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Research Article

The Coupling and Coordinated Development of Intellectual Property and High-Quality Economy: Using China's 30 Provinces as an Example

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Research Background and Content. Intellectual property and high-quality economic development are mutually reinforcing and restrictive, China is a large but not a strong intellectual property country, and China's high-quality economic development still has problems of inadequacy and imbalance. Based on the above research background, this paper mainly studies the relationship between the intellectual property system and the high-quality economic development system from the perspective of coupled and coordinated development. *Research Objective*. The objective is to measure the coupling and coordination degree between the intellectual property development system and the high-quality economic development system and to explore the spatiotemporal characteristics and differences in the coupling and coordination between the two systems. *Research Method*. Based on the data of 30 provinces (autonomous regions and municipalities) from 2013 to 2020, the methods used in this paper to analyse include entropy weight method, grey correlation analysis, coupling coordination degree model, and Dagum Gini coefficient. *Research Results*. The development of economic openness and innovation are more closely related to the development of intellectual property, and the protection, utilization, and creation of intellectual property are more closely related to high-quality economic development; the coupling coordination degree of the two systems shows the characteristics such as "high in the east and low in the west" and "coastal area is better than inland," and the development of intellectual property lags behind the high-quality economic development; the coupling and coordination degree of the two systems shows a slight growth trend in most provinces, but the overall differences shows an expanding trend, and differences between regions are the main sources of overall regional differences. *Research Innovation*. Research innovation is to study the two-way relationship between intellectual property and high-quality economic development and to measure the coupling and coordination degree between the development system of intellectual property and the high-quality economic development system, and its spatiotemporal characteristics, regional differences, and sources of differences are analyzed. *Research Value*. Research value is to provide decision reference for the two-way empowerment of intellectual property and high-quality economic development and regional coordinated development.

1. Introduction

China's economy has shifted from a high-speed growth stage to a high-quality development stage. In the new development stage, intellectual property has become a strategic resource for promoting high-quality economic development. The China's national intellectual property administration has issued the "Annual Work Guidelines for Promoting High-quality Development of Intellectual Property" for three consecutive years, aiming to fully implement the decision-making and deployment of high-quality development (Source: the official website of the State Intellectual Property Office of China); intellectual property management departments at all levels have also actively held special topics conference on high-quality development of the intellectual property to discuss local strategies to promote high-quality regional economic development. Intellectual property and high-quality economic development interact

with each other. Intellectual property empowers innovation, which in turn drives high-quality economic development. High-quality economic development places higher requirements on intellectual property development and supports intellectual property development. China's comprehensive intellectual property development index increased from 100 in 2010 to 304.7 in 2020. The average annual growth rate of intellectual property creation, utilization, protection, and intellectual property institutional environment exceeded 10%. However, China is still a large country of intellectual property and not intellectual property powerful country. In recent years, the high-quality development of China's economy has shown a steady and positive trend. The average annual growth rate of the five submodules is 7.47% in the green development index, 4.38% in the open development index, 3.9% in the innovation development index, 2.87% in the coordinated development index, and 2.62% in the shared development index (Source: the official website of the State Intellectual Property Office of China), but there are still problems such as inadequate and unbalanced economic high-quality development [1]. In particular, after the COVID-19 pandemic swept the world, traffic control and enterprise shut down in response to COVID-19 pandemic have increased nontraditional security risks to economic development [2], and the necessary measures taken globally in response to the pandemic have had a serious impact on economic growth [3], and China's high-quality economic development faces more serious challenges. Therefore, clarifying the matching status of intellectual property and high-quality economic development and improving the adaptability of the two are the key issues to be solved urgently. This paper analyzes the degree of correlation between the intellectual property development system and the subsystems of high-quality economic development, as well as the degree of correlation between the high-quality economic development system and subsystem of intellectual property development, measures the degree of coupling and coordination between the two systems, and portrays the spatiotemporal characteristics and differential performance of the coupling and coordinated development of the two systems, which helps the relevant entities improve the current situation of intellectual property development to adapt to the high-quality economic development, facilitates the two-way empowerment of intellectual property and high-quality economic development, and also provides theoretical guidance for the introduction of regional coordinated development policies and measures.

2. Literature Review

The existing literature on the relationship between intellectual property and high-quality economic development is mainly reflected in the following three aspects.

The first is the one-way impact of intellectual property on high-quality economic development. The world economy is transforming from an economy based on tangible assets to a piece of knowledge and a creative economy based on intangible assets such as patents and copyrights, and intellectual property plays an important role in achieving national and regional economic development goals [4, 5], and intellectual property indirectly affects economic growth by stimulating the accumulation of factors such as R&D and physical capital [6, 7]. Scholars have studied the impact of intellectual property creation, protection, and management on economic development, respectively. When intellectual property creation reaches a certain level, intellectual property development will improve economic performance [8]; intellectual property protection can promote economic growth and development [9], and the poor transmission mechanism caused by unfavorable intellectual property protection is detrimental to the conversion of intellectual property achievements into intellectual capital for innovative enterprises, thereby inhibiting economic development [10]; intellectual property management, such as the management of Intellectual Property Clauses, can promote technology transfer and innovation development in developing countries, thereby promoting economic development in emerging economies [11]; the development of intellectual property finance can accelerate the transformation of intellectual property and thus promote the high-quality innovation and development of the economy [12]; for example, SMEs can secure operational production and guarantee economic growth through intellectual property pledge financing.

The second is the one-way impact of high-quality economic development on intellectual property. High-quality economic development is a double-edged sword for intellectual property development, and economic factors such as the amount of investment in fixed assets and per capita GDP have a significant impact on promoting intellectual property competitiveness [13]; at the same time, they also pose new challenges to intellectual property protection, etc. Especially with the development of the digital economy, the current patent review, privacy protection, and new data property rights division are no longer adapted for the development of copyright and digital technology [14, 15].

The third is the two-way effect of intellectual property rights and economic development. Adams argued that this interaction is manifested in the positive correlation between the development of intellectual property and the coordinated economy of income inequality [16]. Du et al. found that there is a good coupling relationship between intellectual property and economic development in China's Yangtze River Economic Belt, intellectual property plays a key role in economic development, and intellectual property develops faster in economically developed regions [17]. Neves et al. believed that there is a complex interaction between intellectual property development and economic growth. In the underdeveloped areas, with the development of intellectual property creation, intangible assets such as knowledge gradually replace tangible assets such as land and labor and become the driving force of economic development; while economic growth promotes the underdeveloped areas to introduce foreign advanced intellectual property achievements and to obtain their intellectual property development by imitating foreign innovation [18].

The above research results have laid the theoretical foundation for this paper. However, most kinds of literature have discussed the impact of intellectual property on

high-quality economic development, but there are few studies on the impact of high-quality economic development on intellectual property development; although some literatures have studied the two-way effect of intellectual property rights and economic development, they only focus on the level of the relationship between intellectual property development and GDP or are limited to the study of a certain region, and they fail to study the coordination and interaction between intellectual property and high-quality economic development in a wider range, so the breadth and depth of the research are not enough. Based on this, the innovation points of this study are as follows: firstly, the two-way effect of intellectual property and high-quality economic development is systematically studied, and it deepens the research on the relationship between intellectual property and economic development, provides theoretical support for the integration of the two, and helps the country to become an intellectual property power country while achieving sustainable economic quality development; secondly, we measure the degree of correlation between the intellectual property and high-quality economic development, identify the correlation between each subsystem and the system from the perspective of local connection, measure the degree of coupling and coordination between the two systems, and interpret the matching relationship between the two from the perspective of overall connection, to help find the entry point to realize the coordinated development of intellectual property and economic quality from the perspective of the whole intellectual property chain and economic development systems; thirdly, we measure the coupling and coordination degree between the two systems in eight regions of China, portray the regional differences and sources of differences in the coupling and coordination between the two systems based on the Dagum Gini coefficient, tailor the development plan for the coordinated development of the two systems in each region, reduce the regional imbalance in the coordinated development of the two systems according to local conditions, and accelerate the realization of coordinated regional development.

3. Research Design

3.1. Index System Construction. According to China's "Outline of Building a Powerful Intellectual Property Country (2021–2035)," "The 14th Five-Year Plan for National Intellectual Property Protection and Utilization Plan" and the research of related scholars, this paper divides the intellectual property development system into five subsystems such as intellectual property creation, utilization, protection, management, and service. The selection ideas of indicators for each subsystem are as follows: (1) Invention patents with novelty, practicability, and creativity can better reflect the level of intellectual property creation, so the intellectual property creation indicators are constructed from the perspective of invention patents; (2) the level of intellectual property utilization is ultimately tested by the value of intellectual property, so the intellectual property utilization index is constructed from the perspective of the implementation of intellectual property and the benefits obtained from intellectual property; (3) the purpose of protecting intellectual property is to provide legal protection for intellectual property creation and intellectual property operation, so whether intellectual achievements are effectively protected and whether intellectual property operations are carried out in a safe environment are the key to measuring the level of intellectual property protection; (4) intellectual property management runs through the whole process of intellectual property creation, protection, and utilization, and the construction of intellectual property management institutions and management systems determines the level of intellectual property management; and (5) the number of intellectual property service institutions and the degree of recognition can reflect the level of intellectual property services in a region. The greater the number of intellectual property service institutions and the higher the business volume, the higher the level of their intellectual property services. The indicators of the intellectual property development system determined based on the above ideas are shown in Table 1. The existing literature has conducted in-depth research on the measurement indicators of high-quality economic development.

This paper divides the system of high-quality economic development into five subsystems such as coordinated development, green development, shared development, open development, and innovation development, referring to the research results of Wei et al. etc [19–22]. The indicators are shown in Table 1.

3.2. Data Sources. The 18th National Congress of China in 2012 explicitly identified innovation as the first driving force of development and the intellectual property system as the basic guarantee and important support for stimulating innovation, and since then, the role of intellectual property has become increasingly prominent for economic and social development. Therefore, this paper uses the panel data of 30 provinces (autonomous regions and municipalities) in China except for Tibet, Hong Kong, Macao, and Taiwan from 2013 to 2020 as the research sample. The data on intellectual property development indicators are derived from China Statistical Yearbook, China Statistical Yearbook on Science and Technology, China Torch Statistical Yearbook, and the China National Intellectual Property Administration. The data of high-quality economic development indicators are derived from China Statistical Yearbook, China Statistical Yearbook on Science and Technology, and Provincial Statistical Yearbooks. This paper deals with missing data as follows: the actual utilization of foreign capital data in Beijing, Anhui, Hainan, Ningxia, and Xinjiang in 2019 has not been updated, so this paper uses the exponential smoothing method to calculate the missing values; the remaining missing data is filled by the linear interpolation method and the ARIMA model.

3.3. Research Methodology. Firstly, based on data processing, the entropy weight method is used to calculate the comprehensive index of the intellectual property development

Table 1: The index system of the intellectual property development system and high-quality economic development system.

Integrated system	System	Subsystem	Specific measurement index	Index attribute
Intellectual property development and economic high-quality development coupling system	Intellectual property development system	Creation	Number of domestic invention patents granted	Positive
			Invention patent ownership per 10,000 population	Positive
		Utilization	Amount of technology transaction contract	Positive
			Income from transfer of patent ownership	Positive
		Protection	Enforcement of intellectual property administrative protection	Positive
			Degree of standardization of the intellectual property market	Positive
		Management	Documents of intellectual property laws and regulations	Positive
			Number of high-tech enterprises	Positive
		Service	Number of agents for invention patent application in China	Positive
			Number of technology incubators	Positive
	High-quality economic development system	Innovative development	R&D expenditure as a percentage of GDP	Positive
			Number of R&D personnel per 10,000 employees	Positive
			Income-generating degree of high-tech enterprises	Positive
		Coordinated development	Urban-rural per capita disposable income gap	Negative
			The output value of the tertiary industry as a percentage of GDP	Positive
			Population aging level	Negative
		Green development	Wastewater produced per unit of GDP	Negative
			Elasticity coefficient of energy consumption	Negative
			Energy consumption per unit GDP	Negative
		Open development	Total import and export of goods	Positive
			The proportion of foreign investment	Positive
			Foreign exchange earnings from international tourism	Positive
		Shared development	Urban-rural consumption gap	Negative
			The proportion of labor compensation	Positive
			The proportion of people's livelihood fiscal expenditure	Positive

system and the high-quality economic development system; secondly, the grey relation analysis method is used to measure the degree of correlation between the subsystems of a single system and another system, and from the perspective of local connection, to identify the relationship between each subsystem and the system; thirdly, the degree of coupling and coordination of the two systems is measured, and interpret the matching relationship between the two systems from the perspective of overall connection; finally, the Dagum Gini coefficient is used to calculate and analyze the regional differences and the sources of differences in the coordinated development of the two systems.

(1) *Calculation of System Comprehensive Index*. In this paper, the range standardization method is used to perform dimensionless processing on the index data, and the information entropy is used to determine the weight of the index. On this basis, the comprehensive development index S_{ij} of the two systems is calculated by the weighted summation. The entropy weight method can objectively determine the weight of each indicator and deeply reflect the distinguishing ability of the indicators, but the method is highly dependent on the sample, which requires comprehensive indicators and real data; otherwise,

the assignment is easily distorted. In this paper, the indicators will be determined based on a large number of literature studies, to ensure that the selection of indicators is comprehensive and scientific. The data are obtained from authoritative official sources, thus ensuring that the data are true and accurate:

$$S_{\mathrm{ij}} = \sum_{j=1}^{n} \omega_j x_{\mathrm{ij}}, \tag{1}$$

where ω_j is the weight of each indicator in the total score, n is the number of indicators, i represents the year, and x_{ij} represents the standardized value of the indicator j in year i.

(2) *Calculation of the Correlation Coefficient*. This paper uses the grey correlation analysis method to calculate the degree of correlation between each subsystem of intellectual property development and the system of high-quality economic development and the degree of correlation between each subsystem of high-quality economic development and the system of intellectual property development, as shown in equation (2). The grey correlation analysis method can analyze the development trend of panel data, and the method has low data requirements and can retain the collected panel data to the greatest extent so that the quantitative analysis results are consistent with the qualitative results to the greatest extent, and the workload is relatively small, and the calculation steps are clear, which can reduce the loss caused by information asymmetry to a large extent:

$$\xi_k(i) = \frac{\min_k \min_i \left|x_0(i) - x_k(i)\right| + \lambda \max_k \max_i \left|x_0(i) - x_k(i)\right|}{\left|x_0(i) - x_k(i)\right| + \lambda \max_k \max_i \left|x_0(i) - x_k(i)\right|}. \tag{2}$$

Among them, i represents the province, k represents the five subsystems of high-quality economic development, and x_0 is the ideal data column, and this article refers to the comprehensive index of the intellectual property development system, where $i = 1, 2 \ldots 30$; $k = 1, 2 \ldots 5$, λ takes 0.5. (or k represents the five subsystems of intellectual property development, x_0 is an ideal data column, and this paper refers to the comprehensive index of high-quality economic development, and the rest remain unchanged).

(3) *Measurement of Coupling Coordination*. To avoid the false evaluation results caused by the small value of the comprehensive index of the two systems when calculating the coupling coordination degree, this paper uses equation (3) to calculate the coupling degree and uses equation (4) to obtain the coupling coordination degree, referring to the research results of Lu and Zhou [23] and Zhang et al. [24]:

$$C_{\mathrm{ab}} = 2 \times \left| \frac{S_a S_b}{(S_a + S_b)^2} \right|^{1/2}, \tag{3}$$

S_a and S_b are the comprehensive indices of the intellectual property development system and the high-quality economic development system, and $C_{\mathrm{ab}} \in (0, 1)$ is the coupling degree value of the two systems:

$$D_{\mathrm{ab}} = \left(C_{\mathrm{ab}} \times T_{\mathrm{ab}}\right)^{(1/2)}, \tag{4}$$

$$T_{\mathrm{ab}} = \lambda S_a^{\theta} S_b^{1-\theta}, \tag{5}$$

Among them, $D_{ab} \in (0, 1)$ is the coupling coordination degree value of the two systems. T_{ab} represents the development index of the composite system composed of the two systems. The development degree function of the two systems in this paper follows the Cobb–Douglas form and has strict quasi-concave and invariant returns to scale in nature, and $\lambda = 1$ is an exogenous variable, and θ and $1 - \theta$, respectively, reflect the importance of the two systems relative to the total system, and this paper takes $\theta = 0.5$.

(4) *Calculation and Decomposition of Regional Differences in the Coupled and Coordinated Development.* In terms of regional division, this paper adopts the division method of eight major economic zones. Compared with the traditional Gini coefficient method, the Dagum Gini coefficient method considers the distribution state of subgroups, which has obvious advantages in studying regional disequilibrium problems [25], and the Dagum Gini coefficient method can not only effectively explain the sources of regional disparities but also overcome the defects of overlapping of samples between groups [26], so this paper uses the Dagum Gini coefficient to measure and analyze the differences and sources of the coupling coordination between the two systems. The overall Gini coefficient is the sum of the intraregional difference contribution (G_w), the interregional difference contribution (G_{nb}), and the hypervariable density contribution (G_t), and the calculation formula is as follows:

$$G = \frac{\sum_{j=1}^{k}\sum_{h=1}^{k}\sum_{i=1}^{n_j}\sum_{r=1}^{n_h}\left|y_{\mathrm{ji}} - y_{\mathrm{hr}}\right|}{2n^2\mu},$$

$$G_{\mathrm{jj}} = \frac{1/2\mu_j\sum_{i=1}^{n_j}\sum_{r=1}^{n_j}\left|y_{\mathrm{ji}} - y_{\mathrm{jr}}\right|}{n_j^2}, G_{\mathrm{jh}} = \frac{\sum_{i=1}^{n_j}\sum_{r=1}^{n_h}\left|y_{\mathrm{ji}} - y_{\mathrm{hr}}\right|}{n_j n_h\left(\mu_j + \mu_h\right)},$$

$$G_w = \sum_{j=1}^{k} G_{\mathrm{jj}} p_j s_j,\ G_{\mathrm{nb}} = \sum_{j=2}^{k}\sum_{h=1}^{j-1} G_{\mathrm{jh}}\left(p_j s_h + p_h s_j\right) D_{\mathrm{jh}}, \tag{6}$$

$$G_t = \sum_{j=2}^{k}\sum_{h=1}^{j-1} G_{\mathrm{jh}}\left(p_j s_h + p_h s_j\right)\left(1 - D_{jh}\right),\ D_{\mathrm{jh}} = \frac{d_{\mathrm{jh}} - p_{\mathrm{jh}}}{d_{\mathrm{jh}} + p_{\mathrm{jh}}},$$

$$d_{\mathrm{jh}} = \int_0^{\infty} dF_j(y)\int_0^{y}(y - x)dF_h(x),\ p_{\mathrm{jh}} = \int_0^{\infty} dF_h(y)\int_0^{y}(y - x)dF_j(y).$$

Equations (4) and (5) calculate the overall Gini coefficient G, the regional Gini coefficient G_{jj}, and the inter-region Gini coefficient G_{jh} of j and h, where $y_{ji}(y_{\mathrm{hr}})$ is the coupling coordination degree of the two systems in any province in the $j(h)$ region, μ is the average value of the coupling coordination degree of each province, n is the number of provinces, k is the number of regions, and $n_j(n_h)$ is the number of provinces in the $j(h)$ region.

4. The Spatiotemporal Characteristics of the Coupled and Coordinated Development

4.1. Analysis of the Correlation between the Economic High-Quality Development Subsystem and the Intellectual Property Development System. To identify whether there are differences in the correlation between the economic high-quality development subsystems and the intellectual property development system, this paper uses SPSSAU to calculate the comprehensive index of economic high-quality development and the comprehensive index of intellectual property development in each province, and on this basis, it uses SPSS Statistics26 software to carry out grey correlation analysis on five subsystems of high-quality economic development and intellectual property development system, respectively, and sort out the change of correlation coefficient, as shown in Figure 1.

The grey correlation coefficients of the subsystems of high-quality economic development and the intellectual property development system are all greater than 0.7, which fully shows that there is a significant correlation between the two. Among them, the development of economic openness and innovation are more closely related to intellectual property development. This is mainly because the open economy promotes the transnational flow of information, knowledge, talents, and capital, which contributes to the creation, utilization, protection, management, and service of intellectual property, and the development of intellectual property promotes the transnational protection and trade of more high-quality intellectual achievements, which further promotes the open economic development; innovation economy and intellectual property development achieve a virtuous circle based on mutual promotion, intellectual property development has consolidated the foundation of innovative economic development, and innovation economic development has pointed out the direction for intellectual property development.

4.2. Analysis of the Correlation between the Intellectual Property Development Subsystem and the Economic High-Quality Development System. As shown in Figure 2, the grey correlation coefficients between the intellectual property development subsystems and the economic high-quality development system are all greater than 0.7, which fully demonstrates that there is a significant correlation between the two, among which, the protection, utilization, and creation of intellectual property are more closely related to high-quality economic development. Intellectual property protection promotes the improvement of resource allocation efficiency and R&D efficiency through system optimization, thereby promoting technological innovation and ultimately promoting high-quality economic development in terms of economic vitality, innovation efficiency, green development, and social harmony; high-value intellectual property creation is the source of the innovation economy, the utilization of intellectual property transforms "intellectual property" into "assets," making intellectual property a new force for sustainable development and promoting high-quality economic development. Therefore, the protection, application, and creation of intellectual property directly affect high-quality economic development and have a higher degree of

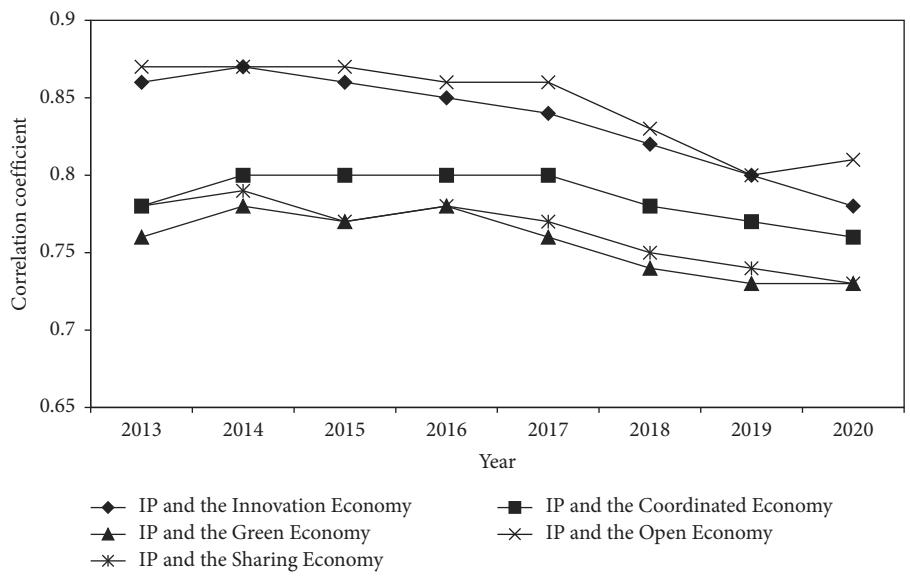

Figure 1: Changes in the correlation coefficient between the economic high-quality development subsystem and the intellectual property development system.

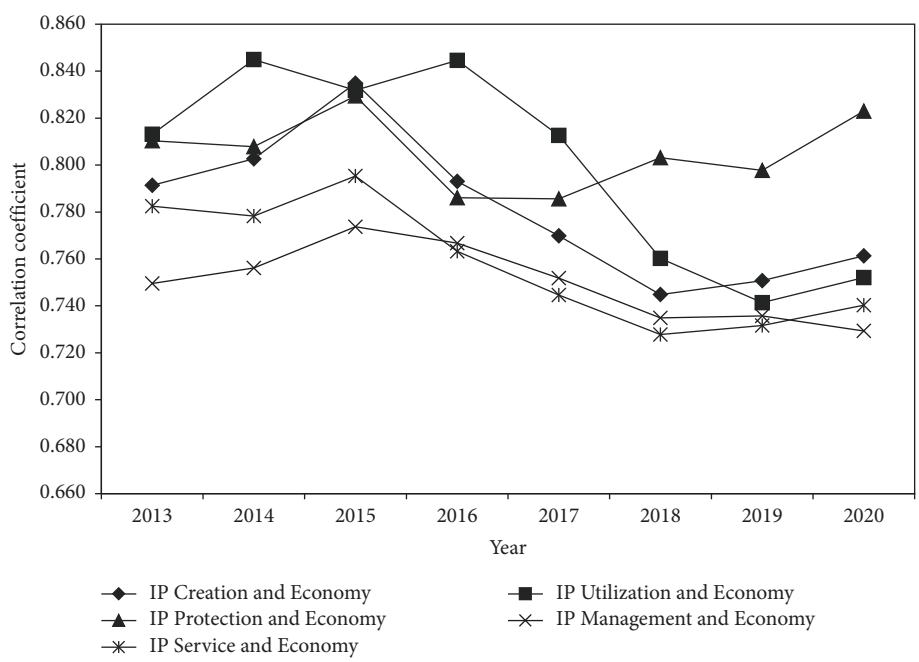

Figure 2: Changes in the correlation coefficient between the development subsystem of intellectual property and the high-quality economic development system.

relevance, while intellectual property management and services play a role in high-quality economic development by ensuring the protection, utilization, and creation of intellectual property, so their direct effect is weaker than the first three.

4.3. Analysis of Coupling Coordination. This paper uses SPSS Statistics26 and SPSSAU to calculate the coupling coordination degree between the two systems in each province from 2013 to 2020. The results are shown in Table 2. From a horizontal perspective, the coupling coordination degree of the two systems in each province has obvious uneven spatial distribution characteristics of "high in the east and low in the west" and "coastal region is better than inland." The coupling coordination degree of Guangdong, Beijing, and Jiangsu is of good coordination (the average value is between 0.8 and 0.9); Shanghai and Zhejiang are in the primary coordination stage (the average value is between 0.6 and 0.7); Shandong, Tianjin, and Hubei are in the bare coordination stage (the average value is between 0.5 and 0.6); seven provinces including Anhui and Fujian are on the

Table 2: The degree of coupling and coordination between the intellectual property development system and the high-quality economic development system.

Province	2013	2014	2015	2016	2017	2018	2019	2020	Average	Type
Guangdong	0.825	0.834	0.836	0.884	0.879	0.922	0.995	0.969	0.893	Good coordination
Beijing	0.863	0.870	0.841	0.877	0.870	0.854	0.855	0.867	0.862	Good coordination
Jiangsu	0.804	0.828	0.777	0.804	0.770	0.769	0.822	0.851	0.803	Good coordination
Shanghai	0.687	0.679	0.645	0.680	0.641	0.691	0.711	0.799	0.692	Primary coordination
Zhejiang	0.644	0.640	0.648	0.679	0.666	0.686	0.704	0.719	0.673	Primary coordination
Shandong	0.542	0.537	0.532	0.571	0.647	0.603	0.596	0.629	0.582	Barely coordination
Tianjin	0.676	0.639	0.619	0.609	0.534	0.504	0.505	0.565	0.581	Barely coordination
Hubei	0.478	0.482	0.497	0.520	0.493	0.487	0.515	0.540	0.502	Barely coordination
Anhui	0.448	0.453	0.472	0.499	0.481	0.510	0.501	0.540	0.488	On the verge of disorder
Fujian	0.469	0.474	0.481	0.516	0.478	0.487	0.498	0.504	0.488	On the verge of disorder
Shaanxi	0.421	0.395	0.409	0.427	0.412	0.431	0.591	0.582	0.459	On the verge of disorder
Hunan	0.463	0.413	0.397	0.454	0.461	0.448	0.510	0.507	0.457	On the verge of disorder
Henan	0.413	0.405	0.431	0.462	0.461	0.494	0.488	0.475	0.454	On the verge of disorder
Sichuan	0.415	0.398	0.383	0.397	0.436	0.444	0.496	0.467	0.430	On the verge of disorder
Liaoning	0.502	0.458	0.359	0.375	0.415	0.447	0.406	0.387	0.419	On the verge of disorder
Hebei	0.340	0.340	0.301	0.327	0.391	0.437	0.425	0.431	0.374	Mild disorder
Chongqing	0.357	0.365	0.391	0.344	0.340	0.364	0.405	0.405	0.371	Mild disorder
Guangxi	0.312	0.325	0.321	0.352	0.344	0.310	0.419	0.379	0.345	Mild disorder
Heilongjiang	0.346	0.325	0.309	0.322	0.315	0.327	0.315	0.383	0.330	Mild disorder
Jiangxi	0.299	0.265	0.281	0.291	0.311	0.348	0.410	0.399	0.326	Mild disorder
InnerMongolia	0.394	0.363	0.353	0.373	0.350	0.313	0.209	0.179	0.317	Mild disorder
Guizhou	0.310	0.247	0.213	0.316	0.345	0.363	0.235	0.251	0.285	Moderately disorder
Jilin	0.298	0.261	0.250	0.315	0.264	0.278	0.255	0.306	0.278	Moderately disorder
Hainan	0.323	0.218	0.309	0.272	0.324	0.229	0.228	0.261	0.271	Moderately disorder
Shanxi	0.274	0.240	0.252	0.253	0.301	0.262	0.252	0.254	0.261	Moderately disorder
Yunnan	0.255	0.218	0.213	0.245	0.269	0.261	0.260	0.235	0.244	Moderately disorder
Gansu	0.238	0.196	0.199	0.263	0.226	0.147	0.159	0.153	0.198	Severely disorder
Ningxia	0.138	0.149	0.157	0.155	0.162	0.204	0.194	0.233	0.174	Severely disorder
Xinjiang	0.198	0.123	0.171	0.175	0.148	0.161	0.162	0.159	0.162	Severely disorder
Qinghai	0.129	0.115	0.127	0.127	0.149	0.298	0.135	0.134	0.152	Severely disorder

verge of disorder (the average value is between 0.4 and 0.5); and the rest of the provinces have different degrees of imbalance, among which Gansu, Ningxia, Xinjiang, and Qinghai are in the stage of serious imbalance (the average value is between 0.1 and 0.2). Combining the comprehensive level of intellectual property and high-quality economic development in each province, it can be found that the development of intellectual property in most provinces lags behind high-quality economic development. From a vertical perspective, the degree of coupling and coordination between the two systems in most provinces has shown a slight increase, which is not only due to the sustainable virtuous circle between the two systems but also due to the implementation of the national strategy of "open up the whole chain of intellectual property" and "innovation-driven economic high-quality development."

From the perspective of the eight major economic regions, the coupling and coordination degree of the two systems in the eight major economic regions in China is quite different. The coastal area has the highest coupling coordination degree, followed by the middle reaches of the Yangtze River, the middle reaches of the Yellow River, and the northeast and southwest regions, and the northwest region has the lowest coupling coordination degree, which is only 0.107 (as shown in Table 3).

4.4. Regional Differences in Coupling and Coordinated Development. This part uses MATLABR2022a software to measure the Gini coefficient of the coupling coordination degree of the two systems and further explores the overall difference, intraregional difference, inter-regional difference, and the sources of the differences in the coupling and coordination degree of the two systems.

4.4.1. Overall Difference. The overall Gini coefficient of the coupling and coordination degree between the two systems is between 0.24 and 0.28. The overall difference shows a small range of repeated fluctuations, rising from 0.246 in 2013 to 0.277 in 2014, then declining to 0.243 in 2018, and finally rising again to 0.275 in 2020. Thus, it can be seen that the regional differences in the coupling and coordination degree of the two systems have shrunk to a certain extent and then becomes larger, and the overall difference shows a widening trend, but the changing trend is more moderate.

4.4.2. Intragroup Difference in the Eight Regions. From the perspective of intragroup difference, the Gini coefficient of the coupling coordination degree of the two systems on the southern coast is the largest, followed by the northern coast, indicating that the two systems in these two regions are the

Table 3: The mean value of coupling coordination degree of eight economic regions.

Region	Northeast region	North coast	East coast	Southern coast	Middle reaches of Yangtze River	Middle reaches of Yellow River	Southwest region	Northwest region
Average	0.342	0.600	0.723	0.551	0.443	0.373	0.335	0.107

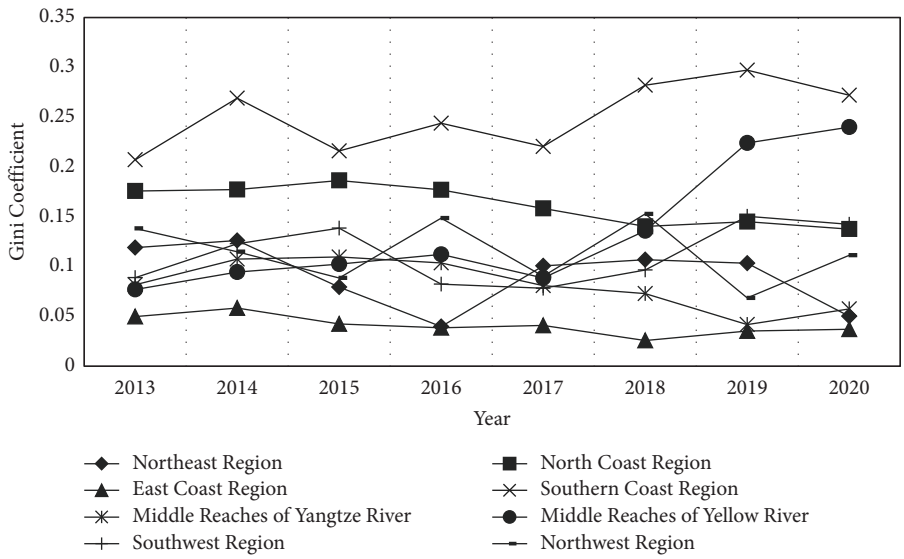

Figure 3: Evolution trend of Gini coefficient of coupling coordination degree.

most unbalanced in the coupling and coordinated development, and the main reason for this is that the coupling coordination degree of Fujian and Hainan provinces in the southern coastal area is far behind than that of Guangdong Province, and the coupling coordination degree of Hebei Province in the northern coastal area is far behind than that of Beijing and Tianjin. The Gini coefficient of the coupling coordination degree in the eastern coastal area is the smallest, indicating that the coupling and coordinated development of the two systems in this region have little differences. Judging from the variation trend of intragroup difference, the evolution trend of the Gini coefficient of the coupling coordination degree in the southern coastal, northwest, northeast, and southwest regions is not stable, showing a wave-like repeated change trend, and there are no rules to follow in the change direction of the coupling and coordinated development of the two systems. The Gini coefficient of the coupling coordination degree in the northern coastal, eastern coastal, and middle reaches of the Yangtze River showed a slight decrease, and the pace of the coupling and coordinated development of the two systems in the provinces in the region tended to converge. The Gini coefficient of the middle reaches of the Yellow River experienced a sudden increase after small-scale changes from 2013 to 2017, from 0.089 in 2017 to 0.240 in 2020, and the main reason is that the coupling coordination degree of Shaanxi Province increased rapidly after 2017, while the coupling coordination degree of Shanxi, Henan, and Inner Mongolia all decreased to a varying degree, which led to an increase in the intragroup difference in this region year by year, as shown in Figure 3.

4.4.3. Intergroup Difference in the Eight Regions. The intergroup difference is mainly reflected in the northwest region and the eastern coastal, northern, and southern coastal areas. Although the rise and fall of the intergroup difference in specific time are not completely consistent, the overall trend in 2020 compared to 2013 was that the intergroup difference increased. The regions with a small intergroup difference are not fixed, but the differences also show an overall upward trend. The intergroup difference between the middle reaches of the Yellow River and the middle reaches of the Yangtze River and the southwest regions was small in 2013, and the intergroup difference between the northeast and southwest regions was small in 2020, as shown in Table 4. To sum up, the interregional difference in coupled and coordinated development of China's intellectual property rights and the high-quality economy has shown an expanding trend, and the gap between the high-level coupled coastal economic zones and the low-level coupled inland economic zones has widened significantly. The large intergroup gap between the coastal area and the northwest area is mainly due to the influence of economic strength and geographical characteristics. The strong economic strength and convenient geographical location of the coastal areas have brought considerable market prospects and broad development space, attracted many high-tech enterprises to invest and high-quality talents to take root, and promoted the realization of a virtuous circle between intellectual property rights and high-quality economic development. However, the lack of economic vitality, remote geographical location, and weak ability to attract capital and talent in the northwest region has led to a low-level constraint on intellectual property and high-quality economic development.

Table 4: Intergroup Gini coefficients of eight economic regions.

	North coast	East coast	Southern coast	Middle reaches of Yellow River	Middle reaches of Yangtze River	Southwest region	Northwest region
Northeast region	0.269 (0.255)	0.375 (0.302)	0.303 (0.228)	0.213 (0.124)	0.161 (0.126)	0.118 (0.126)	0.358 (0.370)
North coast		0.145 (0.142)	0.239 (0.210)	0.278 (0.261)	0.146 (0.223)	0.288 (0.304)	0.572 (0.550)
East coast			0.242 (0.199)	0.359 (0.309)	0.228 (0.255)	0.389 (0.367)	0.646 (0.604)
Southern coast				0.324 (0.226)	0.233 (0.196)	0.317 (0.260)	0.546 (0.508)
Middle reaches of Yellow River					0.203 (0.110)	0.220 (0.111)	0.386 (0.363)
Middle reaches of Yangtze River						0.186 (0.149)	0.490 (0.412)
Southwest region							0.343 (0.305)

Note. Due to space limitations, this paper only gives the calculation results of the Gini coefficient between the eight economic regions in 2013 (in brackets) and 2020.

Table 5: The sources decomposition of regional differences in the coupling coordinated development.

Year	Intragroup contribution (contribution rate)	Intergroup contribution (contribution rate)	Hypervariable density contribution (contribution rate)
2013	0.014 (5.85%)	0.202 (81.91%)	0.030 (12.24%)
2014	0.017 (6.04%)	0.222 (80.05%)	0.039 (13.91%)
2015	0.016 (6.05%)	0.216 (81.58%)	0.033 (12.37%)
2016	0.015 (5.89%)	0.205 (80.61%)	0.034 (13.5%)
2017	0.014 (5.58%)	0.203 (83.26%)	0.027 (11.16%)
2018	0.015 (6.21%)	0.191 (78.34%)	0.038 (15.45%)
2019	0.017 (6.19%)	0.210 (76.99%)	0.046 (16.82%)
2020	0.016 (5.93%)	0.217 (79.01%)	0.041 (15.06%)
Average	0.016 (5.97%)	0.208 (80.17%)	0.036 (13.86%)

4.4.4. Sources and Contribution Analysis of Regional Differences in the Coupling Coordination Degree. In this paper, MATLABR2022a software was used to calculate the intragroup difference, intergroup difference, and the contribution rate of hypervariable density and further reveals the sources of regional differences in coupling coordination degree between the two systems. As shown in Table 5, the contribution rate of intergroup difference is between 76% and 84%, which indicates that the intergroup difference is the main reason for the regional differences in coupling coordination. The contribution rate of intragroup difference is between 5% and 7%, and the contribution rate of hypervariable density is between 11% and 17%, which contributes less to the regional differences in coupling coordination. Therefore, reducing the inter-regional difference has become a breakthrough point for realizing the coupled and coordinated development of intellectual property and a high-quality economy.

5. Conclusions and Recommendations

5.1. Conclusions. Based on the panel data of 30 provinces (autonomous regions and municipalities) in China from 2013 to 2020, this paper constructs the index system for the two systems of intellectual property development and high-quality economic development, uses the entropy weight method to calculate the comprehensive development index of the two systems, identifies the degree of correlation between the subsystems of a single system and the other system of intellectual property and high-quality economic development from the perspective of local correlation, measures the degree of coupling coordination between the two systems from the perspective of overall correlation, and uses the Dagum Gini coefficient to measure and decompose the space differences of coupling coordination degree, and the research conclusions are as follows.

First, from the perspective of local correlation, the development of economic openness and innovation are more closely related to the development of intellectual property rights, indicating that intellectual property matches high-quality economic development mainly by promoting economic openness and innovation. The protection, utilization and creation of intellectual property are more closely related to high-quality economic development, reflecting that intellectual property protection, utilization, and creation have become new engines to pull high-quality economic development.

Second, from the perspective of the overall correlation, the coupled and coordinated development of intellectual property and high-quality economy in various provinces show the obvious characteristics such as "high in the east and low in the west" and "coastal area is better than inland," and the development of intellectual property in most provinces lags behind the high-quality economic development. The

coupling coordination degree of Guangdong, Beijing, and Jiangsu are in the stage of good coordination; Shanghai and Zhejiang are in the initial stage of coordination; Shandong, Tianjin, and Hubei are in the stage of bare coordination, and seven provinces including Anhui and Fujian are in the stage of endangered-disorder, and the rest of the provinces have a varying degree of disorder. Among them, Gansu, Ningxia, Xinjiang, and Qinghai are in the stage of serious disorder. From the perspective of the eight major economic zones, the coupling coordination degree of the eastern coastal, northern coastal, southern coastal, and middle reaches of the Yangtze River are in the coordination stage, while the coupling coordination degree of the other four economic zones is in the stage of different degree of imbalance. The coupling coordination degree in most provinces shows a small increase, and the growth trend in high-level coupling areas is more common.

Third, from the perspective of regional differences and sources of differences in coupled and coordinated development, the overall difference in the degree of coupling and coordination between intellectual property and high-quality economic development in each province shows an expanding trend. The uneven development of provinces in the southern coastal and northern coastal regions resulted in the largest intragroup difference within the two regions, while the smallest intragroup difference was within the eastern coastal region. The intergroup difference is mainly reflected between the northwest region and the coastal region, echoing the character of the coupling coordination degree of "coastal is better than inland." The contribution rate of intergroup difference to the overall regional difference reaches 76%–84%, which proves that the intergroup difference is the main source of the overall regional difference. Therefore, reducing the intergroup difference should be regarded as a breakthrough point to reduce the overall regional difference.

5.2. Recommendations. Based on the above conclusions, this paper puts forward the following recommendations.

First, because the correlation between intellectual property development and economic open development and innovation development is the highest and the correlation between economic high-quality development and intellectual property protection, application, and creation is even higher, the key to improving the coupling and coordination degree between the intellectual property development system and the high-quality economic development system lies in tapping the coupling potential of intellectual property protection, utilization, and creation with the open economy and innovation economy. Firstly, follow the principles of industry orientation and demand traction, focus on innovation in key fields, key technologies, and key products, break through the bottleneck in the development of the innovation economy and improve the foreign export capacity of intellectual property and its products. Secondly, strengthen the protection of the whole chain of intellectual property, enhance the international awareness and international protection capacity of intellectual property of innovators, create an innovation ecosystem that respects the intellectual property, and establish a solid guarantee for the transnational flow of intellectual property rights. Thirdly, create an intellectual property operation channel for the whole value chain of "research-results-products-market-industry competitive advantage," taking supply demand coupling as the starting point and supply demand-medium tripartite cooperation as the guideline, build a multi-stakeholder community of government, industry, university, research, and application, which injects lasting power into the innovative economy and open economy.

Second, according to the conclusion of the study, the coordinated development of the two systems in each province shows the characteristics such as "high in the east and low in the west" and "coastal are is better than inland," and this is an important idea to promote the coordinated development of the regional economy and the coordinated development of the regional intellectual property. The government should do a good job in the top-level design of the coordinated development of the regional economy and the coordinated protection of intellectual property and give preferential policies to the less developed regions according to local conditions to break down the barriers to the flow of information and resource elements between regions. Developed coastal areas should implant the concept of coordinated regional development, actively play a role in radiation and drive, appropriately relax intellectual property protection while safeguarding their intellectual property development, and actively build an open-source innovation ecosystem so that their experience and achievements in intellectual property development and high-quality economic development can benefit to the low-level coupling regions. Regions with low-level coupling should take advantage of external forces and cultivate internal strength to embark on a differentiated path of coordinated coupling development of intellectual property and a high-quality economy. For example, the northwest region should seize the opportunity of the "the Belt and Road" construction, introduce knowledge-based talents and high-tech enterprises to consolidate the foundation of its knowledge economy, learn from the experience of high-level coupling regions, give full play to its comparative advantages in resource and environment, and achieve the positive interaction between intellectual property and high-quality economic development.

Third, the study found that most provinces' intellectual property development lags behind high-quality economic development, which seriously restricts the coupling of the two. Therefore, we should focus on the synergetic development of intellectual property and a high-quality economy. The study found that the development of intellectual property in most provinces lags behind high-quality economic development, which seriously restricts the coupling between the two. These regions should further release the energy of intellectual property to high-quality economic development and explore the path of intellectual property development empower to high-quality economic development in frontier regions. For example, the digital economy in Beijing and Shanghai accounts for a large proportion of

GDP, but the insufficient high-end supply, low production efficiency, the emphasis on technology investment over process implementation, and the emphasis on supply over demand are still prominent. These regions should actively use intellectual property creation to solve the pain points of the core technology in the production field being restricted by others, overcome the difficulties of confirming, flowing, and safeguarding rights with digital technology through intellectual property protection, correct the deviation of paying attention to technical input and ignoring process implementation through the operation of intellectual property, improve the efficiency of digital technology research and development, protection, and implementation through intellectual property management, and connect the gambling points of digital technology supply and demand through intellectual property services. The development of intellectual property rights in Hubei, Hunan, Guangxi, Sichuan, Liaoning, Heilongjiang, and other places is at the middle level. These regions should find the weak links of intellectual property development as soon as possible to achieve precise breakthroughs in a targeted manner. For example, Heilongjiang Province has a large output of scientific and technological achievements and strong intellectual property protection capabilities, but the development of intellectual property operations and services lags, resulting in the less local transformation of scientific and technological achievements and a serious outflow situation. Therefore, actively promoting the supply, demand, and intermediary to form a joint force to solve the problem of local operation of intellectual property is the top priority. The development of intellectual property rights in western regions such as Yunnan, Gansu, Ningxia, Xinjiang, and Qinghai is in the last echelon. These regions should face up to the gap, clarify the orientation of intellectual property development, and make full use of their resource endowment advantages to take the road of character development. For example, Yunnan and Xinjiang have inherent advantages to develop geographical indications that benefit from the unique natural conditions. Therefore, they should actively consolidate the foundation of resources of geographical indications, expand the application and promotion of geographical indications, formulate scientific and reasonable development plans for geographical indications industries, and promote geographical indications as a new driving force for high-quality economic development.

This paper is based on the provincial panel data from 2013 to 2020. Due to the limited access to data, the index system constructed is not comprehensive enough. This paper uses grey correlation analysis to measure the association of each subsystem with the system, the method has low data requirements and less workload. The calculation steps are well thought out and can largely reduce the loss due to information asymmetry. However, the grey correlation analysis method requires the current determination of the optimal value of each indicator, and the concepts of "optimal value" and "curve similarity" are not clearly defined, which makes it difficult to determine the optimal value of some indicators in the grey correlation method due to the strong subjectivity. In the future, the new formula of the grey correlation method will be expected to improve this limitation by correcting the normality of the method and adopting the TOPSIS idea for standardization from the grey correlation discriminatory criteria and normality requirements. This paper uses the Dagum Gini coefficient method to analyze regional differences in the coupling and coordination of intellectual property and economic high quality. The Dagum Gini coefficient method can not only effectively explain the sources of regional disparities but also overcome the defects of crossover of samples between subgroups, which has obvious advantages for studying regional nonequilibrium problems, but the analysis of the sources of regional differences is only from the overall perspective, which is relatively simple and can be done in the future by variance decomposition and other methods to clarify the main sources of structural differences based on each subsystem subdimension.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest with this paper.

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