and make several important contributions to theory and practice.

7.1. The impact of open innovation on competitive advantage

The findings suggest significant, positive, direct and indirect impacts of open innovation on sustainable competitive advantage. These findings are consistent with those of several previous studies (e.g., Caputo et al., 2016; Cheng and Huizingh, 2014; Chen et al., 2011; and Greco et al., 2017) that highlight and confirm the benefits of open innovation in terms of financial performance, suggesting that an open paradigm of innovation is helpful for Chinese technical firms. Moreover, the finding of significant indirect effects indicates that open innovation strategy may not only contribute to competitive advantage directly but also influence it indirectly through a mediating mechanism. This finding provides new evidence supporting the argument of several previous studies (Greco et al., 2016; Lazzarotti et al., 2017; Carmona-Lavadoa et al., 2021) that there exist some mechanisms through which open innovation leads to competitive advantage. Especially, beyond the findings of extant literature, this study verifies the role of organizational learning as mediating mechanism of the relationship between open innovation and competitive advantage.
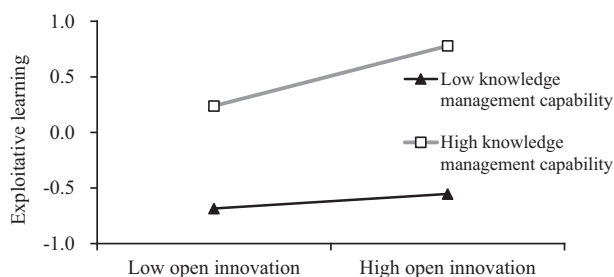

Fig. 4. The moderating effect of knowledge management capability on open innovation and exploitative learning.
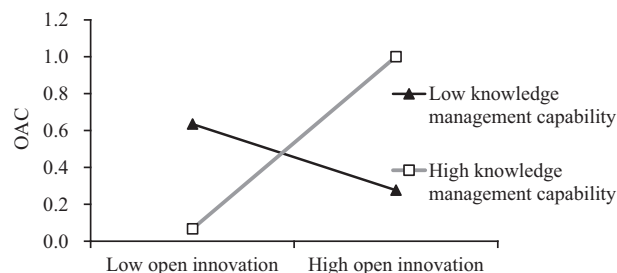

Fig. 5. The moderating effect of knowledge management capability on open innovation and OAC.

More importantly, the finding of the mediation mechanism of organizational learning provides evidence confirming the logic of SCC in the live streaming context as well as the importance of knowledge in the KBV. First, the finding suggests that organizational learning is an important process and competence that helps turn the strategy of open innovation into competitive advantage. Organizational learning has been widely regarded as an important means to acquire and generate knowledge that leads to achieve competitiveness (Gerschewski et al., 2015), thus this finding enriches the KBV literature by underlining the importance of knowledge. Second, the finding reveals the internal functional path of transforming macrolevel, abstract business strategies into an actual competitive edge, which is in line with the logic of SCC that strategies may not be competitive advantage unless they can help firms build some specific competencies, therefore enriches the SCC literature. In addition, this finding helps open the back box between open innovation and competitive advantage and helps partially resolve the problem of the inconsistent findings on this relationship.

These findings also provide implications for managers. First, managers should be open to external environment to acquire resources, technology, and knowledge for innovation, as taking open innovation strategy is more likely to better compete in the rapid developed market (Lichtenthaler, 2011). Moreover, binding in mind that open innovation itself may be not sufficient for generating competitive advantage, managers should cultivate the competence of organizational learning through encouraging employees to acquire knowledge from both internal and external, refine existent knowledge, and generate new knowledge. With such organizational learning, they can benefit more and easier from open innovation.

7.2. The mediating role of ambidextrous organizational learning

Beyond previous studies focusing on the mediating role of organizational learning in terms of exploration and exploitation, this study examines the mediating role of organizational ambidexterity of organizational learning. Numerous studies have explored the antecedents and consequences of the two learning modes, but less attention has been given to the possible mediating role of organizational ambidexterity (Lee et al., 2017). This study confirmed the mediating mechanisms of exploration and exploitation, as well as their balance, through which open innovation led to sustainable competitive advantage. Moreover, the findings suggest that open innovation can be more effectively transformed into competitive advantage through balanced effects between exploration and exploitation, rather than synergistic effects between them. This is in line with the views of Wang et al. (2012) and Bai and Wang (2016), who emphasized the effects of the high level of balance between exploration and exploitation on innovation behavior and performance. In addition, the findings further show that "low exploration-high exploitation" is better than "high exploration-low exploitation."

More importantly, these findings enrich the organizational learning literature by identifying the optimal matching modes of the two types of learning. The findings imply that when exploratory and exploitative

learning were balanced, a high level of balance had a greater promotional effect on sustainable competitive advantage. Therefore, this paper breaks through the single assertion of the balanced or opposing view for exploration and exploitation (Lewis et al., 2010; Atuahene-Gima and Murray, 2007; Koryak et al., 2018; Cao et al., 2009; Jin et al., 2016; Junni et al., 2013), and brings a more comprehensive understanding of the relationship between organizational ambidexterity and a company's competitive advantage.

While the findings reveal that open innovation can help generate competitive advantage via firms' pursuit of balancing exploitation and exploration, managers should reasonably match these two types of learning activities. First, when organizational ambidexterity develops from low-level balance to high-level balance, managers should pay attention to the synchronous promotion of exploration and exploitation to reduce the risks of overemphasizing either of them. Furthermore, due to China's development stage, many Chinese firms generally adopt imitation strategies of "watching by learning" or "learning by doing" as the mode of technology frontier expansion (Ali, 2021; Kumar and Srivastava, 2020). Therefore, they start from exploitative learning, gradually shift to high-level (exploratory) learning, and finally realize the improvement of indigenous innovation capability. In this process, they should follow the principle of "the lesser of the two evils" and first strengthen exploitative learning to avoid the negative effects of excessive exploratory learning on the organization. Finally, companies should strengthen external cooperation and build a perfect cooperation network to acquire knowledge, information, and other external resources, break through internal resource constraints, and provide a foundation for the simultaneous development of exploration and exploitation.

7.3. The moderating role of knowledge management capability

This study finds that knowledge management capability moderates the mediating mechanism of organizational learning through which open innovation contributes to sustainable competitive advantage. In line with the KBV that outlines the importance of knowledge in generating competitive advantage, this finding shows that the high level of knowledge management capability can be an enabler helping open innovation creates competitive advantage. Moreover, this finding contributes to the open innovation literature by helping resolve the problem of mixed findings on the relationship between open innovation and competitive advantage: a firm with high level of knowledge management capability can benefit from open innovation, but one with low level of knowledge management capability may fail to translate open innovation into performance.

Bearing in mind this important role of knowledge management capability, managers should devote to the cultivation of knowledge management capability when they take an open innovation strategy. Moreover, the findings also suggest that knowledge management capability can amplify the role of while organizational learning in terms of exploration and exploitation as well as their ambidexterity, managers need to strengthen their firms' knowledge management capability when they tend to leverage organizational learning or configure the combination of explorative and exploitative learning. In sum, improving knowledge management capability is an important task for mangers who leverage open innovation to create sustainable competitive advantage.

7.4. Limitations and future studies

This study has several limitations. First, this study only examines the mediating effect of organizational learning. But, with the logic of SCC, many kinds of competences take the roles of transforming open innovation strategy into competitive advantage. Future research may explore other mediation mechanisms such as dynamic capabilities, adaptive capabilities, among others. Second, this study only examines the

moderating effect of knowledge management capability to help resolve the inconsistent findings on the relationship between open innovation and competitive advantage. Future studies may further to resolve this problem by investigating other factors (such as industrial factors, managers' personalities, among others) that affect such relationship. Third, the using cross section data collected by survey may be another limitation, as it fails to interpret the temporal relationships among open innovation, exploitative and exploratory learning, and sustainable competitive advantage (Latan, 2018; Latan et al., 2019; Ullah et al., 2018). Future works may employ panel data to examine these relationships with considering the issue of endogeneity. Fourth, while the data was collected from firms locating in the Yangtze River Delta region, and the sample was relatively small, which may affect the generalizability of the conclusions to some extent.

The nomenclature of acronyms

OI	Open innovation
ERL	Exploratory learning
EIL	Exploitative learning
KMC	Knowledge management capability
SCA	Sustainable competitive advantage
OAB	Organizational ambidexterity-balanced
OAC	Organizational ambidexterity-combined
SCC	Strategy-competence-competitive
KBV	Knowledge-based view
RBV	Resource-based view

CRediT authorship contribution statement

Xiaobin Zhang: Conceptualization, Methodology, Data curation, Writing – original draft, Investigation. **Zhaofang Chu:** Conceptualization, Resources, Writing – review & editing, Supervision. **Lei Ren:** Methodology, Formal analysis, Data curation. **Jianguo Xing:** Visualization, Investigation.

Funding

Data availability

Data will be made available on request.

Appendix I. Survey questionnaire

Questionnaire items (5-point Likert scale: 1 "strongly disagree"; 5 "strongly agree")

Open innovation: Over the last three years

1 Our company obtains a large number of technologies and patents through external purchase.

2 Our company gets more technical experience from outside experts.

3 Our company often introduces external ideas and technologies into internal R&D activities.

4 Our company often licenses and transfers technology and patents to outsiders.

5 Our company often provides technical services to outsiders.

6 Our company is proactive in bringing its internal knowledge to the external market.

Knowledge management capability: Over the last three years

1 Our company acquires knowledge from suppliers, customers (feedback), and partners.

2 Our company can harness existing knowledge to develop new knowledge.

3 Our company has an internal mechanism for knowledge

dissemination and sharing.

4 Our company holds regular meetings to inform employees of the latest innovations.

5 The employees in our company often share knowledge and exchange information, and summarize beneficial experience accumulated in work.

6 Our company has systematic procedures or methods to apply new knowledge to develop new products or services.

7 Our company can effectively manage and coordinate all kinds of knowledge to serve the practical application.

Exploitative learning: Over the last three years

1 We upgraded current knowledge and skills for familiar products and technologies.

2 We invested in enhancing skills in exploiting mature technologies that improve productivity of current operations.

3 We enhanced competencies in searching for solutions to customer problems that are near to existing solutions rather than completely new solutions.

4 We upgraded skills in product development processes in which the firm already possesses significant experience.

5 We strengthened our knowledge and skills for projects that improve efficiency of existing innovation activities.

Exploratory learning: Over the last three years

1 We acquired knowledge of manufacturing technologies and skills entirely new to the firm.

2 We learned product development skills and processes (such as product design, prototyping new products, timing of new product introductions, and customizing products for local markets) entirely new to the industry.

3 We acquired entirely new managerial and organizational skills that are important for innovation (such as forecasting technological and customer trends; identifying emerging markets and technologies; coordinating and integrating R&D; marketing, manufacturing, and other functions; and managing the product development process).

4 We learned new skills in areas such as funding new technology, staffing R&D function, training and development of R&D, and engineering personnel for the first time.

Sustainable competitive advantage: Over the last three years

1 The quality of the products or services that our company offer is better than that of the competitor's products or services.

2 Our company is more capable of R&D than the competitors.

3 Our company has better managerial capability than the competitors.

4 Our company's profitability is better.

5 The corporate image of our company is better than that of the competitors.

6 The competitors are difficult to take the place of our company's competitive advantage.

References

Ali, M., 2021. Imitation or innovation: to what extent do exploitative learning and exploratory learning foster imitation strategy and innovation strategy for sustained competitive advantage? Technol. Forecast. Soc. Chang. 165 (5), 527–544.

Andriopoulos, C., Lewis, M.W., 2010. Managing innovation paradoxes: ambidexterity lessons from leading product design companies. Long Range Plan. 43 (1), 104–122.

Atuahene-Gima, K., Murray, J.Y., 2007. Exploratory and exploitative learning in new product development: a social capital perspective on new technology ventures in China. J. Int. Mark. 15 (2), 1–29.

Bai, J.K., Wang, J., 2016. Balance effect and interaction effect of ambidextrous learning and firm innovation performance. In: Research on Financial and Economic Issues, 9, pp. 94–100.

Barrett, G., Dooley, L., Bogue, J., 2021. Open innovation within high-tech SMEs: a study of the entrepreneurial founder's influence on open innovation practices. Technovation 103 (5), 232–248.

Bentler, P.M., Bonett, D.G., 1980. Significance tests and goodness of fit in the analysis of covariance structures. Psychol. Bull. 88 (3), 588–606.

Bianchi, M., Cavaliere, A., Chiaroni, D., 2011. Organisational modes for open innovation in the bio-pharmaceutical industry: an exploratory analysis. Technovation 31 (1), 22–33.

Bogers, M., Chesbrough, H., Moedas, C., 2018. Open innovation: research, practices, and policies. Calif. Manag. Rev. 60 (2), 5–16.

Camisón, C., Villar-López, A., 2011. Non-technical innovation: organizational memory and learning capabilities as antecedent factors with effects on sustained competitive advantage. Ind. Mark. Manag. 40 (8), 1294–1304.

Cao, O., Gedajlovic, E., Zhang, H., 2009. Unpacking organizational ambidexterity: dimensions, contingencies, and synergistic effects. Organ. Sci. 20 (4), 781–796.

Caputo, M., Lamberti, E., Cammarano, A., 2016. Exploring the impact of open innovation on firm performance. Manag. Decis. 54, 1788–1812.

Carmona-Lavadoa, A., Cuevas-Rodrigueza, G., Cabello-Medinaa, C., 2021. Does open innovation always work? The role of complementary assets. Technol. Forecast. Soc. Chang. 162 (5), 316–326.

Castro, M.D., 2015. Knowledge management and innovation in knowledge-based and high-tech industrial markets: the role of openness and absorptive capacity. Ind. Mark. Manag. 47, 143–146.

Chakma, R., Paul, J., Dhir, S., 2021. Organizational ambidexterity: a review and research agenda. IEEE Trans. Eng. Manag. 1–17.

Chalikias, M., Kyriakopoulos, G., Skordoulis, M., Koniordos, M., 2014. Knowledge management for business processes: employees' recruitment and human resources' selection: a combined literature review and a case study. In: Communications in Computer and Information Science, 466. CCIS, pp. 505–520.

Chang, C.H., 2011. The influence of corporate environmental ethics on competitive advantage: the mediation role of green innovation. J. Bus. Ethics 104 (3), 361–370.

Chen, J., Chen, Y., Vanhaverbeke, W., 2011. The influence of scope, depth, and orientation of external technology sources on the innovative performance of chinese firms. Technovation 31, 362–373.

Chen, C.J., Huang, J.W., 2009. Strategic human resource practices and innovation performance-the mediating role of knowledge management capacity. J. Bus. Res. 62 (1), 104–114.

Chen, Y.S., Lin, M.J.J., Chang, C.H., 2009. The positive effects of relationship learning and absorptive capacity on innovation performance and competitive advantage in industrial markets. Ind. Mark. Manag. 38 (2), 152–158.

Cheng, C.C.J., Huizingh, E.K.R.E., 2014. When is open innovation beneficial? The role of strategic orientation. J. Prod. Innov. Manag. 31, 1235–1253.

Chesbrough, H., 2003. Open Innovation: The New Imperative for Creating and Profiting From Technology. Harvard Business School Press, Cambridge.

Chesbrough, H.W., 2006. Open Innovation: The New Imperative for Creating and Profiting From Technology. Harvard Business School Press, Boston.

Chesbrough, H., Schwartz, K., 2007. Innovation business models with co-development partnerships. Res. Technol. Manag 50 (1), 55–59.

Chesbrough, H., Crowther, A.K., 2006. Beyond high tech: early adopters of open innovation in other industries. R&D Manag. 36 (3), 229–236.

Chesbrough, H., Bogers, M., 2014. Explicating open innovation: clarifying an emerging paradigm for understanding innovation. In: Chesbrough, H., Vanhaverbeke, W., West, J. (Eds.), New Frontiers in Open Innovation. Oxford University Press, Oxford, pp. 3–28.

Drechsler, W., Natter, M., 2012. Understanding a firm's openness decisions in innovation. J. Bus. Res. 65 (3), 438–445.

Duysters, G., Lokshin, B., 2011. Determinants of alliance portfolio complexity and its effect on innovative performance of companies. J. Prod. Innov. Manag. 28 (4), 570–585.

Edwards, J.R., Parry, M.E., 1993. On the use of polynomial regression equations as an alternative to difference scores in organizational research. Acad. Manag. J. 36 (6), 1577–1613.

Fidel, P., Schlesinger, W., Cervera, A., 2015. Collaborating to innovate: effects on customer knowledge management and performance. J. Bus. Res. 68 (7), 1426–1428.

Fornell, C., Larcker, D., 1981. Evaluating structural equation models with unobservable variables and measurement error. J. Mark. Res. 18, 39–50.

Gassmann, O., 2006. Opening up the innovation process: towards an agenda. R&D Manag. 36 (3), 223–228.

Gassmann, O., Enkel, E., 2004. Towards a theory of open innovation: three core process archetypes. In: Proceedings of The R&D Management Conference, Lisbon, Portugal, July 6-9.

Gassmann, O., Enkel, E., Chesbrough, H., 2010. The future of open innovation. R&D Manag. 40 (3), 213–221.

Gerschewski, S., Rose, E.L., Lindsay, V.J., 2015. Understanding the drivers of international performance for born global firms: an integrated perspective. J. World Bus. 50 (3), 558–575.

Gibson, C.B., Birkinshaw, J., 2004. The antecedents, consequences, and mediating role of organizational ambidexterity. Acad. Manag. J. 47 (2), 209–226.

Grant, R.M., 1996. Toward a knowledge-based theory of the firm. Strateg. Manag. J. 17 (S2), 109–122.

Greco, M., Grimaldi, M., Cricelli, L., 2016. An analysis of the open innovation effect on firm performance. Eur. Manag. J. 34 (5), 501–516.

Greco, M., Grimaldi, M., Cricelli, L., 2017. Hitting the nail on the head: exploring the relationship between public subsidies and open innovation efficiency. Technol. Forecast. Soc. Chang. 118, 213–225.

Hayes, A.F., 2017. Introductionto Mediation, Moderation, and Conditional Process Analysis: A Regression-based Approach. The Guilford Press.

Hull, C.E., Covin, J.G., 2011. Learning capability, technological parity, and innovation mode use. J. Prod. Innov. Manag. 27 (1), 97–114.

Hung, K.-P., Chiang, Y.-H., 2010. Open innovation proclivity, entrepreneurial orientation and perceived firm performance. Int. J. Technol. Manag. 52, 244–257.

He, Z.L., Wong, P.K., 2004. Exploration vs. exploitation: an empirical test of the ambidexterity hypothesis. Organ. Sci. 15 (4), 481–494.

Hsieh, C.-T., Huang, H.-C., Lee, W.-L., 2016. Using transaction cost economics to explain open innovation in start-ups. Manag. Decis. 54, 2133–2156.

Jin, J.L., Zhou, K.Z., Wang, Y., 2016. Exploitation and exploration in international joint ventures: moderating effects of partner control imbalance and product similarity. J. Int. Mark. 24 (4), 20–38.

Junni, P., Sarala, R.M., Taras, V.A.S., 2013. Organizational ambidexterity and performance: a meta-analysis. Acad. Manag. Perspect. 27 (4), 299–312.

Kang, K.H., Kang, J., 2009. How do firms source external knowledge for innovation? Analysing effects of different knowledge sourcing methods. Int. J. Innov. Manag. 13 (1), 1–17.

Kiss, A.N., Libaers, D., Barr, P.S., 2020. CEO cognitive flexibility, information search, and organizational ambidexterity. Strateg. Manag. J. 41 (2), 2200–2233.

Kock, N., 2015. Common method bias in PLS-SEM: a full collinearity assessment approach. Int. J. e-Collaboration (IJeC) 11 (4), 1–10.

Koryak, O., Lockett, A., Hayton, J., 2018. Disentangling the antecedents of ambidexterity: exploration and exploitation. Res. Policy 47 (2), 413–427.

Kratzer, J., Meissner, D., Rould, V., 2017. Open innovation and company culture: internal openness makes the difference. Technol. Forecast. Soc. Chang. 119, 128–138.

Kumar, V., Srivastava, R., 2020. New perspectives on business model innovations in emerging markets. J. Acad. Mark. Sci. 48 (5), 815–825.

Kyriakopoulos, G.L., Kapsalis, V.C., Aravossis, K.G., Zamparas, M., Mitsikas, A., 2019. Evaluating circular economy under a multi-parametric approach: a technological review. Sustainability 11 (21).

Latan, H., 2018. PLS path modeling in hospitality and tourism research: The golden age and days of future past. In: Ali, F., Rasoolimanesh, M.S., Cobanoglu, C. (Eds.), Applying of Partial Least Squares in Tourism and Hospitality Management. Bingley, Emerald, pp. 53–83.

Latan, H., Jabbour, C.J.C., De Sousa Jabbour, A.B.L., 2019. To blow or not to blow the whistle: the role of rationalization in the perceived seriousness of threats and wrongdoing. J. Bus. Ethics 169, 1–19.

Lazzarotti, V., Bengtsson, L., Manzini, R., 2017. Openness and innovation performance. An empirical analysis of openness determinants and performance mediators. Eur. J. Innov. Manag. 20 (3), 463–492.

Lee, K., Kim, Y., Joshi, K., 2017. Organizational memory and new product development performance: investigating the role of organizational ambidexterity. Technol. Forecast. Soc. Chang. 120, 117–129.

Lewis, M., Brandon-Jones, A., Slack, N., Howard, M., 2010. Competing through operations and supply: the role of classic and extended resource-based advantage. Int. J. Oper. Manag. 30, 1032–1058.

Li, Y., Wei, Z., Zhao, J., Zhang, C., Liu, Y., 2013. Ambidextrous organizational learning, environmental munificence and new product performance: moderating effect of managerial ties in China. Int. J. Prod. Econ. 146 (1), 95–105.

Lichtenthaler, U., Lichtenthaler, E., 2009. A capability-based framework for open innovation: complementing absorptive capacity. J. Manag. Stud. 46 (8), 1315–1338.

Lichtenthaler, U., 2009. Absorptive capacity, environmental turbulence, and the complementarity of organizational learning processes. Acad. Manag. J. 52 (4), 822–846.

Lichtenthaler, U., 2011. Open innovation: past research, current debates and future directions. Acad. Manag. Perspect. 2, 75–93.

Lin, J.-Y., 2014. Effects on diversity of R&D sources and human capital on industrial performance. Technol. Forecast. Soc. Chang. 85, 168–184.

Lopes, A.P.V.B.V., De Carvalho, M.M., 2018. Evolution of the open innovation paradigm: towards a contingent conceptual model. Technol. Forecast. Soc. Chang. 132, 284–298.

March, J.G., 1991. Exploration and exploitation in organizational learning. Organ. Sci. 2 (1), 71–87.

Meier, L.L., Spector, P.E., 2013. Reciprocal effects of work stressors and counterproductive work behavior: a five-wave longitudinal study. J. Appl. Psychol. 98 (3), 529–539.

Mom, T.J.M., Van Den Bosch, F.A.J., Volberda, H.W., 2007. Investigating managers' exploration and exploitation activities: the influence of top-down, bottom-up, and horizontal knowledge inflows. J. Manag. Stud. 44 (6), 910–931.

Mueller, B.A., Titus, V.K., Covin, J.G., 2012. Pioneering orientation and firm growth: knowing when and to what degree pioneering makes sense. J. Manag. 38 (5), 1517–1549.

Naqshbandi, M.M., Kaur, S., Ma, P., 2015. What organizational culture types enable and retard open innovation? Qual. Quant. 49, 2123–2144.

Naqshbandi, M.M., 2016. Managerial ties and open innovation: examining the role of absorptive capacity. Manag. Decis. 54 (9), 2256–2276.

Nunnally, J.C., 1978. Psychometric Theory. McGraw- Hill, New York, NY.

Pérez-López, S., Alegre, J., 2012. Information technology competency: knowledge processes and firm performance. Ind. Manag. Data Syst. 112, 644–662.

Podsakoff, P.M., Organ, D.W., 1986. Self-reports in organizational research: problems and prospects. J. Manag. 12 (4), 69–82.

Podsakoff, P.M., MacKenzie, S.B., Podsakoff, N.P., 2012. Sources of method bias in social science research and recommendations on how to control it. Annu. Rev. Psychol. 63 (1), 539–569.

Popa, S., Soto-Costa, P., Martinez-Conesa, I., 2017. Antecedents, moderators, and outcomes of innovation climate and open innovation: an empirical study in SMEs. Technol. Forecast. Soc. Chang. 118, 134–142.

Prud'homme Van Reine, P., 2015. A networking culture to benefit from open innovation- a comparison between technology and business services industries in the Netherlands. J. Innov. Manag. 3, 71–105.

Rass, M., Dumbach, M., Danzinger, F., 2013. Open innovation and firm performance: the mediating role of social capital. Creat. Innov. Manag. 22 (2), 177–194.

Rigby, D., Zook, C., 2002. Open-market innovation. Harv. Bus. Rev. 80 (10), 80–89.

Santoro, G., Thrassou, A., Bresciani, S., Giudice, M.D., 2021. Do knowledge management and dynamic capabilities affect ambidextrous entrepreneurial intensity and firms' performance? IEEE Trans. Eng. Manag. 68 (2), 378–386.

Shanock, L.R., Baran, B.E., Gentry, W.A., 2010. Polynomial regression with response surface analysis: a powerful approach for examining moderation and overcoming limitations of difference scores. J. Bus. Psychol. 25 (4), 543–554.

Soto-Acosta, P., Popa, S., Martinez-Conesa, I., 2018. Information technology, knowledge management and environmental dynamism as drivers of innovation ambidexterity: a study in SMEs. J. Knowl. Manag. 22 (4), 824–849.

Stanko, M.A., Fisher, G.J., Bogers, M., 2014. Under the wide umbrella of open innovation. J. Prod. Innov. Manag. 34 (4), 543–558.

Tanriverdi, H., Venkatraman, N., 2005. Knowledge relatednessand performance of multibusiness firms. Strateg. Manag. J. 26, 97–119.

Teece, D.J., Pisano, G., Shuen, A., 1997. Dynamic capabilities and strategic management. Strateg. Manag. J. 18 (7), 509–533.

Tu, Y., Wu, W.K., 2021. How does green innovation improve enterprises' competitive advantage? The role of organizational learning. Sustainable Production and Consumption 26, 504–516.

Ullah, S., Akhtar, P., Zaefarian, G., 2018. Dealing with endogeneity bias: the generalized method of moments (GMM) for panel data. Ind. Mark. Manag. 71, 69–78.

Valentim, L., Lisboa, J.V., Franco, M., 2016. Knowledge management practices and absorptive capacity in small and medium-sized enterprises: is there really a linkage? R&D Manag. 46 (4), 711–725.

Wang, F.B., Chen, J.X., Yang, Y., 2012. Exploratory and exploitative technological innovation and its balance effect analysis. Manage. World 3, 96–112.

Wang, Y., Li, J., Ning, L., Zeng, D., 2014. Dynamic patterns of technology collaboration: a case study of the Chinese automobile industry, 1985–2010. Scientometrics 101 (1), 663–683.

West, J., 2006. Does appropriability enable or retard open innovation. In: Chesbrough, H., Vanhaverbeke, W., West, J. (Eds.), Open Innovation: Researching a New Paradigm. Oxford University Press, Oxford.

Yang, W., 2006. Research on intellectual property management theory based on open innovation. Stud. Sci. Sci. 24 (2), 311–314.

Yu, J., Engleman, R.M., Van de Ven, A.H., 2005. The integration journey: an attention-based view of the merger and acquisition integration process. Organ. Stud. 26 (10), 1501–1528.

Zhao, J., Li, Y., Liu, Y., 2016. Organizational learning, managerial ties, and radical innovation: evidence from an emerging economy. IEEE Trans. Eng. Manag. 63 (4), 489–499.

Zhu, X.X., Xiao, Z.X., Dong, M.C., 2019. The fit between firms' open innovation and business model for new product development speed: a contingent perspective. Technovation. 86-87, 75–85.

Xiaobin Zhang: Ph.D. student of Business School, Soochow University. Her main research interests are in innovation management and organizational learning.

Zhaofang Chu: professor of Business School, Anhui University. His main research is focused on logistics and supply chain management, international trade and business model innovation.

Lei Ren: Ph.D. student of Business School, Soochow University. His main research interests are in human resources management and organizational behavior.

Jianguo Xing: professor of Business School, Soochow University. His main research is focused on transnational business and management and enterprise growth.