Evaluation and Comparative Study on the Innovation Primacy of Xuzhou Benchmarking Central Cities

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Abstract: *From the perspective of the innovation value chain, this paper takes the data of seven cities in Xi'an, Guangzhou, Chengdu, Wuhan, Zhengzhou, Nanjing and Xuzhou from 2010 to 2020 as the research object and uses the point-to-face, CRITIC weighting method and matrix analysis to carry out empirical analysis. This paper evaluates the innovation primacy of Xuzhou and explores the problems and gaps of Xuzhou's innovation primacy by comparing it with the national central city. Finally, it gives corresponding suggestions on the problems of Xuzhou's innovation primacy and how to improve Xuzhou's innovation primacy.*

Keywords: *innovation value chain, innovation primacy, knowledge innovation primacy, R&D innovation primacy, industrial innovation primacy*

1. Introduction

The geographical characteristics of different regions vary greatly, so economic development has always had very distinct regional differences. which has become more prominent with the continuous development of the economy and society. To shorten the development differences between different regions in China, each region is divided into different zones, and each zone focuses on the development of several cities in it, making them the center of the zone and promoting the development of other cities in the zone with the regional driving role of the central city.

Xuzhou is the central city of the Huaihai Economic Zone in China and plays an important role in promoting the development of surrounding cities. Since the establishment of the Huaihai Economic Zone, Xuzhou has always been a city with a relatively developed economic aggregate, infrastructure and opening up in the Huaihai Economic Zone. Therefore, it is possible to promote the further development of the Huaihai Economic Zone by making Xuzhou larger and stronger and making it the engine of the development of the Huaihai Economic Zone.

The urban primacy ratio can indicate the extent to which a city can exert radiation, influence and driving force in social development. The key to improving the urban primacy ratio is to improve the innovation primacy ratio. Innovation is the source of power to support the development of a city. In this context, it is necessary and meaningful to study the innovation ability gap between Xuzhou and the national central city and the promotion path. From the perspective of the innovation value chain, this paper takes the data of the national central cities Xi'an, Guangzhou, Chengdu, Wuhan, Zhengzhou, Nanjing and Xuzhou from 2010 to 2020 as the research object, evaluates the urban innovation primacy of Xuzhou, analyses the problems and gaps between Xuzhou's innovation ability and others by comparison with national central cities, and proposes corresponding promotion strategies.

2. Literature Review

The concept of primacy was first proposed by Jefferson (1939) [1], who pointed out that primacy is the ratio of the population size of a country's largest city and second largest city. Ades and Glaeser[2] (1997) analyzed the reasons for the emergence of the first city at the national level. They believe that political factors are more influential than economic factors. Lusito Bertinelli and Eric Strobl (2003) [3] analyzed the urbanization level of 39 developing countries and found that the urban primacy of developing countries except Brazil and India is generally between 0.20 and 0.45, and it shows an upward trend from 1960 to 1990.

In the early 1980s, Chinese scholars began to study the primacy ratio. For example, Yan et al. [4] (1981) performed a statistical analysis of the development and changes in the primacy ratio of 26 provinces in China from 1952 to 1978. In recent years, scholars have performed increasing research on urban primacy. There is research and analysis of urban primacy from multiple levels. For example, Yu Xiangying finished a study and analysis on how to enhance the primacy of Zhengzhou city; Zhu (2015) [5] evaluated the primacy ratio of Nanning from three aspects: population, economy and social service ability. Chen Zhongyi (2017) [6] adopted the four-city index method to compare the central urban area of Wenzhou with the other three counties (cities) in Wenzhou and analyzed the primacy of the central urban area of Wenzhou from the five dimensions of urban scale, economic aggregate, industrial development, technological innovation and public service. At the same time, some scholars have studied the innovation field of primacy and studied the evaluation and promotion of urban innovation primacy. For example, Cai Jinchen (2018) [7] specifically evaluated and analyzed the innovation primacy of Xuzhou, the central city of the Huaihai Economic Zone. Although Xuzhou's innovation level ranks first, there is still a certain gap with the real innovation primacy city. Zeng Cheng (2021) [8] evaluated and compared the innovation primacy of Nanjing and other central cities from the perspective of the value chain by means of principal component analysis and a primacy matrix.

In general, with the vigorous development of modern cities, the literature on urban primacy is increasing year by year, and the theories and methods of research are more comprehensive and rich. From the object of study, there are studies on the primacy ratio of national central cities, provincial central cities, provincial subcentral cities and regional central cities, as well as studies on various regions of a city. From the perspective of evaluation methods, the primacy index method is used, and factor analysis, principal component analysis, entropy method and correlation regression analysis are used to study the primacy. From the perspective of the research dimension, there are multidimensional and multilevel studies on population primacy, economic primacy, science and technology primacy, and there are also studies on the primacy of scientific and technological innovation. However, in general, there are few studies on the innovation primacy ratio, and there are relatively few studies comparing regional central cities and national central cities. Therefore, this paper evaluates and analyses the innovation primacy ratio of Xuzhou, analyses the gap in the innovation primacy ratio between Xi'an, Zhengzhou and other national central cities, and explores the path and countermeasures to improve the innovation primacy ratio to provide theoretical support and practical references for relevant research on the comparison of the innovation primacy ratio of central cities.

3. Research Design

3.1. Evaluation index system

Table 1: The evaluation index system of innovation primacy

First-level index	Second-level index	Three-level index	Method of calculation
Innovation primacy	Knowledge innovation primacy	Number of SCI papers	The proportion of SCI papers in the whole province
		Number of SSCI papers	The proportion of SSCI papers in the whole province
		Number of CPCI-S papers	CPCI-S total number of papers province share
	R&D innovation primacy	Number of valid invention patents	The proportion of effective invention patents in the whole province
		Number of patents granted	Province-wide proportion of patent licensing
		Number of patent applications	Province-wide proportion of patent applications
	Industrial innovation primacy	High-tech zone torch plan statistics number of enterprises	High-tech Zone Torch Plan statistics the number of enterprises in the province
		High-tech industry output value (billion yuan)	High-tech industry output value of the province as a percentage
		New product sales revenue (billion yuan)	Sales of new products accounted for the proportion of the province

This paper studies innovation primacy from the perspective of the innovation value chain. The innovation value chain theory was proposed by Hansen (2007) [9] and others. They believe that the

innovation value chain is composed of three links: idea generation, idea transformation and idea dissemination. This theory has been widely used in China's innovation research. For example, Yu Yongze et al. (2013) [10] divided the innovation process into three stages, knowledge innovation, scientific research innovation and product innovation, and evaluated the factors of innovation primacy in different stages. Zeng Cheng (2021) [8] divided the innovation process into three stages, knowledge innovation, R&D innovation and industrial innovation, and evaluated and compared the innovation primacy of Nanjing. Based on the relevant research on the first degree, combined with the availability of data, this paper designs the innovation first degree index system according to the three links of the innovation value chain [8], see Table 1. The index system data of this paper come from the China Torch Statistical Yearbook, regional science and technology statistical bulletins, Web of Science database, National Intellectual Property Office patent statistical annual report and regional statistical yearbooks.

3.2. Research methods

Using the point-to-surface method, this paper first calculates the provincial primacy value of each index. The main reason is that the two-city index and point-to-point method are not feasible. On the one hand, there are great differences in the economic development of different regions of China, and the development pace of each central city is inconsistent. Using the two-city index, four-city index and other point-to-point determination of the first city is not scientific; on the other hand, because the index evaluation system of this paper covers a wide range, it basically covers the whole process of a city's R&D from project establishment to successful market transformation. The urban primacy of each stage is also inconsistent, so it is not suitable to use the point-to-point method. Based on the above reasons, this paper uses a point-to-face approach to seek innovation primacy. Then, the CRITIC weighting method is used to calculate the specific weight of each index, and finally, the evaluation score of each city's innovation primacy is calculated. At the same time, this paper also constructs the knowledge-R&D innovation primacy matrix, knowledge-industry innovation primacy matrix and R&D-industry innovation primacy matrix according to the three subindicators of innovation primacy. According to the average score of each subitem primacy score, it is divided into high and low grades to evaluate the innovation primacy of the other central city and Xuzhou, respectively.

3.3. CRITIC weighting method to determine the index weight process

The CRITIC weighting method is a calculation method that can objectively reflect the objective weight of indicators. The idea is to calculate the amount of information of all evaluation indicators; the greater the amount of information, the greater the relative importance of the index, and the greater the weight. To eliminate the dimension between variables, this paper uses the range method to standardize the indicators[11]. The calculation method is as follows:

If the evaluation index is positive, then:

$$V_{ij}^{'} = \left[V_{ij} - MIN(V_{ij}) \right] \Big/ \left[MAX(V_{ij}) - MIN(V_{ij}) \right] \tag{1}$$

If the evaluation index is negative or moderate, then:

$$V_{ij}^{'} = \left[MAX(V_{ij}) - V_{ij} \right] \Big/ \left[MAX(V_{ij}) - MIN(V_{ij}) \right] \tag{2}$$

Among them, $1 \le i \le a$, $1 \le j \le b$.

Calculate the amount of information for each indicator based on the standardized results:

$$C_j = \sigma_j \sum_{j=1}^{n} (1 - R_{ij}) \tag{3}$$

where R_{ij} is the correlation coefficient between $V_i^{'}$ and $V_j^{'}$, σ_j is the standard deviation of $V_j^{'}$.

After obtaining the amount of information, the weight of each indicator can be calculated:

$$W_j = C_j \Big/ \sum_{j=1}^{n} (C_j) \tag{4}$$

The calculation results according to the CRITIC weighting method are obtained. Then, according to the weight of each index, the overall index system weight is obtained as shown in Table 2.

Table 2: The index weight of the innovation primacy index

First- level index	Second- level index	Second-level weight	Third-level index	Third-level weight
Innovation primacy	Knowledge innovation primacy	32.47%	Number of SCI papers	11.12%
			Number of CPCI-S papers	9.95%
			Number of SSCI papers	11.40%
	R&D innovation primacy	33.52%	Number of patent applications	8.94%
			Number of patents granted	9.68%
			Number of valid invention patents	14.90%
	Industrial innovation primacy	34.03%	New products sales revenue (billion yuan)	8.96%
			High-tech zone torch plan statistics number of enterprises	9.95%
			High-tech industry output value (billion yuan)	15.12%

4. Results analysis

4.1. Overall analysis

This paper calculates the innovation primacy scores of these cities from 2010 to 2020. To intuitively compare the innovation primacy of these cities, this paper takes their averages for comparative analysis. The results are shown in Table 3 and Fig. 1.

Table 3 shows that the ranking order of innovation primacy is Xi'an, Chengdu, Wuhan, Zhengzhou, Guangzhou, Nanjing and Xuzhou. The innovation primacy scores of several national central cities are much higher than those of Xuzhou. The scores of these central cities are all above 38, indicating that Xi'an, Chengdu and Wuhan can play a good role in the influence and driving role of regional centers. Nanjing received 36.85 points, but the ranking was lower. The main reason is that in addition to Nanjing, there are other cities with strong innovation ability in Jiangsu Province, such as Suzhou, which will have an impact on the status and role of the Nanjing central city. Xuzhou scored only 2.09 points at the end of the ranking. Although Xuzhou has become the central city of the Huaihai Economic Zone, there is still a large gap in innovation ability compared with other cities. It also shows that Xuzhou's location advantage has not been fully exerted, and its influence needs to be further expanded to better play its economic radiation and driving role in the Huaihai Economic Zone.

Table 3: Comparison of innovation primacy between Xuzhou and national central cities

City	Innovation primacy	Knowledge innovation primacy	R&D innovation primacy	Industrial innovation primacy
Xi'an	77.5979	29.2891	24.4166	23.8922
Chengdu	67.5667	28.8104	18.8408	19.9156
Wuhan	66.8817	30.3311	17.8205	18.7302
Zhengzhou	39.2600	15.9661	11.5185	11.7754
Guangzhou	38.2842	28.5713	4.7004	5.0125
Nanjing	36.8503	23.6777	6.8955	6.2771
Xuzhou	2.0904	1.0162	0.5223	0.5518

From Figure 1, we can see that the ranking order of knowledge innovation is Wuhan, Xi'an, Chengdu, Guangzhou, Nanjing, Zhengzhou and Xuzhou; the ranking order of R&D innovation primacy is Xi'an, Chengdu, Wuhan, Zhengzhou, Nanjing, Guangzhou and Xuzhou; and the ranking order of industrial innovation primacy is Xi'an, Chengdu and Wuhan, Zhengzhou, Nanjing, Guangzhou and Xuzhou. Although the innovation primacy of each national central city is relatively high, it is also uneven in terms of partial innovation primacy, indicating that the innovation and development of each city is uneven. Among the partial innovation primacy of each city, the score of knowledge innovation primacy is the highest, followed by the score of R&D innovation primacy, and the lowest is industrial innovation primacy. Three partial innovation primacy cover the whole process of an innovation activity from theory to experimental results to market transformation. If the score of the three partial innovation primacy is higher, the score of innovation primacy will be higher. The result is that the first degree of theoretical innovation is far more than the first degree of R&D and industrial innovation. This shows that the development of the first degree of innovation in each city is relatively unbalanced, and the innovation of the central city is still in the category of strong theoretical innovation. The lack of motivation to transform

theoretical results into market results reflects the unbalanced kinetic energy of innovation and development in central cities.
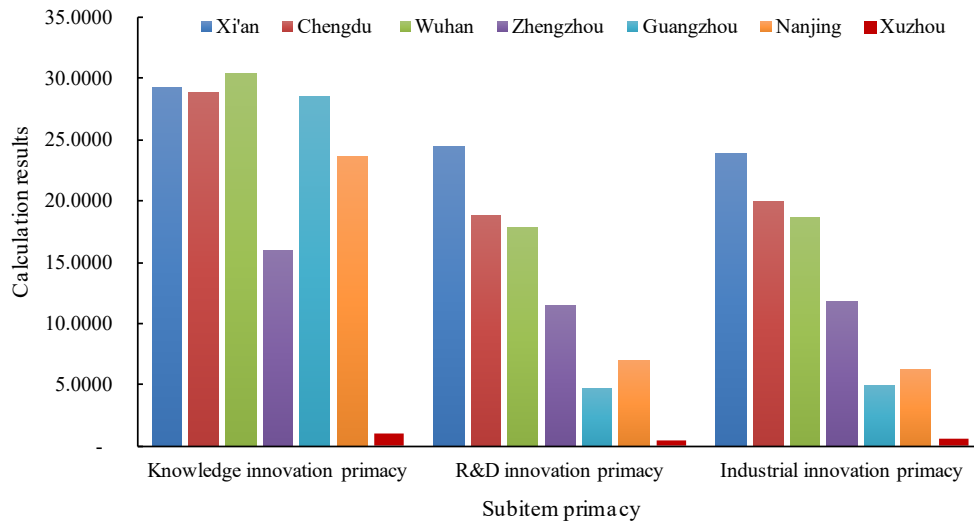

Figure 1: Ranking of Central Cities according to Subitem primacy

4.2. Overall change analysis

Figure 2 shows that during 2010-2020, Xi'an, Chengdu and Wuhan belonged to the first camp, Zhengzhou, Guangzhou and Nanjing belonged to the second camp, and Xuzhou belonged to the last camp. From the perspective of development and change, the primacy of innovation in each city is basically maintained in a relatively stable state. In addition to the fluctuation of Wuhan, Zhengzhou and Xuzhou, other cities show a downward trend of fluctuation. From the perspective of subitems, mainly the score of the primacy of knowledge innovation is declining, and the primacy of industry and R&D innovation is improving, indicating that the theoretical in novation of the city has entered a certain bottleneck period and began to turn to the research and development of market-oriented achievements to improve the quality of innovation in the city. During the period 2010-2020, the innovation primacy score of Xuzhou city is constantly improving, especially after Xuzhou city is determined to be the central city of the Huaihai economic zone, and its innovation primacy score is higher. This shows that the central position of Xuzhou City has a certain attraction to industrial agglomeration, and the radiation effect that Xuzhou City can play is more obvious.
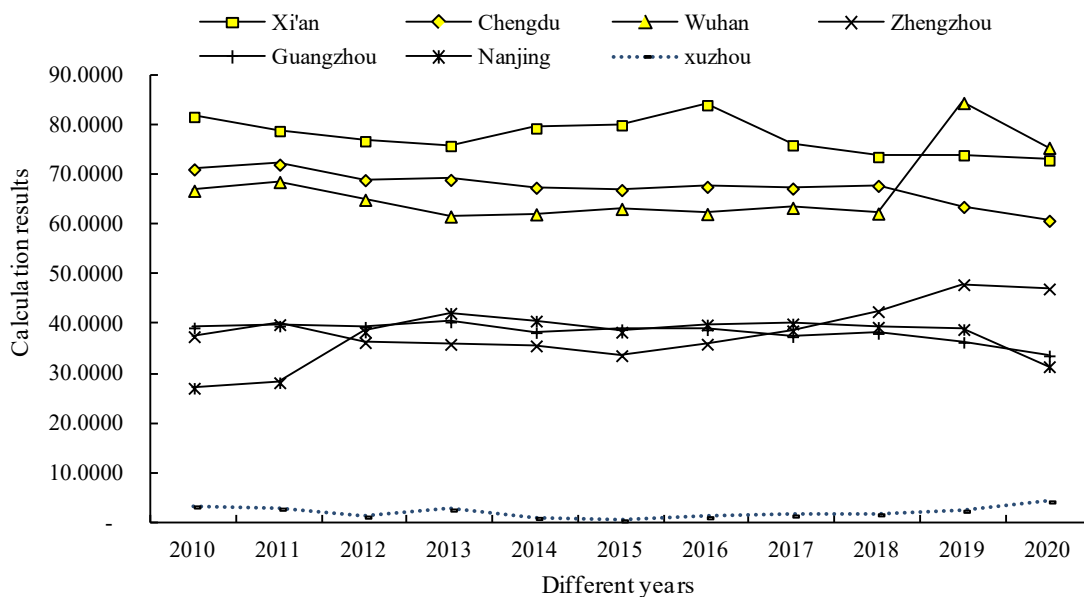

Figure 2: Trend of innovation primacy in central cities from 2010 to 2020

4.3. Matrix analysis of item primacy

According to the subindicators of the three innovation primacy ratios, this paper constructs the knowledge-R&D innovation primacy ratio matrix, the knowledge-industry innovation primacy ratio matrix and the R&D-industry innovation primacy ratio matrix. According to the average score of each subpriority score, it is divided into high and low levels to evaluate the innovation primacy ratios of these central cities. The matrix is shown in Figures. 3-5 below:
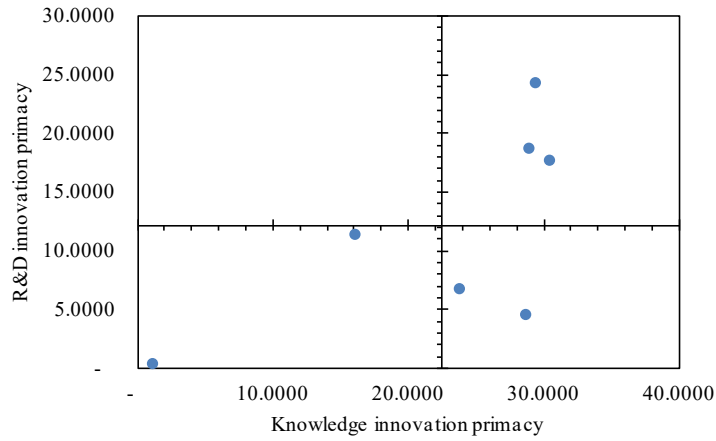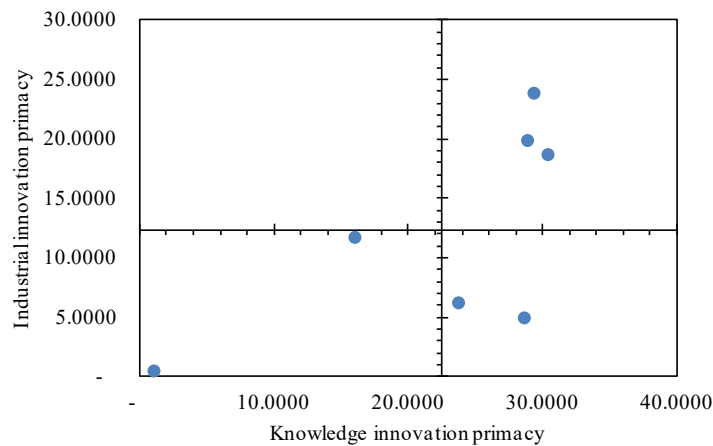

Figure 3: R&D knowledge innovation primacy matrix

Figure 4: Industry-knowledge innovation primacy matrix
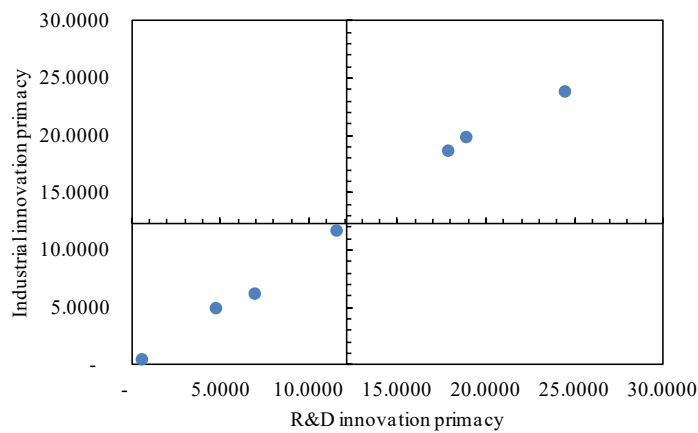

Figure 5: R&D-industrial innovation primacy matrix

Based on Figure 3 to Figure 5, the central cities can be divided into three categories. Chengdu, Xi'an and Wuhan belong to the first category and are located in the first quadrant. These cities with high

knowledge innovation primacy, high R&D innovation primacy and high industrial innovation primacy are also basically consistent with their positioning. Under the strategy of strong provincial capital, these cities are the central cities pushed out by the whole province, which have a strong siphon effect on the surrounding cities and a strong agglomeration effect on other industries, so the innovation primacy of these cities is relatively high.

The second category has two cities, Guangzhou and Nanjing, with high knowledge innovation primacy, low industrial innovation primacy and low R&D innovation primacy. These two cities have a long history. There is not only one large economic city, Nanjing but also Suzhou, Wuxi, Yangzhou and other cities with strong economic strength in Jiangsu Province. In regard to Guangzhou city in Guangdong Province, Shenzhen, Foshan, and Dongguan, these economic industries are all developed cities, so the innovation primacy ratio of the two cities is relatively scattered, and the advantages of the city are not very obvious.

The cities with three weak innovation first degrees belong to the third level. Xuzhou and Zhengzhou, with slow development speeds, were recognized as central cities relatively late. The two cities are located in the central region, to the north of the Beijing-Tianjin-Hebei economic circle, to the south of the Shanghai economic belt and to the east of the Bohai economic circle. The siphon effect of these several economic circles on these two cities is obvious, and the two cities are located inland. Transportation is not too diverse, so its innovation first degree score is low, and it is difficult to reflect the economic status of its central city.

From the perspective of the subprioritization matrix, it can be clearly seen that Xuzhou's innovation primacy is very low in comparison with the other central cities, and it is difficult to compete with powerful economic cities, even the inland city Zhengzhou. First, with weak theoretical results, Xuzhou's theoretical basis is not solid enough to make Xuzhou's knowledge innovation output rich. Second, Xuzhou's R&D innovation score is low. R&D is an activity with a huge investment of resources and is accompanied by high risks. It is necessary to rely on theoretical research results, with the help of corresponding equipment and resources, to conduct a small-scale experiment on theoretical results, and product output finished and passed the market test before starting large-scale production into the market and forming a joint force with industrial innovation. Finally, as Xuzhou is a typical resource-based city, its foundation of industrial innovation is weak. Xuzhou's largest listed company is Xugong Machinery. The single industrial model will inevitably have a certain impact on the economic development of Xuzhou. Without forming a relatively reasonable industrial structure in the past, Xuzhou lacked industrial shields in the development process. How to transform and continuously make up for shortcomings is essential, which is also a relatively difficult process [12-14].

5. Research conclusions

Based on innovation chain theory, this paper draws on the evaluation index system of innovation primacy of other scholars and uses the critic weighting method to analyze and evaluate the innovation primacy of the national central city and Xuzhou city. Although Xuzhou City was rated as the central city of the Huaihai Economic Zone in 2017, there is still a large gap compared with other national central cities. There are still problems such as weak theory, few R&D innovation achievements and poor industrial innovation foundations. This paper proposes the following solutions:

First, in view of the weak theoretical foundation, government departments should intensify efforts to promote the development of colleges and universities in Xuzhou and increase research funding and any other resources invested in colleges and universities. At the same time, relevant government departments should introduce relevant policies to introduce high-quality talent, encourage them to conduct theoretical research, increase the output of theoretical results, and improve the local scientific research level and the quality of scientific research results. Second, the Xuzhou municipal government can build a platform for industry, universities and research institutions. The research institutions provide R&D theoretical results, R&D personnel to the production base for trial production of experimental products, and the enterprises carry out market-oriented operation for R&D products, put forward demand from the perspective of the market, and improve the success rate of market-oriented transformation of R&D products. At the same time, the government should continue to introduce high-tech industries in urban areas and focus on new technologies, new materials, new products and new formats. A diversified industrial structure would be gradually formed to promote the further development of the local economy. Finally, according to the characteristics of the city, the government should introduce a number of green and environmentally friendly enterprises to form an environmental protection industry chain so that the city can change from

a resource-consuming city to a resource-protected and renewable city[15-16].

Acknowledgments

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