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Summer 5-27-2016

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Abstract: Boundary-spanning search has been argued to be important for the success of innovation. There are various kinds of dimensions about organizational search activities. Past studies on boundary-spanning search have focused mainly on technological dimension. We characterize the boundary-spanning search on geographic dimension. We propose a conceptual model and 6 hypotheses. Data from 156 firms were collected to test above hypotheses. The results show that both local search and nonlocal search have positive effect on incremental innovation. What's more, local search is more positive than nonlocal search on incremental innovation. Meanwhile, both local search and nonlocal search have positive effect on breakthrough innovation. However, it is not supported by data that nonlocal is more positive than local search on breakthrough innovation.

Keywords**:** geographical boundary-spanning search; local search; nonlocal search; incremental innovation; breakthrough innovation

1. INTRODUCTION

In the face of the changeable market and technology and updated products, enterprises have to constantly search for innovation opportunities[1]. It shows that internal experience and knowledge cannot meet the needs of enterprises' sustainable innovation in practice. Under the opening innovation, more and more enterprises choose to search the outside heterogeneous knowledge to make up the deficiency of their own resources and ability structure. In 2015, China's R&D funds more than 1.422 trillion Yuan, an increase of 9.2% than last year. Since knowledge search is one of enterprise R&D activities[2], there is a pressing need to understand how to motivate enterprises to explore more knowledge on R&D.

Boundary-spanning search originated from organizational search theory which proposed by Nelson and Winter[3]. After that many scholars launched a lot of relevant researches and got remarkable achievements. This theory involves many disciplines such as organizational science, behavior science and evolutionary economics, etc., which was also introduced into the field of strategic management, organizational learning and so on.

There are a lot of classifications of organizational search based on different time background and research purposes. Such as, innovative search, local search, distant search, cross search, product search, technical search. In a stable environment, local search is conducive to reducing the cost of boundary-spanning search and to the formation of unique core capabilities in specific areas. So, the majority of the searches are localized, that is, enterprises tend to follow the past experience and custom for search activities. Therefore, path dependence and limited rationality is the essential feature of local search.However, too much local search may cause enterprises' core rigidity [4], ability trap [5] and innovation dilemma [6]. Nonlocal search is beneficial for enterprises to obtain the heterogeneous dynamic environment [7-8].

It is proposed to distinguish search depth from search range, that is, geographic search should not be simply divided into local and nonlocal, the depth and breadth also should be considered [9]. Local search is designed to meet the needs of the existing market and customers. Nonlocal search is designed to meet the needs of the formative market and customers [10]. Meanwhile, local search is a search behavior for new knowledge within the

proximal geographic or the similar technical boundary. Nonlocal search is for new knowledge across a certain geographic boundary in the different technical fields [11]. According to the different intensity of innovation, it can be divided into incremental and breakthrough innovation. Incremental innovation refers to improve and enhance the existing products and services. Breakthrough innovation refers to great changes to existing products and services [12].

Both search depth and search scope are taking an inverted U-shape relationship to the number of new products introduced by a firm[13]. Geographical boundary-spanning search has an U-shape relationship with product innovation[14]. Both cluster firm's local search (breadth and depth) and nonlocal search (breath and depth) will positively relate to their product innovation [9].It is found that a broad search of local knowledge contributes to product innovation for technological laggards, but not beneficial for technological leaders. They depend more on nonlocal knowledge instead. Furthermore, the findings highlight the liquidity of innovation knowledge for localized enterprises[15]. In the highly focused environment of a regional cluster, successful innovation can also be more easily distinguished from less successful or even failed innovation. The advantages of the exchange of tacit, complex and uncertain knowledge ensure that regional agglomenration and geographic proximity relate positively to the search for new knowledge[16].

After reviewing previous literatures, we know that the relationships between search and enterprises' innovation are different from each other. On the one hand, geographic boundary-spanning search can help enterprises to get new knowledge and opportunities which are different from the local, so it has a positive impact on enterprise innovation. On the other hand, the knowledge from different regions is less related to the local system and culture. So, it will leads to higher searching cost and uncertainty. Therefore, boundary-spanning search may leads to negative impact. Also, studies on the relationship between geographic search and enterprise's innovation are relatively limited. More studies should be developed to discuss these problems.

In our study, the search is divided into local and nonlocal search by geographical dimension. Meanwhile, introducing incremental and breakthrough innovation as explained variables, putting forward the hypotheses of geographical boundary-spanning search and enterprises' innovation. Finally, the valid samples are used to verify the rationality of the hypotheses then propose some suggestions for enterprise' innovation.

2. THEORETICAL BACKGROUND AND HYPOTHESES

2.1 Incremental and breakthrough innovation

The concept of exploitation and exploration innovation is put forward[17]. Subsequently, incremental and breakthrough innovation follow. Incremental innovation and breakthrough innovation is used to describe the perception of innovation results after innovative activities [18]. According to the different results of innovation, incremental innovation refers to improve the existing products, production processes, production technology, etc., to open up the existing market, which belongs to the lower level of innovation. Breakthrough innovation refers to complete creation of the existing products and processes, it obsolete existing knowledge, technology, products and is a higher level of innovation.

2.2 Local search

Geographic search includes local and nonlocal search. Search in the existing knowledge base called local search and search cross the existing knowledge base called cross-border search which also called nonlocal or exploration search. Geographic boundary-spanning search is a search behavior of enterprises for obtaining the knowledge and innovation opportunity [19-20].

There has been a long-term relationship among enterprises in the local network. Similar routines and cultures make it more available for enterprises to learn others' complex professional internal knowledge. After

acquiring these knowledge enterprises can improve product function and realize incremental innovation [21].

Local knowledge is always old, familiar and easy to access and benefit enterprises obtaining them in lower search cost. In other words, integrating them to bring a stable income for enterprises is not difficult. Therefore, enterprises are more apt to local search [22-23].

First, when the local search is carried out, the acquired knowledge is highly correlative with the internals. Second, it is not completely heterogeneous between local and nonlocal knowledge. When the correlative contents are used, it also improves the existing technology and product. Eventually, both local and nonlocal search do have positive effect on incremental innovation. So, the hypothetical relationship is proposed as follows.

Hypothesis 1a: local search has positive effect on incremental innovation.

Hypothesis 1b: nonlocal search has positive effect on breakthrough innovation.

Hypothesis 1c: compared with nonlocal search, local search has a more significant effect on incremental innovation.

2.3 Nonlocal search

Nonlocal search refers to search heterogeneous knowledge cross a certain geographic boundary. The geographic boundary may be city, province or nation. Phene regards searching cross nation as boundary-spanning search[24]. However, enterprises have been in a big challenge of searching and integrated cost for innovative knowledge and opportunities with the nonlocal search. Knowing that geographic knowledge means tacit knowledge which is related to the local system, culture and customs, and the knowledge tend to spread in a small area. So it is hard to acquire, understand and integrate them in a short time. Finally, it will lead to high innovative costs.

External environment of dynamic market, highly complex products and rapidly developing technology make enterprises hard to integrate old and new things. Therefore, they urge to communicate with the outside world to collect various innovative resources. To be specific, enterprises always promote innovation through learning, trading and cooperation. Nonlocal search refers to the search activities for distant and unfamiliar knowledge. It usually spans across city or province for these knowledge and makes it possible to build second-order competence to achieve a breakthrough innovation.

Although the local knowledge is highly similar with internal knowledge, the different degrees and forms of integration achieve technological breakthroughs and maybe totally new product innovation.

Hypothesis 2a: local search has positive effect on breakthrough innovation.

Hypothesis 2b: nonlocal search has positive effect on breakthrough innovation.

Hypothesis 2c: compared with local search, nonlocal search has a more significant effect on breakthrough innovation.

Eventually, the hypothetical relationships are constructed as below.

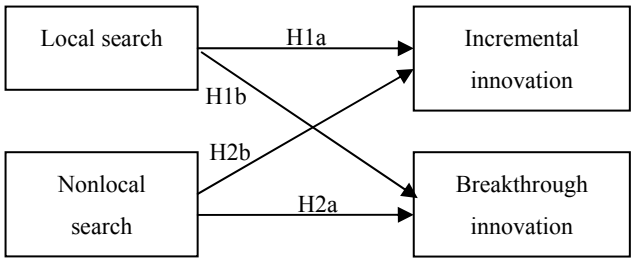

Figure 1 hypothetical model

3. RESEARCH METHODOLOGY

3.1 Sample and data collection

At this stage, we read some related domestic and foreign literatures. Then, to reference previous constructs to design our questions. Considering the market environment of China, the questionnaire is modified. Then, the primary questionnaire is finished and put into use.

This questionnaire involved two parts of questions, the first part refers to the measuring of explanatory and explained variables, the second part refers to the basic information of the enterprise. Each part is supposed to be finished by two managers. Managers who are familiar with daily operation about enterprise are chosen to answer the questionnaire through e-mail. Finally, 192 questionnaires are collected including 156 valid questionnaires. Through the valid questionnaires, the information about enterprises' characteristics of age, staff size and so on can be seen clearly. However, questions about search and innovation are most important part.

3.2 Independent variables

In our study, the LIkert seven-scale is used to describe the extent of geographical boundary-spanning search (1=don't know, 7=know well) and the level of enterprise' innovation activities (1=very low, 7=very high).

According to He, Wong and Rufei Ma' research about innovation constructs, this paper will use these constructs to describe incremental and breakthrough innovation. There are two constructs of explained variables and each construct includes five items. The descriptions of incremental innovation are as below. First, company can develop new product model. Second, company can improve the production process of the existing leading products. Third, company can improve the technical level of existing products. Forth, company can improve the quality of existing products or services. Fifth, company can improve the performance of existing products or services. Meanwhile, the descriptions of breakthrough innovation are as below. First, company is able develop new leading products or services. Second, company can develop new technologies. Third, the products of the company include new technology. Forth, company can open up new market. Fifth, company will eliminate the original leading product line.

3.3 Dependent variables

According to Sidhu et al.' research about geographical search constructs, this paper use these constructs to describe local and nonlocal search [25]. There are two constructs of explanatory variables and each construct includes three items. The descriptions of local search are as below. First, what's the status of technical development of other companies. Second, what's the status of new product' development of other companies. Third, what's the status of market sales of other companies. And the questions about nonlocal search are the same as local search.

3.4 Analysis result

Descriptive statistics mainly describes and analyzes the basic situation of the research object, through the description of the characteristics, frequency, percentage to test the overall representative of the samples. The basic information contains age, scale, property right, industry attribute and so on. According to the descriptive statistics, the following results are obtained. As shown in Table 1, 53% of enterprise age is more than 10 years. In Table 2, the proportion of enterprise scale 101-500 is 22.4% followed by 51-100, 505-1000 12.8%, 10.3%. In Table 3, 19.9% of enterprises belong to software and information technology industry, 11.5% of these belong to internet and E-commerce industry. In Table 4, the type of property rights of enterprises is mainly private enterprises, counting for 60.3%.

Table 1. Description of enterprises' age

	Characteristic	Count	Percentage
Enterprises' age	< 5 years	36	23%
	6-10 years	37	24%
	> 10 years	83	53%
	Total count	156	100%

Table 2. Description of enterprises' scale

	Characteristic	Count	Percentage
Enterprises' scale(staff number)	< 10 staffs	9	5.8%
	11-30 staffs	21	13.5%
	31-50 staffs	13	8.3%
	51-100 staffs	20	12.8%
	101-500 staffs	35	22.4%
	501-1000 staffs	16	10.3%
	>1000 staffs	42	26.9%
	Total count	156	100%

Table 3. Description of industry attribute

	Characteristic	Count	Percentage
Industry attribute	Software and information technology service	31	19.9%
	Internet and E-commerce	18	11.5%
	Opto mechatronics	7	4.5%
	Pharmaceutical chemicals and biological pharmacy	10	6.4%
	Household electric appliances	9	5.8%
	Textiles and clothing	7	4.5%
	Others	60	38.5%
	Total count	156	100%

Table 4. Description of property right

	Characteristic	Count	Percentage
Property right	Nationalized or holding	26	16.7%
	Private	94	60.3%
	Foreign or holding	12	7.7%
	Others	24	15.4%
	Total count	156	100%

Meanwhile, as shown in table 5, each average value is higher than five or close to it. All standard deviation values are below one except local search.

Table 5. Variables

Variable	Count	Minimum	Maximum	Aver5.16age	SD
Local	156	3	7	5.49	1.02
Nonlocal	156	3	7	5.16	0.97
Incremental	156	3	7	4.78	0.80
Breakthrough	156	3	7	4.62	0.97

We examine the measurement model by convergent and discriminative validity. The validity of the measurements is assessed using the item reliability, the construct reliability, the composite reliability (CR) and average variance extracted (AVE). The item reliability is assessed using standard factor loadings. As Table 6 and Table 7 shown that the factor loading of the measures range from 0.715 to 0.872, which exceed the 0.7 loading criterion [26]. The construct reliability is assessed using Cronbach's α. As table 8 shown that Cronbach's α of the constructs range from 0.838 to 0.871, which exceed the recommended value of 0.7 [27].

Table 6. Items' factor loading of incremental innovation

Local 1	0.843		
Local 2	0.856		
Local 3	0.799		
Nonlocal 1		0.737	
Nonlocal 2		0.862	
Nonlocal 3		0.852	
Incremental 1			0.762
Incremental 2			0.777
Incremental 3			0.753
Incremental 4			0.715

Table 9 and Table 10 show that the CR ranges from 0.839 to 0.882, which exceed the recommended value of 0.7. The AVE ranges from 0.566 to 0.713, which exceed the recommended value of 0.5 [28]. In addition, the

Table 7. Items' factor loading of breakthrough innovation

Local 1	0.804		
Local 2	0.856		
Local 3	0.872		
Nonlocal 1		0.775	
Nonlocal 2		0.850	
Nonlocal 3		0.851	
Breakthrough 1			0.838
Breakthrough 2			0.879
Breakthrough 3			0.804

Table 8. Reliability of constructs

Construct	Items	Cronbach's α
Local search	3	0.871
Nonlocal search	3	0.857
Incremental innovation	4	0.838
Breakthrough innovation	3	0.868

Table 9. Inter-construct correlations/correlation of incremental innovation

	CR	AVE	Local	Nonlocal	Incremental
Local	0.872	0.694	0.833		
Nonlocal	0.859	0.671	0.661	0.819	
Incremental	0.839	0.566	0.450	0.428	0.752

Table 10. Inter-construct correlations/correlation of breakthrough innovation

	CR	AVE	Local	Nonlocal	Incremental
Local	0.882	0.713	0.844		
Nonlocal	0.866	0.682	0.661	0.826	
Breakthrough	0.879	0.707	0.445	0.418	0.840

squared root of the AVE of each construct is larger than its correlations with other constructs. Therefore, the convergent and discriminative validity are confirmed.

The fitness of the measurement model are tested by χ^2, goodness-of-fit index (GFI), adjusted goodness-of-fit index (AGFI), normed fit index (NFI), comparative fit index (CFI), root mean square error of approximation (RMSEA) and Pclose. The proposed model 1 in Table 11 shows that χ^2/df is 0.775 (χ^2=23.247; df=30) which is less than 2. The GFI and AGFI are 0.971 and 0.947 which are higher than 0.9. The NFI and CFI are 0.973 and 1.000 which are higher than 0.9 [29]. The RMSEA is 0.000 which does not exceed 0.05 [30]. Meanwhile, Pclose is 0.805 which is higher than 0.05 [31]. All indices of model 1 fall within acceptable ranges.

The proposed model 2 in Table 12 shows that χ^2/df is 1.154 (χ^2=26.548; df=23) which is less than 2. The GFI and AGFI are 0.962 and 0.926 which are more than 0.9. The NFI and CFI are 0.855 and 0.976. The RMSEA is 0.032 which does not exceed 0.05. In addition, Pclose is 0.276 which is higher than 0.05. Although the NFI is slightly less than 0.9, most of indices are acceptable.

The model 1 examines the structural equation modeling by test the hypothesized relationships between local search, nonlocal search and incremental innovation. The results in Figure 2 show that both local search and nonlocal search have significant effect on incremental innovation ($\beta = 0.319$, P=0.018; $\beta = 0.264$, P=0.05). The two variables account for 29% of the variance in incremental innovation. What's more, the coefficient of local is larger than nonlocal. Local search do has more effect than nonlocal on incremental innovation. Finally, H1a, H1b, H1c are supported.

The results in model 2 show that both local and nonlocal search have significant effect on breakthrough innovation ($\beta = 0.318$, P=0.018; $\beta = 0.278$, P=0.037). The two variables account for 31% of the variance in breakthrough innovation. However, it shows that the coefficient of nonlocal search is lower than local. Finally, H2a, h2b are supported except H2c.

Table 11. Fitting index of incremental innovation

Fitting index	Recommended value	Our research value
χ^2 / df	< 2	1.154
GFI	> 0.9	0.971
AGFI	> 0.9	0.947
NFI	> 0.9	0.973
CFI	> 0.9	1.000
RMSEA	< 0.05	0.000

Table 12. Fitting index of breakthrough innovation

Fitting index	Recommended value	Our research value
χ^2 / df	< 2	0.775
GFI	> 0.9	0.962
AGFI	> 0.9	0.926
NFI	> 0.9	0.855
CFI	> 0.9	0.876
RMSEA	< 0.05	0.032

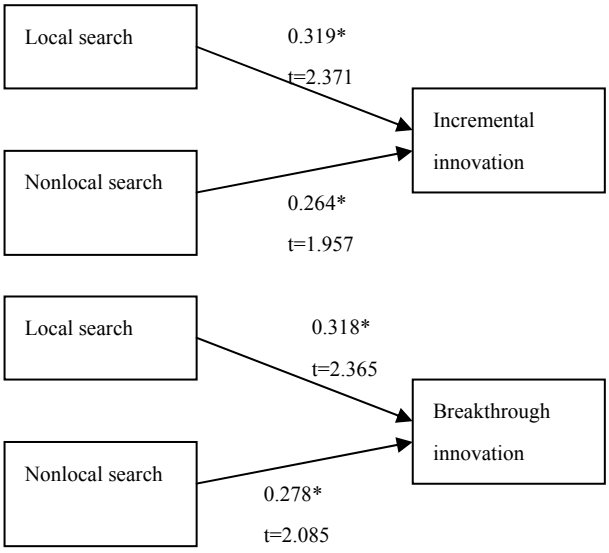

Figure 2. Model fitness

Local coefficient is 0.319, nonlocal coefficient is 0.264. So the impact of local on incremental innovation is greater than nonlocal and the H1c is supported. Unfortunately, the H2c is not supported. Local coefficient is 3.18, nonlocal coefficient is 0.278. The impact of nonlocal on breakthrough innovation is not greater than local.

The results show that H1a, H1b, H2a, H2b, H1c are supported. In a word, local and nonlocal search are positive to enterprise innovation separately. Compared to the nonlocal search, local search is more significant to incremental innovation. However, compared to the local search, nonlocal search isn't more significant to breakthrough. So H2c is not supported by our data. Enterprises concentrate more on local search because of lower search cost. They used to keep trouble away and hold core technology and product which they already have. In other word, while they meet some trouble in innovation activities, they seek local search and forces for help for the first time. So, it well explains why local search have greater effects both on incremental and breakthrough innovation.

4. CONCLUSIONS

4.1 Contributions

First of all, the researches on the relationship between geographical boundary-spanning search and different innovation modes are quite little. This paper is more concentrate on that. The possible contributions lie in: enriching the existing researches about geographical boundary-spanning search and innovation in theoretically, and providing empirical support of the positive effect of geographical search on innovation.

Sometimes, people are confused about the dimension of the geographical boundary-spanning. After theoretical and empirical analysis, we get some insights as follows. Our research divides geographical search into local and nonlocal search. Meanwhile, we emphasize local search as search inside a city boundary and nonlocal search as search outside. This concrete division guarantees the possibility of this research.

Meanwhile, this research has a practical significance to enterprise innovation. Innovation can guarantees the development and progress of enterprises and effective search activities are helpful to enhance their innovation capability and competitive advantage. Knowledge search plays more and more important role in innovation. According to this result, enterprises can enhance their incremental and breakthrough innovation by extensive local or nonlocal search. And the combination of the two search ways will also enhance innovation. After deeper analysis, the degree of concern for local search should be greater than nonlocal search because of the greater effect on both incremental and breakthrough innovation..

4.2 Limitations and outlooks

This study also has some shortcomings. About the difference between H2c and result, the main reason is that the questionnaires mostly concentrated in developed provinces and cities. There are more novel knowledge about product and technology which may meets the requirements of the incremental and breakthrough innovation. So, local search may has a greater impact on breakthrough comparing with nonlocal search. About the limitation of H2c, more attentions to the effect of different regions on research should be paid. And enlarging sample quantity seems a good way to solve this problem. Or sorting out different regions before data analysis is also benefit for research.

This paper mainly talks about the effect of geographical dimension on innovation perhaps other different dimensions could be considered in the future.

ACKNOWLEDGEMENT

This research was supported by the National Natural Science Foundation of China (Project No.71472169 and No.71572187), the Natural Science Foundation of Zhejiang Province (LY15G020016, LQ13G020019) and the Philosophy and Social Science Planning Project (14NDTC249YB).

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