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Comparison of Innovation Capabilities - The Case of Chinese Regions -

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[Abstract]

Innovation is not only one of the factors determining the competitiveness of national regions, but also an engine for economic development, and plays an important role in breaking out of the trap of middle-income countries. This paper constructs a regional innovation index from the perspectives of innovation input, innovation output, and innovation environment, and measures the regional innovation index of 31 provinces, municipalities, and autonomous regions in China from 2006 to 2019 by using principal component analysis and cluster analysis. The results concluded that there are large provincial and municipal differences in China's regional innovation capacities, and the provinces with higher comprehensive levels are mainly concentrated in the southeastern coastal region. Cluster analysis divides the 31 provinces, municipalities, and autonomous regions into five types, and the results find that the respectively developed coastal regions are in the high-level and the high-level regions relying on the advantages of location and national policies.

▸ **Key words**: China, Innovation capacity, Regional innovation capacity, Regional economic development, Principle component analysis, Cluster analysis

[요 약]

혁신은 지역의 경쟁력을 높이는데 있어서 중요한 역할을 할뿐만 아니라 중진국의 함정에서도 빠져 나올 수 있는 역할을 할 수 있다. 본 논문은 중국의 지역별 혁신역량을 비교하기 위해 혁신 투입, 혁신 산출, 혁신 환경의 관점에서 지역혁신지수를 구성하고, 주성분 분석과 클러스터 분석을 이용하여 2006년부터 2019년까지 중국 31개 성, 직할시, 자치구의 지역혁신지수를 추정하였다. 추정결과에 따르면 중국의 지역혁신역량은 지역별 차이가 크며 혁신역량이 높은 지역은 주로 지역경제발전 수준이 상대적으로 높은 동남 연해안 지역에 집중되어 있다. 이는 혁신역량과 지역경제발전 수준과 관계가 있음을 나타낸다. 군집분석은 31개의 지역을 5개 유형으로 분류하였다. 분류결과에 의하면 지역경제발전 수준이 상대적으로 높은 연해안 지역의 혁신역량이 높고 이는 이들 지역이 입지적인 우위와 국가정책에서의 우위를 가지고 있기 때문이다.

▸ **주제어**: 중국, 혁신능력, 지역혁신지수, 지역경제발전, 주성분분석, 군집분석

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I. Introduction

Innovation has overtaken traditional economic growth factors as the new key driver. According to Schumpeter, the economy would be in a so-called "cyclical" equilibrium without innovation. But economic development is constantly changing, a new transformation of production methods. Therefore, innovation is a break of the "cycle", a "creative destruction", in which the factors of production are optimally combined in the process of innovation to invent more optimal products, which in general means that innovation leads to the upgrading of industrial structure and thus economic development. It is the ability to transform factors of production into new products or technologies and to market them. Innovation capability pulls the economy to accelerate development, and regions with faster economic growth will increase innovation investment, and the two complement each other. However, since different regions have different levels of economic development and the innovation capacity of different regions varies greatly, it is necessary to make an objective evaluation of the innovation capacity of each region and lay the foundation for future research on how innovation affects regional economic development. The construction of innovation indicators provides an important reference for studying the construction of regional innovation indicators in China, further enriching the theoretical and empirical research on regional development. The study of regional innovation capacity has important practical significance for China to implement an innovation development strategy, optimize the innovation environment, and avoid falling into the middle-income trap.

II. Indicator system for regional innovation capacity

Through the operation of the innovation system, innovation input continuously from the direct products of innovation, such as new products and new patents, which are then gradually commercialized and marketed through the allocation and effective utilization of enterprises. Innovation patents are transformed into productivity and bring economic benefits. It promotes the upgrading of regional industrial structure, and the upgrading of regional industry brings about the improvement of the regional innovation environment. A good economic development foundation and innovation environment will bring more investment in innovation, which eventually results in a high level of regional innovation.

GII builds the evaluation index system on the innovation input-output perspective, and Xie Pan (2008)[1] considers the innovation environment as the guarantee of innovation capability. Therefore, this paper designs the regional innovation capability index system into three elements: innovation input, innovation output, and innovation environment.

Innovation input is the basis of innovation activities and is the process of the regional innovation process in which a series of innovation conditions, such as human and financial resources, continuously from innovation output. Rapidly generating innovative knowledge through continuous input is the most direct action a region takes to improve its innovation capability and is an important indicator of a region's innovation strength. Jia Yingying and Guo Peng and Zhao Jing (2015) argue that innovation inputs are split into human and financial resources[2]. As human resources and financial investment are two crucial factors in the improvement of regional innovation capacity, this paper will select indicators from two major directions: human resources and financial investment.

One of the mainstays of innovative activity is the research and development workforce, which is at the heart of the entire scientific and technological activity. Talent is the carrier of knowledge and intelligence. The development experience of countries around the world shows that there is a considerable relationship between the development of regional innovation capacity and the intensity of talent. Once one of the major industrial cities of the United States. Boston's economy entered a downturn in the early 20th century when the United States shifted its manufacturing base. In 1862, the Morrill Land-Grant Act was enacted in the United States, bringing higher education and socio-economic development closer together and pioneering the direct service of higher education in social development. At the end of the 20th century, Boston underwent its latest round of transformation, thanks to the concentration of higher education talent and institutions, and succeeded in becoming one of the financial, educational, and high-tech hubs in the United States. This is explained by the fact that Boston is a world-renowned university city, home to several internationally renowned institutions and research institutes such as Harvard University and MIT. The rich and high-quality research, education, and talent resources for important intellectual support for regional innovation. Boston also offers and builds a wide range of entrepreneurial and employment opportunities for these talented resources Boston has made intellectual property the greatest incentive for technological innovation. Zabala-Iturriagagoitia, J. M., et al (2007) chose the number of lifelong educators and R&D expenditures in Europe as composite input indicators when studying regional innovation capacity in Europe[12]. Kim Sangwook (2018) chose full-time research and experimental development (R&D) staff as one of the indicators to measure innovation manpower investment[11]. In summary, this paper selects R&D personnel full time equivalent and the number of students enrolled in general higher education institutions, and the R&D Practitioners as a tertiary indicator of human resources.

The R&D internal expenditure intensity index reflects a country's technological strength and core competitiveness, while a country's level of R&D determines its political and economic strength. Ren, Shenggang, and Peng, Jianhua (2007) use research investment as one of the indicators for evaluating innovation investment of innovation agents, which is very comparable[13]. The China Science and Technology Development Strategy Research Group use government investment in science and technology as research and development investment[10]. This demonstrates that local fiscal expenditure reflects the strength and intensity of investment in innovation. In summary, this paper selects local financial expenditures on science and technology and education, and R&D internal funding expenditures as the three-tier indicators of funding input.

Input comes to output. The research team for China's regional innovation capacity report proposes that regional innovation capacity is the ability of a region to transform knowledge into new products, processes, and services. Knowledge based economic and knowledge production will inevitably lead to knowledge dissemination, and inevitably to new products, new market gains, etc. Therefore, this paper focuses on the description of innovation output in terms of both knowledge innovation and industrial innovation. The number of patent applications granted is the sum of the number of patents granted for utility models, inventions, and designs, and is an internationally recognized critical indicator of the level of innovation output of a country or region. The Global Knowledge Competitiveness Index, Global Innovation Index, the Chinese Innovation Index System, and the innovative countries evaluation index system all use patents as an indicator of innovation output. Scientific and technical papers and scientific publications are both important expressions of the intellectual achievements of scientists and technicians, they are records and descriptions of the results of scientific research, the crystallization of experience and lessons learned from working in the field of scientific research and the transmission of the spirit of scientific researchers. Generally speaking, the more these two results are obtained, the greater the potential for regional innovation.

Mansfield (1986) patents are the knowledge output of regional R&D and are indicators that can be used to effectively study regional innovation capacity[9]. Hagedorn and Cloodt (2003) argue that R&D input, patent volume, and new product output can all be used to evaluate regional innovation capacity[8]. Therefore, this paper focuses on the number of patent applications granted, the number of scientific and technical papers published, and the number of scientific and technical books published.

Science and technology projects are the most basic form of enterprises to carry out scientific and technological activities, and the final implementation of enterprise science and technology activities to the development of science and technology projects, the number of enterprise science and technology projects, projects in human and financial resources investment efforts, can reflect the active degree of enterprises to carry out scientific and technological activities and the actual scale, level and capacity of enterprise science and technology activities. Industrial value-added represents the final results of industrial enterprises in production activities. Technology market turnover refers to the number amount involved in the contracts reached in the technology market, which indicates the extent to which scientific knowledge is transformed into practical application ability, and is an important measurement indicator of the transformation of scientific and technological achievements, the larger the turnover in the technology market, the stronger the transformation ability of scientific and technological achievements, and thus the greater the impetus to regional scientific and technological innovation. The number of registered trademarks represents enterprises and well-known products with a good enough market share, reflecting the fruitful output of innovation input, the result of productivity transformation, and the market realization of innovation ability. Liu Fengzhao (2005) used the number of trademark registrations, the number of well-known trademarks, and the number of famous trademarks as a three-level indicator of independent innovation[14]. Jinghao Ma and Sangwook Kim (2020) used the market technology turnover as an indicator of innovation output[7].

Table 1. China's Regional Innovation Capability Index System

Innovation Input	Human Resources	R&D personnel full time equivalent
		Number of students enrolled in general higher education institutions
		R&D Practitioners
	Funding input	Local financial science and technology expenditure
		Local financial expenditure on education
		R&D internal expenses
Innovation Output	Knowledge Innovation	Number of domestic patent applications granted
		Published Scientific Papers
		Publication of scientific and technical works
	Industrial Innovation	The number of new product projects in industrial enterprises above the scale
		Industrial value added
		Technology Market Turnover
		1991 to present approved registered trademarks
Innovation Environment	Government Support	Cumulative local regulations passed by local people's congresses since '06
	Innovation Carriers	Number of industrial enterprises above the scale
		Research and development institutions R&D personnel number of institutions
	Economic and Social Environment	Value added of tertiary industry
		GDP per capita

Therefore, in this paper, the number of new product projects in industrial enterprises above the scale, industrial value-added, technology market turnover, and the number of approved registered trademarks from 1991 to the present is taken as the three-tier indicators of industrial innovation.

Cooke, Heidenreich, Braczyk (2004), on the other hand, argue that regional innovation capacity gaps are related to research systems, education systems, and technology transfer systems, and depend on regional policy-making capacity, funding resources, and policy orientation in the governance model[3][6]. Ni, Zhiqing, etc. (2011)'s innovation environment is divided into an economic and social environment and innovation vehicles[4]. Therefore, this paper analyzes the innovation environment from three perspectives: government support, innovation carrier, and socio-economic environment. The World Competitiveness Report has undergone three major changes in the evaluation system over the past 28 years, but all will have one element of government support. The role of government influences innovation capacity. The influential Silicon Valley Index also includes provincial administration as one of the key elements in its evaluation reports. In the Chinese Innovation Capability Index system, the innovation environment includes the strength of policy support for innovation and the supporting conditions that underpin the development of innovation capabilities. It is easy to understand from the various work reports of the Chinese government that China attaches importance to innovation strategies. Active government encouragement and support are a strong guarantee for regional innovation building. Therefore, this paper selects local innovation regulations cumulatively passed by local people's congresses since 2006 as a three-tier indicator of government support. The stronger the cultivation of innovation, the stronger the ability to turn intellectual property rights and scientific and technological achievements. And innovation carriers guide the R&D activities of enterprises, universities, and research institutes to establish an industry-university-research community of interest. Therefore, this paper selects the number of enterprises and institutions as the three-tier indicator of innovation carriers.

Regional GDP per capita is the proportion of GDP to the regional resident population and is the most representative indicator of the level of regional economic development. Generally speaking, economically developed regions have a larger economy and a larger stock of human capital and are more capable of innovation. Zhao Ying (2010) there is a two-way causality between the value-added of the tertiary sector and GDP, as economic growth can influence the development of the tertiary sector and the development of the tertiary sector can also contribute to economic growth[15]. Therefore, in this paper, the value-added of the tertiary sector and GDP per capita are used to represent the economic and social environment. In this paper, based on the research results of others, the following <Table-1> indicator system was selected according to the principle of indicator construction.

III. Empirical Analysis

1. Method and Data

The principal component method uses the method of dimensionality reduction to transform most indicators into a few principal components. It analyzes them through the principal components of a more significant variance contribution rate, which can better evaluate the strength of regional innovation capacity by reducing the corresponding workload. Most of the data involved in this paper come from official publications, including the China Science and Technology Statistical Yearbook, the China Provincial and Municipal Statistical Yearbook, Beidafabao(Chinese language), and the official website of the National Bureau of Statistics of China. Some of the missing data are compensated by a single-integer autoregressive moving average model for prediction. Since 18 evaluation indicators outlined in the present paper have unique attributes and units, the data were standardized before the principal component method analysis was conducted. Since the Chinese government proposed in 2006 to strengthen the construction of a national innovation system with Chinese characteristics, to establish China as an innovative country, and realize the transformation from factor-driven to innovation-driven. Due to the limited data from Hong Kong, Taiwan, and Macao of China, this paper selects data from 31 provinces, cities, and autonomous regions of China (except Hong Kong, Macao, and Taiwan) for 2006-2019 years for analysis.

2. Principal Component Analysis

In this paper, the standardized data were tested for the cross-sectional data of 2019 as an example. As shown in <Table-2> below, the KMO test value is 0.742, which is very suitable for using principal component analysis; the sig 0.000 < 0.05 of Barlett's sphericity test indicates that the regional innovation capacity data belong to a normal distribution and the variables have certain correlation, which can continue to be analyzed by using principal component analysis.

Table 2. KMO and Bartlett's Test

KMO	Approx. Chi-Square	0.742
		1234.965
Bartlett Test	df	153.000
	P value	0.000

According to the principle of eigenvalues greater than 1, three principal components were extracted, and the variance explained by the three principal components was 69.83%, 16.66%, 5.76%, and the cumulative variance explained was 9%. As showing in <Table-3> below. Statistical software was used to derive the <Table-4> component score coefficient matrix and to construct regression evaluation equations for the three principal components. As following.

$F1=0.077\times X1+0.056\times X2+\cdots+0.049\times X18$

$F2=-0.053\times X1-0.095\times X2+\cdots+0.174\times X18$

$F3=-0.154\times X1+0.615\times X2+\cdots-0.358\times X18$

In the above equations, X1, X2, X3, ..., X18 are the 18 tertiary indicators respectively. Where F1 is the first time that principal component, F2 is the second principal component, and F3 is the third principal component. Extraction method is a principal component analysis. The final composite score is calculated by dividing the cumulative variance contribution by the product of the variance explained and the component scores cumulatively.

Table 3. Eigenvalues and cumulative contribution rates

Component	Intial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	12.6	69.83	69.83	12.6	69.83	69.83
2	2.99	16.66	86.49	2.99	16.66	86.49
3	1.04	5.76	92.26	1.04	5.76	92.26

The formula is

$F=(69.830\times F1+16.664\times F2+5.762\times F3)/92.256$

The following <Table-5> yields the overall regional innovation capacity score for China in 2019.

Table 4. Component Score Coefficient Matrix

Name	Component		
	1	2	3
X1	0.077	-0.053	-0.154
X2	0.056	-0.095	0.615
X3	0.043	0.265	0.102
X4	0.078	0.034	-0.107
X5	0.074	-0.035	-0.206
X6	0.071	-0.089	0.246
X7	0.074	-0.080	-0.22
X8	0.069	0.119	0.12
X9	0.063	0.161	0.226
X10	0.073	-0.030	-0.249
X11	0.070	-0.129	-0.231
X12	0.072	-0.124	0.095
X13	0.052	0.239	-0.064
X14	0.063	-0.100	0.161
X15	0.070	-0.147	-0.029
X16	0.049	0.205	0.192
X17	0.078	-0.030	0.055
X18	0.049	0.174	-0.358

3. Comparison of Regional Innovation Capability Index

China's Regional Innovation Capability Index has five levels, with the higher the score, the darker the fill color of the region. This is shown in <Figure-1>. Looking at the distribution charts for the two time periods 2006 and 2019, the innovation capability of all regions has changed within their respective ranges, except for Heilongjiang, Jilin, Liaoning, Shanxi, Jiangsu, Yunnan, and Guangxi, which are in a phase of constant dynamic change, indicating that the remaining regions are not in a period of stable and continuous development with prominent changes in innovation capability. As can be seen from the graph, the areas of change are concentrated in the central, southern, and north-eastern regions, while the western regions are in a more stable state. Overall, the regional innovation capacity of China's provinces and cities varies widely, with those provinces with a higher level of integration having a stronger innovation capacity. Provinces with higher comprehensive levels are mainly concentrated in the southeast coastal region, a situation that has become increasingly prominent in recent years, but the overall development trend has taken shape initially.

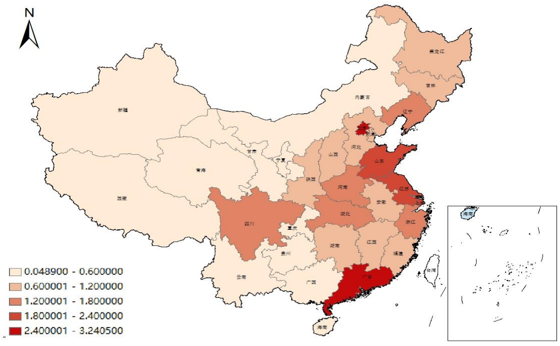
Table 5. Comprehensive Score of China's Regional Innovation Capability in 2019

Region	Overall Score	Ranking
Beijing	2.9123	2
Tianjin	0.6305	18
Hebei	0.9203	14
Shanxi	0.5976	21
Inner Mongoria	0.4519	25
Liaoning	0.7801	15
Jilin	0.5476	23
Heilongjiang	0.5512	22
Shanghai	1.6276	6
Jiangsu	2.5512	3
Zhejiang	1.8165	5
Anhui	1.0216	12
Fujian	0.9782	13
Jiangxi	0.7615	16
Shandong	1.8702	4
Henan	1.4279	8
Hubei	1.3912	9
Hunan	1.1173	11
Guangdong	2.9487	1
Guangxi	0.6099	20
Hainan	0.1417	28
Chongqing	0.6805	17
Sichuan	1.4848	7
Guizhou	0.4959	24
Yunnan	0.6164	19
Xizang	0.0231	31
Shanxi	1.1697	10
Gansu	0.3840	26
Qinghai	0.0564	30
Ningxia	0.0907	29
Xinjiang	0.3435	27

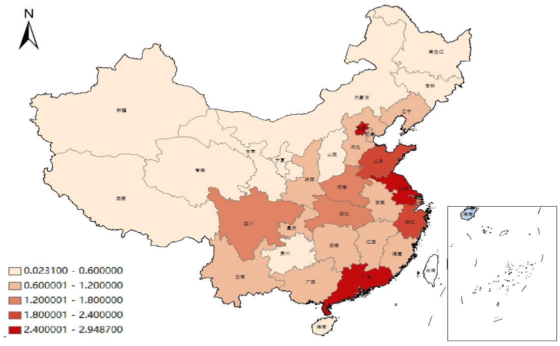
4. Cluster Analysis

This paper clusters the regional innovation capabilities of China based on the principles of cluster analysis. In this paper, following Wang Chengjun, Yu Xiaofang, Chen Zhongwei. (2016)[5], a cluster analysis was conducted using the mean of the composite scores of the innovation capacity of 31 provinces, cities, and autonomous regions in China from 2006 to 2019 as the variable, and 31 provinces, cities and autonomous regions as the dependent variable, and group connections were selected to generate a cluster dendrogram with a squared Euclidean measure of distance. Then, based on the results of the cluster analysis, the 31 provinces, cities, and autonomous regions were divided into five different categories. As shown in the following <Table-6>. The high economic level regions make up the economically developed regions and have the highest innovation capacity. Beijing, the capital of China, is under a clear advantage and is far ahead of other provinces. Guangdong benefits from the reform and opening-up policy, and its investment in research and development is also located in the 1st position in China. Jiangsu's progress is because the southern region gets a better sense of market economy, a well-developed market, and a high degree of openness.

The higher-level economic regions are all developed eastern coastal regions with high innovation capacity. Shanghai and Zhejiang are both in the Yangtze River Delta provinces and cities. This shows that since the reform and opening up. The Yangtze River Delta has relied on its location and national policies to develop an open economy and attract a large number of multinational companies to invest. With the long-term accumulation, the regional innovation capacity has gradually been part of the higher-level regions. Shandong promulgated an innovation policy in 2006, and after these years of development, the regional innovation capacity of Shandong has been significantly advanced. The regional innovation power of the middle-level economic region is in the middle position. Although the provinces in this region are not so geographically located in the first two regions, most of them are in the central or northeastern part of the country and have a strong industrial base. The regional innovation capacity of these regions will certainly be greatly improved in the future.



(a) 2006



(b) 2019

Fig. 1. Spatial Differences in Regional Innovation Capacity Indices in China in 2006 and 2019

The lower economic development regions generally have lower innovation capacity levels. It lags even more behind the rest of the country in general. In the case of Tianjin, although both Tianjin and Shanghai are municipalities directly under the central government, the innovation input, innovation output, and innovation environment are much worse. Tianjin has suffered a serious loss of manufacturing industries, and its economic development and high-end employment have been compressed. Binhai New Area and Pudong New Area, located in Tianjin and Shanghai respectively, are both national-level new areas and are "sub-provincial" in terms of administrative level, but there are still gaps in terms of economic output, industrial structure, transportation, and linkage and echoing with urban centers. The distance between the Binhai New Area and the main urban area of Tianjin is long, and there is a lack of synergy between the two areas. Tianjin is closer to the capital, which is bound to have a certain siphon effect on Tianjin in terms of talents, technology, and resources.

Regions with low economic development levels have the lowest regional innovation capacity. Xizang Autonomous Region has special policies that strongly safeguard Xizang Autonomous Region's development needs. China has supported Xizang Autonomous Region with huge investment in innovation, including a series of initiatives to assist Xizang Autonomous Region, such as granting funds, sending personnel, and transferring scientific research results.

Table 6. Regional Division of Cluster Analysis

Classification	Number	Province Name
Zone Ⅰ	3	Beijing, Jiangsu, Guangdong
Zone Ⅱ	3	Shanghai, Zhejiang, Shandong
Zone Ⅲ	9	Hebei, Liaoning, Anhui, Fujian, Henan, Hubei, Hunan, Sichuan, Shaanxi
Zone Ⅳ	12	Tianjin, Shanxi, Mongolia, Jlin, Heilongjiang, Jiangxi, Guangxi, Chongqing, Guizhou, Yunnan, Gansu, Xinjiang
Zone Ⅴ	4	Hainan, Xizang, Qinghai, Ningxia

Despite this, Xizang Autonomous Region's overall score has always been in the low-level region. This shows that it is sometimes difficult to make regional innovation competitiveness strong if the improvement of innovation capacity relies only on government investment, ignoring the regional location factors, natural conditions, and economic development. In other words, the government's macro regulation can only have a decisive effect on the innovation system if it is carried out under the laws and trends of economic development.

IV. Conclusions

Regional innovation capacity in the context of economic globalization and a knowledge-based economy is an important factor in gaining regional and international competitiveness, and creating a regional innovation system can further improve regional innovation capacity. On this basis, how to evaluate regional innovation capacity becomes immensely important. In this paper, a comparative analysis of the innovation capacity of 31 provinces, cities, and autonomous regions in China during 2006-2019 was conducted to measure the regional innovation capacity of all Chinese provinces, and the following conclusions were drawn. (1) Based on the previous research, this paper constructs a regional innovation capability index system from innovation input, innovation output, and innovation environment. The secondary core indicators mainly include 7 indicators such as human resources, knowledge innovation, and socio-economic environment, the tertiary core indicators mainly include 18 indicators such as the intensity of R&D expenditure investment, the number of patent applications, the number of scientific and technological papers and the turnover of the technology market, which provide important references for the study of constructing regional innovation indicators in China. (2) The regional innovation indices of 31 provinces, municipalities, and autonomous regions in China were measured using principal component analysis and cluster analysis for the period from 2006 to 2019. Divided into five types of regions, it can be seen that there is an obvious regional clustering phenomenon between high-level and higher-level regions. From 2006 to 2019, economically developed regions such as the provinces and cities in the Yangtze River Delta region ranked high in most numbers. This proves to a certain extent that the economic base has an important positive influence on their innovation. The conclusions of this paper are consistent with the basic reality and show that the evaluation indexes of this paper are reasonable and feasible. (3) From the spatial analysis, except for individual provinces and cities with large changes, other provinces and cities have small changes, which indicates that the regional innovation capacity of each province and city has no outstanding changes and is in a stable and continuous development period. At the level of each region, except for the three northeastern provinces, the innovation capacity of other regions occasionally declined, but they all showed a steady development trend. The three northeastern provinces are changing more around 2019, with a downward trend, indicating that they can no longer rely on industrial-based development and have to upgrade their industries, otherwise their innovation capacity will continue to decline, looking towards the west. The comparison of innovation capacity among regions has important practical significance for China to implement an innovation development strategy, enhance the innovation capacity of each region, and optimize the innovation environment. (4) Innovation not only shows a positive correlation with economic growth but also is an important engine for avoid developing countries from falling into the middle-income trap. In this paper, human resources are considered as a secondary indicator of innovation input, and the analysis in Chapter 2 shows that human input to innovation is one of the most important aspects of innovation activities. Eichengreen, Park, Shin(2013) finds that higher levels of education can enable middle-income countries to avoid falling into the middle-income trap[16]. In this paper, the number of students enrolled in higher education is introduced as a tertiary indicator in the human input, and the quantity and quality of education play a major role not only in innovation and economic development but especially in avoiding the middle-income trap, where the quality of human resources plays a decisive role. This shows that human resources are a key factor for regional innovation, which has some reference value for relevant policy formulation in China. This paper, there are limitations in the research process, and it fails to study the interaction between regional innovation factors, which is one of the future research directions. In constructing the regional innovation capacity index system, all quantitative indicators are used, ignoring the influence of qualitative indicators on regional innovation capacity, which needs to be improved.

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