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The impact of external search, tie strength, and absorptive capacity on new product development performance

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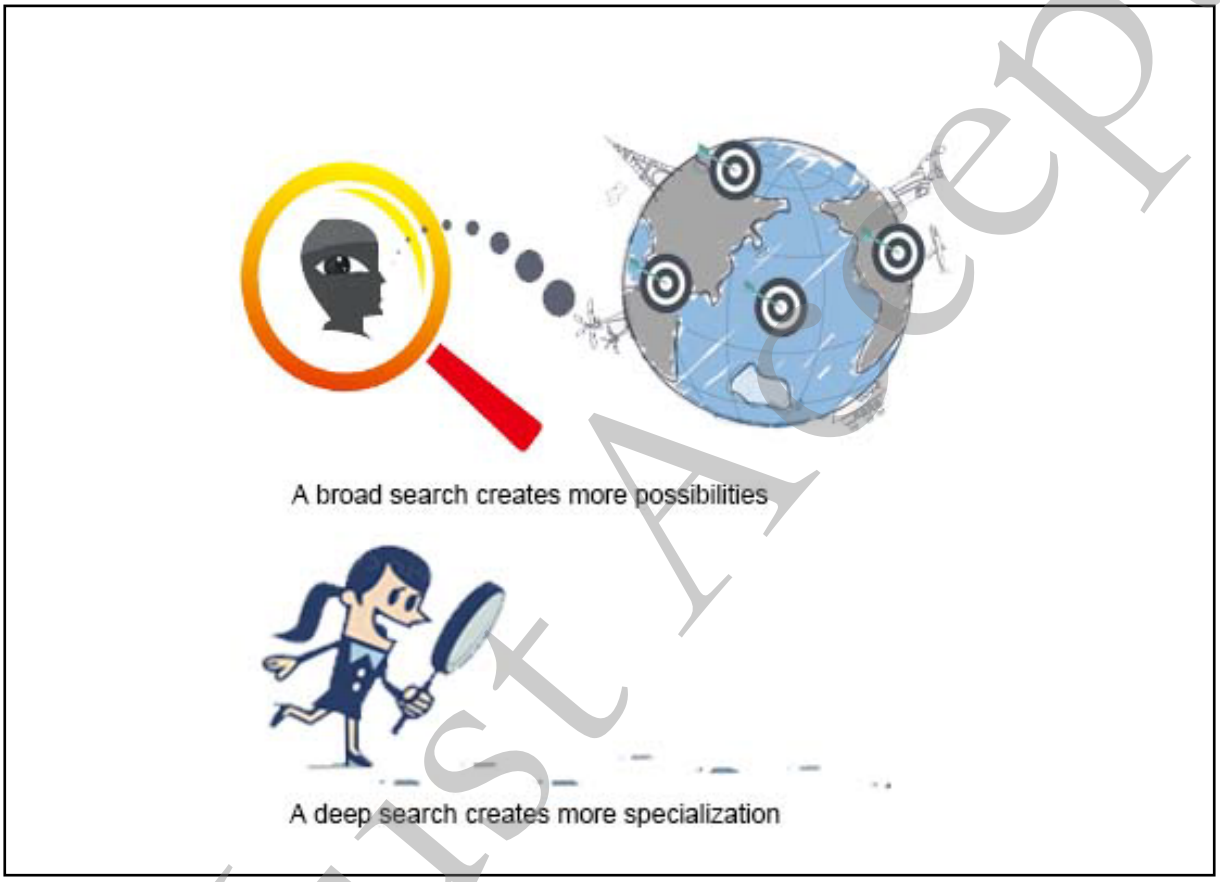
Graphical abstract



This research demonstrates the different roles of search breadth and depth in NPD performance.

Public summary

- Search breadth facilitates new product creativity, whereas search depth facilitates development speed.
- Tie strength weakens the positive effects of search breadth on new product creativity but strengthens the positive effects of search depth on development speed.
- The synergistic effect of tie strength and absorptive capacity weakens the positive effects of search breadth on new product creativity but strengthens the positive effects of search depth on development speed.

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Abstract: This study examines the influences of external search breadth and depth on new product development performance from a knowledge-based view. In particular, we introduce tie strength and absorptive capacity as two contextual variables in this study. The findings from data on 281 Chinese firms indicate that search breadth facilitates new product creativity, whereas search depth facilitates development speed. Tie strength weakens the relationships between search breadth and new product creativity but strengthens the relationship between search depth and development speed. Furthermore, the synergistic effect of tie strength and absorptive capacity negatively moderates the relationship between search breadth and new product creativity but positively moderates the relationship between search depth and development speed.

Keywords: external search; absorptive capacity; new product development

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1 Introduction

Firms need to develop new products constantly to keep their competitive edge[1]. However, not all companies have enough knowledge to meet the need for continuous product innovation[2]. To bridge this gap, firms build interorganizational relationships to obtain key resources, acquire external knowledge, and improve new product development (NPD) performance[3]. As an increasing number of scholars have begun to pay attention to external search, its importance has become widely recognized (Wolfgang et al., 2014; Savino et al., 2017) [4].

External search is an effective way for organizations to strengthen knowledge reserves by recreation and reorganization of specific external knowledge[5]. Meanwhile, it assists firms in acquiring key information resources and adapting to the changing environment[6]. In the existing external search research, the knowledge-based view (KBV) has recently gained prominence. The basic premise of the KBV is that new product creativity is primarily a function of the firm's ability to manage, maintain, and create knowledge. According to the KBV, a firm's knowledge base represents its most unique resource for new product development. The greater the intensity of the search, the more likely it is that the amount of knowledge available will increase[7] and effectively improve firms' NPD ability[8].

Despite the significant contribution of previous empirical research, the literature is not consistent on how a firm's external search, that is, search breadth and depth, influences NPD performance. Some research suggests a positive linear correlation between external search and innovation (e.g., Refs. [9, 10]), while other scholars believe that there exists a point where additional search becomes unproductive (taking an inverted U shape) (e.g., Refs. [5, 11]). Regarding this inconsistency, Laursen and Salter[12] argue that openness to external sources helps companies absorb valuable ideas from outsiders, thereby increasing the technological opportunities available to them. Nevertheless, "oversearch" will result in higher costs and redundant resources for most firms, which requires firms to rethink the "degree" of external search and conduct search strategy pertinently. Subsequent research should be subdivided based on different search strategies and innovation choices because NPD is still a relatively broad measure of innovation output.

Theoretically, the internalization of external knowledge cannot be separated from ties of relation (e.g., Refs.[13, 14]). Especially in the Chinese context, more attention should be given to the Chinese *Guanxi* context in the relationship building process. *Guanxi* context can be defined as the closeness of the relationship and the frequency of interaction, and can range from weak to strong, namely, tie strength in the study[15, 16]. Firms that adopt an external search strategy need to establish close relationships with partners, involving trust, good communication frequency, stability, and fairness[17]. Tie strength is considered to be an important variable in strategic alliance studies[18], but its role in the context of external search strategy has not been fully researched. We posit that tie strength plays an important moderating role in the relationship between external search and NPD performance because it will affect the efficiency and effectiveness of knowledge transfer.

Moreover, many scholars believe absorptive capacity to be essential for external search outputs[19, 20]. However, Cuervo-Cazurra and Rui[21] found that the absorptive capacity of firms in emerging economies was deficient. The process of knowledge accumulation in these companies is different from that

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in developed countries. Therefore, the role of absorptive capacity in NPD needs to be further studied in emerging markets. We also take it as a moderating variable, as many prior scholars have done, and further extend the application of absorptive capacity theory in the Chinese context.

To address these research gaps, this study studies the impacts of external search (search breadth and depth) on NPD performance (creativity and speed) and introduces tie strength and absorptive capacity as two contextual variables in this study. The high complexity and dynamism of the Chinese economy provide a rich research background for our model. This study's findings will provide empirical support for the further development of external search and absorptive capacity theories along with suggestions on how firms in countries such as China should actively develop their own search strategies to promote NPD performance.

2 Theoretical background and hypotheses

2.1 External search and NPD performance

For many firms, creativity and speed are the main outcomes of NPD (Ganesan et al., 2005) [22]. New product creativity refers to the novelty and usefulness of new products through the accumulation of new knowledge elements. It allows firms to formulate rules that competitors cannot imitate and, thereby, meet the needs of customers and expand the market (Jansen et al., 2006 [23]; Voss & Voss, 2013 [24]). New product development speed refers to the speed at which a product concept is transformed into a market product. It helps firms attain higher efficiency and a faster trading mode to serve existing customers in a timely manner (Kollmann & Stöckmann, 2014) [25]. New product creativity and development speed require knowledge with different features, which will differentiate an organization's implementation of an external search strategy. In this study, we divide search strategy into breadth search and depth search according to different attributes of knowledge. This classification is widely accepted by many scholars (Chiang & Hung, 2010 [26]; Ferreras-Méndez et al., 2015 [6]; Katila & Ahujia, 2002 [5]), and many controversies still exist, as mentioned in the introduction, which need to be further revealed. This study will discuss the diverse effects of search breadth and depth on new product creativity and development speed. This is a fresh research perspective that has not yet been revealed.

Search breadth represents the extent to which firms explore different fields and external technical resources (Chiang & Hung, 2010) [26]. The larger the breadth of the search is, the greater the amount of new knowledge that firms are exposed to; in other words, search breadth explains how firms search for new knowledge. Searching broadly in different fields helps firms obtain more creative opportunities and ideas to generate potential differentiation advantages. It can expand organizational vision, enhance strategic flexibility, broaden the scope of an innovation network, and increase firms' enterprising and exploration abilities (Golgeci et al., 2019) [27]. New product creativity is the result of finding new organizational practices and discovering new methods, technologies, businesses, processes, and products (Lin, McDonough, 2014) [28], which is closely linked with search breadth. Therefore, we believe that wider search breadth helps firms obtain more novel and heterogeneous knowledge and access more possibilities for new product creativity.

Search depth refers to the intensity and repeatability of organizing and developing each bundle of external technical resources (Chiang & Hung, 2010) [26]. The larger the depth of the search, the more an organization accesses similar knowledge; this explains the extent to which an organization reuses existing knowledge (Henttonen & Ritala, 2013) [14]. Search depth helps firms enrich their knowledge bundles and reduce the possibility of error and loss and enables them to access existing knowledge in similar fields (Leiponen & Helfat, 2010) [13]. Search depth can improve existing technology, products, and services by reorganizing old knowledge and, therefore, promoting efficiency, reducing costs, upgrading channels, and solving problems for refining and improving existing knowledge (Shi et al., 2020 [29]; Tang et al., 2019 [30]).

Deeper search depth helps firms improve knowledge professionalism, accelerate the process of learning and knowledge upgrading, and promote the efficiency of new product development. Thus, we believe that deeper search depth is conducive to improving inherent capability, reducing the chance of failure, breaking through technical bottlenecks, and accelerating NPD speed. Therefore, we propose the following hypotheses.

H1: Search breadth is positively related to new product creativity.

H2: Search depth is positively related to development speed.

2.2 Moderating role of tie strength

The external search for cross-organizational boundaries requires the establishment of relationships with the aid of suppliers, customers, and agents (Zhang & Li, 2010) [17]. According to quality, trust, fairness, and persistence, a partnership can be classified as having either a strong or a weak tie. A strong tie reflects a stable and close relationship with partners, which aids a deep communication of knowledge and promotes convergence between firms. On the other hand, a weak tie is beneficial for the transfer of heterogeneity and diversity of knowledge (Lavie, 2007) [31]. Although the efficiency of knowledge transfer in weak ties does not equal that in strong ties partnership, strong and weak ties each have pros and cons with respect to knowledge transfer both are important situational factors for implementing external search strategies (Michelfelder & Kratzer, 2013) [32]. In this study, we use tie strength as a situational variable to explore the influence of external search on NPD performance.

We suggest that search breadth performs better on new product creativity when weak ties are employed than when strong ties are employed. First, firms need to establish more new relationships with external suppliers, customers, universities, and agents to improve search breadth. Weak ties can minimize the cost of maintaining such relationships. In other words, weak ties save firms more energy to make more external connections. Second, firms that search widely are exposed to a variety of new knowledge from partners. Weak ties

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function as information bridges, thus offering more heterogeneity and diversity in knowledge transfer (Michelfelder & Kratzer, 2013) [32]. Unlike strong ties, weak ties have lower knowledge redundancy in acquisition and have more advantages in transferring novel and heterogeneous knowledge, which provides more possibilities for new product creation.

Conversely, we believe search depth performs better in terms of development speed when strong ties are employed than when weak ties are employed. First, firms that focus on search depth emphasize the intensity of the search and professionalism of knowledge. Compared with weak ties, strong ties are more beneficial for deep knowledge communication, as they can effectively transfer high-quality information and complex knowledge. Strong ties are established based on a contract (Bergenholtz, 2011) [33] to effectively reduce opportunistic behavior and enhance the reliability of knowledge transfer (Low et al., 2012) [34]. Second, firms that employ strong ties are based on relatively stable and long-term relationships among firms. Search depth emphasizes long-term tracking and enhancement of existing knowledge bundles. Strong ties ensure continuous interfirm communication and thus apply external experience to technology replacement and process promotion over a relatively long period of time. Therefore, applying stronger ties to the search depth is conducive to effective communication and deep learning, quickly realizing knowledge updates, technology upgrades and ability improvements to improve the speed of new product development. The following hypotheses are developed:

H3: Tie strength weakens the positive effects of search breadth on new product creativity.

H4: Tie strength strengthens the positive effects of search depth on development speed.

2.3 Moderating roles of absorptive capacity

External search involves regrouping and creating external knowledge. Firms that adopt an external search strategy should have the capability to identify the value of external knowledge, namely, absorptive capacity (Grimpe & Sofka, 2009) [20]. If external search provides potential opportunities for NPD, the ability to absorb cross-border knowledge becomes a key factor for NPD performance (Enkel & Gassmann, 2010) [35]. Absorptive capacity helps mitigate potential threats or risks in the external search process; it assists firms across organizational or technical boundaries (Rothaermel & Alexandre, 2009) [19]. Firms that increase their absorptive capacity can promote NPD performance in interorganizational networking (Huang & Rice, 2009) [36].

Firms that emphasize search breadth obtain diverse new knowledge from suppliers, customers, agents, and universities, many of whom are not associated with the existing knowledge of the enterprise. The key to improving performance is knowing how to apply new knowledge in the development of products, services, or technology (Leal-Rodríguez et al., 2014) [37]. Absorptive capacity contains the processes of acquisition, assimilation, transformation and exploitation (Zahra & George, 2002) [38], which help to transform external new knowledge into an innovative output and market the new knowledge (Fosfuri & Trib, 2008) [39]. Therefore, absorptive capacity can promote a positive relationship between search breadth and new product creativity.

Depth-first strategy involves a search for existing technologies, products, and services. It obtains specialized and complex leading knowledge from outside and integrates it with the existing knowledge base to update technology, as well as upgrade products and services through knowledge reorganization. It is vital to communicate deeply with partners, acquire key external knowledge, and comprehensibly assimilate this knowledge (Enkel & Heil, 2014) [40]. Firms with greater absorptive capability can acquire more related external knowledge, reorganize existing knowledge, and assimilate more complex and tacit knowledge**.** Therefore, we believe that absorptive capacity can strengthen the positive relationship between search depth and development speed. The following hypotheses are developed:

H5: Absorptive capacity strengthens the positive effects of search breadth on new product creativity.

H6: Absorptive capacity strengthens the positive effects of search depth on development speed.

Furthermore, we believe that tie strength and absorptive capacity have a synergistic effect on the main effect because tie strength and absorptive capacity will jointly affect the transfer efficiency of external knowledge.

Firms that focus on search breadth always obtain new ideas and plans from different external partners. In this case, weak ties are helpful because they provide more possibilities to establish heterogeneous knowledge connections through information bridges. This also requires a strong absorptive capacity to transform and use the various knowledge. By combining weak ties and absorptive capacity, firms can effectively integrate external diversified knowledge. Therefore, we believe that the synergy between weak ties and absorptive capacity positively regulates the relationship between search breadth and new product creativity. That is, the three-way interaction between search breadth, tie strength, and actual absorptive capacity is negatively related to exploratory innovation performance.

Firms that focus on search depth always obtain leading knowledge to renew existing knowledge. In this case, strong ties are important because they allow firms to establish mutual trust and deep communication with their partners. At the same time, absorptive capacity helps in complex and tacit knowledge acquisition and assimilation. Thus, strong ties and absorptive capacity are mutually complementary; they can greatly enhance interfirm learning, accelerate the deep level transfer of complex and tacit knowledge, and renew existing knowledge.

Therefore, we believe that the synergy between strong ties and absorptive capacity positively regulates the relationship between search depth and development speed. That is, the three-way interaction between search depth, tie strength, and absorptive capacity is positively related to development speed.

H7: The three-way interaction between search breadth, tie strength, and absorptive capacity is negatively related to new product creativity.

H8: The three-way interaction between search depth, tie strength, and absorptive capacity is positively related to development speed.

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3 Methodology

3.1 Sample and data collection

A questionnaire survey was used to collect data. A maturity scale was used for all questions in the questionnaire. Initially, we set up an English-language version of the questionnaire. Then, a two-way translation was used to ensure conceptual equivalence. To ensure content and face validity in the Chinese context, we conducted a pilot study comprising 30 questionnaires. According to the responses received in the pilot study, the items on the questionnaire were fine-tuned and modified.

We randomly selected 1000 firms from the list of high-tech enterprises in China. A total of 525 out of 1000 firms agreed to participate in the study. To ensure that the respondents could clearly understand and answer the questions in this survey, we mainly chose senior managers in the investigated firms. We distributed 525 questionnaires and received 348 responses in total. After further screening, 281 valid questionnaires were obtained, and the effective response rate was 28.1% (281/1000). The survey showed that the average respondent's tenure was more than ten years. The majority (86%) of them had bachelor's degrees, and some (36%) even held a master's or doctoral degree, ensuring that they clearly answered the questions in the questionnaire. In addition, this study gave the respondents cash rewards to improve their participation in the questionnaire.

3.2 Variables and measures

Two categories of NPD performance were measured: creativity and speed (Ganesan et al., 2005) [22]. New product creativity included six items, which captured the extent to which units develop novel and interesting products, offer new ideas, and promote fresh thinking. Development speed consisted of four items, which captured the extent to which units are faster than the industry norm, faster than they expected, and faster than their typical product development time. The Appendix reports the measures of the constructs.

External search was measured from two dimensions: search breadth and search depth (Laursen & Salter, 2006) [12]. Search breadth was constructed as a combination of 16 sources of knowledge or information for innovation. These include suppliers, clients, competitors, consultants, commercial laboratories, universities, government research firms, other public sector institutes, private research institutes, professional conferences, trade associations, technical/trade press, exhibitions, technical standards, health and safety standards and regulations, and environmental standards and regulations. Each of the 16 sources was encoded as a binary variable, with 0 indicating "no use" and 1 indicating "use" of a given source of knowledge. Search depth was constructed using the same 16 sources, with 0 denoting "no, low, or medium use" of the given knowledge and 1 denoting "use" of the given knowledge to a high degree. The sixteen dummies are subsequently added up so that each firm gets a score of 0 when no partners are used, while the firm gets a value of 16 when the firm is collaborating with all potential collaboration partners.

Following Molina-Morales et al. (2013) [41], the tie strength of relationships was measured using five items that assess the frequency of communication and closeness of connections between firms. Because senior managers have a clearer understanding of the interfirm relationships, they were able to make clear assessments of the tie strength.

Borrowing from Zahra & George (2002) [38], we develop the measure of absorptive capacity to include 21 items that assess a firm's ability to acquire, assimilate, transform, and exploit, which reflects the entire process from acquisition to utilization of external knowledge.

Finally, this study included five control variables: firm size, firm age, competitiveness, geographic dispersion, and network embeddedness. Firm size is indicated as the logarithm of the number of employees, and firm age is the logarithm of the number of years the firm has been in operation. We used four questions of the Jansen (2006) [42] scale to measure competitiveness. The geographic decentralization degree of the partners was measured by geographic dispersion ranging from 1, "very concentrated," to 7, "very dispersed," and the size of network embeddedness is the logarithm of the number of current partners the organization has.

4 Analysis and results

4.1 Analysis

Appendix 1 reports the results of standardized parameter estimates. All loading factors (ranging from 0.668 to 0.890) show up in the normal range, and all composite reliabilities (CR) exceeded the 0.70 benchmark. These measures demonstrate adequate reliability.

We employed confirmatory factor analysis (CFA) to test the validity of the measures. The indices suggested a reasonable fit ($\chi^2/df = 1.37$, comparative fit index = 0.96, non-normed fit index = 0.96, and root mean square error of approximation= 0.037). Table 1 shows that the square root of the average variance extracted (AVE) for each of the constructs exceeded the indicators of correlations, which further supported the discriminant validity of the constructs.

4.2 Results

We used hierarchical regression analysis to test the hypotheses. Tables 2 and 3 present the results of the regression analysis. We only included control variables in M1 and M3, and M2 adds the search breadth and depth based on M1. We find that the coefficient of search breadth ($= 0.323, p < 0.001$) is significant, indicating its linear relationship with new product creativity. M4 adds the search breadth and depth as independent variables based on M3. We find that the coefficient of search depth ($= 0.368, p < 0.001$) is significant, indicating its positive linear relation with development speed. Thus, Hypotheses 1 and 2 are supported.

Table 3 reports the results of the regression analysis that verifies the moderation effect. For new product creativity, we build M5–M7. M5 indicates that both search breadth ($\beta = 0.114$, $p < 0.05$) and tie strength ($\beta = 0.336, p < 0.001$) are significant, and the intersection item ($\beta = 0.127, p < 0.001$) is significant with a negative coefficient. Thus, tie strength negatively regulates the relationship between search breadth and new product creativity. Therefore, Hypothesis 3 is supported.

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Table 1. Correlation matrix of variables.

	1	2	3	4	5	6	7	8	9	10	11
1. Search breadth	1										
2. Search depth	0.491**	1									
3. Tie strength	0.564**	0.436**	0.827								
4. Absorptive capability	0.484**	0.623**	0.548**	0.725							
5. New product creativity	0.336**	0.383**	0.364**	0.425**	0.827						
6. Development speed	0.400**	0.315**	0.422**	0.449**	0.634**	0.788					
7. Firm size	0.077	0.101	-0.054	0.009*	0.003	0.022	1				
8. Firm age	0.139*	-0.022	-0.045	-0.135*	0.030	0.040	0.332**	1			
9. Competitiveness	0.125*	0.096	0.167**	0.153*	0.091	0.110	-0.086	-0.063	0.801		
10. Geographic dispersion	0.105	0.090	0.104	0.232**	0.171*	0.265**	0.025	0.024	0.037	1	
11. Network embeddedness	0.044	0.094	0.023	0.042	0.030	0.037	-0.049	-0.028	-0.114	0.169*	1
Mean	6.054	1.076	5.312	4.895	5.173	5.423	5.85	2.90	4.934	4.87	2.65
S.D.	2.436	0.652	1.028	0.663	1.073	0.950	1.89	0.96	1.021	1.23	1.13

The diagonal elements (in bold) are the square roots of the AVE values, *$p < 0.05$; **$p < 0.01$; (two-tailed tests)

Table 2. Direct effects test.

	New product creativity		Development speed	
	M1	M2	M3	M4
Firm size	0.039	0.002	0.037	0.004
Firm age	0.154*	0.164*	0.192*	0.123
Competitiveness	0.134	0.091	0.127	0.087
Geographic dispersion	0.180**	0.145*	0.255**	0.221***
Network embeddedness	0.082	−0.60	0.292*	0.173
Search breadth		0.323***		0.127
Search depth		0.150		0.368***
R^2	0.069	0.218	0.128	0.286
Adjusted R^2	0.038	0.181	0.099	0.253
F	2.249**	5.925***	4.464***	8.537***

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

Regarding the contingent role of absorptive capacity, our results in M6 show that the coefficient of the interaction term ($\beta = 0.269, p < 0.01$) between absorptive capacity and search breadth is significant and positive, indicating that *Hypothesis 5* is supported.

M7 incorporates tie strength, absorptive capacity, search breadth, and the interaction terms. We find that the interaction term ($\beta = -0.158, p < 0.05$) of search breadth, tie strength, and actual absorptive capacity is significant and negative, showing that Hypothesis 7 is supported.

For development speed, we build M8–M10. M8 verifies the moderating effect of tie strength ($\beta = 0.220, p < 0.001$) on the relationship between search depth and development speed. Hypothesis 4 is supported. M9 validates the moderating effect of absorptive capacity on the relationship between search depth and development speed. The results indicate that the interaction item ($\beta = 0.256, p < 0.01$) between search depth and absorptive capacity is significant and positive, and thus, Hypothesis 6 is supported.

M10 indicates that the interaction term ($\beta = 0.221$, $p < 0.01$) of search depth, tie strength, and absorptive capacity is significant and positively related to development speed, showing that *Hypothesis 8* is supported. To better explain the three-way interaction, we used Dawson and Richter's[43] three-way interaction method to represent the effects in Figs. 1 and 2.

Fig. 1 shows the three-way interaction between search breadth, tie strength, and absorptive capacity on new product creativity. Line 2 has the highest impact coefficient, indicating that the most beneficial method for new product creativity is to strengthen absorptive capacity, increase search breadth, and establish lower level tie strength.

Fig. 2 shows the three-way interaction between search depth, tie strength, and absorptive capacity on development speed. Line 1 has the highest impact coefficient on development speed. Thus, the most effective way to improve development speed is to enhance absorptive capacity, strengthen search depth, and establish higher level tie strength.

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Table 3. Moderating Effects Test

	New product creativity			Development speed		
	M5	M6	M7	M8	M9	M10
Firm size	0.054	−0.015	0.034	0.074	−0.009	0.052
Firm age	0.129	0.185*	0.188*	0.178*	0.247*	0.213**
Competitiveness	0.066	0.086	0.053	0.017	0.042	−0.032
Geographic dispersion	0.114	0.106	0.070	0.218**	0.204*	0.174**
Network embeddedness	0.024	−0.035	−0.014	0.205*	0.155	0.197
Search breadth	0.114*	0.178*	0.164*		0.338***	
Search depth				0.049	0.083	−0.062
Tie strength	0.336**		0.237*	0.459***		0.437***
Absorptive capability		0.335***	0.235*		0.361***	0.242**
Tie strength*Search breadth	−0.127**		0.181**			
Tie strength*Search depth				0.220***		0.263**
Absorptive capability*Search breadth		0.269**	−0.114**			
Absorptive capability*Search depth					0.256**	−0.082
Tie strength*Absorptive capability			0.035			0.016
Tie strength*Absorptive capability * Search breadth			−0.158*			
Tie strength*Absorptive capability * Search breadth						0.221**
R^2	0.175	0.281	0.492	0.361	0.327	0.592
Adjusted R^2	0.218	0.229	0.431	0.326	0.286	0.539
F	5.057***	5.458***	14.641***	10.184***	9.649***	16.159***

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

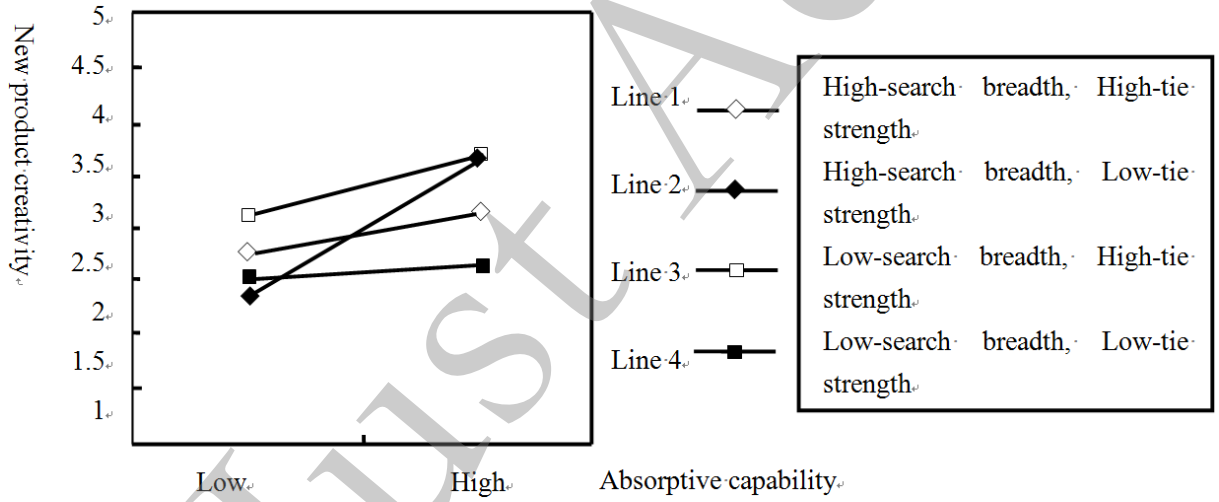

Fig. 1. Three-way interaction effects (a).

To summarize, the eight hypotheses proposed in this paper have all been supported through data analysis.

5 Conclusions

Despite the presence of rich literature on external search, our unique approach based on a knowledge-based view provides valuable information for firms to build their own external search strategy according to NPD goals.

First, our findings provide a more nuanced understanding of the effects of search breadth and depth on new product creativity and development speed. Previous literature has highlighted the linear and U-inverted relationship between external search and innovation performance (Wu et al., 2015 [9]; Wu & Wei, 2013 [10]; Henttonen & Ritala, 2013 [14]; Leiponen & Helfat, 2010 [13]). However, our study was not involved in the linear or U-shaped relationship controversy because many firms' oversearch behavior is insufficient in developing countries such as China. Inconsistent with this logic, we take a closer look at two segmented variables: new product creativity and development speed. Interestingly, we find that search

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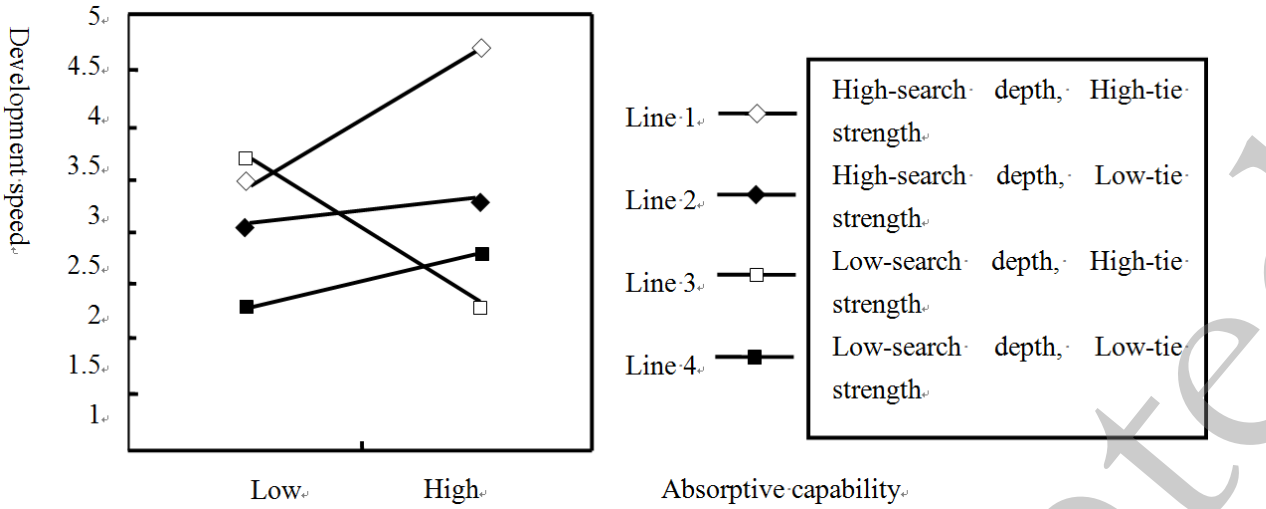

Fig. 2. Three-way interaction effects (b).

Table 4. Slope difference tests for Fig. 2.

	t value	*p* value
Line 1——Line 2	−0.152	0.880
Line 1——Line 3	0.013	0.990
Line 1——Line 4	0.048	0.962
Line 2——Line 3	0.167	0.868
Line 2——Line 4	0.218	0.828
Line 3——Line 4	0.029	0.977

Table 5. Slope difference tests for Fig. 3.

	t value	*p* value
Line 1——Line 2	0.078	0.938
Line 1——Line 3	0.268	0.789
Line 1——Line 4	0.129	0.897
Line 2——Line 3	0.195	0.846
Line 2——Line 4	0.027	0.979
Line 3——Line 4	−0.199	0.842

breadth benefits new product creativity, whereas search depth benefits development speed. When a firm focuses on search breadth, it may have more opportunities to approach new knowledge, achieve strategic flexibility, and be more likely to devote its resources to creativity. When a firm focuses on search depth, it may become more effective in extending and refining existing skills, which will increase efficiency and facilitate development speed.

This finding enriches the extant literature by demonstrating the different roles of search breadth and depth in NPD, which is helpful to the application of search theory in the Chinese context. In a rapidly changing economy such as China, the market environment changes rapidly, and new products are introduced into the market at an unprecedented pace. To better adapt to the trend of open innovation, firms must not only exploit their existing knowledge but also search for external knowledge to improve innovation performance.

Second, we advance the extant literature by proposing and empirically confirming that effective tie strength helps firms sustain better NPD performance when conducting external search strategies. This finding supports prior studies and confirms the important role of tie strength in external search (Michelfelder & Kratzer, 2013) [32]. Notably, we found that tie strength weakens the positive relationship between search breadth and new product creativity, whereas it strengthens the positive relationship between search depth and development speed. This can be explained by attention-based theory (Li et al., 2013) [44] and the search cost view (Henttonen & Ritala, 2013) [14]; that is, low-level tie strength is a loose governance structure containing more bridging ties that create the potential for novel knowledge recombination, allow more external connections to be made at a lower cost, and provides a good condition for the implementation of search breadth. Meanwhile, high-level tie strength is conducive to effective knowledge sharing and in-depth communication, which provides convenience for the implementation of search depth.

This finding promotes a cross-integration of search theory and tie theory and guides firms in establishing ties that appropriately match the search strategy. For example, to pursue new product creativity, managers should draw new ideas from multiple external knowledge sources. Hence, maintaining low-level tie strength will reduce the costs of developing broad contacts and benefit from the function of information bridges.

Third, the results support the findings of most researchers (e.g., Enkel & Gassmann, 2010 [35]; Rothaermel & Alexandre, 2009 [19]; Huang & Rice, 2009) [36], suggesting that absorptive capacity enhances innovation performance, i.e., firms with strong absorptive capacity have a higher innovative output under the same conditions. This perspective is also supported in our research scenario. Many scholars believe that the absorptive capacity of developing countries is weak due to backward technology and sparse R&D reserves, which is different from that of developed countries (Cuervo-Cazurra and Rui, 2017) [21]. Our research, based on data collected in China, verified the moderating effects of absorptive capacity on the relationship between search strategy and NPD performance, which extended the application of absorptive capacity theory in emerging markets.

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Furthermore, we described the synergistic effect of absorptive capacity and tie strength. Interestingly, we found that absorptive capacity and tie strength have synergistic moderating effects. This can be explained by Obstfeld's (2005) [4] theory, that the successful accomplishment of innovation requires a diversity of knowledge and capabilities provided by ties and the mechanisms to integrate them. Absence of the former presents as the idea problem and the latter as the action problem. Therefore, ties and absorptive capacity are like the two hands of a person, and their synergistic effect can better promote the improvement of NPD performance. This finding indicates that managers should pay attention to their external search strategy, build appropriate ties and strengthen firms' absorptive capacity. That is, for a firm with a diverse innovation purpose, ignoring the cultivation of absorptive capacity is counterproductive. This finding is also consistent with Huang & Rice's (2009) [36] argument that innovation outcomes are elusive in the absence of absorptive capacity, even if valuable technology has been successfully obtained from outside. China has a long tradition of using *guanxi* (ties) to coordinate cooperation matters, and this finding reminds managers that *guanxi* alone is insufficient; they also need to improve their own absorptive capacity.

Finally, this study provides important theoretical implications for firms in emerging markets such as China. Our findings provide managers with direct implications for managing knowledge resources for NPD. First, managers must examine their NPD goals and identify whether they focus on creativity or speed. Second, managers should adjust their external search strategy to fit the goals. Third, to maximize the benefits of external search and enhance NPD performance, firms should simultaneously establish suitable tie strength with partners and enhance their absorptive capacity.

However, this study has several limitations. First, there are limitations in the design method of the cross-sectional research. The data used in this study were collected during a specific time frame, thereby restricting our ability to evaluate long-term causality among variables.

Second, other important situational variables, such as search costs and cultural differences, warrant further discussion. In the future, scholars should strengthen longitudinal data tracking and consider more situational variables to improve the authenticity and applicability of the conclusions.

Third, our research context of manufacturing firms in an emerging economy (China) may limit our findings' generalizability to service industries or developed economies. Future research could extend our model to other emerging economies and even developed countries.

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Conflict of interest

The authors declare that they have no conflict of interest.

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Appendix

Table A1. Measurement items and validity assessment.

Constructs	Loading
NPD performance	
New product creativity (α = 0.749, CR = 0.915, AVE = 0.684)	0.771
"Very ordinary for our industry/very novel for our industry"	0.785
"Not offering new ideas to our industry/offering new ideas to our industry"	0.846
"Not creative/creative"	0.890
"Uninteresting/interesting"	0.836
"Not capable of generating ideas for other products/capable of generating ideas for other products"	0.783
"Not promoting fresh thinking/promoting fresh thinking"	
Development speed (α = 0.761, CR = 0.919, AVE = 0.621)	0.821
"Far behind our project timeline/far ahead of our project timeline"	0.864
"Slower than the industry norm/faster than the industry norm"	0.699
"Much slower than we expected/much faster than we expected"	0.844
"Slower than our typical product development time/faster than our typical product development time"	
Tie strength *(α = 0.723, CR = 0.915, AVE = 0.684)*	0.828
"We frequently exchange high-quality tacit knowledge with our partners"	0.869
"The existence of information and knowledge in the relationship is useful for solving problems and helps in making decisions"	
"The relationships are based on common objectives and aims"	0.841
"The repercussions of the reputations of the enterprises in the network are good"	0.812
"The existence of unwritten rules prevents opportunist behavior form occurring."	0.781
Absorptive capacity *(α = 0.885, CR = 0.949, AVE = 0.526)*	
Acquisition:	
"Our unit has frequent interactions with corporate headquarters to acquire new knowledge"	0.722
"Employees of our unit regularly visit other branches"	0.738
"We collect industry information through informal means"	0.731
"Other divisions of our company are hardly visited"	0.696
"Our unit periodically organizes special meetings with customers or third parties to acquire new knowledge"	0.719
"Employees regularly approach third parties such as accountants, consultants, or tax consultants"	0.763
Assimilation:	
"We are slow in recognizing shifts in our market"	0.713
"New opportunities to serve our clients are quickly understood"	0.668
"We quickly analyze and interpret changing market demands"	0.724
Transformation:	
"Our unit regularly considers the consequences of changing market demands in terms of new products and services"	0.685
"Employees record and store newly acquired knowledge for future reference"	0.727
"Our unit quickly recognizes the usefulness of new external knowledge to existing knowledge"	0.722
"Employees hardly share practical experiences"	0.718
"We laboriously grasp the opportunities for our unit from new external knowledge"	0.722
"Our unit periodically meets to discuss consequences of market trends and new product development"	0.782
Exploitation:	
"It is clearly known how activities within our unit should be performed"	0.793
"Client complaints fall on deaf ears in our unit"	0.698
"Our unit has a clear division of roles and responsibilities"	0.756
"We constantly consider how to better exploit knowledge"	0.844
"Our unit has difficulty implementing new products and services"	0.882
"Employees have a common language regarding our products and services"	0.822
Competitive environment *(α = 0.810, CR = 0.877, AVE = 0.641)*	
"Competition in our local market is intense"	0.834
"Our organizational unit has relatively strong competitors"	0.773
"Competition in our market is extremely high"	0.852
"Price competition is a hallmark of our local market"	0.739

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