International Journal of u- and e- Service, Science and Technology
Vol.8, No. 12 (2015), pp.139-150
http://dx.doi.org/10.14257/ijunesst.2015.8.12.14

The Effect of Openness and Absorptive Capacity of Leading Firms on Innovation Performance: A Perspective of Innovation Ecosystem

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Abstract

Based on the perspective of innovation ecosystem, the paper studies the relationships between openness and absorptive capacity of leading firms', and how they make effects on innovation performance. Based on a survey of 126 high-tech firms' in China, we found both the openness and absorptive capacity have a positive impact on innovation performance. A finding shows that the scope of openness is wider, the knowledge acquisition capability contributes more to the innovation performance; also, the depth of openness is deeper, the knowledge exploitation capability is more helpful to improve the innovation performance.

Keywords*: leading firms; openness; absorptive capacity; innovation performance*

1. Introduction

With the complex and variety of the marketing environment, it has changed to the serious competition among innovation ecosystems from among firms' [1]. More and more international firms (*e.g.*, IBM, Microsoft, Apple, Qualcomm, Huawei) began to construct and complete their innovation ecosystem in order to gain sustainable competitiveness by continuous collaborative innovation. The proposal of innovation ecosystem performs a change of innovation paradigm.

Leading firms occupy the core of strategies and resources in the ecosystem, being equipped with the ability of controlling and leading the partners, and also set up platform for ecosystem to develop and manage the innovation activities. The role of leading firm has changed to be a draw person of glorious vision of the evolution system, aiming to drive their actors jointly to realize the vision [2].

Innovative openness and absorptive capacity are two key factors that affect the innovative performance [3-5]. [6] found that openness and innovation performance showed the relationship as an inverted U-shaped, which meant that a certain degree of openness would have a positive impact on innovative performance, while too open situation would result in a negative effect, such as technology secret leak. Absorptive capacity emphasizes the acquisition, assimilation, transformation and exploitation of external knowledge. The literature has indicated that absorptive capacity is the key to innovation ability of enterprise, and only equipped with a high absorption capacity, can the enterprises effectively access to new knowledge and enhance innovation performance [3-5]. Through different ways, [7-9] verified that absorptive capacity has a significant impact on corporate performance.

Previously, some relevant literatures analyzed the relationship between two variables, such as openness and innovation performance or absorptive capacity and innovation performance, but fewer researches involve the links among openness,

ISSN: 2005-4246 IJUNESST

absorptive capacity and innovation performance. Thus, we should simultaneously consider the two factors' interaction influence on innovation performance. Therefore, based on the survey data of 126 high-tech enterprises, with multilayer regression model, the article explores the complex relationships among innovation openness, absorptive capacity and innovation performance, and we look forward to getting out the interaction relationship and then provide some inspirations and references for enterprises practice in the future.

2. Theoretical Basis and Research Hypothesis

The paper tries to examine the links between innovation openness, absorptive capacity, and innovation performance. Figure 1 provides an overview of the relationships to be tested.

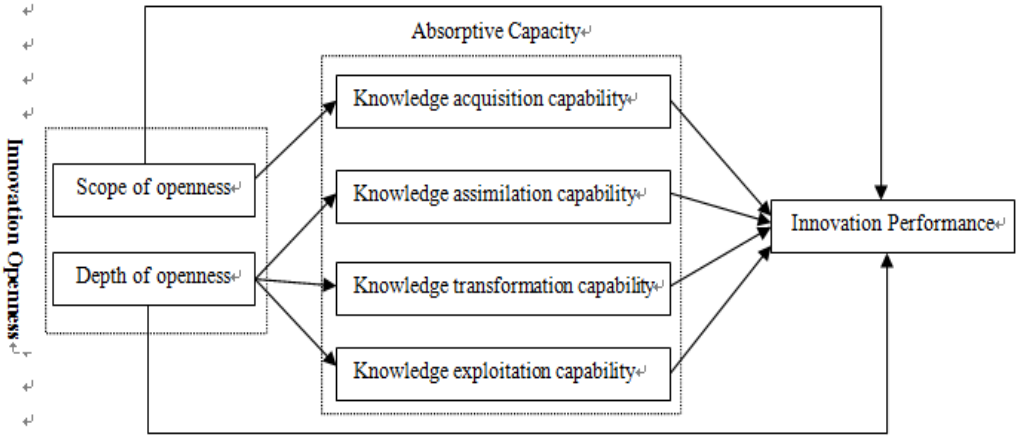

Figure 1. Research Framework

2.1. Innovation Openness and Innovation Performance

Innovation openness just as its name implies is the degree of openness [6], including two dimensions of breadth and depth [10]. The scope of openness refers to the number of cooperation with external innovation elements, including suppliers, clients, research organizations, government, *etc.*, which means that the larger is the number, and the wider is the scope. The depth of openness refers to the frequency of cooperation with external innovative elements of the enterprise [10]. [6] studied how the innovation openness act on innovation performance, and based on which, [10] analyzed how the scope and depth of openness functioned on the innovation performance of Chinese enterprises, which showed that there was a high positive correlation between openness and innovation performance. Among them, innovation openness and innovation performance exist curve correlation in the technology-driven enterprises and positive linear dependence in experience-driven enterprises. Therefore, the paper hypothesizes:

H1: Innovation openness is significantly and positively associated with innovation performance.

2.2. Absorptive Capacity and Innovation Performance

The concept of absorptive capacity was first defined as a firm's 'ability to recognize the value of new information, assimilate it, and apply it to commercial ends' by [3]. Absorptive capacity has been a research focus in the two decades.

Many scholars [10-12] verified through empirical research that the absorptive capacity has a positive impact on innovation performance of enterprises, and considered that the

enterprises with better absorption capacity were often more prominent in innovation capability. [13] thought that the enterprises with stronger absorptive capacity would benefit more from external knowledge. Based on [3] one-dimensional measure, some scholars provided different measure indicators of absorptive capacity, among whom, [4] exerted a significant influence, and their research was widely recognized. [4] redefined the definition as 'absorptive capacity is a set of organizational routines and processes by which firms acquire, assimilate transforms and exploit knowledge to produce a dynamic organizational capability.' and divided absorptive capacity into four dimensionalities, which were knowledge acquisition, assimilation, transformation, and exploitation, and each of which were defined clearly. Therefore, the paper adopts [4] four dimensions about absorptive capacity to carry on the research theoretically and empirically.

2.2.1. Knowledge Acquisition Capability and Innovation Performance: Knowledge acquisition capability 'refers to a firm's capability to identify and acquire externally generated knowledge that is critical to its operations' [4]. Knowledge acquisition can strengthen the knowledge store, and provide more critical thinking and knowledge trick for enterprise innovation [14]. Knowledge acquisition is not only able to enhance the whole learning ability, but also help to increase the success probability of obtaining business opportunities [15]. So we think knowledge acquisition ability can promote innovation performance by obtaining key information and business opportunities. Therefore, the paper hypothesizes:

H2: Knowledge acquisition capability is significantly and positively associated with innovation performance.

2.2.2. Knowledge Assimilation Capability and Innovation Performance: Knowledge assimilation 'refers to the firm's routines and processes that allow it to analyze, process, interpret and understand the information obtained from external sources'[4]. Knowledge assimilation capability is reflected as how to combine the new knowledge and enterprise itself to promote the development of innovation. Assimilation capability of external knowledge could enhance the whole efficiency of production and operation, and shorten the research and development cycle of new products[16]; and also could update knowledge store by adapting to the external environment overcome some of the 'competency trap' [17]. Therefore, the paper hypothesizes:

H3: Knowledge assimilation capability is significantly and positively associated with innovation performance.

2.2.3. Knowledge Transformation Capability and Innovation Performance: Knowledge transformation capability can be defined as 'a firm's capability to develop and refines the routines that facilitate combining existing knowledge and the newly acquired and assimilated knowledge' [4]. While enterprise acquires and assimilates new knowledge, it faces a problem that is how to combine new knowledge with its existing knowledge and then apply it into practice. Hence knowledge transformation capability is the key of absorptive capacity and directly affects the absorption of new knowledge and their future application. Through the transformation process, enterprises can generate new ideas, identify opportunities, examine themselves and the prospects of competition, finally improve the innovation performance of enterprise [4]. Therefore, the paper hypothesizes:

H4: Knowledge transformation capability is significantly and positively associated with innovation performance.

2.2.4. Knowledge Exploitation Capability and Innovation Performance: Knowledge exploitation capability is basically the organizational capacity of a firm to apply the newly acquired, assimilated, transformed knowledge in product or services that it can get existing capacity refining, extending, balancing or creating a create new capacity [4].

Through acquisition, assimilation and transformation process, new knowledge is transferred from external to the organization internal; however, how to integrate new knowledge is still a key issue. Is the new knowledge applied to product development or market launch? Is the new patent used for future production or patent transferred? The above questions are all related to the strategic choice of knowledge exploitation, furthermore the correctness of the choice has a direct effect on innovation performance [15]. Therefore, the paper hypothesizes:

H5: Knowledge exploitation capability is significantly and positively associated with innovation performance.

2.3. The Interactive Impact of Innovation Openness and Absorptive Capacity on Innovation Performance

Absorptive capacity influences innovation performance directly, however, with the changes of the openness, the effect will be various. Even if the enterprises are equipped with the same absorptive capacity, in different degree of openness, innovation performance may be significantly different. [15] found that the impact of openness on innovation performance was mediated by absorptive capacity, and it can significantly enhance the open innovation performance of suppliers and research institutes.

The scope of openness is mainly reflected in the number of cooperation with external innovation sources, meaning that the more the cooperative number is, the wider is the scope of openness [10]. New knowledge is just originated from those external innovation sources, so knowledge acquisition capability is associated with the scope of openness. When an enterprise faces tremendous external knowledge with wider openness, how to identify and select valuable new knowledge, is a manifestation of knowledge acquisition capability. Therefore, the paper hypothesizes:

H6: The wider is the scope of openness, the more significant is the effect of knowledge acquisition capability on innovative performance.

The depth of openness is mainly reflected in the level of close enterprises cooperation with outside innovation sources [10], the higher frequency of cooperation, the deeper is the depth of openness. During the process of cooperation with external innovation sources, enterprises are constantly facing a series of problems such as how to acquire, assimilate, transforms and exploit the new knowledge. With the increase of open depth, the frequency of knowledge exchange between the partners increases, and the chance to acquire core knowledge increases. However, the core knowledge of the partners would not necessarily be transferred into the core of this enterprise itself, which requires enterprises to be qualified with the ability that can transfer external knowledge into their own knowledge and select the appropriate strategy [4], only then can new knowledge have a truly positive impact on innovative performance [15]. Therefore the following hypotheses are developed:

H7: The deeper is the depth of openness, the influence of knowledge assimilation capability on innovative performance is more significant.

H8: The deeper is the depth of openness, the influence of knowledge transformation capability on innovative performance is more significant.

H9: The deeper is the depth of openness, the influence of knowledge exploitation capability on innovative performance is more significant.

3. Research Design

3.1. Sample and Data

In order to test above theoretical assumptions, the study collected data through questionnaires to the responsible person of 300 Chinese high-tech enterprises, used Likert 7 scales to rate, and gave out 300 questionnaires, among which 173 was

received and 126 was valid, the questionnaire valid rate was 72.8%. The structure of the sample of valid questionnaires shows that the sample has good representation and meets the requirements of the study (Table 1).

Table 1. Sample Structure

	Category	Sample number	Percentage (%)
Enterprise scale	small	50	39.7
	medium	57	45.2
	large	19	15.1
Types of industries	electronic and communication equipment manufacture	22	17.5
	electronic computer and office supply manufacture	26	20.6
	Pharmaceuticals	19	15.1
	medical equipment and device scale manufacture	23	18.3
	electronic machinery and device manufacture	29	23.0
	aerospace vehicle manufacture	7	5.5
Enterprise development phase	start up	9	7.1
	developing	79	62.7
	developed	38	30.2

3.2. Variables Measurement

3.2.1. Innovation Openness: Most of innovative ideas are from outside of enterprise, and suppliers, customers, research institutions and competitors are the mainly external source of innovation knowledge. The article divides openness into two dimensions—the scope and the depth of openness, by referencing the measure indicators from [6]and [10].The way to measure the scope of openness is to calculate the quantity that enterprises cooperate with external innovative source (including primary users, suppliers, competitors, enterprises from other fields, universities / research institutions, technology intermediaries, intellectual property organizations, venture investment organizations, and government, nine elements total). For example, if the enterprise cooperates with primary user, denoted by "1", otherwise denoted by "0"; and other innovative elements score with the same way, finally calculate the score of the scope of openness.

In addition, measuring the depth of openness is to measure the frequency of cooperation with external innovation sources, learnt from [10] measurement scale, and used software IBM SPSS to extract the principal component, and calculate the score of the depth of openness.

3.2.2. Absorptive Capacity: In the early studies of absorptive capacity, many scholars regarded R & D investment as a proxy variable of absorptive capacity, which mainly followed the initially traditional measure on absorptive capacity from [3]. With further study, scholars have not been satisfied with a simple proxy variable to measure absorptive capacity, because it is a multi- dimensional concept. The article agrees with [4] that divides absorptive capacity into four dimensionalities, and on the basis of Jansen's (2005) scale about absorptive capacity [18], combining with the characteristics of absorptive capacity in the open innovation paradigm, we design a total of 23 question items, measuring capability of knowledge acquisition (7 items), assimilation (2 items), transformation (5 items), and exploitation (9 items).

3.2.3. Innovation Performance: On the basis of innovation performance measurement scale from [10, 19, 20], we apply seven indicators to measure innovation performance, including the number of new products annually, sales rate of new products, the R&D rate of new products, the R&D cost of new products, the success rate of innovation project, the number of patent applications, and the number of taking over or participating to make industry standard.

3.2.4. Control Variables: Besides innovation openness and absorptive capacity, innovation performance is also affected by the situation of the enterprises themselves, such as enterprise scale, types of industry, and development phase. The larger is the enterprise, the more abundant resource it stores, so the innovation performance may be more significant; the types of industry and innovation performance are also closely related, for example, the innovation performance is often far ahead in knowledge-intensive industries than in labor-intensive industries. Therefore, in order to reduce the impact of these factors on the results of this study, and to highlight the impact of innovation openness and absorptive capacity on innovation performance, we regard enterprise scale, types of industry, and development phase as control variables.

Table 2. Summary Index

Variable	Index
Innovation Openness	The scope of openness
	The depth of openness
Absorptive Capacity	knowledge acquisition cap
	knowledge assimilation
	knowledge transformation
	knowledge exploitation
Innovation Performance	number of new products annually
	sales rate of new products
	R&D rate of new products
	R&D cost of new products
	success rate of innovation project
	number of patent applications
	number of taking over or participating to make industry standard

4. Empirical Analysis and Results

Author names and affiliations are to be centered beneath the title and printed in Times New Roman 12-point, non-boldface type. Multiple authors may be shown in a two or three-column format, with their affiliations below their respective names. Affiliations are centered below each author name, italicized, not bold. Include e-mail addresses if possible. Follow the author information by two blank lines before main text.

4.1. Analysis on Reliability and Validity

The reliability and validity of questionnaire is verified by software IBM SPSS. The KMO index of each variable are all above 0.85, and Bartlett's test of sphericity is significant ($p<0.01$), both of which justify the validity of the questionnaires; then after two adjustments of each question item, the Cronbach's Alpha coefficient and CITC total correlation coefficient of variables are all larger than 0.8, which indicate that the questionnaires pass the reliability test.

Table 2. Results of Multivariate Regression Analysis

Variable	Innovation performance				
	Model 1	Model 2	Model 3	Model 4	VIF
Enterprise scale	.080	.056	.109	.102	1.484
Types of industry	.204	-.177**	-.041	-.032	1.585
Enterprise development phase	.214*	.098	.174**	.192***	1.294
Scope of openness		.085*	.123*	.087*	3.559
Depth of openness		.654***	.085**	.173*	2.307
Knowledge acquisition capability			.429*	.301*	3.895
Knowledge assimilation capability			.178	.218	3.860
Knowledge transformation capability			.141	.185	4.678
Knowledge exploitation capability			.950***	.855**	4.808
Scope of openness * Knowledge acquisition capability				.074*	6.485
Depth of openness * Knowledge assimilation capability				.029	8.294
Depth of openness * Knowledge transformation capability				.178	8.842
Depth of openness * Knowledge exploitation capability				.121*	9.172
R^2	.164	.641	.790	.820	
Adj- R^2	.099	.601	.750	.778	
F	2.516**	15.837***	19.831***	21.331***	
Durbin-Watson	1.645	2.009	1.662	1.595	

It shows standardization regression coefficient in table; * indicates $p<0.10$, ** indicates $p<0.05$, and *** indicates $p<0.01$

4.2. Hypothesis Testing

Based on the above assumptions, we construct three models, which are analyzed by multiple regression method. Model 1 in Table 3 is the regression model of the control variables making effects on the dependent variable innovation performance, and the result indicates that the enterprise development phase has a significant positive impact on innovation performance. However, enterprise scale and types of industry do not act on innovation performance significantly, which may be that the samples are all related to the high-tech enterprises, that is, regardless of scale, high-tech enterprises all treat innovation as the only path to exist.

Based on the control variables, two more independent variables are added in Model 2, which are the scope of openness and the depth of openness, just as the change of the adj-R^2 value (from 0.099 to 0.601), the explanatory power of the model has been increased significantly. This shows that the impact of innovation openness on innovation performance is significant and thus the assumption H1 has been supported. Innovation performance is influenced by both of the scope of openness ($\beta = 0.085$, $p < 0.1$) and the

depth of openness ($\beta = 0.654$, $p<0.01$), from which we found that the depth of openness is much more effective.

On the basis of the control variables and openness, four independent variables of absorptive capacity are added in Model 3. Adj-R^2 increases up nearly 0.15 than model 2, the result indicates that absorptive capacity acts as significant role on innovation performance. Across the four dimensionalities of absorptive capacity, knowledge assimilation capability and knowledge transformation capability do not make marked effects on innovation performance, which may due to the weak awareness of open innovation and the lower degree of openness in Chinese enterprises. The results of the survey shows, just is 2 the average number of building partnerships with external sources in Chinese enterprises, far lower than the total number of 9; moreover, up to 50% Chinese enterprises only value the relationship with government and clients. All the above explains the low degree of openness in Chinese enterprises, further shows the lack of the ideas of knowledge assimilation and transformation, finally explains the reasons why knowledge assimilation capability and knowledge transformation capability do not make marked effects on innovation performance. Differently, knowledge acquisition capability and knowledge exploitation capability have high-positive correlation with innovation performance, especially the regression coefficient β of knowledge acquisition capability is up to 0.95, $p <0.01$, hence assumptions H2 and H5 gets verified.

Model 4 is for measuring the interactive impact on innovation performance between openness and absorptive capacity. In order to effectively avoid the problem of multicollinearity between the interactive items, the independent variables, and the control variables, the data is all standardized, and making sure the values of VIF are all less than 10. As shown in Table 3, adj-R^2 increases, indicating that the explanatory power of model 4 significantly improves. The result shows that the interaction of knowledge exploitation capability and depth of openness has the most significant impact on innovation performance ($\beta = 0.121$, $p <0.01$), which supports the assumption H9; besides, knowledge acquisition capability and scope of openness impact on innovation performance secondarily significantly ($\beta = 0.074$, $p <0.1$), supporting the assumption H6; however, assumption H7 and H8 do not pass the test because interaction between knowledge assimilation capability and depth of openness, and between knowledge transformation capability and depth of openness effect on innovation performance not significantly.

To show the interactive impact more visualized, we use interactive graph for further analysis. The standardized score of openness (scope and depth) is divided into two groups, one of which belongs to high degree of openness (the score is equal or greater than zero), and the other of which belongs to low degree of openness (the score is less than zero). And then through the scatter diagram we describ the liner trend. Figure 1 illustrates interactive impact on innovation performance between knowledge acquisition capability and the scope of openness. Figure 1 (a) shows the linear dependence between knowledge acquisition capability and innovation performance in the case of narrower scope of openness, while Figure 1 (b) shows the linear dependence between knowledge acquisition capability and innovation performance in the case of wider scope of openness. After comparing the two figures, it can be seen that the slope of the line is greater in wider scope of openness, which means that the wider the scope of openness is, the more significantly knowledge acquisition capability makes effects on innovation performance.

Similarly, Figure 2 illustrates the interactive impact of knowledge exploitation capability and the depth of openness on innovation performance. Comparing two lines in figure 2(a) (b), it can be known that knowledge exploitation capability will contribute more effectively to innovation performance in the case of deeper openness.

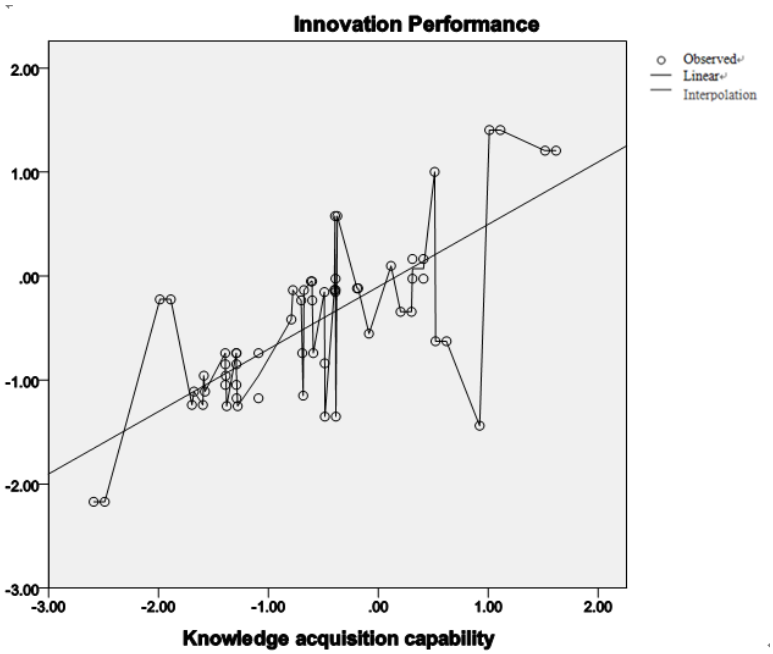

Figure 2 (a). In the Case of Narrower Scope of Openness, the Interactive Impact of Knowledge Acquisition Capability and Scope of Openness on Innovation Performance

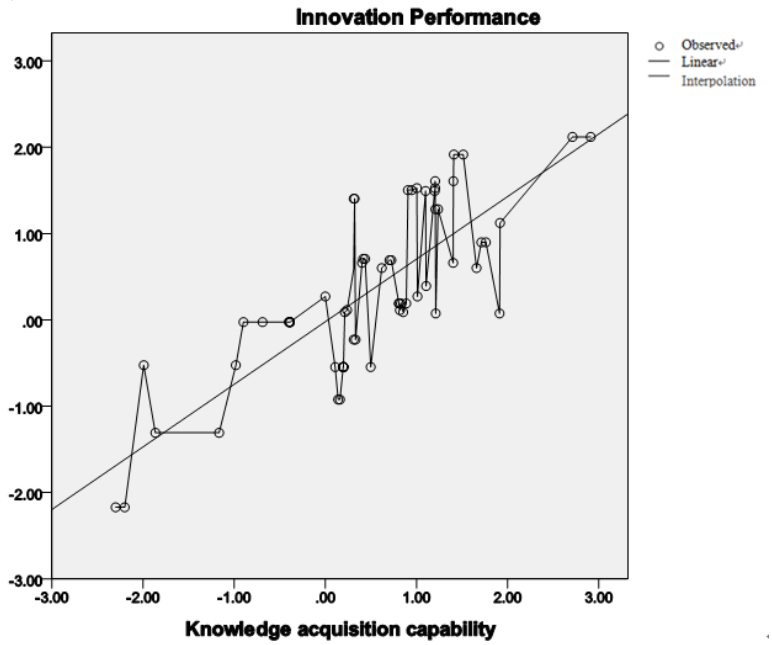

Figure 2 (b). In the Case of Wider Scope of Openness, the Interactive Impact of Knowledge Acquisition Capability and Scope of Openness on Innovation Performance

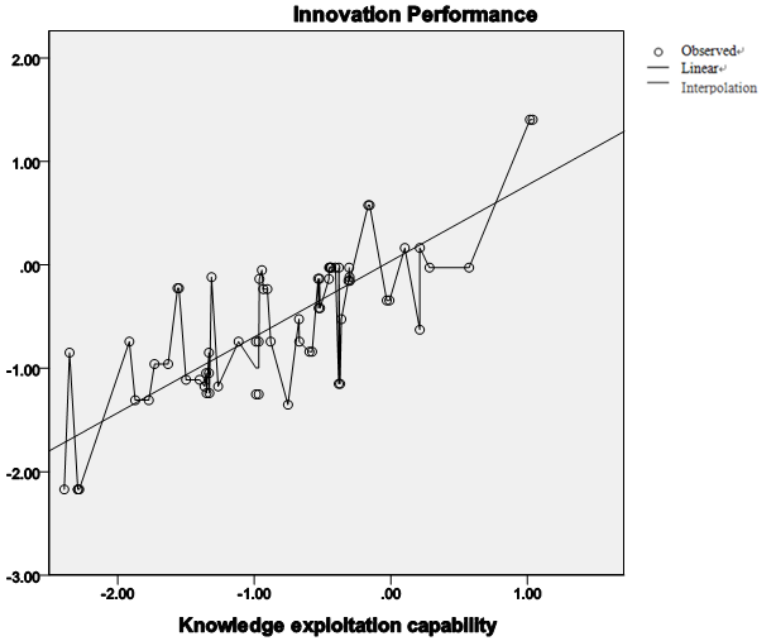

Figure 3 (a). In the Cases of Less Depth of Openness, the Interactive Impact of Knowledge Exploitation Capability and the Depth of Openness on Innovation Performance

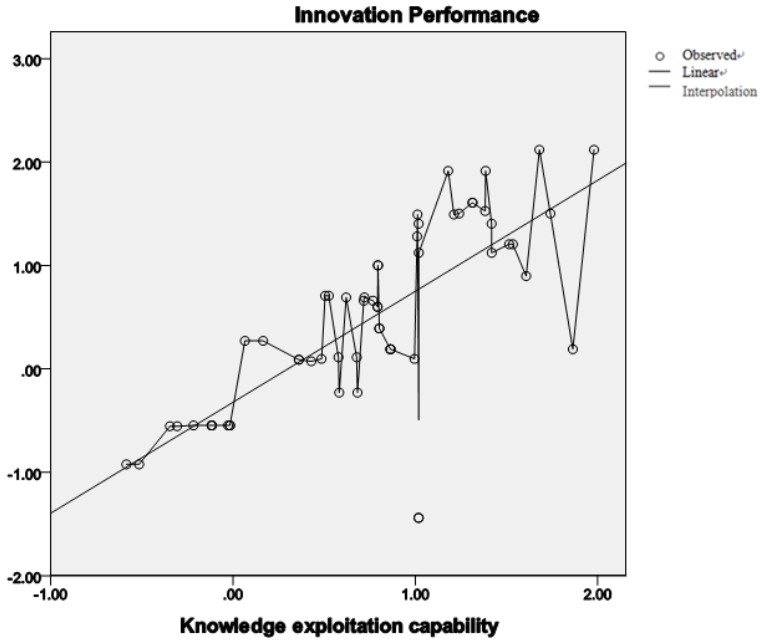

Figure 3 (b). In the Cases of Deeper Depth of Openness, the Interactive Impact of Knowledge Exploitation Capability and the Depth of Openness on Innovation Performance

5. Conclusions

With the sample of 126 Chinese high-tech enterprises, the paper empirically analyzes the impacts of innovation openness and absorptive capacity on innovation performance. Study results show that openness along with absorptive capacity have a positive impact on innovation performance. The wider is the scope of openness,

the more knowledge acquisition capability helps to improve the innovation performance; the deeper is the depth of openness, the more knowledge exploitation capability helps to improve the innovation performance. The interaction between openness and knowledge assimilation capability and between openness and knowledge transformation capability do not significantly impact on innovation performance.

The study contributes to the development of theory and practice to some extent. First of all, after integrating the theory point of openness and absorptive capacity, we explore the action of related factors of leading firms on innovation performance, and import the interaction of openness and absorptive capacity into the research model, further expand the study category. In addition, the results of this study have some significance to enterprise strategic planning. If the enterprise is in the case of wider scope of openness, it should emphasize the development of knowledge acquisition capability, and if the enterprise is in deeper openness, it should pay attention on developing knowledge exploitation capability.

However, the study has some limitations. Influenced by the sample data, the study failed to find out the interaction of the other two dimensionalities of absorptive capacity (knowledge assimilation capability and knowledge transformation capability) and openness on innovation performance; at the same time, because of the sample from the high-tech enterprises, whether the study results are suitable for traditional industries needs further verification.

For future studies, it is recommended to excavate measure indicators of absorptive capacity via the view of open innovation, to be able to use other proof techniques for further studying of the interaction among three fields. In addition, it is suggested that do verification with a large sample of traditional industries, to test whether the conclusions of this study apply to the non-high-tech enterprises.

Acknowledgments

The paper is funded by projects of National Natural Science Foundation (NO.71173059, 71372020) and the project of The Specialized Research Fund for the Doctoral Program of Higher Education (20132304110025).

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