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*Original Paper*

# What Kind of Innovation Ecosystem Is Conducive to Innovation Performance

Zhiwei Tang[1,4], Yi Luo[2] & Xueying Chen[3]

[1] School of Public affairs administration, University of Electronic Science and Technology of China, Chengdu, Sichuan, China

[2] School of Economics and Management, University of Electronic Science and Technology of China, Chengdu, Sichuan, China

[3] School of Economics and Management, University of Malaya, Kuala, Lumpur, China

[4] Shenzhen Institute for Advanced Study, University of Electronic Science and Technology of China, Guangdong, Shenzhen, China

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***Abstract***

*Universities have gathered abundant innovation resources, which are important carriers for innovation implementation and an important component of the national innovation system. Studying how to achieve high innovation performance in universities is of great significance. Based on the innovation ecological systems theory, this paper examines how the combination of intellectual resources, financial support, evaluation system, collaboration system, talent attraction, and peer pressure can lead to high innovation performance of universities. This paper constructs an analytical framework of "factor-system-space" and uses necessary condition analysis (NCA) methods and Fuzzy set qualitative comparative analysis (fsQCA) to empirically analyze the data of 40 universities in China. This article finds that at a lower level of funding and intellectual resources, intellectual resources and financial support are necessary for high talent innovation performance, and different levels of innovation performance have different requirements for conditions. There are three types of configurations that generate high innovation performance, namely institutional boosting under spatial dependence, institutional boosting under factor dependence, and factor-spatial dual drive.*

***Keywords***

*Innovation ecosystem, Innovation performance of universities, Qualitative Comparative Analysis (QCA), Necessity Analysis (NCA)*

**JEL codes:**

**O32**

**P51**

## 1. Introduction

Innovation is the key to generating new development momentum, achieving high-quality economic development, and reshaping competitive advantages in various countries. Universities have gathered abundant innovation resources, which are important carriers for innovation implementation and an important component of the national innovation system. Therefore, studying how to achieve high innovation performance of universities is of great significance. So, what are the necessary conditions for university innovation performance? Are there any bottleneck conditions that constrain the innovation performance of universities? How should these conditions be combined and configured to achieve ideal university innovation performance? What is the environment that is not conducive to the innovation performance of universities? Unfortunately, there are not many studies that have answered these questions.

Existing studies have pointed out some conditions that affect the innovation performance of universities, involving different levels of factors such as internal factors, institutional design, and external environment of universities. Some studies provide evidence at the micro and meso levels, indicating the role of factors such as human capital (Fandel, 2007), R&D investment (Agasisti & Belfield, 2014), and innovation atmosphere (Agasisti et al., 2011). Other studies point out the impact of achievement ownership system (Kenney & Patton, 2011), collaborative transformation mechanism, evaluation system (Boudreau, 2020), and reputation system (Jeon & Menicucci, 2008) on university innovation. Following discussions at the micro and meso levels, some scholars have also pointed out the significance of external policies (Bradbury et al., 2013), urban development levels (Wang et al., 2020), macro social capital (Qu et al., 2022), and other factors on innovation at the macro level. The existing research has the following shortcomings. First, in terms of research content, few studies use a comprehensive perspective to study innovation performance, such as the perspective of ecological systems theory. Secondly, in terms of research methods, empirical research is relatively lacking. Most existing empirical studies use classical quantitative research methods represented by regression analysis, with little consideration given to the interaction between various influencing factors. Finally, in terms of research logic, there is a lack of research discussing variable relationships from the perspective of necessity, resulting in insufficient exploration of complex causal relationships. The innovation performance of universities is not only influenced by various factors but may also be constrained by certain necessary conditions. Therefore, the information provided by the necessary conditions is also important.

Based on the above analysis, this article will design a "factor-system-space" analysis framework from the perspective of innovation ecology theory, using a hybrid method of NCA (Necessity Condition Analysis) and fsQCA (Fuzzy Set Qualitative Comparative Analysis) to reveal the necessary conditions for generating high innovation performance in universities; Revealing the bottleneck effect of various conditions on the innovation performance of universities; Answer what combination of conditions can generate high university innovation performance, and what combination of conditions can lead to non high university innovation performance, and provide enlightening suggestions.

## 2. Theoretical Framework

The theory of innovation Ecological systems theory can be traced back to Moore's systematic discussion on enterprise ecosystem in 1993 (Moore, 1993). According to Moore's viewpoint, the innovation ecosystem, as an analogy to natural ecosystems, is an interactive complex that is defined in subsequent research as a dynamic system structure that encompasses many subjects and elements. The innovative Ecological systems theory has gained richer connotation through the development of Iansiti and Adner. Ianti pointed out that different constituent entities in the innovation ecosystem are interrelated (Iansiti & Levien, 2004). Adner further emphasized the collaborative relationship between different members in the innovation ecosystem, pointing out that the innovation ecosystem is a collaborative mechanism, and noting the impact of external environment on system innovation (Adner & Kapoor, 2010).

With the deepening of research, innovation Ecological systems theory is widely used in the research of innovation generation (Angrisani et al., 2023; Xie & Wang, 2020). Some scholars introduced innovative Ecological systems theory into the field of university innovation(Angrisani et al., 2023). Innovation Ecological systems theory and its application have the following points: innovation ecosystem includes different types of subjects, which is a system composed of subjects and their external environment, often including micro, meso and macro elements; There is a certain network of connections between various entities, making collaborative linkage between them possible; Interactions between multiple entities can improve overall innovation and productivity, creating value that cannot be achieved by a single entity (Adner, 2006).

The key points of this theory provide useful insights for the study of this article. In fact, universities are not only a member of the innovation ecosystem, but also the result of the comprehensive action of system elements, involving different variables from micro to macro. Therefore, based on the innovation Ecological systems theory theory, combined with the multi-level influencing factors of university innovation performance, this paper designs the theoretical analysis framework of "factor system space", divides the factors affecting university innovation performance into three categories: factor, system, and space, and discusses the complex causal relationship between each variable and innovation performance. The analysis framework is shown in Figure 1.

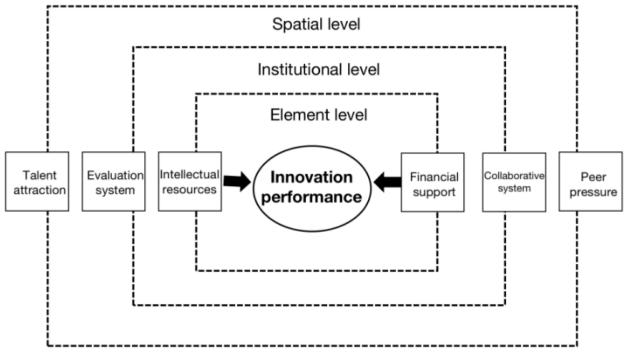


**Figure 1. Conceptual Framework**

As shown in Figure 1, the element layer represents the basic elements that affect the innovation performance of universities, including intellectual resources and financial support. Intellectual resources are the fundamental element and main guarantee for stimulating innovation performance in universities, and their importance is increasingly emphasized. The stimulation of innovation performance in universities first requires the accumulation of high-quality human resources, utilizing their good production and learning abilities to improve innovation (Nafukho et al., 2004). It is generally believed that the investment of funds has a significant positive impact on innovation, and a good level of funds can improve innovation efficiency and stimulate innovation output (Fan et al., 2021; Gong et al., 2020). Therefore, this article also considers the variable of financial support.

The institutional layer represents the institutional influencing factors that affect the innovation performance of universities, including evaluation systems and collaborative systems. The stimulation of innovation performance in universities requires a reasonable evaluation system, and an evaluation system with insufficient comprehensiveness can easily weaken the quality of innovation achievements and limit innovation (Venable et al., 2016). In July 2018, the State Council of China explicitly proposed to "establish a performance evaluation system guided by innovation quality and contribution" and requested the construction of a classified performance evaluation system, adopting a reasonable evaluation cycle to increase the scientific and rational nature of the evaluation (China, 2018). At the same time, open collaboration between organizations can break through the barriers between innovation entities, effectively integrate innovation resources, and promote the smooth operation of the innovation system (Huang et al.; Zhuang et al., 2021).

The spatial layer represents the external spatial factors that affect the innovation performance of universities, including talent attraction and peer pressure. Talent attraction refers to the ability of the region to attract talents, which is the external spatial condition for talent aggregation. A good talent attraction is conducive to the absorption of high-level talents at home and abroad, providing a foundation for intellectual reserves for university innovation performance, generating agglomeration effects and knowledge spillover effects to improve innovation, and conducive to the circular updating of human resources. Peer pressure represents the external impact of the performance of similar innovation entities in terms of innovation power on other innovation entities. Peer pressure is a manifestation of the peer effect, which can stimulate the motivation and willingness of innovation subjects, and promote more effective stimulation of innovation performance(Baum et al., 2010).

## 3. Methodology

### *3.1 Method*

This article aims to investigate the necessary and sufficient relationship between conditions and university innovation performance, and it is necessary to simultaneously explore the necessity and sufficiency of conditions. Therefore, this article adopts a mixed method of NCA and QCA.

Firstly, this article uses the NCA method to test the necessity of independent variables over dependent variables, examining whether a certain independent variable is a necessary condition for high university innovation performance, and to what extent it is a necessary condition for high university innovation performance. NCA is a necessary condition testing method advocated by Dul, which can compensate for the logical flaw that traditional regression analysis cannot discover necessary conditions (Dul & J., 2016). Although QCA analysis often includes testing for necessary conditions, it can only answer whether an antecedent variable is a necessary condition for the dependent variable and cannot reflect the degree of necessity of the antecedent variable. The limitations of QCA in necessary condition analysis have created a demand for the hybrid application of NCA and QCA. Therefore, this article mainly uses the NCA method to test the necessary conditions, to obtain more detailed and rich conclusions.

Secondly, this article uses the fsQCA method to test the adequacy of the antecedent variables to the dependent variables, explaining what combinations of antecedents can achieve high university innovation performance, and what combinations of antecedents can lead to non high university innovation performance. QCA is a method proposed by Ragin in 1987, which can discover the linkage relationship between various conditions through comparison between cases, making it suitable for examining complex causal relationships of multiple factors (Ragin, 2009). At the same time, QCA has more flexible requirements for sample size compared to traditional regression analysis and can handle samples of different sizes. Finally, QCA is based on Boolean Algebraic logic and will not be biased by omitting variables. QCA analysis method can be further divided into clear set qualitative comparative analysis (csQCA), Fuzzy set qualitative comparative analysis (fsQCA) and multivalued set qualitative comparative analysis (mvQCA). Based on the consideration of the data characteristics in this article, the fsQCA method was adopted.

*3.2 Data and Measurements*

This article selects 40 universities in China as samples for the following reasons: firstly, this article attempts to examine the complex causal relationship related to university innovation. As a typical talent gathering field, universities are highly concentrated places for scientific and technological talents, and the main carrier of innovation, making them suitable as samples for this article. Secondly, the sample covers colleges and universities from different levels in central China, eastern China, and western China, covering both developed areas and underdeveloped areas, with diversity and typicality.

This article uses the number of effective patents per sample unit to measure the innovation performance of universities, which is the dependent variable of this article. Valid patents refer to patents that are currently authorized and valid, and the data is from the China University Patent Statistics Database (Company, 2022). Intellectual resources and financial support belong to the element level variables. Among them, intellectual resources are measured by the proportion of doctoral degree holders among all scientific researchers, financial support is measured by the annual budget and financial allocation of universities, and data is summarized from public sources such as university websites, news reports, and policy documents. The evaluation system and collaborative system belong to institutional level variables. Among them, the evaluation system is measured by three dimensions: whether the university's scientific research evaluation policy covers representative achievements, classified evaluation, and a reasonable evaluation cycle. Each dimension is scored 1 point, and finally the cumulative score is used. The collaborative system is measured by the number of provincial and ministerial level collaborative innovation centers owned by universities, and the data is summarized from public materials such as university websites, news reports, and policy documents. Talent attraction and peer pressure belong to spatial variables. Talent attraction is measured by the talent attraction ability of the city where the university is located, and the data is sourced from the 2021 "China Urban Talent Attraction Ranking" report (Macro, 2021). Peer pressure is measured by the number of "211 Project" universities in the same province, and the data is sourced from the Ministry of Education of China (China, 2023). To avoid causal reversal, the dependent variable data year in this article is 2022, and the independent variable data year is 2021.

This article calibrates variable data by setting three calibration points: complete membership, intersection, and complete non membership, and assigning them set membership relationships. Specifically, the 5% and 95% Quantile of sample data are set as "completely non subordinate" and "completely subordinate", and the value reflecting the intermediate degree of variables is set as "intersection point", to obtain the calibration value of subordinate degree between 0 and 1. The calibration of variables and descriptive statistics are shown in Table 1.

**Table 1. Calibration Anchors of Each Fuzzy Set and Description**

| Sets | Calibration anchors | | | Description | | | |
|---|---|---|---|---|---|---|---|
| | Fully in | Crossover | Fully out | Mean | SD | Minimum | Maximum |
| Innovation performance | 12 686.00 | 2 000.00 | 292.00 | 3 708.73 | 3 489.60 | 66.00 | 12 686.00 |
| Intellectual resources | 0.96 | 0.61 | 0.02 | 0.606 | 0.21 | 0.02 | 0.96 |
| Financial support | 136.21 | 37.44 | 2.27 | 37.44 | 36.11 | 2.27 | 136.21 |
| Evaluation system | 3.00 | 2.00 | 0.00 | 2.20 | 1.08 | 0.00 | 3.00 |
| Collaborative system | 7.00 | 1.58 | 0.00 | 1.58 | 1.76 | 0.00 | 7.00 |
| Talent attraction | 100.00 | 51.63 | 24.6 | 51.63 | 23.01 | 24.60 | 100.00 |
| Peer pressure | 26.00 | 5.65 | 1.00 | 5.65 | 6.52 | 1.00 | 26.00 |

## 4. Analysis

### *4.1 Necessity Analysis*

This article first conducted a necessary condition analysis to identify whether each condition can be used as a separate necessary condition. This article will comprehensively use QCA and NCA methods for necessary condition testing and comparative analysis, presenting more detailed and robust results (Ding, 2022).

The necessary condition analysis results are shown in Table 2. Among all conditional variables, the consistency of only intellectual resources exceeds 0.8, indicating that intellectual resources are a sufficient condition for the dependent variable and have a strong explanatory power for the dependent variable, which is a key factor affecting the innovation performance of universities. The consistency of all antecedent variables is below 0.9, indicating that they cannot constitute a necessary condition for high innovation performance in universities. Setting each variable as negative and backward, with consistency below 0.9, indicates that none of them constitute a necessary condition for non high innovation performance in universities. The results of the QCA necessary condition analysis indicate that it is necessary to further analyze the combination of conditions.

**Table 2. Analysis of Necessity for High Innovation Performance**

| Sets of conditions | Consistency | Coverage |
|---|---|---|
| Intellectual resources | 0.877 | 0.578 |
| ~Intellectual resources | 0.484 | 0.736 |
| Financial support | 0.716 | 0.311 |
| ~Financial support | 0.581 | 0.947 |
| Evaluation system | 0.880 | 0.669 |
| ~Evaluation system | 0.342 | 0.524 |
| Collaborative system | 0.579 | 0.434 |
| ~Collaborative system | 0.729 | 0.834 |
| Talent attraction | 0.729 | 0.432 |
| ~Talent attraction | 0.606 | 0.860 |
| Peer pressure | 0.532 | 0.337 |
| ~Peer pressure | 0.737 | 0.898 |

*Note*. ~indicates the absence or a low level.

Although both QCA and NCA can perform necessary condition analysis, there are fundamental differences in their calculation principles. In NCA analysis, when many data points appear above the reference line, that is, when the dependent variable is at a lower level, the reference line will move or rotate upwards to dynamically adjust the ceiling zone, while the reference line in QCA is fixed and unchanged. Therefore, compared to the necessary condition analysis of QCA, NCA is able to discover the necessity of the antecedent variable for the dependent variable at a lower level, and usually discovers more necessary conditions (Vis & Dul, 2016). Therefore, this article will further test the necessary conditions using the NCA method, and the analysis results are shown in Table 3.

Table 3 reports the results of two analysis methods based on the Ceiling Regression (CR) and Ceiling Envelopment (CE). The key parameters are Effect size and Monte Carlo Simulations of Permutation Tests. If a certain condition is a necessary condition, the Effect size should be greater than 0.1 and $P < 0.01$. Based on the data in Table 3, it can be found that the evaluation system, collaborative system, talent attraction, and peer pressure are not necessary conditions for generating high innovation performance in universities, while intellectual resources and financial support meet the parameter requirements, indicating that both are necessary conditions for generating high innovation performance in universities at a lower level.

**Table 3. Results of Necessary Condition Analysis**

| Condition[a] | Method | Accuracy | Effect size[b] | P-value[c] |
|---|---|---|---|---|
| Intellectual resources | CR | 90.00% | 0.273 | 0.004 |
| | CE | 100.00% | 0.092 | 0.387 |
| Financial support | CR | 77.50% | 0.213 | 0.000 |
| | CE | 100.00% | 0.185 | 0.000 |
| Evaluation system | CR | 100.00% | 0.082 | 0.144 |
| | CE | 100.00% | 0.163 | 0.057 |
| Collaborative system | CR | 100.00% | 0.030 | 0.070 |
| | CE | 100.00% | 0.060 | 0.028 |
| Talent attraction | CR | 90.00% | 0.146 | 0.022 |
| | CE | 100.00% | 0.064 | 0.049 |
| Peer pressure | CR | 92.50% | 0.038 | 0.052 |
| | CE | 100.00% | 0.032 | 0.044 |

*Note*. 1) Use the calibrated Fuzzy set membership value; 2) $0.0 \leq d < 0.1$: "Low level"; $0.1 \leq d < 0.3$: "medium level"; 3) Permutation test in NCA analysis (repeated sampling times = 10000).

Subsequently, this article conducted a bottleneck analysis, and the results are shown in Table 4. Bottleneck analysis can reflect the different requirements of dependent variables for each condition. For example, to achieve a high level of 50% innovation performance in universities, financial support, evaluation system, and talent attraction need to reach levels of 19.70%, 11.20%, and 11.50%, respectively. The remaining dependent variables did not reflect bottleneck limitations under the requirement of 50% of the dependent variables.

**Table 4. Results of Bottleneck Analysis**

| Innovation performance | Intellectual resources | Financial support | Evaluation system | Collaborative system | Talent attraction | Peer pressure |
|---|---|---|---|---|---|---|
| 0 | NN | NN | NN | NN | NN | NN |
| 10 | NN | NN | NN | NN | NN | NN |
| 20 | NN | NN | NN | NN | NN | NN |
| 30 | NN | NN | NN | NN | NN | NN |
| 40 | 7.00 | NN | NN | NN | 5.20 | NN |
| 50 | 19.70 | 11.20 | NN | NN | 11.50 | NN |
| 60 | 32.50 | 23.30 | NN | NN | 17.70 | NN |

| | | | | | | |
|---|---|---|---|---|---|---|
| 70 | 45.20 | 35.50 | 4.00 | NN | 24.00 | NN |
| 80 | 58.00 | 47.60 | 19.30 | 5.90 | 30.20 | NN |
| 90 | 70.70 | 59.80 | 34.70 | 14.00 | 36.50 | 18.60 |
| 100 | 83.50 | 71.90 | 50.00 | 22.20 | 42.70 | 43.10 |

*Note*. a CR method was used for calculation, NN represents unnecessary

### *4.2 Sufficiency Analysis*

This section will conduct a adequacy analysis and analyze and interpret the corresponding configurations. Set the original consistency threshold to 0.8, PRI consistency threshold to 0.7, and case frequency threshold to 1. To ensure sufficient information in the conclusion, this article selects a configuration that reports complex solutions, which includes core conditions, edge conditions, and missing conditions. The analysis results are shown in Table 5, which includes the configuration of high and non high university innovation performance, with a total coverage of 0.748 and 0.785, and a total consistency of 0.854 and 0.916, respectively.

**Table 5. Sufficient Configurations for High Innovation Performance**

| Conditions | High innovation performance | | | | | Non high innovation performance | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A1 | A2 | A3 | A4 | A5 | B1 | B2 | B3 | B4 | B5 |
| Intellectual resources | ● | ○ | ● | ● | ● | ○ | | ○ | ● | |
| Financial support | ● | ○ | ○ | ● | | ○ | ○ | ○ | ○ | ○ |
| Evaluation system | ● | ● | ○ | ● | ● | | ● | ● | ○ | ○ |
| Collaborative system | | ○ | | ● | ○ | | ○ | ○ | | ○ |
| Talent attraction | ● | ● | ○ | | ● | ○ | ○ | ● | ○ | ○ |
| Peer pressure | | | ● | ○ | ● | ○ | ○ | | ● | ○ |
| Consistence | 0.949 | 0.846 | 0.843 | 0.989 | 0.930 | 0.947 | 0.893 | 0.930 | 0.924 | 0.943 |
| Raw coverage | 0.519 | 0.310 | 0.179 | 0.397 | 0.419 | 0.633 | 0.446 | 0.297 | 0.171 | 0.200 |
| Unique coverage | 0.040 | 0.069 | 0.037 | 0.052 | 0.0430 | 0.213 | 0.074 | 0.058 | 0.000 | 0.005 |

| | | |
|---|---|---|
| Solution consistency | 0.854 | 0.916 |
| Solution coverage | 0.748 | 0.785 |

*Note*. ●/● Indicates that the condition appears, where ● represents the edge condition, ● represents the core condition, ○ represents that the condition does not appear, and blank indicates that the condition is not important to the result.

4.2.1 Configuration with High Innovation Performance

There are 5 configurations of high innovation performance in universities, namely A1-A5. According to the three levels of the analysis framework in this article, these configurations can be divided into institutional boosting type under spatial dependence (A2), institutional boosting type under factor dependence (A4), and factor-spatial dual driving type (A1, A3, A5). In each configuration, the core condition is the condition that appears simultaneously in the intermediate solution and the reduced solution, while the edge condition is the condition that only appears in the intermediate solution. The following will analyze three types of configurations.

a. Institutional boosting under spatial dependence. In this type of configuration, variables at the spatial level constitute the core conditions, supported by institutional conditions, and together generate high innovation performance in universities. Therefore, in this type of case, high innovation performance of universities depends on the good talent attraction or significant peer pressure in the region and is supported by a good evaluation system and collaborative system. Configuration A2 in Table 5 belongs to this type, with talent attraction as the core condition and evaluation system as the marginal condition. The consistency of A2 configuration is 0.846, and the original coverage is 0.310, indicating that it can explain 31% of cases.

b. Institutional boosting under factor dependence. In this type of configuration, variables at the element level constitute the core conditions, supported by institutional conditions, and together generate high innovation performance in universities. Therefore, in this type of case, high innovation performance of universities depends on deep element support, such as intellectual resources or financial support, and is supported by a good evaluation system or collaborative system. Configuration A4 in Table 5 belongs to this type, with financial support constituting the core condition and intellectual resources, evaluation system, and collaborative system constituting the marginal condition. The consistency of A4 configuration is 0.989, and the original coverage is 0.397, indicating that it can cover 39.7% of cases.

c. Factor-spatial dual drive type. In this type of configuration, the variables of the element layer and the spatial layer jointly constitute the core conditions, supported by the institutional layer conditions, and together generate high innovation performance in universities. Therefore, in this type of case, high school innovation performance mainly benefits from the support of intellectual or financial factors, as well as the good talent attraction or significant peer pressure in the region. Configuration A1, A3, and A5 in Table 5 belong to this type. In A1 configuration, financial support and talent attraction constitute the core conditions, while intellectual resources and evaluation system constitute the edge conditions, with a consistency of 0.949 and an original coverage of 0.519, indicating that it can cover 51.9% of cases; In the A3 configuration, intellectual resources and peer pressure constitute the core conditions, with a consistency of 0.843 and an original coverage of 0.179, indicating that it can cover 17.9% of cases; In the A5 configuration, intellectual resources, talent attraction, and peer pressure constitute the core conditions, while the evaluation system constitutes the edge conditions, with a consistency of 0.930 and an original coverage of 0.419, indicating that it can cover 41.9% of cases.

4.2.2 Configuration of Non High Innovation Performance

This article also examines the five configurations that lead to non high innovation performance in universities. Configuration B1 shows that a lack of high intellectual resources, high financial support, high talent attraction, and high peer pressure in the ecosystem will lead to non high innovation performance in universities. Configuration B2 shows that in an ecosystem lacking high financial support, high collaborative systems, high talent attraction, and high peer pressure, even with a good evaluation system, the innovation performance of universities is not ideal. Configuration B3 shows that in an ecosystem lacking high intellectual resources, high financial support, and good collaborative systems, even with good evaluation systems and high talent attraction, it will still lead to non high innovation performance in universities. Configuration B4 shows that in an ecosystem lacking high financial support, high evaluation systems, good collaborative systems, and high talent attraction, even with high intellectual resources and peer pressure, the innovation performance of universities is not high. Finally, Configuration B5 shows that a lack of high financial support, good evaluation and collaborative systems, high talent attraction, and high peer pressure in the ecosystem will lead to non high innovation performance in universities.

The above analysis indicates that it is difficult to achieve ideal university innovation performance in situations where support conditions are generally lacking. At the same time, although there is support from more than one level of resources in some configurations, none of them are core conditions, indicating that high university innovation performance requires coordination of multiple elements and the cultivation of core advantages.

## 5. Robustness Analysis

This article adjusts the consistency threshold to perform robustness checks on the results. The original consistency threshold was raised from 0.8 to 0.85, and the PRI consistency was raised from 0.7 to 0.75. The other steps and processing remained unchanged. After running the software, the results showed that they were basically consistent with the above analysis. Under a stricter consistency threshold, the consistency of the new configuration results slightly increases, and the coverage correspondingly decreases. The configuration remains basically consistent with the original result and is a subset of the original configuration. Therefore, there has been no substantial change in the results of the robustness test, and it can be considered that the conclusion of this article has a certain degree of robustness.

## 6. Discussion

### *6.1 Conclusions*

This article constructs a framework of "factor-system-space" analysis, discussing the relationship between intellectual resources, financial support, evaluation system, collaborative system, talent attraction, peer pressure, and innovation performance of universities. The research conclusion indicates that at lower levels of funding and intellectual resources, intellectual resources and financial support are necessary for higher innovation capabilities in universities, and different levels of innovation performance have different requirements for conditions. There are three types of highly generated university innovation performance ecosystems, namely institutional boosting under spatial dependence, institutional boosting under factor dependence, and factor-spatial dual driving. In addition, this article examines the configuration of non high school innovation performance and reveals some situations that are not conducive to university innovation performance.

### *6.2 Contributions*

Firstly, this article explores the role of various conditions on university innovation performance from the perspective of necessity. The positive significance of these conditions on innovation performance has been widely recognized in previous studies (Chen et al., 2013; Fan et al., 2019), but few studies have explored their significance from the perspective of necessity. This article found a complex relationship between intellectual resources and financial support and university innovation. At lower levels of funding and intellectual resources, intellectual resources and financial support are necessary for high university innovation performance. This indicates that in situations where funds are relatively scarce and human resources are relatively scarce, these two types of resources can become "short boards of wooden buckets" that limit innovation performance. This Empirical evidence provide a new perspective for the discussion of variable relations. On the basis of necessity analysis, this article points out that different levels of innovation performance have different requirements for conditions and measures the necessity of conditions in detail.

Secondly, this article identifies three types of ecosystems that generate high innovation performance in universities from a configuration perspective. At the same time, the configuration that generates non high innovation performance in universities was examined, revealing some situations that restrict innovation. Compared to existing studies examining the factors influencing innovation performance, this study fully considers the linkage between these factors and the complex innovation ecosystem. The research conclusion of this article acknowledges the view that innovation is a result of multiple factors working together (Metcalfe & Ramlogan, 2008), and the ways to achieve ideal innovation performance can be diverse (Schneider & Wagemann, 2012).

Thirdly, this article analyzes the issue from the perspectives of necessity and sufficiency, providing comprehensive reference information for practice. On the one hand, the complexity of university innovation should be taken seriously (Zhao & Wu, 2017). High innovation performance in universities not only requires funding, talent, and reasonable systems, but also depends on the region's ability to attract talent. The government should also play its role in the spatial level, establish a competitive talent introduction policy system, and guide healthy competition among universities. On the other hand, there are various paths to achieving high innovation performance, and innovation should be promoted based on one's own advantages. At the same time, attention should also be paid to the possible barrel effect. For example, when financial investment and intellectual support remain at a relatively low level, the primary task is to improve financial investment and human capital.

*6.3 Limitations and Future Research*

There are still the following shortcomings in future research. Firstly, the research framework of this article can be further developed after enriching the research conclusions in the field. Secondly, due to the availability of data, there is still room for improvement in the measurement of variables in this article. Finally, based on the conclusions of this study, we can discuss regional heterogeneity and spatial spillover effects, and obtain new empirical evidence.

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**Data Availability**

The data used in the current study are available on request from the corresponding author on reasonable request.

**Competing Interests**

The authors declare no competing interests.

**Ethical Approval**

This article does not contain any studies with human participants performed by any of the authors.

**Informed Consent**

This article does not contain any studies involving human participants performed by any of the authors.

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