

Article

The Impact of Knowledge Power on Enterprise Breakthrough Innovation: From the Perspective of Boundary-Spanning Dual Search

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Abstract: Breakthrough innovation is key for enterprises to achieve extraordinary development, transformation and upgrading. In the open innovation environment, breakthrough innovation activities are considered to be closely related to enterprise knowledge power and external search strategies. However, there has been no systematic empirical study to explore the internal relationships among the three factors mentioned above. Based on resource dependence theory, this paper explored the impact of knowledge power on enterprise breakthrough innovation from the perspective of boundary-spanning dual search, and examined the moderating effect of absorptive capacity. Using the sample data of 239 knowledge intensive enterprises from China, this paper empirically tested the research hypothesis. The results showed that: (1) the two dimensions of knowledge power (including knowledge control and knowledge influence) have a significant positive impact on enterprise breakthrough innovation; (2) the breadth and depth of boundary-spanning search play a mediating role between knowledge power and enterprise breakthrough innovation; (3) enterprise absorptive capacity significantly strengthens the positive effect of boundary-spanning search on enterprise breakthrough innovation. This study clarified the relationship between knowledge power and breakthrough innovation and provided theoretical support for enterprises to actively take advantage of knowledge power to improve their breakthrough innovation performance.

Keywords: knowledge power; enterprise breakthrough innovation; boundary-spanning dual search; absorptive capacity



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1. Introduction

The application of Internet information technology has promoted the integration of industries and shortened the protection time of enterprise competitive advantage [1,2]. Facing the fierce competition of technology, standards, and patents, only enterprises that are good at innovation and breakthrough can seize the opportunity to achieve extraordinary development, transformation, and upgrading [3,4]. In recent years, breakthrough innovation has attracted extensive attention from scholars and practitioners. It originates from the extensive knowledge of enterprises and the idea of continuous reconstruction, which is the core of enterprise creativity [5–7]. Breakthrough innovation is obviously different from conventional innovation, as it requires enterprises to conduct extensive internal and external search to obtain breakthrough patents, valuable ideas, and heterogeneous knowledge [8,9]. In practice, enterprises such as Apple, Huawei, Amazon, BYD, etc., have established extensive connections with domestic and foreign counterparts, suppliers, universities, and research institutions etc. Through boundary-spanning search and knowledge reconstruction, these enterprises have realized the “creative destruction” of the traditional technological paradigm and promoted the emergence of high-level sci-

tific research achievements and frontier technologies [10]. Therefore, it has become the perspective of boundary-spanning search in industrial value networks.

The existing literature shows that previous studies have mainly focused on the differences between enterprise breakthrough innovation and general innovation [11], the significance of breakthrough innovation to enterprises [12], and the process and management difficulties of enterprise breakthrough innovation [13–15]. However, these studies mainly emphasized the internal factors that affect breakthrough innovation, such as a CEO's power [16,17], R&D investment [18], intelligent design and planning [19], intellectual capital [20,21], innovation team capabilities, and enterprise innovation reputation [8,22]. Despite that, it did not clearly explain the sources of heterogeneous knowledge required for enterprise breakthrough innovation. In addition, these studies mainly focused on catch-up enterprises and start-ups, and did not pay more attention to those incumbent enterprises which have patented technology and industrial influence in the innovation network [23,24]. In practice, with the enhancement of technological complexity [25], how incumbent enterprises take advantage of knowledge power to change the mainstream technological paradigm of the industry and solve the bottleneck problem in the high-tech field has become a subject of great theoretical value and practical significance.

Therefore, this paper takes incumbent enterprises with knowledge power as the research object and summarizes the core research topic as “how to take advantage of existing knowledge power to acquire heterogeneous knowledge resources across boundaries, so as to improve the breakthrough innovation performance of enterprises”. Specifically, this paper will study three key issues. Firstly, the direct effect of different dimensions of knowledge power on enterprise breakthrough innovation. Secondly, the mediating effect of boundary-spanning search on the relationship between knowledge power and breakthrough innovation. Thirdly, the breakthrough innovation activities that are also influenced by the absorptive capacity of enterprises [26,27]. Previous studies have not paid enough attention to this, so this paper introduced the variable absorptive capacity to investigate its moderating effect on boundary-spanning search and enterprise breakthrough innovation.

Based on the resource dependence theory and the enterprise innovation theory, the relationship model of knowledge power, boundary-spanning search, absorptive capacity, and enterprise breakthrough innovation is constructed in Section 2. The relevant research methods and sample data from Chinese knowledge-intensive enterprises is introduced in Section 3. Through hierarchical regression analysis of the sample data, the empirical research results are presented in Section 4. Finally, the research conclusions, contributions, and limitations are discussed in Section 5. This paper enriched the existing theoretical research results on knowledge power and breakthrough innovation and provided theoretical support for enterprises to take advantage of knowledge power effectively to improve their breakthrough innovation performance, and even to climb to the high-end position of “smile curve” in the industrial value chain.

2. Literature Review and Research Hypothesis

2.1. Literature Review

2.1.1. Knowledge Power

Foucault (1980) was the first person to study the relationship between knowledge and power [28]. He argued that knowledge was the main reason for the generation of power, and power was reflected through dependence or dominance. Latiff [29] proposed that knowledge was unevenly distributed in the global manufacturing network. Enterprises with key information or core technologies have unequal power with their partners, which is knowledge power [30]. Shafir [31] proposed that enterprises with high knowledge power dominated the flow direction of knowledge and information in the network, thus affecting innovation performance. Mitchell [32] argued that enterprises with knowledge power can establish connections among unrelated members, reduce the cost of information acquisition and the barriers to knowledge sharing through relationship connections, and create conditions for boundary-spanning search of enterprises [33–35]. Referring to the

above research, this paper defines knowledge power as the ability of enterprises to control and influence the decisions and behaviors of other enterprises, which is based on their advantages in technology and knowledge from the perspective of network embedding, and describes knowledge power from the two dimensions of knowledge control and knowledge influence. Knowledge control mainly measures the ability of enterprises to establish network cooperation rules and paradigms based on the innovation factors they have mastered. Knowledge influence mainly measures the ability of enterprises to act as the “bridge” or intermediary of knowledge transmission in the network, thereby influencing and coordinating the cooperative behavior among enterprises.

2.1.2. Boundary-Spanning Search

Boundary-spanning search reflects the essential characteristics of open innovation. It is the behavior of enterprises to acquire heterogeneous knowledge and unique resources from external stakeholders across organizational and technological boundaries [36,37]. According to the different search direction, positioning, and content type, boundary-spanning search can be divided into local search and international search [38,39], breadth search and depth search [40,41], technical knowledge search and market knowledge search, etc. [42]. Different classifications of boundary-spanning search are applicable to different types of enterprises. Referring to the research of Laursen [36] and the actual performance of knowledge-intensive enterprises, this paper divides boundary-spanning search into search breadth and search depth. Search breadth refers to the richness and diversity of external resources obtained by enterprises, which mainly depends on the number and types of resources obtained from suppliers, key customers, and other different channels. Search depth refers to the intensity and repeatability of knowledge extracted from innovation networks. It mainly depends on the degree of the focus of enterprise search and the degree of the repeated invocation, learning, mining, and understanding of external knowledge.

2.1.3. Breakthrough Innovation

Different from other types of innovation, breakthrough innovation is an innovation mode that fundamentally changes the original technological paradigm and market strategy [9]. It has two prominent characteristics: at the micro level, the technology is sufficiently novel to bring significant technological progress and new value-added space to the enterprise, so that the core competitiveness of the enterprise is ahead of other competitors in the industry. At the macro level, it has a great impact on the market, with the emergence of a series of new products and the satisfaction of new customers' needs, which leads to the linkage change of the industrial pattern and the transformation and upgrading of the industrial structure [9,12]. It can be seen that breakthrough innovation with high innovation efficiency is an important way to relieve the downward pressure of the economy and help enterprises to achieve “overtaking in a curve” [10]. Referring to the research of previous scholars, this paper proposes that breakthrough innovation emphasizes the breakthrough and transcendence of existing technology and existing research results. It requires enterprises to understand the scientific principles of technological change and the trend of market development and rebuild a new rule system by breaking the process, technology, and the original industrial pattern [43]. However, with the complexity of the innovation environment, breakthrough innovation puts forward higher requirements on the knowledge, resources, and capabilities of enterprises [44], and the risks and costs of independent breakthrough innovation of a single enterprise are increasing. The external knowledge network provides the environment and basic conditions for enterprises to acquire external heterogeneous knowledge and reshape the technological development trajectory [45].

2.1.4. Absorptive Capacity

Breakthrough innovation requires critical resources and unique capabilities. Knowledge, as a key resource of innovation, shows the characteristics of invisibility, embedded-

ness, and complexity [46], which requires enterprises to have the ability to identify the value of new knowledge and apply it to the achievement of organizational goals, which is called absorptive capacity [47]. Cohen [26] introduced absorptive capacity into the field of knowledge management and argued that knowledge stock of enterprises constituted the basis of absorptive capacity. The process of enterprise knowledge absorption can be divided into four stages: acquisition, absorption transformation, and exploitation. Grimpe [48] proposed that enterprises with a stronger absorptive capacity are more innovative and flexible, and their performance will be better than that of enterprises with low absorptive capability.

2.2. Research Hypotheses

2.2.1. Influence of Knowledge Power on Breakthrough Innovation

Different dimensions of knowledge power have different effect mechanisms on enterprise breakthrough innovation. Enterprises with strong knowledge control have the ability to formulate cooperation rules and technological paradigms which help enterprises influence the decisions and actions of other enterprises and enhance the success rate of breakthrough innovation [10]. Kahkonen [35] studied the impact of knowledge control on the depth of cooperation. He found that knowledge control dominates the flow of innovation resources and provides institutional guarantees for information exchange, new knowledge learning, and new opportunity acquisition among enterprises. Mitchell [32] proposed that the stronger the knowledge control of enterprises, the stronger the regulations and constraints on the opportunistic behavior of members in the innovation network, which thus helps to reduce the risk of breakthrough innovation activities.

Meanwhile, knowledge influence makes enterprises become an important “node” in the innovation network, and helps enterprises coordinate and stabilize the relationship between members by creating a “bridge”. Dallas [49] studied the impact of the status of enterprises in the industrial value network on their knowledge creation and found that the enterprises with industrial influence more easily obtain the trust, support, and willingness to share from other enterprises in the value network. This enables enterprises to quickly obtain global patents, valuable ideas, and heterogeneous knowledge, and to accelerate the generation of breakthrough innovation. Yi [50] found that knowledge-based network influence can help enterprises obtain tacit resources such as know-how and experience required by breakthrough innovation and improve the performance of breakthrough innovation. To sum up, this study puts forward the following hypotheses:

Hypothesis 1a (H1a). *Knowledge control has a positive impact on enterprise breakthrough innovation.*

Hypothesis 1b (H1b). *Knowledge influence has a positive impact on enterprises breakthrough innovation.*

2.2.2. Influence of Knowledge Power on Boundary-Spanning Search

Different dimensions of knowledge power have different effect mechanisms on boundary-spanning search. An enterprise with knowledge control has the ability to dominate the formulation of cooperative rules, stabilize the relationship with innovation partners, and to extensively obtain heterogeneous knowledge resources needed for innovation [34,51]. From the perspective of knowledge asymmetry, Hahl [33] argued that enterprises with more patented technologies usually have higher knowledge control, which will help enterprises to perceive the opportunistic behavior of innovation partners in advance and avoid cooperation risks. Knowledge control can also help enterprises to find significant opportunities of innovation in advance and enhance the depth of knowledge mining and learning. Ritala [52] found that in an open innovation environment, an enterprise may disclose their own knowledge while acquiring external knowledge. Effective knowledge control can alleviate the above uncontrolled risks and ensure that the innovation activities are carried out within the overall framework of the enterprise.

Knowledge influence also has a positive impact on boundary-spanning search. Iorio [53] argued that enterprises occupying the holes in the structural network have higher knowledge influence. Enterprises with high knowledge influence are able to gain the trust, emotion, and commitment from members in the innovation network, which can help enterprises transfer complex and diversified knowledge from suppliers, universities, scientific research institutions, and technical service companies. Golgeci [54] found that European multinationals use their high popularity and knowledge influence to embed in global innovation networks, so as to expand the search scope and obtain diversified knowledge. In addition, through in-depth communication and repeated discussions with professional institutions, European multinationals maximize the value of external knowledge in the business field and enhance the performance of breakthrough innovation. To sum up, this study puts forward the following Hypotheses:

Hypothesis 2a (H2a). *Knowledge control has a positive impact on the breadth of boundary-spanning search.*

Hypothesis 2b (H2b). *Knowledge control has a positive impact on the depth of boundary-spanning search.*

Hypothesis 3a (H3a). *Knowledge influence has a positive impact on the breadth of boundary-spanning search.*

Hypothesis 3b (H3b). *Knowledge influence has a positive impact on the depth of boundary-spanning search.*

2.2.3. Impact of Boundary-Spanning search on Breakthrough Innovation

Breakthrough innovation refers to the innovation that changes the needs of mainstream customers and takes the lead in stepping into a new technology track or implementing a new business model [9]. Breakthrough innovation requires continuous, extensive, and high-quality heterogeneous knowledge sources [55]. Boundary-spanning search can enrich the knowledge sources for organizations, increase the diversity of knowledge reorganization, and reduce the risk of breakthrough innovation [23]. First, the breadth of boundary-spanning search affects breakthrough innovation from two aspects: knowledge diversity and exploratory learning. Breakthrough innovation comes from the novel connection of multi-dimensional knowledge, and the breadth of boundary-spanning search can provide extensive and novel knowledge for breakthrough innovation, increase more valuable knowledge combinations for selection, and improve the probability of breakthrough innovation [56]. In addition, extensive external search also improves the ability of enterprises to analyze problems from multiple perspectives and helps enterprises learn problem-solving methods from other fields [57]. Golgeci [54] emphasized that the extensive knowledge generated by boundary-spanning search can facilitate exploratory learning and help enterprises flexibly adapt to unforeseen changes and create new products that are significantly different from existing products.

It has also been found that the depth of boundary-spanning search can influence breakthrough innovation from two aspects: knowledge specialization and cognitive frontier. Flor [47] proposed a model of breakthrough innovation for high-technological enterprises, and argued that the observation, interpretation, and reconstruction of abnormal phenomena and heterogeneous knowledge are the fundamental motivation for the breakthrough and transition of the technological trajectory. However, trends and the internal principle of frontier technologies are not easily perceived and understood. Only by repeatedly invoking and accessing external knowledge can enterprises deepen their understanding and cognition of the specialized technical fields, systematically grasp the correlation among complex knowledge, predict the trend of technological change, and discover new ideas with commercial potential ahead of other competitors [58]. Therefore, the depth of boundary-

spanning search is considered an important driver for breakthrough innovation. Thus, we put forward the following hypotheses:

Hypothesis 4a (H4a). *The breadth of boundary-spanning search has a positive impact on enterprise breakthrough innovation.*

Hypothesis 4b (H4b). *The depth of boundary-spanning search has a positive impact on enterprise breakthrough innovation.*

2.2.4. Mediating Effect of Boundary-Spanning Search

It is found that boundary-spanning search plays a mediating role between some variables and innovation breakthrough [38]. Yi [50] proposed that enterprises with patented technologies and network bridging capabilities can widely absorb knowledge modules and novel resources from external partners and promote the smooth development of breakthrough innovation through the diversified integration of internal and external knowledge. Therefore, boundary-spanning search plays a mediating role between knowledge power and breakthrough innovation. Specifically, enterprises take advantage of their knowledge control to lead the formulation of innovation cooperation rules which can help enterprises expand valuable knowledge sources and reduce the cost and cycle of breakthrough innovation. In addition, enterprises take advantage of their knowledge influence to build trust and interaction with members and deepen their understanding of professional fields by repeatedly discussing key knowledge with partners. Diversified high-quality knowledge resources provide support for breakthrough innovation of enterprises [59]. Thus, we propose the following hypotheses:

Hypothesis 5a (H5a). *The breadth of boundary-spanning search plays a mediating role between knowledge control and enterprise breakthrough innovation.*

Hypothesis 5b (H5b). *The breadth of boundary-spanning search plays a mediating role between knowledge influence and enterprise breakthrough innovation.*

Hypothesis 6a (H6a). *The depth of boundary-spanning search plays a mediating role between knowledge control and enterprise breakthrough innovation.*

Hypothesis 6b (H6b). *The depth of boundary-spanning search plays a mediating role between knowledge influence and enterprise breakthrough innovation.*

2.2.5. Moderating Effect of Absorptive Capacity

Breakthrough innovation is a process in which enterprises seek and reconfigure internal and external knowledge resources, and finally form a harmonious new knowledge system [9]. Whether the heterogeneous knowledge searched for by enterprises across borders can be integrated and created with their own knowledge depends on the absorptive capacity of enterprises [26]. Grimpe [48] argued that absorptive capacity can reduce the potential threats and risks in the process of knowledge transformation and help organizations cross the boundary from external acquisition to internal application, which is the key factor of breakthrough innovation. Duan [60] found that the contribution of the same knowledge of boundary-spanning search to breakthrough innovation varied with the absorptive capacity of enterprises. When the absorptive capacity is enhanced, enterprises can combine knowledge modules in various fields through “kaleidoscope thinking” to generate new ideas in the form of novel links. Low absorptive capacity will prevent enterprises from identifying and utilizing knowledge searched from outside, resulting in the waste of valuable resources [61]. Therefore, the absorptive capacity has significantly enhanced the impact of boundary-spanning search on breakthrough innovation. Therefore, this paper proposes the following hypotheses:

Hypothesis 7a (H7a). *Absorptive capacity positively moderates the relationship between the breadth of boundary-spanning search and enterprise breakthrough innovation.*

Hypothesis 7b (H7b). *Absorptive capacity positively moderates the relationship between the depth of boundary-spanning search and enterprise breakthrough innovation.*

2.2.6. Mediating Effect with Moderating of Absorptive Capacity

Based on the above hypotheses, this paper proposes that different levels of absorptive capacity enhance or weaken the impact of boundary-spanning search on breakthrough innovation and adjust the mediating effect of boundary-spanning search between knowledge power and enterprise breakthrough innovation. When the absorptive capacity of enterprises is high, enterprises can make better use of knowledge control and knowledge influence, expand the breadth and depth of boundary-spanning search, increase the resources of the knowledge base and obtain professional and cutting-edge resources, and finally promote the improvement of enterprise breakthrough innovation performance. Therefore, this study puts forward the following hypothesis:

Hypothesis 8a (H8a). *Absorptive capacity positively moderates the mediating effect of breadth of boundary-spanning search on the relationship between knowledge power and enterprise breakthrough innovation.*

Hypothesis 8b (H8b). *Absorptive capacity positively moderates the mediating effect of depth of boundary-spanning search on the relationship between knowledge power and enterprise breakthrough innovation.*

Based on the above hypotheses, we built a comprehensive theoretical model among knowledge power, boundary-spanning search, absorptive capacity, and enterprise breakthrough innovation, as shown in Figure 1.

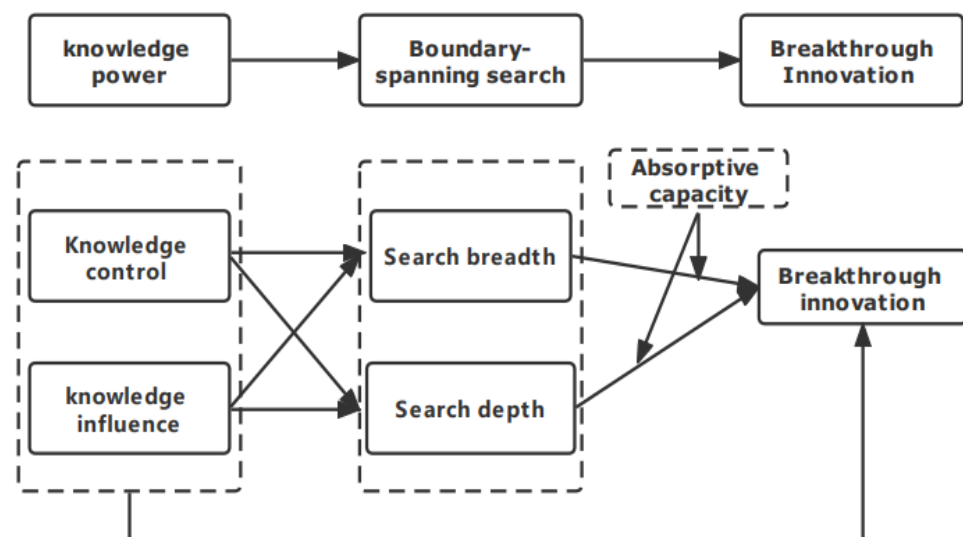


Figure 1. The theoretical model.

3. Research Methods

3.1. Sample and Data Collection

This study focused on the impact of knowledge power on enterprise breakthrough innovation from the perspective of boundary-spanning search. Therefore, questionnaires were distributed to Chinese knowledge-intensive enterprises with obvious innovation intention, primarily including innovative enterprises in the automobile, biomedicine, com-

munication electronics, transportation, new energy, new materials, and high-end equipment manufacturing industries. To ensure the quality of the survey, the questionnaires were primarily distributed to middle and senior managers who are familiar with the overall operation and innovation cooperation of the company.

The questionnaires were primarily collected through electronic questionnaires and field visits. From November 2021 to February 2022, this survey lasted for 4 months. A total of 450 questionnaires were distributed and 360 questionnaires were recovered, among these, 239 questionnaires were valid with an effective recovery rate of 66.39%. The descriptive statistics of the samples are shown in Table 1.

Table 1. Distribution statistics of basic characteristics of samples.

Characteristics	Classification	Number	Proportion	Characteristics	Classification	Number	Proportion
Enterprise size (employees)	≤100	23	9.6%	Enterprise ownership	State-owned	38	15.9%
	101–500	32	13.4%		Private	104	43.5%
	501–1000	68	28.5%		Joint venture	46	19.2%
	1000–5000	90	37.7%		Foreign-owned	44	18.5%
	>5000	26	10.8%		Other	7	2.9%
Enterprise age (years)	<3	18	7.5%	Industry	Automobile	49	20.5%
	3–5	37	15.5%		Biomedicine	58	24.4%
	6–10	62	25.9%		Electronics	40	16.7%
	11–20	74	31.0%		Transportation	65	27.2%
	>20	48	20.1%		Other	27	11.2%

In order to prevent the non-response bias caused by different research batches, the Armstrong [62] method was used to conduct independent chi-square test on the questionnaires collected in advance and later. The results showed that there was no significant non-response bias ($p > 0.05$) in the enterprise size, enterprise age, and enterprise ownership between the early and later responding enterprises.

3.2. Variable Measurement

Variables involved this study mainly include knowledge power, boundary-spanning search, absorptive capacity, and enterprise breakthrough innovation. In order to ensure good reliability and validity, the maturity scales widely used by scholars at home and abroad were used to measure variables and were appropriately adjusted according to the research scenarios. All items in the questionnaire adopt the Likert five-point scoring method, and scores of 1 to 5 represented the attitudes of respondents from “very disagree” to “very agree”.

Knowledge power. Referring to the research of Ahituv [30], the scale of knowledge power was designed from two aspects: knowledge control and knowledge influence, each of which includes four items.

Boundary-spanning search. Referring to the external knowledge search measurement method proposed by Laursen [36] and Leiponen [37], four items were used to measure the breadth and depth of boundary-spanning search respectively. It mainly focused on the number of knowledge acquisition channels and the frequency with which the enterprise accesses external knowledge sources.

Absorptive capacity. Referring to the scale developed by Flor [47] and Cohen [26], we designed four items to measure the absorptive capacity of enterprises according to the four stages of knowledge absorption: acquisition, absorption, transformation, and utilization.

Breakthrough innovation. Based on the research of Srivastava [24] and Kiani [63], five items were designed to measure the breakthrough innovation of enterprises, mainly focusing on the number of breakthrough patents, the proportion of products with major technological breakthroughs in total sales, the number of new technologies and production

processes, new business methods and innovative approaches, and the number of new products or service in new markets.

Control variables. Generally, enterprises with larger scale and longer operation time have more resources and experience, which have a positive impact on breakthrough innovation [64]. Therefore, according to the previous literature research, enterprise size and enterprise age were included in the research scope as control variables. Enterprise size was measured by the number of employees and enterprise age was measured by the year of establishment.

3.3. Reliability and Validity Analyses

SPSS 21.0 and Amos 21.0 statistical software were used to test the reliability and validity of the main variables. The inspection results were shown in Table 2. It can be seen that the Cronbach's α values of each variable surpass the threshold of 0.70, and the composited reliability (CR) values of all variables exceeded the minimum threshold of 0.70, indicating that all variables have acceptable reliability. In addition, confirmatory factor analysis was performed on the measurement scale, and it was shown that the standardized factor loadings of each variable was above 0.50 and the average extraction variance value ($0.623 < AVE < 0.756$) of each variable was above the recommended 0.70 level, indicating the convergent validity. Moreover, this study also found that the Pearson correlation coefficient of any two variables was less than the square root of the corresponding AVE estimates, indicating that the scale has good discriminate validity. Finally, we compared the six factor integration model with other models, and found that the integration model with six factors exhibited the optimal fitting effect (the fitting indicators were as follows: $\chi^2/df = 1.467 < 3$, CFI = 0.973 > 0.90, TLI = 0.959 > 0.90, NFI = 0.981 > 0.90, RMSEA = 0.067 < 0.08), indicating that the six factor measurement model had good structural validity.

Table 2. Reliability and validity test of variables.

Variables	Items	Standardization Factor Loading	Cronbach's α	AVE	CR
Knowledge Control (KC)	KC1	0.761	0.808	0.623	0.850
	KC2	0.821			
	KC3	0.784			
	KC4	0.775			
Knowledge Influence (KI)	KI1	0.812	0.776	0.624	0.869
	KI2	0.803			
	KI3	0.747			
	KI4	0.773			
The Breadth of Boundary-Spanning Search (BS)	BS1	0.822	0.798	0.649	0.902
	BS2	0.789			
	BS3	0.805			
	BS4	0.796			
The Depth of Boundary-Spanning Search (DS)	DS1	0.778	0.814	0.636	0.873
	DS2	0.792			
	DS3	0.855			
	DS4	0.772			
Absorptive Capacity (AC)	AC1	0.783	0.837	0.729	0.904
	AC2	0.761			
	AC3	0.855			
	AC4	0.872			
Breakthrough Innovation (BI)	BI1	0.789	0.779	0.756	0.860
	BI2	0.807			
	BI3	0.828			
	BI4	0.823			
	BI5	0.836			

3.4. Common Method Variance Test

In order to ensure the preciseness of the study, Harman single factor analysis was used to test the common method deviation. First, exploratory factor analysis was carried out on all the subjects. The results showed that six factor constructs were obtained, and their cumulative explanatory power to the total variance reached 75.97%. Among them, the largest factor only explained 19.27% of variance variation, which was less than the criterion of <50%, indicating that there was no serious homology variance problem in this study. Secondly, the confirmatory factor analysis model was compared. Compared with the six factor integration model, the single factor model obviously lacked sufficient fitting degree, indicating that there was no homologous variance in the study. Meanwhile, by calculating the variance expansion factor VIF value of each regression equation, it was found that the maximum VIF was far less than the collinearity criterion 10, and the value of Durbin-Watson met the criterion of approaching 2, indicating that there was no serious multicollinearity problem in this study.

4. Empirical Analysis

4.1. Descriptive Statistics and Correlation Analysis

Table 3 showed the mean, standard deviation, and correlation coefficient of the main variables. It can be seen that the correlation coefficients between variables were all less than the minimum threshold of 0.70. Among them, knowledge control and knowledge influence were positively correlated with enterprise breakthrough innovation. Knowledge control and knowledge influence were positively correlated with search breadth and search depth, respectively. The breadth and depth of boundary-spanning search were positively correlated with enterprise breakthrough innovation. These analysis results were in line with theoretical expectations and provided preliminary support for subsequent hypothesis testing.

Table 3. Descriptive statistics and correlation analysis results.

Variable	1	2	3	4	5	6	7	8
1. Enterprise size	1							
2. Enterprise age	0.131	1						
3. Knowledge control	0.067	0.162	0.789					
4. Knowledge influence	0.123	0.095	0.513 **	0.790				
5. Search breadth	0.083	0.116	0.434 **	0.465 **	0.806			
6. Search depth	0.096	0.107	0.509 **	0.425 **	0.550 **	0.797		
7. Absorptive capacity	0.072	0.125	0.323 **	0.370 **	0.457 **	0.565 **	0.854	
8. Breakthrough innovation	0.134	0.175	0.493 **	0.457 **	0.512 **	0.540 **	0.493 **	0.869
Mean	2.55	3.37	3.89	3.93	3.89	3.92	3.92	3.98
S.D	1.172	1.119	0.634	0.625	0.592	0.635	0.678	0.906

Note: Diagonal entries (in bold) are the square root of the AVE; * $p < 0.05$; ** $p < 0.01$ (bilateral test).

4.2. Hypotheses Testing

Hierarchical regression analysis in SPSS 21.0 software was used to verify the hypothetical relationships between variables in the model. Before constructing the regression analysis model, the mean value of the interaction term variables was centralized to reduce the influence of multicollinearity (Keith, 2019) [65] and enhance the reliability and validity of the research results.

4.2.1. Direct Effect Test

To verify the effect of knowledge control and knowledge influence on enterprise breakthrough innovation, we constructed regression Model 1 and Model 2 with enterprise breakthrough innovation as the dependent variable, as shown in Table 4.

Table 4. Results of hierarchical regression analysis.

Variable	Breakthrough Innovation					Search Breadth		Search Depth	
	M1	M2	M3	M4	M5	M6	M7	M8	M9
Enterprise size	0.085	0.080	0.059	0.068	0.076	0.046	0.046	0.030	0.025
Enterprise age	0.040	0.031	0.008	0.023	0.021	0.039	0.031	0.076	0.066
Knowledge control		0.335 ***					0.342 ***		0.415 ***
Knowledge influence			0.282 ***				0.370 ***		0.309 **
Search breadth				0.215 **					
Search depth					0.289 **				
Absorptive capacity									
R ²	0.016	0.309	0.352	0.398	0.376	0.030	0.582	0.012	0.225
ΔR ²	0.016	0.293	0.336	0.382	0.360	0.029	0.552	0.012	0.213
F	0.778	25.762 **	30.420 **	31.887 *	33.741 **	4.186 *	43.238 **	2.307 *	31.453 **

Note: * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

In Model 1, two control variables enterprise size and enterprise age were introduced. Model 2 added independent variable knowledge control on the basis of Model 1, and Model 3 added independent variable knowledge influence on the basis of Model 1. From the results of hierarchical regression analysis, the explanatory power (R^2) of Model 2 increased to 30.9% and the explanatory power of Model 3 increased to 35.2% when the independent variables were added, respectively, indicating that knowledge control ($\beta = 0.335$, $p < 0.001$) and knowledge influence ($\beta = 0.282$, $p < 0.001$) have significant and positive impacts on the breakthrough innovation of enterprises, and Hypotheses 1a and 1b were verified.

Model 4 and Model 5 were constructed by adding two dimensions of boundary-spanning search on the basis of Model 1. Compared with Model 1, it was shown that the explanatory power (R^2) of Model 4 increased to 39.8%, and the explanatory power (R^2) of Model 5 increased to 37.6%, indicating that the breadth of boundary-spanning search ($\beta = 0.215$, $p < 0.001$) and the depth of boundary-spanning search ($\beta = 0.289$, $p < 0.001$) have significant and positive impacts on the breakthrough innovation of enterprises. Thus, Hypotheses 4a and 4b were supported.

Model 6 reflected the regression of the control variable to the breadth of boundary-spanning search. Model 7 reflected the regression of the control variable and the independent variable knowledge power to the breadth of boundary-spanning search. According to Model 7, knowledge control ($\beta = 0.342$, $p < 0.001$) and knowledge influence ($\beta = 0.370$, $p < 0.001$) had significant and positive effects on the breadth of boundary-spanning search. Thus, Hypotheses 2a and 2b were verified.

Model 8 was the regression between control variables and the depth of boundary-spanning search, and Model 9 was the regression of the control variable and the independent variable knowledge power to the depth of boundary-spanning search. It can be seen from Model 9 that knowledge control ($\beta = 0.415$, $p < 0.001$) and knowledge influence ($\beta = 0.309$, $p < 0.001$) had significant and positive effects on the depth of boundary-spanning search. Therefore, Hypotheses 3a and 3b were verified.

4.2.2. Mediating Effect Test

The Process program and Bootstrap nonparametric test developed by Hayes (2013) [66] were used to verify the mediating effect of boundary-spanning search. The confidence was set to 95% and the number of random sampling was set to 5000. The bias corrected method was used to estimate the upper and lower limits of the intermediate effect interval. It is generally believed that if the 95% confidence interval of the distribution does not contain 0, the mediating effect is significant. The inspection results were shown in Table 5.

Table 5. The mediating test results of Boundary-spanning search.

Mediation Path	Mediating Effect	SE	95% CI	
			LLCI	ULCI
Knowledge control→Search breadth→Breakthrough innovation	0.084 **	0.002	0.024	0.067
Knowledge influence→Search breadth→Breakthrough innovation	0.055 **	0.004	0.025	0.108
Knowledge control→Search depth→Breakthrough innovation	0.112 *	0.025	0.014	0.395
Knowledge influence→Search depth→Breakthrough innovation	0.096 *	0.031	0.026	0.101

Note: * $p < 0.05$; ** $p < 0.01$; Bootstrap = 5000.

It can be seen that in the relationship between knowledge control and breakthrough innovation, the results of analysis on the mediating effect path of boundary-spanning search breadth showed that the upper and lower limits of the 95% confidence interval were positive and did not contain 0 (LLCI = 0.024, ULCI = 0.067), indicating that the breadth of boundary-spanning search played an obvious intermediary role between knowledge control and breakthrough innovation ($p < 0.01$), and the mediating coefficient was 0.084. Hypothesis 5a was verified. In the relationship between knowledge influence and breakthrough innovation, it was found that the upper and lower limits of bootstrap confidence intervals were positive and did not contain 0 (LLCI = 0.025, ULCI = 0.108), indicating that the mediating effect of boundary-spanning search breadth between knowledge influence and breakthrough innovation was significant ($p < 0.01$) and the coefficient is 0.055. Thus, Hypothesis 5b was verified.

Using the above method to test the mediating effect of boundary-spanning search depth, it was found that in the paths where knowledge control acted on breakthrough innovation through boundary-spanning search depth, the Bootstrap value was positive and did not contain 0 (LLCI = 0.014, ULCI = 0.395), indicating that the depth of boundary-spanning search depth played a significant mediating role between knowledge control and breakthrough innovation ($p < 0.05$), and the mediating effect coefficient was 0.112. Hypothesis 6a was verified.

It was also found that in the paths where knowledge influence acted on breakthrough innovation through boundary-spanning search depth, the Bootstrap value was positive and did not include 0 (LLCI = 0.026, ULCI = 0.101), indicating that the depth of boundary-spanning search played a significant mediating role between knowledge influence and breakthrough innovation ($p < 0.05$), and the mediating effect coefficient was 0.096. Hypothesis 6b was verified.

4.2.3. Moderating Effect Test

To verify the moderating effect of absorptive capacity between boundary-spanning search and breakthrough innovation, we standardized the variables to generate interactive item 1 (the breadth of boundary-spanning search $\times$ absorptive capacity) and interactive item 2 (the depth of boundary-spanning search $\times$ absorptive capacity), and then constructed Models 10 to 13 as shown in Table 6.

From Model 11 we can see that the standardized regression coefficient (β) of interactive item 1 on enterprise breakthrough innovation was 0.129, and the regression effect was significant ($p < 0.05$). From Model 13 we can see that the standardized regression coefficient (β) of interactive item 2 on breakthrough innovation was 0.164, and the regression effect was significant ($p < 0.05$). The empirical results showed that absorptive capacity played a significant and positive role between boundary-spanning search and enterprise breakthrough innovation. Thus, Hypotheses 7a and 7b were supported.

Table 6. Hierarchical regression analysis results of moderating effect.

Variables	Breakthrough Innovation Performance			
	M10	M11	M12	M13
Enterprise size	0.079	0.060	0.015	0.028
Enterprise age	−0.030	0.013	−0.020	0.018
Knowledge control				
Knowledge influence				
Search breadth	0.409 ***	0.415 ***		
Search depth			0.434 ***	0.459 ***
Absorptive capacity	0.236 ***	0.214 **	0.226 **	0.196 *
Interactive item 1		0.129 *		
Interactive item 2				0.164 *
R ²	0.260	0.397	0.428	0.536
ΔR ²	0.116	0.137	0.420	0.108
F	25.817 **	33.474 ***	35.053 ***	36.033 ***

Notes: * $p < 0.05$, ** $p < 0.01$, and *** $p < 0.001$.

In order to reveal the moderating effect of absorptive capacity more intuitively, we drew Figures 2 and 3, with reference to Aiken [67], to reflect the moderating effect of absorptive capacity on the relationship between boundary-spanning search and the breakthrough innovation of enterprises. As shown in the figure, the breadth and depth of boundary-spanning search of enterprises with strong absorptive capacity have more significant and positive impact on the breakthrough innovation of enterprises.

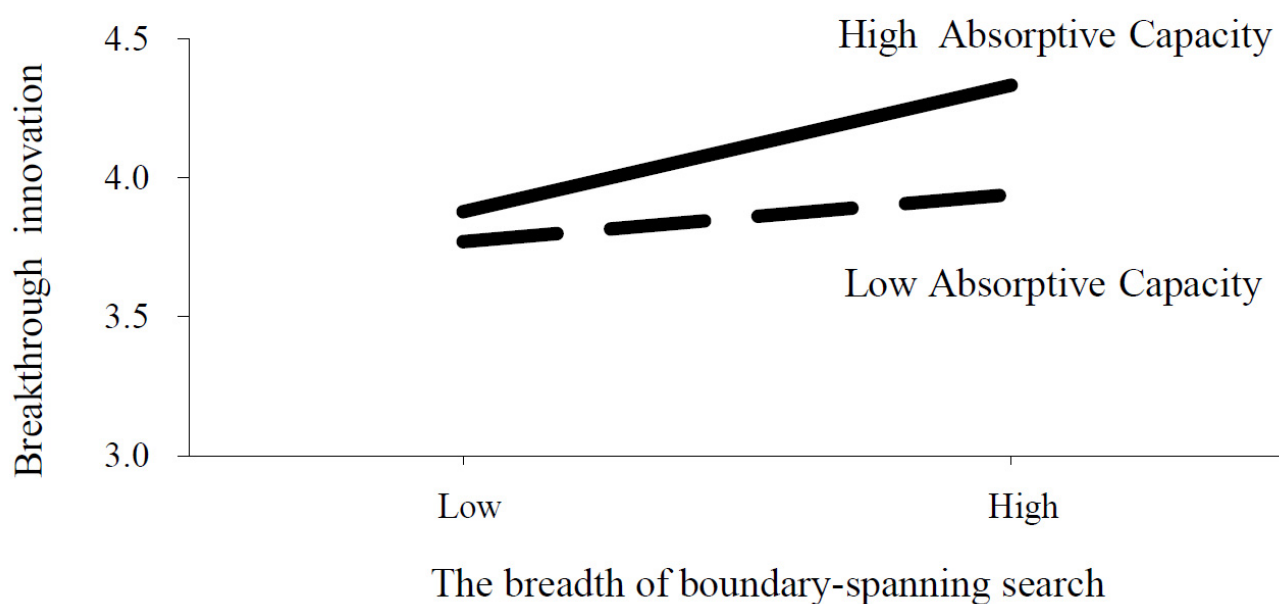


Figure 2. The moderating effect of absorptive capacity on the relationship between the breadth of boundary-spanning search and breakthrough innovation.

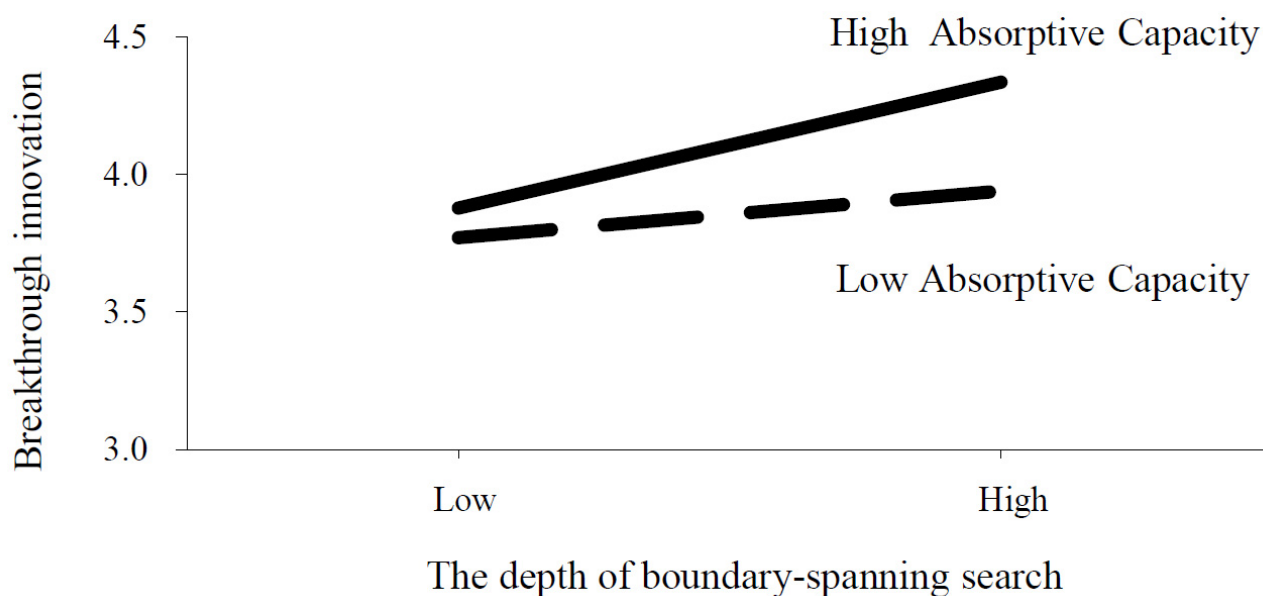


Figure 3. The moderating effect of absorptive capacity on the relationship between the depth of boundary-spanning and breakthrough innovation.

4.2.4. Moderated Mediating Effect Test

We used the Bootstrap test method to verify the moderated mediating effect of absorptive capacity. The test results are shown in Tables 7 and 8.

Table 7. Moderated mediating effect with Bootstrap test.

Mediator Variable	Absorptive Capacity	Indirect Effect	SE	95% CI	
				Lower	Upper
The breadth of boundary-spanning search	3.298(M−1SD)	0.023	0.025	−0.020	0.077
	3.890 (M)	0.168 **	0.036	0.026	0.235
	4.482(M+1SD)	0.195 **	0.043	0.033	0.258

Note: ** $p < 0.01$; Bootstrap = 5000.

Table 8. Moderated mediating effect with Bootstrap test.

Mediator Variable	Absorptive Capacity	Indirect Effect	SE	95% CI	
				Low	Upper
The depth of boundary-spanning search	3.285 (M−1SD)	0.032	0.041	−0.028	0.083
	3.920 (M)	0.223 **	0.053	0.047	0.226
	4.555 (M+1SD)	0.256 **	0.062	0.055	0.318

Note: ** $p < 0.01$; Bootstrap = 5000.

When enterprises' absorptive capacity was low (expressed by the mean minus one standard deviation), the mediating effect of the breadth of boundary-spanning search was not significant, and the 95% confidence interval ranged from −0.020 to 0.077 (including 0). When the absorptive capacity of enterprise was high (expressed by the mean value plus one standard deviation), the mediating effect of the breadth of boundary-spanning search was 0.195, and the 95% confidence interval was 0.033–0.258 (excluding 0), indicating that absorptive capacity has a moderated mediating effect on the relationship between the breadth of boundary-spanning search and enterprise breakthrough innovation.

Using the same test method, we also found that absorptive capacity has a moderated mediating effect on the relationship between the depth of boundary-spanning search and enterprise breakthrough innovation. Thus, Hypothesis 8a and 8b were verified.

4.3. Robustness Test of the Model

The robustness of the regression model was tested. First, 5% of the samples with the highest and lowest enterprise sizes were deleted respectively to test the influence of possible non-randomness and outliers on the regression results. The results showed that the regression results were basically consistent with the characteristics of the variables in the total sample. Secondly, this paper examined the abnormal fluctuations of breakthrough innovation performance caused by industry characteristics. The regression results were basically consistent with the total sample regression results, which indicated that the model obtained in this study was stable and reliable.

5. Discussion and Conclusions

5.1. Results Discussion

From the perspective of boundary-spanning search, this paper empirically studied the path and mechanism of knowledge power affecting enterprise breakthrough innovation and explored the mediating effect of boundary-spanning search and moderating effect of absorptive capacity. The following research conclusions are supported by empirical data.

Firstly, the two dimensions of knowledge power, including knowledge control and knowledge influence have a significant and positive impact on enterprise breakthrough innovation, but the degree of impact is different. Knowledge control plays a more obvious role in promoting the breakthrough innovation of enterprises. This research conclusion is inconsistent with the previous research conclusions of some scholars [17,22,35], because their studies did not distinguish different dimensions of knowledge power. This paper divided the dimension of knowledge power and found that knowledge control was based on irreplaceable and high-value professional knowledge accumulated by enterprises. They provided a formal control system and a framework of cooperation rules for innovation networks, which helped to reduce the cost and risk of breakthrough innovation. Knowledge influence originated from the innovation reputation of enterprise and the recognition, trust, and dependence of other enterprises, which enables enterprises to perceive the development trends of industry, market, and product value iteration in a timely way, and widely acquire new technologies and ideas in the innovation network. This research conclusion also enriched the view of Hao [10] that “different types of power among enterprises have different mechanisms that affect learning and innovation”.

Secondly, boundary-spanning dual search played mediating roles between knowledge power and enterprise breakthrough innovation. Through the mediating effect test, we found that after introducing the mediating variable of boundary-spanning dual search, the direct impacts of knowledge control and knowledge influence on enterprise breakthrough innovation decreased, but it was still significant. Therefore, the impact of knowledge power on enterprise breakthrough innovation is partially achieved through boundary-spanning search. This may be because enterprises with high knowledge control often play the role of cooperative rule makers, providing platforms and channels for enterprises to develop high-value knowledge modules, making it easier to reconfigure and produce breakthrough innovations. Knowledge influence also plays a mediating role between boundary-spanning search and breakthrough innovation, and the mediating effect of the search breadth was more significant than that of search depth. This may be because enterprises with knowledge influence are better at winning the trust and information sharing of member enterprises, which will help enterprises widely search heterogeneous knowledge modules, tap the new value of existing knowledge modules, and make it easier for enterprises to achieve breakthrough innovation. This research conclusion enriches the view put forward by most scholars that “breakthrough innovation depends on boundary-spanning search strategies and enterprise power status” [5,37,50].

Thirdly, absorptive capacity plays a positive role in moderating the relationship between boundary-spanning dual search and enterprise breakthrough innovation. With the enhancement of absorptive capacity, the role of boundary-spanning search strategy in promoting breakthrough innovation of enterprise will increase. When the absorptive capacity

of enterprises weakens, the impact of search depth and breadth on enterprise breakthrough innovation will be reduced. This may be a result of the fact that the knowledge and capability modules required for the transformation of cutting-edge and high-quality knowledge pursued by enterprises into breakthrough innovation depend on the reconstruction and absorption capacity of enterprises. This research conclusion is consistent with the view of Flor [47] that “breakthrough innovation depends on the absorptive capacity of enterprises”, and also explains why many enterprises invest a lot of resources into boundary-spanning search, but breakthrough innovation has little effect.

5.2. Theoretical Implications

The theoretical contributions of this study are as follows: (1) considering the open environment of enterprise innovation, it is concluded that enhancing the knowledge control and knowledge influence of enterprises can improve breakthrough innovation. This result enriched the classification dimension of knowledge power and broadened the relevant research on the driving factors of enterprise breakthrough innovation. (2) It verified that boundary-spanning dual search has an intermediary effect, reveals the internal process “black box” of knowledge power affecting enterprise breakthrough innovation, enriched the mechanism of boundary-spanning search theory and the theory of enterprise innovation. (3) This paper also revealed the positive moderating role of absorptive capacity. We found that the stronger the absorptive capacity of enterprises, the stronger the role of boundary-spanning search in promoting enterprise breakthrough innovation. This conclusion further enriched the theory of enterprise absorptive capacity.

5.3. Management Enlightenment

The conclusions provide some practical implications for improving the breakthrough innovation performance of enterprises: (1) enterprises should increase the input of core knowledge resources, expand the scope of external contacts, and enhance their knowledge power in the network. In the open innovation environment, knowledge power originates from the different knowledge levels and the positions in the network, which is manifested in the control and influence of the decisions and behaviors of other enterprises. According to the innovation orientation, enterprises can cultivate the ability to formulate rules and cooperation paradigms, actively participate in alliance and cooperation networks among enterprises, form the influence on other enterprises, and provide the power guarantee for the breakthrough innovation. (2) The complexity and difficulty of breakthrough innovation force enterprises to obtain diversified and high-quality heterogeneous knowledge resources from external suppliers, competitors, customers, scientific research institutions, and other subjects. However, relevant research has shown that most enterprises are still in the primary stage of boundary-spanning search due to organizational inertia and partner knowledge hiding [68]. Therefore, enterprises should use their patent, technology, brand, and other resources to encourage partners to join, so that boundary-spanning search activities can be dynamically promoted to a wider space. At the same time, through the standardization and joint development and utilization of their own advantageous resources, enterprises can establish their identity as leaders in the industrial network, and gain recognition and influence. This in turn, reduces possible resistance in boundary-spanning search and creates unique competitive advantages, which are crucial for enterprises to achieve unconventional development, transformation, and upgrading. (3) Enterprises should pay attention to internal and external knowledge management and improve the ability to absorb diversified knowledge. By establishing specialized knowledge management departments or knowledge sharing platforms, enterprises can realize the distribution and accumulation of diversified knowledge elements in different technical fields, and improve their ability to combine, collide and create a variety of knowledge. Generally, the knowledge absorbed by the enterprise has an important impact on future innovation, and plays a crucial role in the product iteration, technology development, and market shaping of the enterprise.

5.4. Limitations and Future Directions

This study also has some limitations. First, enterprise knowledge power includes knowledge control and knowledge influence, whether there is interaction between these two dimensions requires clarification through further research. Secondly, this paper only explored the impact of knowledge power on breakthrough innovation from the perspective of boundary-spanning dual search. However, the path of knowledge power to breakthrough innovation may also include other intermediary variables, such as relationship quality, network location, etc. Therefore, in order to establish a more complete theoretical model of the impact of knowledge power on enterprise breakthrough innovation, subsequent research needs to identify and analyze these variables more comprehensively. Third, this paper only considered the moderating role of the absorptive capacity and did not analyze other factors that may affect breakthrough innovation, such as task complexity, cooperation experience, environmental uncertainty, and other external factors. Subsequent studies will include the above situational factors, making the theoretical model instructive. Finally, in order to meet the needs of research, this paper uses cross-sectional data to describe the two key concepts of knowledge power and breakthrough innovation, but the production of breakthrough innovation performance often lags behind, which is the inadequacy of this paper. In the future, we will strengthen the follow-up investigation of longitudinal data and increase the rigor of the research.

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