

Retraction

Retracted: The Modal Analysis of Multifactor Coupling of Regional Industrial Innovation

Mobile Information Systems

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This article has been retracted by Hindawi following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of one or more of the following indicators of systematic manipulation of the publication process:

- (1) Discrepancies in scope
- (2) Discrepancies in the description of the research reported
- (3) Discrepancies between the availability of data and the research described
- (4) Inappropriate citations
- (5) Incoherent, meaningless and/or irrelevant content included in the article
- (6) Peer-review manipulation

The presence of these indicators undermines our confidence in the integrity of the article's content and we cannot, therefore, vouch for its reliability. Please note that this notice is intended solely to alert readers that the content of this article is unreliable. We have not investigated whether authors were aware of or involved in the systematic manipulation of the publication process.

Wiley and Hindawi regrets that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our own Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

- [1] Y. Liu and Q. Guo, "The Modal Analysis of Multifactor Coupling of Regional Industrial Innovation," *Mobile Information Systems*, vol. 2022, Article ID 1261278, 12 pages, 2022.

Research Article

The Modal Analysis of Multifactor Coupling of Regional Industrial Innovation

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In order to maintain the sustainable development of resource-based industrial clusters, research on the coupling relationship between resource-based industrial clusters and regional innovation networks is proposed. Combined with the historical data of 11 typical resource-based cities from 2013 to 2021, the grey relational model is used to measure the correlation between resource-based clusters and regional innovation networks. And the concept of capacity coupling and the capacity coupling coefficient model in physics is used as a reference to obtain the coupling degree model of resource-based industrial clusters and regional innovation networks. The coupling degree model is used to measure the coupling degree of the two, and a reasonable analysis is carried out on the result of the measurement. The results show that there is a correlation between resource-based industrial clusters and regional innovation networks. And the correlation between the two is above 0.65, indicating a strong correlation. The coupling between resource-based industrial clusters and regional innovation networks has entered the subsequent high-level coupling stage from the run-in coupling stage that began in 2013 and continues to maintain a high-level coupling. It is pointed out that cluster governance plans should be formulated according to regional differences and local conditions, so as to guide the transformation and upgrading of resource-based industrial clusters and to avoid the negative impact on the regional economy due to resource exhaustion.

1. Introduction

Environmental problems are a global problem, and many countries around the world often use sustainable development strategies. Chinese Premier Zhu Rongji pointed out at the conference that China will unswervingly pursue the path of sustainable development. China began to implement the sustainable development strategy in 1994 [1]. The Seventeenth National Congress put forward the higher goal of sustainable development to build an ecological civilization.

Coordinated development is a prerequisite for sustainable development, and coordinated development is also a prerequisite for a country's stable, healthy, and efficient operation. Therefore, to achieve sustainable development, coordinated development must be achieved first. During the national "Eleventh Five-Year Plan" period, the grand drama of regional coordination and integrated development kicked

off. The outline of the "Twelfth Five-Year Plan" put forward "promoting coordinated and interactive development of regions," while the "Thirteenth Five-Year Plan" clearly pointed out five new development concepts and put forward a coordinated development concept. In the 2016 government work report, Lin et al. proposed to promote coordinated regional development and ensure the coordinated operation of the economy and society [2].

The future 13th Five-Year Plan clearly proposes five new development concepts including the concept of coordination and the concept of green. At the same time of rapid development, it faces severe resource shortages and environmental pollution tests. At the same time, resource shortages also limit the speed of economic development, and the environmental carrying capacity also limits the healthy development of the economy. Rapid industrialization and urbanization lead to a shortage of mineral resources and

increasingly serious regional and mobile environmental pollution, which has become a major constraint to the city with strong international competitiveness [3]. The issue of sustainable development is a hot topic of current research at home and abroad.

With the growth of the world population, the competition between resource depletion and environmental pollution has become more severe. Foreign researchers have studied the relationship between resources, the environment, and the economy for a long time. The conclusion can be divided into three stages. The first stage is the slow development stage of initial research, mainly before the Second World War. The famous German human geographer Ratzel proposed environmental determinism, proposing that “the environment will determine the development of a race.” At this stage, scholars began to pay attention to the relationship between population and environment but did not pay much attention to the relationship between economy, resources, and environment. The second stage is the stage of rapid development, which mainly occurred from the late 1940s to the late 1980s. This period belongs to the post-World War II peace period. With the surge in population, the serious shortage of natural resources, and the serious damage to the ecosystem, the interrelationships between the economy, resources, and the environment have attracted more and more attention from scholars in various fields. The third stage is the comprehensive deepening stage since the late 1980s [4].

In the research of the ERE system, foreign scholars originated in the late 19th century, and domestic scholars began to study the coordinated development of the ERE system in the 1970s. From the concept of “garden city” in the United Kingdom to the establishment of a series of theoretical systems of regional economics, environmental economics, and other disciplines in the whole society, the research field of the ERE system has been continuously deepened, resulting in a research model with rich research indicators, extensive research content, diverse research methods, theoretical and empirical research, and quantitative and qualitative analysis.

2. Literature Review

Wang et al. proposed to explore the economic development model of resource-based regions and proposed that resource-based regions should develop a regional characteristic model (local modelling), which opened the prelude to the research of resource-based regions [5]. Zonzini et al. put forward the four-stage development theory of resource-based regions, arguing that the development of resource-based regions needs to go through infancy, growth, transition, and maturity. The four-stage development theory has laid the foundation for the staged research on resource-based regions by later scholars [6]. Xia et al. extended the stage theory of the life cycle of resource-based regions and proposed that the development of resource-based regions can be divided into six stages: construction, employment,

transition, maturity, decline, and exhaust gas. These studies provide a theoretical basis for the academic exploration of resource-based regional development [7]. However, due to the depletion and nonrenewability of mineral resources, mineral resources in Western resource-based regions began to deplete in the late 1970s and early 1980s. At the same time, the resource-related extractive and manufacturing economies also began to decline. Therefore, Western scholars began to explore the transformation path of resource-based regions. Among them, Xu and others believed that the development of multilateral industries was an important path for the transformation of resource-based regions, but this was not conducive to the transformation of remote resource-based regions far from developed cities and towns [8]. Ahlemann et al. proposed that resource-based regions should get rid of economic dependence on mineral resources, not only to achieve industrial diversification but also to transform the labor market and product transactions [9]. In the 21st century, after a long period of theoretical exploration and scientific practice, many resource-based regions have gradually completed their economic transformation. For example, Li et al. analyzed the relationship between the control of mineral resources and the development of a resource-based regional economy, in order to achieve sustainable development in the context of the network era [10].

John and Edwards conducted research on industrial geography planning and urban construction planning in coal resource-based regions. Driven by the national macroeconomic policy, our country's industrialization has developed rapidly. Large-scale infrastructure construction and rapid urbanization have led to the prosperity and expansion of resource-based regions. Regarding the boosting effect of mineral energy on regional economic development, scholars undoubtedly hold a positive opinion [11]. Based on the new understanding of resource and environmental carrying capacity, Wang et al. proposed the calculation of ecological service capacity by characterizing the composition of resource and environmental carrying capacity (i.e., resource supply capacity, environmental pollution-absorbing capacity, ecological service capacity, and social support capacity) method to establish a more practical environmental carrying quantitative model [12]. Wu et al. sorted out and summarized the research results on the carrying capacity of resources and environment from the aspects of connotation, evaluation methods, and applications. They believed that the current academic research on the theoretical part of the carrying capacity of resources and environment was not deep enough and lacked unity. However, the scientific evaluation index system still lacked targeted research on different regions and cities in practical application [13]. Cao et al. reviewed the literature on tourism environmental carrying capacity at home and abroad in the past ten years and believed that the focus of future related research should be strengthened in five aspects: theory, method, norm, empirical, and practice [14]. Chen et al. took the western region of China as the research object, set four different

waste emission level scenarios, and then used the resource and environmental carrying capacity as the standard to verify the potential GDP growth rate of Western provinces and cities. This is an in-depth application of resource and environmental carrying capacity [15].

The principle of connecting systems is that there is a good relationship between the two systems. Therefore, in the process of empirical analysis of the relationship between industrial clusters and regional innovation networks, it is necessary to first confirm the relationship between industrial clusters and regional innovation networks and then determine the degree of the relationship. In the research, the grey relational model is selected for subsequent related calculations to illustrate that there is a certain relationship between resource-based industrial clusters and regional innovation networks, and a coupling model based on efficacy function is selected to measure the degree of mutual influence between resource-based industrial clusters and regional innovation networks.

3. Research Methods

3.1. Coupling and Coordination. The level of resources and environment refers to the level of natural resources such as land, water, minerals, and energy and the level of ecological environments such as water environment, forest, atmosphere, and solid waste in the region. The comprehensive development level of expansion, construction land development, etc., is shown in Figure 1. The resource environment is the basic support for regional development and construction. With the increase of regional development intensity, the pressure and coercion on resources and the environment increases, which restricts the scale and intensity of regional development and construction. Regional development and construction change the development and construction mode according to the feedback information from resources and the environment, forming a dynamic interaction relationship [16].

In the physical sense, coupling refers to the phenomenon that two (or more than two) systems or patterns of movement affect each other through various interactions. Connections describe how systems or objects interact with each other. Through integration, the degree of connection and coordination determines the sequence and structure of the system through the critical areas; for example, the system tends to move from the dispute to the judgment. The key to the transformation of the body from disorder to order is in the intersection of nonorder in the body, which affects the level of change and the rules of the system, and the degree of connection is the measure that affects the integration [17].

The level of cooperation is used to measure the development of cooperation between systems or elements, which represents the will of the body from conflict to order and is the quantitative index of cooperation. It can analyze the cooperation between the systems and elements in a system, as well as the degree of connection between the two systems and the order level of the connection between the machines or products.

3.2. Analysis of the Interaction between Resource-Based Industrial Clusters and Regional Innovation Networks. Based on the analysis of the main topic, the main content, and characteristics of the production capital and the new market in the region, the production capital is related to regional innovation networks. Improving the development of the group will help to build a regional innovation network, find key points of innovation, improve regional products, improve regional business models, and improve the regional innovation network. At the same time, the development of new regional networks helps to change the structure of traditional products such as capacity building, improving the competitiveness of the group and thus helping to promote improved economic stability [18]. We consider the interaction between the two in terms of structure, function, and purpose. This study also explains the positive relationship between economic investments and new businesses as economic investments in the region. The connection process of regional innovation networks is shown in Figure 2.

3.3. Coupling Evaluation Index System of Resource-Based Industrial Clusters and Regional Innovation Networks. Based on the above points, evaluation indicators can be formulated to analyze the integration of regional economic resources. Figures 1 and 2 show the evaluation system of economic resource integration and the new regional economy, which consists of 14 specific indicators created at 5 levels. Table 1 shows the coupling evaluation index system of the resource-based industrial cluster and regional innovation network, and Table 2 shows the coupling evaluation index system of the resource-based industrial cluster and regional innovation network.

3.4. Selection of the Empirical Model

3.4.1. Grey Relational Model. The following are the specific analysis steps of the grey relational model:

- (1) Define the reference and comparison sequence. The degree of relationship between the two systems of resource-based business clusters and regional innovation networks will be evaluated. Therefore, the definition of resource-based business group system index factors is continued as used in sequence and shown as follows $X_i (i = 1, 2, \dots, n)$, where $n = 5$ in the research and in the follow-up. In the actual calculation process, X_i is implemented in the indicators, namely, X_1 is the number of industrial enterprises/built-up area, X_2 is the number of employees in the mining industry, X_3 is the total industrial output value, X_4 is the total profit, and X_5 is the growth rate of the regional GDP. Each index factor of the regional innovation network system is a comparison sequence, denoted as $X_j (j = 1, 2, \dots, m)$. In the research, $m = 9$ is also implemented in the subsequent actual measurement and calculation process. X_j is implemented in the

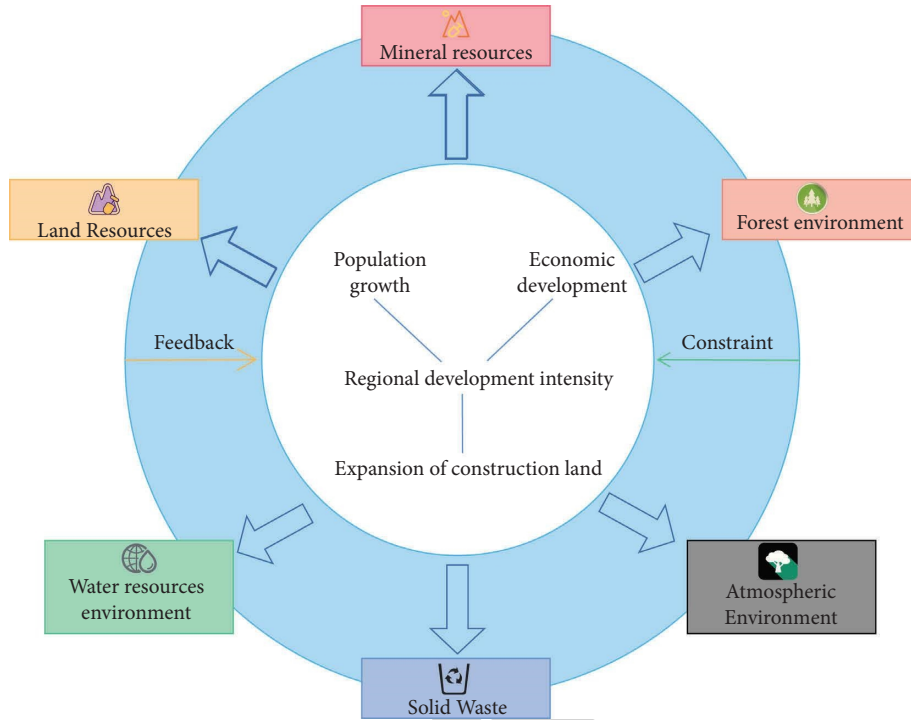


FIGURE 1: Schematic diagram of the interaction between the resource environment and regional development.

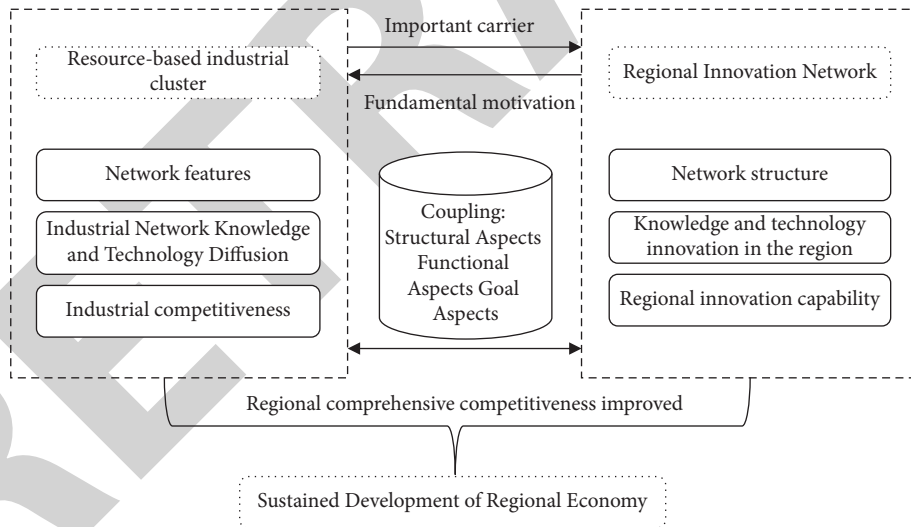


FIGURE 2: Coupling mechanism of resource-based industrial clusters and regional innovation networks.

index. Specifically, X_1 is the number of people for scientific research, technical services, and the geological exploration industry, X_2 is the number of employees in public management and social organizations, X_3 is the number of employees in the financial industry, X_4 is the number of patent applications, X_5 is the number of public library books, X_6 is the balance of various loans of financial institutions, X_7 is the amount of the infrastructure construction investment, X_8 is the number of Internet broadband access users, and X_9 is the amount

of scientific and technological financial expenditure. Combined with the research, panel data will be selected. In general, the original data can be represented as $X_i = (x_i(1), x_i(2), \dots, x_i(t))$ and $X_j = (x_j(1), x_j(2), \dots, x_j(t))$, where the time and year are represented by t [19].

- (2) Dimensionless processing of data. In order to minimize the deviation caused by the difference in the physical meaning and dimension of the index, the initial value processing transformation is adopted. At this time, x'_i and x'_j are the new data after

TABLE 1: Coupling evaluation index system of resource-based industrial clusters and regional innovation networks (target layer: resource-based industrial clusters).

Criterion layer	Indicator layer	Unit
Cluster size	Number of industrial enterprises/built-up area	Per square kilometer
	Number of employees in the mining industry	Ten thousand people
	Industrial output	Ten thousand yuan
Economic benefits	Total profit	Ten thousand yuan
	GDP growth rate	%

TABLE 2: Coupling evaluation index system of resource-based industrial clusters and regional innovation network (target layer: regional innovation network).

Criterion layer	Indicator layer	Unit
Network main body	Number of persons employed in scientific research, technical services, and geological prospecting	Person
	Number of employees in public administration and social organizations	Ten thousand people
	Number of people employed in the financial industry	Person
Network function	Number of patent applications	Pieces
	The number of books in public libraries	Thousands of copies
	Balance of various loans of financial institutions	Ten thousand yuan
Network environment	Investment in infrastructure construction	Ten thousand yuan
	Number of internet broadband access users	Thousands of families
	Government expenditure on science and technology	Ten thousand yuan

processing the original data, as shown in the following formula:

$$x_i = \left(1, \frac{x_i(2)}{x_i(1)}, \dots, \frac{x_i(n)}{x_i(1)} \right), \quad (1)$$

$$x'_j = \left(1, \frac{x_j(2)}{x_j(1)}, \dots, \frac{x_j(m)}{x_j(1)} \right).$$

(3) Here, $\rho \in (0, 1)$ is the resolution coefficient. In the research, the resolution coefficient $\rho = 0.5$ is used for

subsequent calculations, as shown in the following formula:

$$\xi_i(j)(t) = \frac{\min_i \min_j |x'_i(t) - x'_j(t)| + \rho \max_i \max_j |x'_i(t) - x'_j(t)|}{|x'_i(t) - x'_j(t)| + \rho \max_i \max_j |x'_i(t) - x'_j(t)|}. \quad (2)$$

(4) The correlation degree is calculated to obtain the correlation degree matrix, where the correlation degree Y_{ij} in the matrix is the following formula:

$$Y_{ij} = \frac{1}{k} \sum_{i=1}^k \xi_i(j)(t), \quad k = 1, 2, \dots, n, k \text{ is the number of samples}, \quad (3)$$

$$Y_i = \frac{1}{m} \sum_{j=1}^m Y_{ij} (i = 1, 2, \dots, n).$$

3.4.2. Coupling Degree Model. The following are the specific implementation steps of the coupling model.

(1) *Efficacy Function.* Multiple measurement indicators can be used to comprehensively evaluate the system. Since each indicator has inconsistent dimensional units and values, in order to avoid interference with the measurement results, all

measurement indicators in the system must be preprocessed, that is, the efficacy coefficient method is used in the research to further obtain the efficacy function values of the two systems [20]. The efficacy coefficient method can realize the dimensionless processing and the same direction processing of each index, and its calculation process is the following formula:

$$x'_{ij} = \begin{cases} \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)}, x'_{ij}, \\ \frac{\max(x_j) - x_{ij}}{\max(x_j) - \min(x_j)}, x'_{ij}. \end{cases} \quad (4)$$

In formula (4), i represents the system sequence parameter (the research refers to the year and there is $i = 1, 2, \dots, 10$), j represents the index, and x_{ij} is the index value corresponding to each year, that is, the original data value. $\min(x_j)$ and $\max(x_j)$, respectively, represent the minimum and maximum value of the j th item index. x'_{ij} is the index value after processing and is between 0 and 1, representing the contribution value of x_{ij} to the respective system. The larger the value, the greater the contribution of the value of the index to its system. In the research, the first formula is mainly adopted to realize the subsequent calculation.

Thus, the total efficacy function of each system is further obtained, which can be specifically expressed as the following formula:

$$U_{n-1,2} = \sum_{j=1}^m W_j x'_{ij}. \quad (5)$$

In formula (5), U_1 represents the total efficacy function value of the resource-based industrial cluster system, U_2 represents the total efficacy function value of the regional innovation network system, n represents the system, m is the number of indicators of a system (the research has $m = 5$ when $n = 1$ and $m = 9$ when $n = 2$), and W_j is the weight of each index of a system. The larger the U_1 value, the better the comprehensive development level of resource-based industrial clusters, and vice versa; the value of U_2 is larger [21].

(2) *Coupling Model*. The coupling degree can be used to measure the degree of mutual influence between two systems. Based on the power function, the coupling degree model of the interaction of multiple (n) systems is generalized, as follows:

$$C = n \left\{ \frac{(U_1 \cdot U_2 \cdot \dots \cdot U_n)}{[\prod(U_q + U_z)]} \right\}^{1/n}. \quad (6)$$

There are only two systems in the relationship between resource-based enterprises and regional innovation organizations. In order to simplify the research, the above multicomunication network model can be conveniently added to establish a model suitable for production capacity assessment. The ranking model and the model combined with the regional innovation network are shown in

$$C = 2 \left\{ \frac{(U_1 \cdot U_2)}{[(U_1 + U_2)(U_1 + U_2)]} \right\}^{1/2}. \quad (7)$$

3.5. Data Selection and Sources. The cluster referred to in the research is the chain structure of the industrial chain and its value chain with nonrenewable resources (mainly mineral resources) as the basic production factors. Therefore, in terms of data selection, the research will first remove the typical resource-based cities dominated by forest resources. Considering the availability of data, the research selects 11 provinces, cities, or autonomous regions in our country, and the resources cover coal, oil, 11 typical resource-based cities of four types of nonferrous metals and ferrous metals; we conduct empirical research from the data of nearly ten years from 2008 to 2017.

4. Results Analysis

4.1. Correlation Analysis between Resource-Based Industrial Clusters and Regional Innovation Networks. In order to analyze whether there is a correlation between resource-based industrial clusters and regional innovation networks, the following three points are discussed step by step in the research. First, according to the obtained correlation rank matrix, the average value of each column is obtained, and the correlation index value of each resource-based manufacturing group and regional innovation network system index is obtained. This is used to evaluate the existence of the relationship between indicators of capital-based business and regional innovation network systems. Secondly, the average value of the correlation measurement value Y_i of each index of the regional innovation network and the resource-based industrial cluster system by row is obtained. Y_i is used to judge whether there is a correlation between the indicators of the regional innovation network and the resource-based industrial cluster system. Finally, combined with the previous exploration process, the degree of relevance between the resource-based industrial cluster and the regional innovation network is analyzed as a whole. In this whole analysis process, it is necessary to combine the existing classification criteria of association degree in previous studies to judge the degree of association. The specific division criteria are shown in Table 3.

According to the correlation matrix calculated above, the calculation results are divided into 11 urban regions and the relationship between the business input index and the regional innovation network system is studied. We compare resource-based economic cluster and regional innovation index. The ranking table is shown in Table 4. The results corresponding to IR in this table are the five specific indicators of economic resources (number of industrial establishments/plants, workers in the mining sector, value of total output, total income, and GDP growth rate of the region) and regional innovations. The degree of freedom and the value of each degree of freedom vary little across cities, indicating that the relationship between the economy and regional capital has been poorly measured over the past decade. This gradual change suggests that the development of capital-based businesses will lead to new businesses in the region. In addition, resource-based commercial enterprises are the main source of new business opportunities in this

TABLE 3: Classification criteria of correlation degree.

Correlation degree	Evaluation description
$0 < Y_i \leq 0.35$	Weak correlation
$0.35 < Y_i \leq 0.65$	Moderate correlation
$0.65 < Y_i \leq 0.85$	Strong correlation
$0.85 < Y_i \leq 1$	High correlation

TABLE 4: Numerical table of correlation degree between each index of resource-based industry cluster and regional innovation network in 11 cities.

City	r_i				
	r_1	r_2	r_3	r_4	r_5
A city	0.807841	0.834576	0.772171	0.825325	0.7932
B city	0.904282	0.895912	0.906768	0.846104	0.884523
C city	0.761847	0.7643	0.645369	0.684501	0.717437
D city	0.854821	0.876952	0.875045	0.8402	0.827413
E city	0.854657	0.851421	0.877584	0.809168	0.850639
F city	0.829657	0.849554	0.871266	0.796046	0.828472
H city	0.827855	0.813827	0.809255	0.788645	0.807453
I city	0.756242	0.750166	0.715532	0.615913	0.7484
J city	0.800354	0.789741	0.825287	0.751	0.778468
K city	0.912926	0.827623	0.934925	0.910885	0.90965
L city	0.865352	0.875061	0.886214	0.851713	0.839547

region [22–26]. In order to clarify the relationship between economic resources and regional innovation indicators, this paper draws a quantitative report on the relationship between the resource-based economy of 11 cities and all regional innovation networks, as shown in Figure 3. The results shown in the figure show that the relationship between various indicators of capital market network marketing by the economy and regional economy in the last decade is almost more than 0.65, which illustrates the difference in corporate capital. There is a certain relationship between each index of the system and the regional innovation network system.

Then, to study the relationship between the regional innovation network and the resource-based economy [27, 28], the relationship between the regional innovation network and the resource-based economy in the business of 11 cities is shown in Table 5. The value corresponding to r_j in this table is the degree of correlation between the nine specific indicators of the regional innovation network and the resource-based industrial cluster system as a whole. It can be seen from this table that all the correlation degree values fluctuate within a range of only 0.2. This shows that there is a continuous relationship between regional innovation networks and resource-based business clusters, suggesting that the existence of regional innovation networks promotes the creation of resources. In addition, combined with this table, a numerical map of the correlation degree between each index of the regional innovation network and resource-based industrial clusters in 11 cities is drawn, as shown in Figure 4. Combined with the classification criteria of correlation degree, it can be seen that the correlation degree of each index in the regional innovation

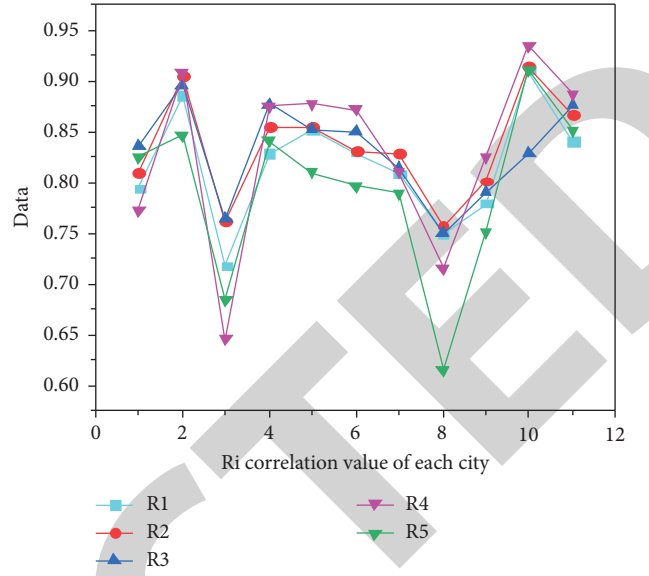


FIGURE 3: Numerical diagram of correlation degree between each index of resource-based industry cluster and regional innovation network in 11 cities.

network system and the resource-based industry cluster system is mainly above 0.65, which also indicates that each index of the regional innovation network is at least strongly correlated with the resource-based industry cluster system.

Based on the above analysis process [29–31], it can be concluded that each index of the resource-based industry cluster system has a strong correlation with the regional innovation network system as a whole, and each index of the regional innovation network also has a strong correlation with the resource-based industry cluster system as a whole. Considering that the selected data objects themselves are representative and involve the east, west, and east regions of China, it can be inferred that, from the whole system, there is a strong correlation between the resource-based industry cluster and the regional innovation network.

4.2. Coupling Analysis of Resource-Based Industrial Clusters and Regional Innovation Networks

4.2.1. Time Evolution of the Coupling between Resource-Based Industrial Clusters and Regional Innovation Networks. The selected coupling degree index model is used, combined with the coupling evaluation index system of resource-based industrial clusters and regional innovation networks constructed in the previous section and the corresponding index data, and the VBA language in EXCEL software [32–34] is used to calculate the model, so as to obtain the coupling degree measurement. Finally, the numerical result table of the coupling degree between resource-based industrial clusters and regional innovation networks as shown in Tables 6 and 7 is compiled.

According to the above-mentioned numerical table of coupling degrees, combined with the classification criteria of coupling degrees in the literature on the study of coupling relationships [35, 36], as shown in Table 8, this study will use

TABLE 5: Correlation degree of each index of innovation network in 11 cities and regions with resource-based industry clusters.

City	r_i								
	r_1	r_2	r_3	r_4	r_5	r_6	r_7	r_8	r_9
A city	0.84857	0.89352	0.86245	0.85773	0.77445	0.71898	0.68934	0.8162	0.79861
B city	0.92141	0.92687	0.92797	0.895	0.91858	0.8302	0.86825	0.90523	0.79765
C city	0.76292	0.7574	0.7564	0.67632	0.7275	0.68223	0.70732	0.66608	0.69657
D city	0.92494	0.94577	0.93843	0.70014	0.8706	0.85886	0.76626	0.78857	0.90066
E city	0.89297	0.90613	0.89868	0.76073	0.8957	0.8514	0.89737	0.8686	0.66672
F city	0.83386	0.90591	0.90669	0.6055	0.87575	0.84585	0.89933	0.80194	0.84027
H city	0.87771	0.88925	0.88887	0.66147	0.80773	0.8022	0.84972	0.78255	0.72503
I city	0.74222	0.77098	0.73469	0.69173	0.72155	0.73544	0.72871	0.6667	0.66343
J city	0.81583	0.88878	0.89385	0.6252	0.75806	0.81556	0.79196	0.74583	0.76764
K city	0.92294	0.92844	0.9293	0.82217	0.9267	0.90965	0.85883	0.92664	0.86763
L city	0.91898	0.92995	0.9468	0.8666	0.85418	0.68133	0.73141	0.88715	0.95561

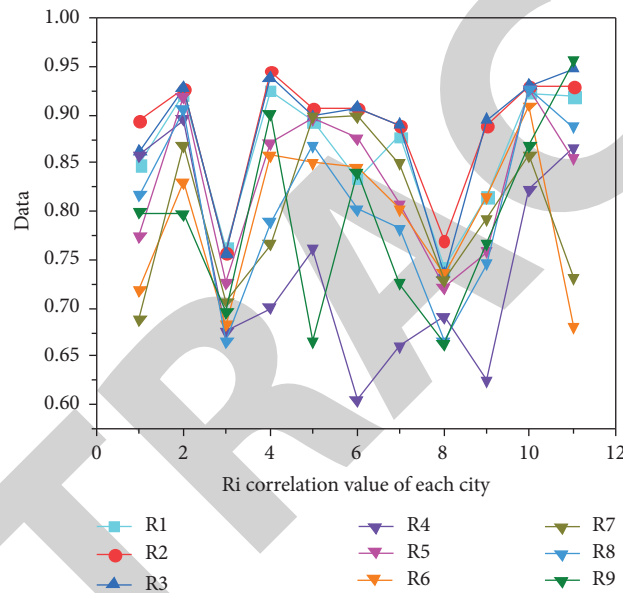


FIGURE 4: Numerical diagram of correlation degree between each index of an innovation network and resource-based industry cluster in 11 cities and regions.

TABLE 6: Coupling degree of resource-based industrial clusters and regional innovation networks (1).

	A city	B city	C city	D city	E city	F city
2008	0.596835	0.026749	0.883327	0.257738	0.325568	0.955275
2009	0.922196	0.808783	0.85817	0.666865	0.657443	0.998035
2010	0.9685	0.766024	0.960345	0.708246	0.770223	0.967442
2011	0.902481	0.815388	0.98278	0.872237	0.867297	0.998546
2012	0.986521	0.916816	0.988848	0.959186	0.947092	0.905854
2013	0.981608	0.917121	0.994489	0.990555	0.999042	0.774407
2014	0.985383	0.961182	0.982524	0.939589	0.99069	0.997452
2015	0.999612	0.993098	0.980505	0.913716	0.973032	0.876197
2016	0.95732	0.893216	0.974616	0.82412	0.931382	0.830295
2017	0.793052	0.914745	0.958772	0.865083	0.681858	0.836118

the resources based on business clusters and regional innovation linkages as the basis for its conclusions. The four levels of horizontal linkage, antagonistic linkage, run-on linkage, and high-level linkage are used to measure the linkage change process of assistance based on production

groups and regional innovation networks [23]. In the low-level coupling stage, the mutual influence of resource-based industrial clusters and regional innovation networks is still slight, and their coupling relationship does not clearly exist. In the antagonistic coupling stage, the two systems of

TABLE 7: Coupling degree of resource-based industrial cluster and regional innovation network (2).

	G city	H city	I city	J city	K city
2008	0.668398	0.432233	0.824567	0.728933	0.608289
2009	0.930099	0.942502	0.898385	0.756595	0.687294
2010	0.781866	0.957656	0.965976	0.751045	0.629124
2011	0.842878	0.999956	0.911597	0.913888	0.85993
2012	0.9732	0.973742	0.89021	0.989817	0.964375
2013	0.998195	0.975976	0.996845	0.957277	0.996136
2014	0.998577	0.993567	0.994191	0.957176	0.977395
2015	0.896125	0.967348	0.945093	0.994486	0.788677
2016	0.929063	0.986957	0.957583	0.993952	0.591245
2017	0.918887	0.991957	0.942762	0.904041	0.842723

TABLE 8: Coupling level division.

Coupling	Level division
[0, 0.3]	Low-level coupling phase
(0.3, 0.5]	Antagonism phase
(0.5, 0.8]	Running-in stage
(0.8, 1]	High-level coupling stage

resource-based industrial clusters and regional innovation networks are internal or external. Driven by the driving force, the cross-catalytic mechanism of the two is gradually formed, and at this time, it is in a state of mutual restriction. In the running-in coupling stage, the interaction relationship between the two systems changes and the survival or development of one of them will affect the other. In the high-level coupling stage, resource-based industrial clusters and regional innovation network systems have entered healthy self-development. The exchange of matter, energy, and information between systems is in a reasonable and orderly state, and the two influence each other to the highest degree [24].

In order to more intuitively reflect the coupling of resource-based industrial clusters and regional innovation networks in these 11 typical resource-based cities from 2008 to 2017, the corresponding results are drawn, as shown in Figure 5. It can be seen from the figure that the coupling degree between resource-based industrial clusters and regional innovation networks in these 11 typical resource-based cities has shown a slow upward trend in the past ten years [37–39]. In addition to the large difference in degrees, the coupling degrees of these two systems in each city in the following years are both above 0.5 and fluctuate, which indicates that over time, the degree of mutual influence between resource-based industrial clusters and regional innovation networks has exceeded the low level. In the coupling and antagonistic coupling stages, the two systems have a strong coupling relationship, and the two systems will not cause constraints on the other due to the excessive advance and lag development of one of them, but both affect each other and develop in a positive direction [25]. At the same time, it is found that the coupling degree between resource-based industrial clusters and regional innovation networks in each city in 2008 is significantly different from

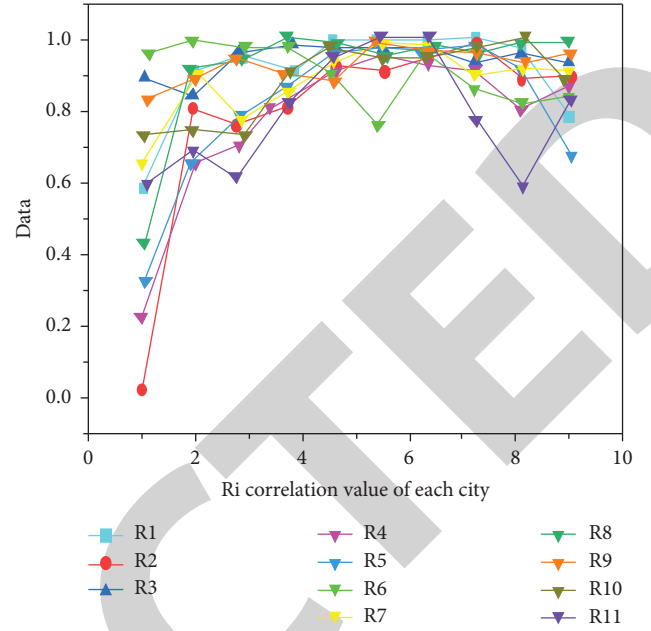


FIGURE 5: Coupling degree of resource-based industrial clusters and regional innovation networks.

other years. The year is generally low, indicating that the regional innovation network is initially formed at this time, and the resource-based industrial cluster is in the process of self-expanding development, relying on resource endowment to achieve regional economic development, and the current demand for innovation activities is less, which makes the two in this year. The degree of mutual influence is lower than in subsequent years. Then, in order to obtain the integration process of each city's production capacity and new development area in the past ten years, the average annual connection level of the two systems has been taken as a city model, and the model is drawn as shown in Figure 6. As this figure shows, the production capacity as a product and new industries in the region are intertwined. Both have entered the next phase of high connectivity from the level of connectivity that started in 2008 and continues to have high connectivity. This often shows that the links between the regional innovation networks of natural resources-based cities and natural resources-based industrial groups have directly entered into their state's development.

4.2.2. Spatial Analysis of Coupling between Resource-Based Industrial Clusters and Regional Innovation Networks. In 2017, according to the regional distribution of land parcels in the east, central, and west China, 11 traditional capital cities and newly connected capital business groups in the region were divided and classified by economic zone. As shown in Tables 9 and 10, the degree of connection between the two can be obtained. According to the table, spatial analysis is conducted on the connection between capacity and new markets in the region.

From Tables 9 and 10, it can be seen that the coupling degree of resource-based industrial clusters and regional innovation networks in these 11 typical resource-based cities

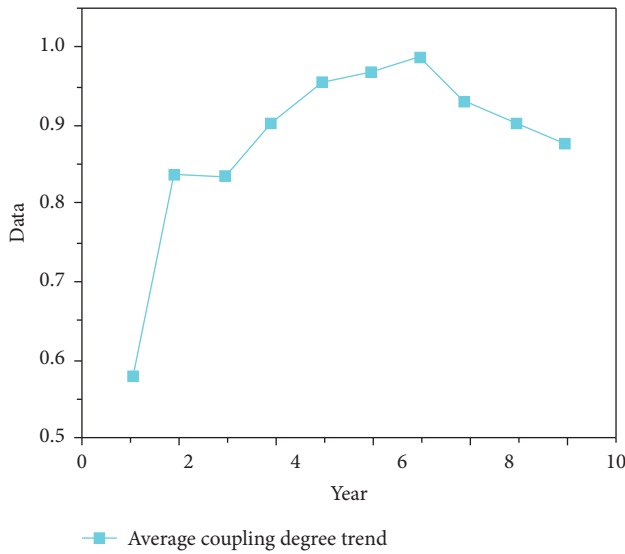


FIGURE 6: Trend chart of average coupling degree from 2008 to 2017.

TABLE 9: Spatial distribution of coupling degree between resource-based industrial clusters and regional innovation networks in 2017 (running-in coupling).

Eastern region	Central region
A city	E city

TABLE 10: Spatial distribution of coupling degree between resource-based industrial clusters and regional innovation networks in 2017 (high-level coupling).

Eastern region	Central region	Western region
B city	C city, D city	F city, G city, H city, I city, J city, K city

has obvious spatial characteristics in the geographical distribution. Overall, calls from the east to the central and western regions are on the rise. Most of the cities have high connectivity, and the western regions have high connectivity. Business development in the eastern and central regions has been successful, and urban planning and construction have become more rational and timely. The business-based business model established in the capital will change over time in response to new needs. The degree of interaction has gone from low to high [40–42]. The economic growth of cities in the western region is generally lower than that in the eastern and central regions. For urban resources based on natural resources, urban development is not sustainable in terms of resource utilization, and new employment opportunities must be created. The simplicity of the business chain is reduced. The integration of urban economic development based on urban capital and regional innovation leads to continuous fixed development, and there is always capital according to the business development, thus

TABLE 11: Spatial distribution of coupling degree by city type in 2017 (running-in coupling).

Mature city	Decay city
A city	E city

TABLE 12: Spatial distribution of coupling degree by city type in 2017 (high-level coupling).

Mature city	Decay city	Regeneration city
D city, F city, I city, K city	C city, G city, H city, J city	B city

making the capital grow. In addition, the National Sustainable Development Plan 2013–2020 in 2017 will further connect resource-based industrial clusters and regional innovation networks in 11 natural resource-based cities. Tables 11 and 12 show location analysis and specific investment results by market and regional market, respectively. The interplay between capacity and new business in the region is important, the report notes. Focusing on developing and declining cities, this is based on the need for resource innovation as cities move into the next stage of development. Among them, resource-based industrial clusters need the promotion of regional innovation networks to achieve diversified development and avoid the weakening of clusters. In addition, except for growth-oriented cities, which do not have corresponding couplings, other types of cities show that resource-based industrial clusters and regional innovation networks have a high level of coupling. Industrial clusters are also in the budding development, relying on their operating mechanism to achieve the development of clusters, thereby bringing sustainable development to the regional economy.

5. Conclusion

There is a correlation between resource-based industrial clusters and regional innovation networks, and the correlation between the two is above 0.65, indicating a strong correlation. Whether from the perspective of the correlation degree between different indicators in the resource-based industrial cluster system and regional innovation network, or from the perspective of the correlation degree between different cities, the value of each correlation degree is almost the same. In recent 10 years, the relationship between regional innovation network and resource-based regional economy has not changed much, which indicates that resource-based industrial cluster is an important factor in regional development. Considering the whole set of resources as a business, the amount of difference between all relevant results is only 0.2, showing the relationship between the indicators of the new business area and the resource-based business. The presence of the regional innovation network is the catalyst for the development of the services sector of the industrial group, and the regional innovation network is the main driving force for the development of the

services of the industrial group. From the point of view of the whole system, there is a strong relationship between the economic resources and the new economy in the region, and the degree of relationship between them is also strong.

The connection between the capital market and the regional economy has steadily increased from the level of connection that began in 2008 and continues. The relationship between the urban economy and the regional economy of 11 cities that can play an economic role shows slow growth in the last decade. The coupling degree of these two systems in each city is in the range of 0.5 or more, which means that with time, the degree of mutual influence between resource-based industrial clusters and regional innovation networks has exceeded the low-level coupling and antagonistic coupling stages. There is a strong coupling relationship between the systems, and the two systems will not restrict the other due to the excessively advanced and lagging development of one of the two systems. But they both affect each other and develop in a positive direction, and the two systems influence each other to a very high degree.

Data Availability

The dataset can be accessed upon request to the corresponding author.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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