Research on Ambidextrous Innovation and Regional Innovation Capability in Innovation Ecosystem from Institutional Perspective

Jian Hu [1, a], Hejia Li [1, b], and Jinhua Sun [1, c]

[1]School of Management, Chongqing University of Technology, Chongqing 400054, China;

[a] jianhu-hit@163.com, [b] 1002611171@qq.com, [c] sjh1009@163.com

Abstract. According to the organizational ambidexterity theory, the mechanism of ambidextrous innovation on regional innovation capability in the innovation ecosystem is explored, institutional environment is introduced as a moderating variable, corresponding theoretical models are constructed, and empirical research is carried out by application of a two-way fixed effects model based on the panel data of 31 provinces in China from 2009 to 2018. The results show that there is a u-shaped relationship between exploratory innovation and regional innovation capability in innovation ecosystem, and exploitative innovation in innovation ecosystem has a significant positive impact on regional innovation capability. The complementarity of exploratory innovation and exploitative innovation in innovation ecosystem positively affects regional innovation capability. Furthermore, institutional environment strengthens the positive correlation between exploitative innovation and regional innovation capability. On the basis of the above conclusion, it is proposed that each innovation population should strengthen the exchange and sharing of technology and knowledge, carry out independent collaborative ambidextrous innovation, and the government should play a governance role in the innovation environment in order to promote the improvement of regional innovation capability.

Keywords: innovation ecosystem, ambidextrous innovation, exploratory innovation, exploitative innovation, regional innovation capability, institutional environment.

1. Introduction

As an essential path for the high-quality and sustainable development of the regional economy, one of the critical drivers for the effective implementation of innovation strategy lies in constructing a perfect innovation ecosystem. Because a good innovation ecosystem can effectively stimulate the innovation vitality of regional innovation populations, further enhance the collaborative innovation effect of innovation populations, and thus bring sustainable growth momentum for regional innovation [1]. An innovation ecosystem is a system formed by analogizing the whole process of innovation with a biological system through the interaction and interdependence among capital, information, technology and energy flows. There are various innovation populations in this system, and various populations interact with each other in a specific innovation environment, thus triggering innovation [2]. However, at present, China's innovation ecosystem still faces problems such as unbalanced development in each region and low overall output efficiency [3], which are rooted in the single type of innovation activities carried out within the regional innovation ecosystem and only one type of innovation activities in exploratory or exploitative innovation based on specific cooperative goals, which cannot effectively play the complementary advantages of ambidextrous innovation to stimulate real-time sharing of innovation resources such as technologies and knowledge among innovation populations, resulting in the synergistic effect with spontaneous cooperation within the network has not been formed, which in turn affects the overall innovation efficiency of the system. According to the analysis of organizational ambidexterity theory, ambidextrous innovation is the optimal mode of organizational technology innovation [4]. Only by carrying out autonomous and collaborative ambidextrous innovation in innovation ecosystem can innovation populations effectively promote the deployment of innovation resources and exchange of materials, overcome the problems of high risk and resource consumption of a single type of innovation, and fundamentally improve the innovation efficiency within the innovation ecosystem and enhance the regional innovation capability, and promote the sustainable improvement of regional innovation capability. However, scholars primarily have studied the impact of ambidextrous innovation from a single innovation population, such as enterprises and universities, and lack the research on ambidextrous innovation from the perspective of innovation ecosystem population synergy [5,6]. In innovation ecosystem constituted by multiple populations, how exploratory innovation and exploitative innovation in an antagonistic and unified relationship exist and develop is still a black box that has not been uncovered by academia. Meanwhile, no matter what type of innovation activities are affected by the institutional environment [7], in the process of innovation, the cooperation enthusiasm among innovation populations, the efficiency of innovation resources allocation, and the protection of innovation achievements all need the guidance and support of certain systems and mechanisms. However, due to the disparity in economic and social development in various regions of China, the regional institutional environment created is also quite different, resulting in inconsistent incentive effectiveness for innovation populations. Therefore, it is still worth exploring whether the current institutional environment can promote ambidextrous innovation among various innovation populations within the regional innovation ecosystem. Given this, this study deeply explores the impact of ambidextrous innovation in the regional innovation ecosystem on regional innovation capability from the perspective of the institutional environment, which has important practical significance for continuously improving the innovation efficiency of China's innovation ecosystem.

2. Theoretical Analysis and Research Hypothesis

2.1 Ambidextrous Innovation and Regional Innovation Capability in Innovation Ecosystem

According to the literature review, the elements of the innovation ecosystem mainly include innovation communities, innovation resources and innovation environment. All enterprises, universities, scientific research institutions, intermediaries and governments in innovation ecosystem can form enterprise populations, university populations, scientific research institutions populations, intermediary institutions populations and government populations. These populations build cooperative relationships through industrial chains, value chains and knowledge chains, forming innovation communities [8,9]. Universities, scientific research institutions and high-tech enterprises are the central communities that carry out ambidextrous innovation in innovation ecosystem. With the support of innovation auxiliary communities such as the government, they can gather various innovation resources, play a collaborative role in innovation and then enhance the regional innovation capability based on different innovation environments.

Ambidextrous innovation means that organizations are engaged in both exploratory and exploitative innovations. Exploratory innovation constantly pursues new knowledge and develops new products and services, while exploitative innovation continuously extends existing technologies and knowledge to expand existing products and services [10]. Exploratory innovation in innovation ecosystem refers to the cooperation of innovation communities for pioneering and emerging technology research and development, creating new technologies and knowledge in the innovation environment to provide new design and create and develop new products and services. Exploitative innovation in innovation ecosystem refers to the cooperation of innovation communities for mature and familiar technology research and development, using existing technologies and knowledge in the innovation environment to improve and expand existing products and services.

2.1.1 Exploratory innovation and regional innovation capability

Based on the perspective of resource integration, scholars come to the conclusion that the relationship between exploratory innovation and innovation performance is "U-shaped", and it is believed that the heterogeneity of resources and the ability to integrate resources impact the innovation capability of the organization. When the investment of innovation resources is insufficient, the occupation of primary business resources by exploratory innovation will negatively affect organizational innovation efficiency. However, with a further investment of resources and the accumulation of experience in resource integration, exploratory innovation will promote the improvement of organizational productive innovation efficiency [11,12]. For exploratory innovation, a primary research activity with a long investment cycle and uncertain returns, the innovation populations within the system at the early stage of innovation are unable to meet the higher requirements of exploratory innovation for resource synergy and matching management due to their weak collaborative innovation capability, resulting in unreasonable utilization of new technologies and knowledge and waste of resources, thus inhibiting the innovation capability of the region. However, with the enhancement of exploratory innovation, the synergistic effect appears among innovation populations emerges, which will promote the entire flow of technology and knowledge within the system and thus generate specific knowledge spillover effects, thus promoting the improvement of regional innovation capability [13]. Based on this, the following hypothesis is proposed:

H1: There is a "U-shaped" relationship between exploratory innovation and regional innovation capability in innovation ecosystem.

2.1.2 Exploitative innovation and regional innovation capability.

Unlike exploratory innovation, exploitative innovation is characterized by low risk and a high success rate [14]. The current research results have taken universities, scientific research institutions and enterprises as the research objects and found that three different types of innovation subjects carry out exploitative innovation to promote innovation capability, among which universities can promote innovation performance by actively using and transforming existing theoretical achievements to realize technology application and promotion [15]. Moreover, scientific research institutions carry out exploitative innovation to effectively resolve technical and financial risks in scientific research, improve the success rate of transforming scientific research results, and enhance innovation capability [16]. Additionally, enterprises can improve their innovation performance by refining and reorganizing existing knowledge and resources, tapping their potential value, and optimizing their products and services through exploitative innovation [17]. In summary, in the regional innovation ecosystem, innovation communities carry out exploitative innovation, which is beneficial for gathering high-quality innovation technologies and knowledge and other resources, promoting the integration and reorganization of existing technologies, generating applied innovation results, and promoting the development of regional innovation capability. Based on this, the following hypothesis is proposed:

H2: Exploitative innovation in innovation ecosystem positively impacts regional innovation capability.

2.1.3 Ambidextrous innovation and regional innovation capability

Scholars based on the organizational ambidexterity theory, argues that although exploratory and exploitative innovations conflict with each other, some successful organizations can often reconcile this conflict to a great extent and thus achieve lasting competitiveness, and innovation populations with ambidexterity characteristic can actively explore new development opportunities while developing existing capability and thus enhance innovation capability [18]. For example, knowledge from exploratory innovation in universities can stimulate exploitative innovation, and exploitative innovation will trigger new research questions, and the two present complementary effects to jointly enhance their innovation capability [5]. Moreover, scientific research institutions perform ambidextrous innovation by setting up direct research institutes and holding companies, which alleviates the pressure of resource constraints on ambidextrous innovation reconciliation and enhances innovation efficiency [16]. Additionally, enterprises have contextual and structural ambidexterity and can explore new development opportunities while developing existing capability, thus enhancing innovation performance [19]. In summary, in the vigorous national promotion of basic research, the ambidextrous innovation mechanism is gradually implemented within each innovation population, and ambidextrous innovation is carried out through ambidextrous organization and contextual design. The innovation populations in innovation ecosystem simultaneously carry out exploratory and exploitative innovation, which can make up for their respective deficiencies, reduce innovation risks, and jointly enhance regional innovation capability through the complementary of both. Based on this, the following hypothesis is proposed:

H3: The complementarity of ambidextrous innovation in innovation ecosystem positively impacts regional innovation capability.

2.2 The regulatory role of the institutional environment

The institutional environment is the sum of a series of political, economic, social and legal ground rules, including both the spontaneously formed market environment and the government policy environment, which provides the basic guidelines for the production, exchange, distribution and other activities of the economy and society [20]. Li and Yan (2019) showed that a good institutional environment could guarantee technological achievements and improve the efficiency of innovation activities by creating a more fair and orderly environment, thus positively regulating the relationship between R&D investment and enterprise innovation output [21]. Wang and Zhang (2015) found that an excellent institutional environment can guide universities and scientific research institutions to integrate into the market, prompting universities, scientific research institutions and enterprises to continuously increase their cooperation, which eventually makes enterprises get more benefits from industry-university-research cooperation, and helps to positively regulate the relationship between industry-university-research cooperation and innovation performance [22]. Comprehensive analysis above shows that the institutional environment is the foundation and prerequisite for regional technological innovation and the essential survival environment for innovation communities. An excellent institutional environment can promote the proper flow of innovation factors in innovation ecosystem, improve the innovation consciousness of R&D personnel and stimulate their innovation enthusiasm. Meanwhile, it can optimize the allocation and utilization efficiency of innovation resources and promote regional innovation output. Furthermore, it can create a more fair and orderly market environment for innovation communities to conduct exploratory innovation and exploitative innovation, and thus guarantee regional innovation output. Based on this, the following hypotheses are proposed:

H4: The institutional environment positively regulates the relationship between exploratory innovation and regional innovation capability in innovation ecosystem.

H5: The institutional environment positively regulates the relationship between exploitative innovation and regional innovation capability in innovation ecosystem.

3. Measures

3.1 Model Design

This study draws on the test methods of scholars such as Wen, Hou and Zhang (2015) to verify the relationship between ambidextrous innovation, institutional environment and regional innovation capability in innovation ecosystem [23]. Six empirical models are constructed to test the above five hypotheses based on this. Among them, Models 1-3 are used to verify the impact of exploratory innovation and exploitative innovation and their complementarity on regional innovation capability in innovation ecosystem. Moreover, models 4-6 are used to verify the moderating role of institutional environment between exploratory innovation, exploitative innovation and regional innovation capability.

$$RI_{it} = \beta_0 + \beta_1 EI_{it} + \beta_2 EI^2_{it} + \beta_3 GS_{it} + \beta_4 HC_{it} + \beta_5 IS_{it} + \beta_6 IL_{it} + \beta_7 PGDP_{it} + \alpha_i + \delta_t + \varepsilon_{it} \tag{1}$$

$$RI_{it} = \beta_0 + \beta_1 EPI_{it} + \beta_2 GS_{it} + \beta_3 HC_{it} + \beta_4 IS_{it} + \beta_5 IL_{it} + \beta_6 PGDP_{it} + \alpha_i + \delta_t + \varepsilon_{it} \tag{2}$$

$$RI_{it} = \beta_0 + \beta_1 EI_{it} + \beta_2 EPI_{it} + \beta_3 EI_{it} \times EPI_{it} + \beta_4 GS_{it} + \beta_5 HC_{it} + \beta_6 IS_{it} + \beta_7 IL_{it} + \beta_8 PGDP_{it} + \alpha_i + \delta_t + \varepsilon_{it} \quad (3)$$

$$RI_{it} = \beta_0 + \beta_1 EI_{it} + \beta_2 IE_{it} + \beta_3 EI_{it} \times IE_{it} + \beta_4 GS_{it} + \beta_5 HC_{it} + \beta_6 IS_{it} + \beta_7 IL_{it} + \beta_8 PGDP_{it} + \alpha_i + \delta_t + \varepsilon_{it} \quad (4)$$

$$RI_{it} = \beta_0 + \beta_1 EI_{it} + \beta_2 EI^2_{it} + \beta_3 IE_{it} + \beta_4 EI_{it} \times IE_{it} + \beta_5 EI^2_{it} \times IE_{it} + \beta_6 GS_{it} + \beta_7 HC_{it} + \beta_8 IS_{it} + \beta_9 IL_{it} + \beta_{10} PGDP_{it} + \alpha_i + \delta_t + \varepsilon_{it} \quad (5)$$

$$RI_{it} = \beta_0 + \beta_1 EPI_{it} + \beta_2 IE_{it} + \beta_3 EPI_{it} \times IE_{it} + \beta_4 GS_{it} + \beta_5 HC_{it} + \beta_6 IS_{it} + \beta_7 IL_{it} + \beta_8 PGDP_{it} + \alpha_i + \delta_t + \varepsilon_{it} \quad (6)$$

Among them, RI_{it} represents regional innovation capability. EI_{it} represents exploratory innovation. EPI_{it} represents exploitative innovation. GS_{it} represents government support. HC_{it} represents human capital. IS_{it} represents industrial structure. IL_{it} represents infrastructure level. $PGDP_{it}$ represents per capita GDP growth rate. IE_{it} represents institutional environment. $EI_{it} \times EPI_{it}$ represents the interaction item of exploratory innovation and exploitative innovation. $EI_{it} \times IE_{it}$ represents the interaction item of exploratory innovation and institutional environment. $EI^2_{it} \times IE_{it}$ represents the interaction item of exploratory innovation square and institutional environment. $EPI_{it} \times IE_{it}$ represents the interaction item of exploitative innovation and institutional environment. Moreover, i、t represent the province and time, respectively. β is the coefficient to be estimated. α_i 、δ_t represent the province fixed effect and time fixed effect, respectively. ε_{it} represents the random disturbance term.

3.2 Variables and Measures

(1) Explained variable: regional innovation capability (RI). This study refers to the research results of Zeng and Zhou (2019), and selects the urban innovation index in the Report on China's Urban and Industrial Innovation Capability to measure urban innovation capability [24]. In measuring the city innovation index, the report uses invention patent grants from the National Intellectual Property Administration in China and microdata from the State Administration for Industry and Commerce. It estimates their values through a patent update model, adding the value of each patent to the city level to get the urban innovation index and making the measurement of city innovation capability more accurate. The research object of this paper consists of 31 provinces. Referring to the practice of this report, the regional innovation index of 31 provinces is obtained by adding up the corresponding urban innovation index of each province to measure the regional innovation capability.

(2) Explanatory variables: exploratory innovation (EI) and exploitative innovation (EPI). This study adopts the innovation communities indicators compiled by Wang et al.(2020), as shown in Table 1 [8]. The entropy method is used to determine the weight of each index in the index system, and the values of exploratory innovation and exploitative innovation are calculated. Moreover, the complementary dimension is measured by the product of exploratory innovation and exploitative innovation [25].

(3) Moderator variable: institutional environment (IE). Referring to the research results of Xia and He (2020), this study adopts a market-oriented marketization index to measure the institutional environment, which includes five aspects: government-market relationship, non-state economy, product market development, factor market development and market intermediary organization development and legal system environment [26]. Furthermore, the marketization index is obtained by a comprehensive evaluation of the five aspects.

(4) Control variables: Based on the selection of core variables, government support (GS), human capital (HC), industrial structure (IS), infrastructure level (IL) and per capita GDP growth rate

(PGDP) are selected as control variables, drawing on existing research results. Government support is measured by the proportion of government funds in R&D funding within each region. Human capital is measured by the proportion of fiscal education expenditure to local fiscal expenditure. Industrial structure is measured by the ratio of the proportion of the secondary industry to the proportion of the tertiary industry. Infrastructure level is measured by the mileage of highway lines per capita (km/10,000 people).

Table 1. Indicators for evaluating ambidextrous innovation capability in innovation ecosystems based on innovation populations

Types of Innovation populations	Exploratory Innovation Indicators	Exploitative Innovation Indicators
Colleges and universities	The full-time equivalent of experimental development personnel in colleges and universities (person-year)	The full-time equivalent of applied researchers in colleges and universities (person-year)
	Internal expenses of development expenses of colleges and universities (10,000 yuan)	Internal expenses of applied funds of colleges and universities (10,000 yuan)
	Number of awards for scientific and technological achievements in colleges and universities (items)	Number of scientific research papers published in colleges and universities (articles)
	Number of invention patents authorized by colleges and universities (items)	Number of utility patents authorized by colleges and universities (items)
Scientific Research Institutions	Number of scientific and technological personnel in scientific research institutions (10,000 people)	Number of employees in scientific research institutions (10,000 people)
	Internal expenses of development expenses of scientific research institutions (10,000 yuan)	Internal expenses of applied funds of scientific research institutions (10,000 yuan)
	Funding income from scientific and technological activities of scientific research institutions (10,000 yuan)	Funding income of scientific research institutions (10,000 yuan)
	Number of valid invention patents of scientific research institutions (items)	Number of valid practical patents of scientific research institutions (items)
High-tech enterprises	Number of development (disruptive) high-tech enterprises (pieces)	Number of applied (development-type) high-tech enterprises (pieces)
	Full-time equivalent of experimental development personnel in high-tech enterprises (person-year)	Full-time equivalent of applied researchers in high-tech enterprises (person-year)
	New product sales revenue of high-tech enterprises (10,000 yuan)	Expenditure on technological transformation of high-tech enterprises (10,000 yuan)

3.3 Data Source

Considering the data availability, this study sets the sample study interval as 2009-2018. The explained variables mainly come from the Report on China's Urban and Industrial Innovation Capability. Explanatory variables mainly come from China Statistical Yearbook, China Statistical Yearbook on Science and Technology, China Statistical Yearbook on High Technology Industry, Compilation of Science and Technology Statistical Data of Colleges and Universities, etc. The moderator variable comes from China Market Index Report by Province.

4. Results

4.1 Descriptive Statistics and Correlation Analysis

Table 2 shows the descriptive statistical results of the main variables. The mean value of regional innovation capability is 0.564 and the standard deviation is 0.185, indicating differences in innovation capability among different regions. Meanwhile, the fluctuations of exploratory innovation and exploitative innovation are not significantly different among regions. Moreover, there is a significant positive relationship between exploratory innovation, exploitative innovation, institutional environment and regional innovation capability. The VIF value of each variable is less than 10, and the mean value is 4.44, so there is no serious problem with multicollinearity.

Table 2. Descriptive statistics and correlation analysis results

variables	sample number	mean	sd	min	max	1	2	3	4
RI	310	0.564	0.185	0	1	1			
EI	310	0.544	0.185	0.038	0.936	0.884***	1		
EPI	310	0.581	0.189	0.031	0.895	0.943***	0.895***	1	
IE	310	0.609	0.199	0	1	0.882***	0.770***	0.870***	1

Note: *, **, *** indicate significant at the statistical level of 10%, 5% and 1%, respectively.

4.2 Hypothesis Results Testing

This study uses a two-way fixed effects model to examine the impact of ambidextrous innovation on regional innovation capability in innovation ecosystem. Firstly, the Hausman test results show that a fixed effect model should be selected. Then, through the time effect test, the results suggest that the time effect should be included in the model. Therefore, a two-way fixed effects model is selected for regression analysis of the parameters. Through the analysis of the sample data, it is found that the sample data has certain heteroscedasticity and autocorrelation. The "xtscc, fe" command proposed by Driscoll and Kraay (1998) is used to correct the influence of heteroscedasticity and autocorrelation on the regression results [27].

Exploratory innovation, exploitative innovation and their complementarity are tested in relation to regional innovation capability. The results of the full-sample test are shown in Table 3, where the results of model 1 show that the relationship between the primary term of exploratory innovation and regional innovation capability is significantly negative ($\beta=-0.150$, $P<0.01$), and the relationship between the squared term of exploratory innovation and regional innovation capability is significantly positive ($\beta=0.164$, $P<0.05$). Moreover, model 1 passes the utest test with $P=0.0158$ and the extreme value point at 0.460. It indicates a "U-shaped" relationship between exploratory innovation and regional innovation capability, and hypothesis H1 is verified. The possible reasons for the "U-shaped" relationship between exploratory innovation and regional innovation capability are: the lack of experience leads to waste of resources, innovation failure and a long time lag of innovation benefits, therefore, exploratory innovation in the early stage of each region has a suppressive effect on the improvement of regional innovation capability. However, with the increase of resource investment and experience accumulation, exploratory innovation can continuously break through the existing knowledge base and innovation structure, reveal innovation benefits and thus improve regional innovation capability. From model 2, it can be seen that the relationship between exploitative innovation and regional innovation capability is significantly positive ($\beta=0.211$, $p<0.05$), indicating that there is a significant positive impact of exploitative innovation on regional innovation capability, and hypothesis H2 is verified. That is, innovation communities actively carrying out exploitative innovation can effectively promote regional innovation capability. Model 3 examines the impact of complementarity between exploratory and exploitative innovation on regional innovation capability. Model 3 shows that the relationship between the complementarity of both is significantly positive ($\beta=0.312$, $p<0.01$), indicating that the complementarity between exploratory and exploitative innovation positively affects regional innovation capability. Therefore, hypothesis H3 is verified.

The moderating effect of the institutional environment is tested. The moderating effect of the institutional environment between exploratory innovation and regional innovation capability is tested in Model 4 and Model 5. The results of model 4 and model 5 show that the coefficient of the primary term between exploratory innovation and regional innovation capability is not significant. Therefore, there is no moderating effect of the institutional environment between exploratory innovation and regional innovation capability, and hypothesis H4 is not tested. The reason is that exploratory innovation depends more on public resources and policy support and is constrained by factors such as the resources of the innovation community itself, and the market-oriented institutional environment cannot strengthen the relationship between exploratory innovation and regional innovation capability. Model 6 examines the moderating effect of the institutional environment between exploitative innovation and regional innovation capability. The results show that the relationship between exploitative innovation and regional innovation capability is significantly positive (β=0.241, p<0.01), and the interaction term between exploitative innovation and institutional environment is significantly positive (β=0.312, p<0.01), indicating that the institutional environment has a positive moderating effect between exploitative innovation and regional innovation capability, that is, institutional environment strengthens the role of exploitative innovation in promoting regional innovation capability. Therefore, hypothesis H5 is verified.

Table 3. Full sample test results

Variables	Explained variable: RI					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
EI	-0.150**		-0.158**	0.020	-0.009	
	(-3.54)		(-4.72)	(0.99)	(-0.21)	
EI2	0.164**				0.028	
	(3.00)				(0.91)	
EI×EPI			0.312***			
			(3.69)			
EPI		0.211**	0.100**			0.241***
		(3.04)	(2.59)			(4.94)
IE				0.029	0.029	-0.012
				(1.02)	(1.04)	(-0.45)
EI×IE				0.201**	0.178	
				(2.57)	(1.72)	
EI2×IE					-0.016	
					(-0.17)	
EPI×IE						0.312***
						(4.36)
GS	-0.063**	-0.069**	-0.045**	-0.072**	-0.070**	-0.059**
	(-2.70)	(-3.62)	(-2.53)	(-3.01)	(-2.83)	(-2.89)
HC	-0.032	-0.044	-0.035	-0.021	-0.021	-0.022
	(-0.71)	(-0.98)	(-1.08)	(-0.48)	(-0.50)	(-0.61)
IS	0.018***	0.012**	0.013**	0.017**	0.017**	0.013
	(3.57)	(3.01)	(2.37)	(2.75)	(3.07)	(1.81)
IL	0.341***	0.190***	0.404***	0.385**	0.391**	0.362**
	(4.22)	(3.28)	(3.98)	(3.01)	(3.09)	(2.85)
PGDP	0.029**	0.036**	0.038**	0.021	0.022	0.027
	(2.35)	(3.07)	(2.80)	(1.56)	(1.66)	(1.79)
cons	0.312***	0.243***	0.180**	0.242**	0.244**	0.146
	(9.34)	(4.30)	(2.36)	(3.11)	(3.25)	(1.64)
Province Effect	YES	YES	YES	YES	YES	YES
Time Effect	YES	YES	YES	YES	YES	YES
N	310	310	310	310	310	310
R2	0.974	0.975	0.978	0.975	0.975	0.977

Note: 1) *, **, *** indicate significant at the 10%, 5% and 1% statistical levels, respectively.

2) Values in parentheses are t-test values.

5. Conclusions and management insights

(1) Considering that there is a "U-shaped" non-linear relationship between exploratory innovation and the regional innovation capability of each innovation population, each innovation population should establish a long-term cooperation relationship to ensure sufficient innovation resources. Firstly, a mutually beneficial and symbiotic cooperation mechanism should be established between innovation populations, focusing on their exploratory innovation cooperation's spontaneity and long-term nature. Cooperating populations can enter into contracts, set common primary research goals, establish cooperation mechanisms for resource sharing, intellectual property sharing and risk sharing, and set certain thresholds and penalty mechanisms for populations that withdraw from cooperation in order to establish solid cooperative relationships and further form population innovation alliances. Secondly, innovation populations should conduct basic research oriented to frontier scientific problems and national innovation policies to get national R&D funding subsidies as well as technical and talent support and to create an innovative resource support system by attracting financial institutions, social capital and etc to participate in innovation.

(2) Considering the significant positive effect of exploitative innovation of each innovation population on regional innovation capability, each innovation population should strengthen the spillover effect of innovation output and promote the transformation and application of innovation results. On the one hand, each innovation population should pay attention to the industrialization of innovation results, strengthen the construction of the applied research system, and set up a special department responsible for the transformation of exploratory innovation results to exploitative innovation, and build an effective evaluation system for the transformation of scientific and technological results, to strengthen the transformation ability of research results. On the other hand, each innovation population should also use effective innovation policies to identify the latest technology and market development trends, so that innovation results can meet market needs.

(3) Considering that ambidextrous innovation in the innovation ecosystem will have the overall effect of "1+1>2" on the improvement of regional innovation capability, each innovation population should focus on the complementarity of ambidextrous innovation and open up the information chain, talent chain, and benefit chain between the populations and the two innovation subsystems to better improve the regional innovation capability. Firstly, the innovation populations should pay attention to the complementary effect between exploratory innovation and exploitative innovation, formulate a dual-path coordinated development strategy and ensure the optimal resource allocation efficiency of ambidextrous innovation by allocating resources effectively and reasonably to give full play to the complementary synergistic effect of both. Secondly, build a perfect science and technology service support system within the innovation ecosystem, and develop several intermediary institutions serving the ambidextrous innovation in information consultation, technology transfer, cooperative planning and talent exchange to improve the efficiency of ambidextrous innovation cooperation among populations.

Funding: This work is supported by the Humanity and Social Science Youth Foundation of Ministry of Education of China (Grant No. 19YJCZH054), the National Social Science Fund of China (Grant No. 21XMZ002), the Innovation Project of Postgraduates in Chongqing University of Technology (Grant No. gzlcx20223109).

References

[1] Liu Fan, Zhang Junyu, Deng Mingliang. Study of health evaluation of regional innovation ecosystem based on improved niche fitness model. Science and Technology Management Research. 2019, 39(16), 1-10.

[2] Wang Shuying, Chang Le, Zhang Shuijuan, Wang Wenpo. Innovative ecosystem, spillovers effect and regional innovation performance based on the spatial durbin model. Journal of Harbin University of Commerce (Social Science Edition). 2019, 1, 107-116+128.

[3] Wang Zhenyu, Wang Ning, Shan Xiaoguang. Research on the practice of science and technology innovation in China at the stage of innovation 3.0. Science of Science and Management of S. & T. 2021, 42(4), 127-141.

[4] Cui Weijun, Sun Cheng, Fu Yu, Cen Shan. Policy uncertainty and enterprise dual innovation behavior choice: 'brave progress' or 'gradual progress'. Science of Science and Management of S.&.T. 2019, 40(11), 68-81.

[5] Cui Yuehui, Ge Baoshan, Dong Baobao. Ambidextrous innovation and new venture performance: A combined moderating effect model based on the multilevel network structure. Foreign Economics & Management. 2022, 40(8), 45-57.

[6] Gao Qing, He Feng, Lv Quan. Ambidextrous innovation and S&T innovation efficiency in Chinese university: Based on the ambidextrous innovation theory. Forecasting. 2021, 40(3), 76-82.

[7] Liangzheng. From science and technology policy to science technology and innovation policy ———A reflection on transformation of policy paradigm in the context of Innovation-Driven Development Strategy. Studies in Science of Science, 2017, 35(2), 170-176.

[8] Wang Yan, Sun Yi, Wang Dandan, Hu Hanhui. Discrimination of ambidextrous capabilities of innovation ecosystem and analysis of its evolution path: Based on a cross-case study from 1998 to 2018. East China Economic Management. 2020, 34(11), 29-42.

[9] Lu Yanchun, Zhao Hong, Wu Chenxi. Research on the influencing factors of regional innovation ecosystem under the change of innovation paradigm. Enterprise Economy. 2016, 3, 168-173.

[10] Jansen J J P, Van Den Bosch F A J, VOLBERDA H W. Exploratory innovation, exploitative innovation, and performance: Effects of organizational antecedents and environmental moderators [J]. Management Science, 2006, 52(11): 1661-1674.

[11] Sheng Mingquan, Wu Shaomin, Zhang Yanan. Exploratory innovation and enterprise total factor productivity. Industrial Economics Research. 2020, 1, 28-41.

[12] Su Xin, Zhou Shengshi. Ambidextrous innovation and firm competitive position: Empirical evidence from listed companies in China. South. Chin. J. Econ. 2019, 5, 52-77.

[13] Zuo Linfeng, He Yubing. Research on the impact of basic research investment on innovation performance of Chinese enterprises —— An empirical analysis based on panel data from 2009 to 2017. Straits Science. 2019, 3, 47-53.

[14] Peng Can, Li Ruixue, Yang Hong, Yu Peng. Research on the relationship between dual innovation and sustainable development of enterprises under dynamic and competitive environment. Science&Technology Progress and Policy, 2020, 37(15), 70-79.

[15] Pan Y. Relationship between dual innovation ability and scientific research performance of high-level talents in colleges and universities [J]. Educational Sciences: Theory and Practice, 2018, 18(6): 3610-3619.

[16] Lin Jun, Zhang Min. Research on the path of ambidextrous innovation in system-transformed institutes: A case study of northwest institute for non-ferrous metal research. Studies in Science of Science. 2017, 35(4), 600-610.

[17] Hou B, Hong J, Zhu R. Exploration/exploitation innovation and firm performance: the mediation of entrepreneurial orientation and moderation of competitive intensity[J]. Journal of Asia Business Studies, 2019, 13(4): 489-506.

[18] Zhang Jie, An Liren, Zhang Chenlu. Research context of the relationship between ambidexterity and performance from an open innovation perspective and future prospects. Foreign Economics & Management. 2015, 37(7), 3-18.

[19] Xiao Dingding, Zhu Guilong. The research on the relationship among boundary-spanning search ambidexterity capacity structure and organizational performance based on the perspective of innovation capability structure. Economic Management.2017, 39(3), 48-62.

[20] Lundvall B. National innovation systems—analytical concept and development tool [J]. Industry and Innovation, 2007, 14(1): 95-119.

[21] Li Mengya, Yan Taihua. Venture capital, incentive R&D investment and enterprise' innovation output: Moderative effect of regional institutional environment. R&D Manage. 2019, 31(6), 61-69.

[22] Wang Baolin, Zhang Mingshen. Marketization, collaboration with academics and innovation performance of enterprises. Studies in Science of Science. 2015, 33(5), 748-757.

[23] Wen Zhonglin, Hou Jietai, Zhang Lei. Comparison and application of moderating effect and mediating effect. Journal of Psychology. 2005, 2, 268-274.

[24] Zeng Jingjing, Zhou Danping. The influence of government innovation investment and city scale on city innovation capability. Urban Issues. 2019, 5, 55-64.

[25] Jansen J J P, Van Den Bosch F A J, Volberda H W. Exploratory innovation, exploitative innovation, and ambidexterity: The impact of environmental and organizational antecedents [J]. Schmalenbach Business Review, 2005, 57(4): 351-363.

[26] Xia Qinghua, He Dan. Do government subsidies stimulate enterprises' innovation--The perspective of signal theory. Science&Technology Progress and Policy. 2020, 37(1), 92-101.

[27] Driscoll J C, Kraay A C. Consistent covariance matrix estimation with spatially dependent panel data. Review of economics and statistics. 1998, 80(4), 549-560.