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Research Article

Regional Economic Upgrading and Development Based on Digital and Intelligent Innovation

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In the development process of the social era at that time, the concept of regional economic upgrading and development was in a very important position. Realizing the conversion of old and new kinetic energy to promote high-quality economic development is the focus of economic work at present and in the future. This study mainly discusses the upgrading and development of regional economy based on digital and intelligent innovation. Through the analysis of the influencing factors of the total economic volume and its growth rate, this study has a preliminary understanding of the development advantages and disadvantages of each district, county, and city in the process of regional economic upgrading. Through the comprehensive evaluation of the regional economic development of the province, it can obtain the distribution of the development degree of each district, county, and city and the comprehensive competitiveness of the regional economy. To sum up, a quantitative analysis has been carried out on the status quo of the provincial regional economic development. It uses a grayscale prediction model to predict the future of digital economic development, intelligent innovation, and regional economic development. The grey prediction model is a prediction method that establishes a mathematical model to make predictions through a small amount of incomplete information. Based on the past and present development laws of objective things, it uses scientific methods to describe and analyze future development trends and conditions and form scientific assumptions and judgments. The study found that province A ranked first in the comprehensive index of digital economy development. With its superior geographical location, it has become the vanguard of reform and opening up. It has been committed to the construction of the national digital economy innovation and development pilot zone and has achieved remarkable results, increasing from 0.6302 in 2017 to 1.317 in 2021. It ranks second in the comprehensive development index of economic growth. Province A increased from 0.4501 in 2017 to 0.8177. Province B ranks second in terms of the comprehensive digital economy development index, increasing from 0.5504 in 2017 to 1.1340 in 2021. Province B, with strong economic strength and prosperous trade, ranked first in the composite economic growth index, increasing from 0.4527 in 2017 to 0.8514. The upgrading of regional economic structure is an important way to achieve high-quality economic development in the new era. In the process of upgrading the regional economic structure, there are changes in factor allocation, resource consumption intensity, input-output efficiency, and environmental quality, which have a certain impact on economic development. This research will help to promote the process of regional economic upgrading and development.

1. Introduction

Since the reform and opening up, the economy has continued to grow. The rapid economic development has brought a series of negative effects, especially the unbalanced development of regional economic upgrading. Due to the innate resources in different regions, the development strategies of local governments, and other factors, regional economic upgrading and development may be unbalanced. However, with the continuous advancement of technology, this imbalance of development has gradually become unbalanced. The widening gap between the rich and the poor will eventually lead to relatively serious social problems, which will further hinder the development of the economy.

The issue of regional economic upgrading and development has attracted great attention from the state and governments at all levels. It puts forward corresponding policies in many aspects, makes corresponding layouts, and takes corresponding remedial measures.

In the process of China's economic transition from high-speed growth to high-quality development, the digital economy has played an extremely important key driving role. The rapid development of the digital economy is unprecedented. The scale of its digital economy and the growth rate of digital economic development are rapidly rising. Although developed countries are still in the first camp of digital economic development, China, as an emerging country in digital economic development, ranks at the forefront of the world. The upward momentum is rapid and there is great potential for future development. At present, in order to create an important new driving force for future economic development, governments in various regions of China are attaching great importance to the further development of the digital economy. At the same time, China is fully entering a digital age. The popular use of the Internet has also promoted the rapid development of information technology.

This research briefly expounds the research background of this paper's digital economy, the research review of digital economy, research content and methods, purpose, and significance, as well as the innovations and deficiencies of this research. It is based on a comprehensive and clear understanding of existing research results. It mainly combs the literature from three aspects: research on the development of digital economy in other countries, research on the relationship between digital economic development and economic growth, and research on grayscale prediction models. After the relevant literature research, it has laid a solid foundation for the empirical research on the coupling and coordination degree between the digital economy and economic growth. The study found that the weight of the digital industry scale dimension is 0.308. Among them, the top three weights are internal expenditure of R&D funds ($w = 0.098$), full-time equivalent of R&D personnel ($w = 0.093$), and number of R&D institutions ($w = 0.071$). R&D funding generally refers to research and experimental development funding.

2. Related Work

There are many constraints in the development of regional economic upgrading. Caropreso C believed that the promotion of rail systems could represent a useful policy to rebalance mode choice and reduce private car use, especially in high-density environments. Clearly, an increase in ridership is only possible if the generalized costs associated with public transport (i.e., the weighted sum of time and monetary costs) decrease. According to recent literature and current professional practice, most strategies to achieve this goal are based solely on infrastructure interventions. This may not be feasible or sufficient in densely populated environments [1]. Kenderdine argued that China's transition economy experiment continues to rely heavily on state-driven industrial policies to structure the economy. He discussed industrial upgrading and innovation policy planning for national strategic emerging industries, regional innovation and industrial cluster planning, and space and marine industry strategies. He placed China's policy trajectories of industrial development, technological innovation, and upgrading in the context of institutional economic analysis [2]. Han believed that regional economic integration can enhance the comprehensive strength and competitiveness of development zones. Through the systematic comparison of the changes in the labor market in the transformation and upgrading of the three major special economic zones, the reform experience is obtained. Urbanization promotes urban employment, industrial agglomeration attracts different types of employment, and labor market system reform promotes labor coordination [3]. Landesmann and Stöllinger believed that the global economy has been undergoing rapid structural changes. Their aim is to assess these developments in order to support their place in the current global context [4]. Their research lacks forecasts for regional economic development. To solve this problem, it refers to the previous literature and proposes digital and intelligent innovation to optimize it.

It is of great significance to study the utility of industrial digitization for sustainable economic development. It is a key issue to promote the transformation of economic structure and achieve regional sustainable development. MD Reuver believed that as digital platforms are transforming nearly every industry today, they are slowly entering the mainstream information systems (IS) literature. Digital platforms are a challenging subject of study because of their distributed nature and interweaving with institutions, markets, and technologies. Due to the exponential growth in the scale of platform innovation, the increasing complexity of platform architectures, and the spread of digital platforms to many different industries, new research challenges have emerged [5]. Scott et al. examined the impact of adopting SWIFT on bank performance. It is a web-based technical infrastructure and a set of global interbank telecommunications standards [6]. Henfridsson et al. believed that digital innovation introduces a new open value landscape for anyone seeking to create or capture new value [7]. Mirra and Garcia examined the ideologies that underpin traditional American forms of civic education and participation. They also offer an alternative vision of civic life based on systemic inequality and the struggle for social justice. Their analysis culminated in a new conceptual model of civic learning and engagement. This model pushes past engagement into the realm of inquiry and innovation [8]. The uneven growth of China's regional economy will affect the coordination and sustainability of the regional economy and even the entire country's economic development. This issue has drawn extensive attention from the Chinese government and all sectors of society. Although there is an important link between industrial intelligence and economic benefits, there is still little empirical research on whether and how industrial intelligence can improve the sustainable development of the Chinese economy. The following sections will introduce the digitalization and intelligent economy.

3. Regional Economic Upgrading and Development Methods

3.1. Regional Economic Upgrading and Development. Regional economics theory originated in the middle of the 20th century. The area includes not only the interaction of various factors within the system, but also a certain connection between the inside of the system and the outside of the system. Regional economy is the result of the distribution of the national economy to various administrative regions. It is a complex formed by the public action of internal and external factors related to economic activities. Regional economic development is the process of changing the original economic scale, economic structure and economic benefits in the process of interaction and mutual influence between the economic factors within the region and the economic factors between different regions. With the continuous deepening of economic development, a country will also have the problem of unbalanced development. Regions with good location advantages and resource endowments can achieve rapid economic development, and their development quality is also better. And without these advantages or conditions, the economic development speed is slow and the quality of economic development is poor. This unbalanced development among regions will lead to low economic efficiency and poor quality of economic development in the whole country. The development of regional economy is affected by various factors such as location, population conditions, and industrial layout. In different historical periods, different social development needs also put forward different requirements for the connotation, thought, and strategic layout of regional economic development. Since the founding of the People's Republic of China, China's regional economic development has gone through four stages: the idea of balanced regional economic development, the idea of regional economic development of "rich first and then rich," the idea of coordinated development of regional economy, and the idea of coordinated regional development. Since the 18th National Congress of the Communist Party of China, China's economy has not been as good as the stage of high-quality development. The main characteristics of high-quality economic development include the following: the tertiary industry, the contribution rate of innovation to economic growth has increased significantly, and the economic structure has been continuously optimized. High-quality economic development has raised China's economic development to a new level of symmetrical economic structure and sustainable economic development. However, in the process of promoting social and economic construction, the differentiation of regional economic development, as an important feature of China's regional economic development, is a major challenge in the process of high-quality economic development. Due to the differences in the economic development conditions of various regions, it is necessary to focus on local conditions when alleviating the problem of unbalanced regional economic development. It is necessary to play the leading role of core cities, urban agglomerations, and economic belts. At the same time, combined with the connotation of regional economic development, the concept of innovative and coordinated development is taken as a favorable way to alleviate the problems of regional economic development in China's new era. Innovation is used to drive economic development and build a modern economic system.

3.2. Digital Innovation. Digital information and knowledge are the elements that support and drive the digital economy. It enables the digital representation of all social activities, including actions and outcomes. Today, the production of digital information is endless and has formed an inestimable scale. The concept of "digital economy" is a companion of the Internet. In the rise of the digital network, the US Department of Commerce took the lead in discovering that it can reduce the consumption of industrial production and change the original situation of low employment and high inflation. It helps to coordinate the balance of supply and demand and uses the "digital economy" to describe this phenomenon. Since then, the digital economy has attracted the attention of many institutions and countries. Digital economy refers to the economic form of human society in the information and network environment based on computer and modern communication technology.

Throughout the theoretical elaboration of digital economy at home and abroad, it combines the experience and characteristics of digital economy construction. The so-called digital economy covers a range of economic behaviors, such as those rooted in digitized knowledge and information, using ICT. The digital organization and management, production transactions, daily consumption, cooperation and exchanges, social governance, etc. have changed the inherent mode of single association and economic operation. It can also be understood as the continuous integration and refinement of various resource elements in the economic and social fields based on the technical means represented by modern network technology. It aims to promote the productivity of factor labor, improve the level of factor coordination, realize efficient and accurate economic and social construction, and facilitate high-quality life and production. People call this economic situation supported by information technology the digital economy.

3.3. Intelligence. The idea of intelligent regional economic development is shown in Figure 1. Because the integration of intelligence and digitalization can have a very important impact on the upgrading of regional economic and industrial structure from many aspects, but the related research is relatively small. This paper has a clear understanding of the actual situation of the integration of intelligence and digitalization in various provinces and cities through the influence of the integration of intelligence and digitalization on the regional economic and industrial structure in various provinces and cities in China. Then it explores the impact of the integration of intelligence and digitalization in the development of regional economy and industry. Finally, it is clear about the problems that need to be paid attention to in

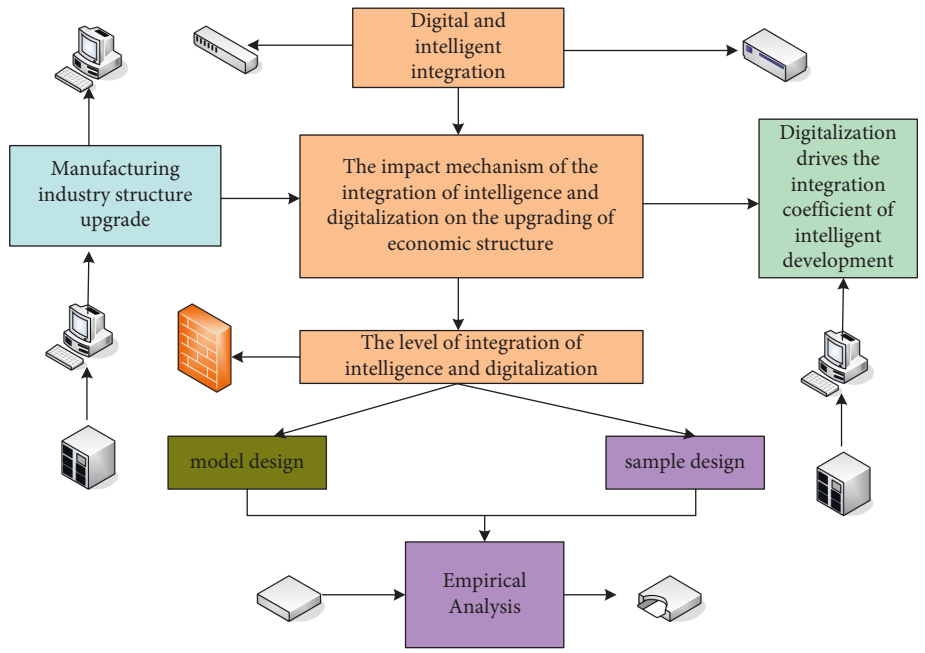

Figure 1: Ideas for the development of intelligent regional economy.

the process of upgrading the regional economic and industrial structure. This is very helpful for relevant departments to take effective policy measures and then promote the upgrading of regional economic and industrial structure. Therefore, this paper studies the impact of the level of intelligence and digital integration in various regions of China on the upgrading of regional economic and industrial structure. It has very important theoretical and practical significance. Through a series of studies, this paper can have a clear understanding of the development of China's intelligence and digitalization, as well as the development of the integration of the two at different levels, and can put forward relevant development opinions in this regard. Moreover, it can also focus on the research results of the upgrading of regional economic and industrial structure for the integration of intelligence and digitalization. And based on this, it formulates the development policy to realize from "manufacturing power" to "manufacturing powerhouse" [9].

3.4. Mechanism of Regional Innovation to Promote Economic Development. The continuous and steady growth of regional innovation capability in a region is the driver of the region's economic development. It makes the economic development of the region show strong vitality. On the contrary, if the regional innovation capacity of a region is declining, the economic development of the region will be greatly restrained and limited. Through the effective allocation of resources by the market, various institutions and facilities in the region can be effectively deployed. In this complete environment, various elements such as capital, human resources, science and technology, information resources, and knowledge will be attracted to this area in large quantities. The corresponding regional innovation investment capacity will be greatly enhanced. The attracted human resources use the corresponding knowledge, facilities, and other elements to convert the attracted raw materials, capital, science and technology, and other elements into new commodities, new technologies, and new services required by the regional market. From an innovation perspective, it examines the well-known principle of input-output effectiveness. And based on this research, each unit subject leading innovation activities in the regional innovation system will be significantly improved in terms of economic benefits and new achievements in technology. At the same time, if a high-quality macro- and microenvironment is created in the above process, the absorption and utilization efficiency of the output of innovation activities will be further optimized. Through the transformation of innovation achievements by the market, the region will be promoted to produce more innovation achievements in economic, social, and other aspects. The above process will greatly promote the improvement of the comprehensive strength of regional innovation according to relevant theories. The improvement of the comprehensive ability of regional innovation will further promote the economic development level of the region. Specifically, it is mainly the regional innovation input, regional innovation output, and regional innovation performance in the regional innovation environment that jointly promote the development level of the regional economy. Generally speaking, regional innovation mainly realizes the promotion of regional economic development indirectly through the promotion of the following aspects. That is, regional innovation promotes the upgrading of regional industries, promotes the formation of new markets in the region, and forms and develops industrial clusters, thereby promoting the economic development of the region.

(1) Regional innovation promotes the renewal and upgrading of regional industries. The innovation

capability of a region has been continuously improved. The development and utilization of new technology produces more new products. And then gradually replace the technology and products in the traditional industry, so that the industrial structure is based on a new foundation. The level of industrial competitiveness determines the comprehensive core competitiveness of a region. Innovation has improved labor productivity in the region, stimulated market demand, and formed new industrial growth points. It promotes the emergence and development of emerging industries with excellent structure, promotes the renewal and upgrading of regional industries, and thus greatly promotes economic development.

(2) Regional innovation promotes the formation of new markets in the region. The continuous improvement of the innovation ability of a region will not only promote the progress of science and technology and the production of new products, but also attract more innovative subjects to join the scientific and technological innovation. Then, it will further stimulate the market demand, which will lead to the expansion of investment scale. Corresponding market development activities will arise, forming new markets and finally promoting regional economic growth.

(3) Regional innovation promotes the formation and development of regional industrial clusters. Regional innovation will lead to the refinement of various types of labor in society and the centralized development of various specialized types of work. This will promote a variety of professional technology-based enterprises to gather separately to form specialized clusters. With the continuous deepening of this specialized cluster development, it will further form a "growth point" that promotes regional economic development. With the continuous expansion of its scale, economies of scale are gradually reflected. In this way, the production cost in the development of regional economy can be reduced, and the comprehensive competitiveness of the region can be greatly improved indirectly. The improvement of the quality of a region's economic development requires a high-quality industrial structure. The idea of economic development should abandon the outdated traditional model and gradually transform into a model with knowledge and technology as the leading elements. To realize the abovementioned transformation, regional innovation bodies need to continuously accumulate and diffuse elements such as knowledge, information, capital, and human resources. In this way, new technologies are generated to promote the upgrading and transformation of the traditional industrial structure. At the same time, cooperation, exchanges, and communication among innovative entities are also required.

Based on the elaboration of the above three points, the mechanism of regional innovation on economic development is shown in Figure 2. The abovementioned mechanism of regional innovation on economic development is in the traditional sense. Today, social development has entered a new era, and economic development has also entered a "new normal." The macroenvironment has changed dramatically. After entering the innovation-driven stage, the fundamental driving force of China's economic development has changed from capital investment, enhancement of domestic demand, and foreign trade scale to technological innovation. The importance of innovation has thus been significantly increased. Going deep into the specific links of innovation to promote economic development, the recent emergence of big data and AI technology (Artificial Intelligence, the English abbreviation is AI. It is a new technical science that studies and develops theories, methods, techniques, and application systems for simulating, extending, and expanding human intelligence) has profoundly changed the efficiency and quality of the government and intermediary agencies to provide innovative resources and services for innovative actors. The investment of innovation resources is more market-based. The government only plays the role of guidance and support. At the same time, new products and technologies based on big data and AI technology can not only promote economic growth in traditional ways, but also serve as a key element in improving service treatment and efficiency in an innovative environment, thereby achieving a circular promotion effect. In the context of the new era, the role mechanism of regional innovation on economic development also has a new connotation [10].

3.5. Measurement of Intelligence and Digital Integration Level Based on the Coordinated Development Coefficient Model. In this paper, the two variables of region and time are introduced into the fusion model of intelligence and digitization in the form of nonparameter. Then build a model of the integration and coordinated development of intelligence and digitalization, so as to calculate the coefficient of integration of intelligence and digitalization. Here, this paper defines the intelligence-promoting digital fusion coefficient as follows: in period t, the intelligence level IDF, the required level of digital development, and all provinces and cities in the sample period are at the same intelligence level IDF. The required gap is in the maximum possible digital development level. Similarly, the fusion coefficient of digitization to promote intelligence can be defined as follows: in period t, the difference between the digitization level required by digitization level INF and the maximum possible intelligence development level in all provinces and cities in the sample in this period. The smaller gap here indicates that the integration of intelligence (digitization) to promote the development of digitalization (intelligence) is relatively high. Therefore, in period t, the fusion coefficient of a certain province and city i intelligence to promote digitalization can be defined as [11]

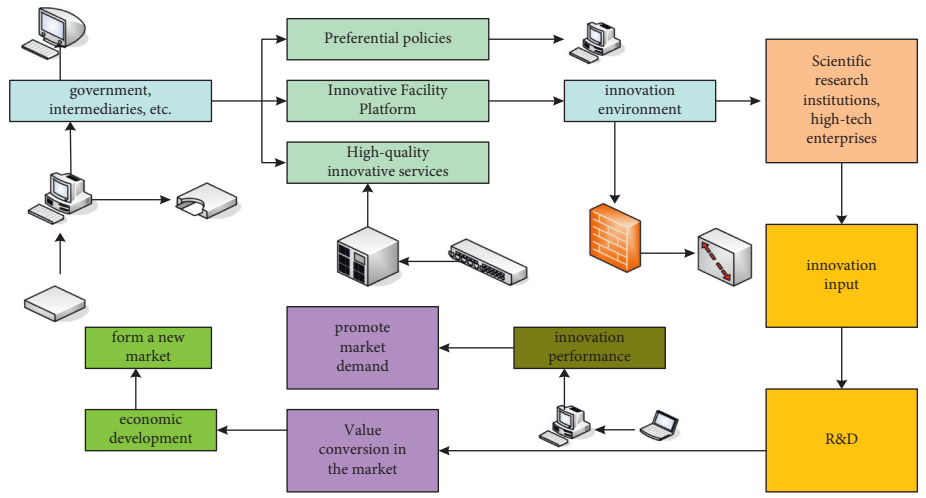

Figure 2: The mechanism of regional innovation on economic development.

$$I_C = \exp\left(g\left(\mathrm{IDF}, i, t\right), \max\left(\mathrm{IDF}, j, t\right)\right). \tag{1}$$

Similarly, in period t, the fusion coefficient of the digitalization of a province and city driving the development of intelligence can be defined as [12]

$$I_{C2} = \exp\left(f\left(\mathrm{INF}, i, t\right), \max\left(\mathrm{INF}, i, t\right)\right). \tag{2}$$

According to the judgment method of the coordinated development coefficient, the integration level of intelligence and digitization can be measured [13]:

$$C_{\mathrm{Ct}} = \frac{\min\left(IC_1, IC_2\right)}{\max\left(IC_1, IC_2\right)}. \tag{3}$$

The intelligent and digital fusion coefficient $C_{Ct} \in [0, 1]$; the closer its value to 1, the higher the level of intelligent and digital fusion. On the contrary, the closer it is to 0, the lower the level of integration of intelligence and digitalization is.

3.6. Comprehensive Calculation of Digital Economy Index. The entropy method is a mathematical method used to judge the degree of dispersion of an indicator. The greater the degree of dispersion, the greater the impact of the index on the comprehensive evaluation. The entropy value can be used to judge the degree of dispersion of an indicator. Since the entropy value method can fully obtain the original data information, overcome the randomness of subjective selection of indicators, and have the characteristics of scientific objectivity and hierarchy, this method is selected to determine the weight of indicators [14]:

$$\beta_\theta = \min\left(\mu_\theta\right). \tag{4}$$

The specific steps are as follows: Set the variable μ_θ as the index value of the jth order parameter of the ith province in the θth year that constitutes the coupling system, with a total of r years, n cities, and M indexes.

(1) Standardization of indicators. In order to eliminate the inconsistency of units and dimensions among various indicators, it is necessary to standardize the data before determining the weights. Let [15]

$$\alpha_\theta = \mu_\theta. \tag{5}$$

Then for the positive index, the larger the value of α_θ, the higher the order degree of the subsystem. The smaller the value, the lower the order of the subsystem. Negative indicators are just the opposite. Its calculation formula is as follows [16]:

$$\begin{aligned} \mu_{\theta 1} &= \left[\frac{\left(\mu_{\theta 2} - \beta_2\right)}{\left(\alpha_{\theta 1} - \beta_2\right)}\right] * 0.8 + 0.2, \\ \mu_{\theta 2} &= \left[\frac{\left(\alpha - \mu_{\theta 2}\right)}{\left(\alpha_{\theta 1} - \phi_2\right)}\right] * 0.8 + 0.2. \end{aligned} \tag{6}$$

(2) Calculation of the proportion of each region in different years under the j indicator P_B:

$$P_B = \frac{\mu}{\sum\sum \mu_1^*}. \tag{7}$$

Calculate the entropy value S_j of the index j:

$$S_j = -\frac{1}{k}\sum\sum P_B \ln P_B. \tag{8}$$

Among them,

$$k = \ln\left(M\right), \tag{9}$$

M is the index value [17].

Calculate the coefficient of variance g_c:

$$g_c = 1 - ej. \tag{10}$$

(3) Calculate the weight Z_Q of each index of each system [18]:

$$Z_Q = \frac{G_j}{\sum G}. \tag{11}$$

3.7. GM (1, 1) Model and Forecast of Regional Economic Development. At present, through the analysis of the influencing factors of the total economic volume and its growth rate, it has a preliminary understanding of the development advantages and disadvantages of each district, county, and city. Then through the comprehensive evaluation of the regional economic development of the province, it roughly knows the distribution of the development degree of each district, county, and city and the comprehensive competitiveness of the regional economy. To sum up, a quantitative analysis has been made on the status quo of provincial and regional economic development, and it is necessary to have an expectation for the future. Therefore, it is now necessary to study and analyze the development trend of the provincial regional economy. Based on the research on the comprehensive evaluation of the province and region, it knows the comprehensive score of the economic development of each district, county, and city in the past five years. The grey GM (1, 1) model is used to forecast the economic development trend in the next three years. In order to have a reasonable forecast of future trends, it needs to be based on the comprehensive evaluation of provincial and regional economic development in the past few years. If time series forecasting is used, the data requirement is very large. For this kind of data with a short age, this study uses a grey model to predict. It is a prediction that eventually forms an exponential function by accumulation.

Letting the time series $Y^{(0)}$:

$$Y^{(0)} = \left(y^{(1)}(1), y^{(1)}(2), y^{(1)}(3), \ldots, y^{(1)}(n)\right), \tag{12}$$

where $Y^{(0)}$ has n observations, and then the corresponding differential formula of the GM (1, 1) model is [19]:

$$\frac{dY^{(1)}}{dt} + aY^{(1)} = b. \tag{13}$$

In the formula, a is called the development grey number and b is called the endogenous control grey number.

Letting $\hat{a}$ be the parameter vector to be estimated:

$$\hat{a} = \begin{pmatrix} a \\ b \end{pmatrix}. \tag{14}$$

Using the least squares method to estimate the parameter sequence to solve, it can get [20]

$$\hat{a} = \begin{pmatrix} a \\ b \end{pmatrix} = \left(B^T B\right)^{-1} B^T Y_n. \tag{15}$$

Among them,

$$B = \begin{bmatrix} -\frac{1}{2}\left[Y^1(1) + Y^1(2)\right] & \cdots & 1 \\ \cdots & \cdots & \cdots \\ -\frac{1}{2}\left[Y^1(n-1) + Y^1(n)\right] & \cdots & 1 \end{bmatrix}, \quad Y_n = \begin{pmatrix} x^0(2) \\ \vdots \\ x^0(n) \end{pmatrix}. \tag{16}$$

It solves the differential equation to get the predictive model:

$$Y(k+1) = \left[Y^{(0)}(1) - \frac{b}{a}\right]e^{-k} + \frac{b}{a}. \tag{17}$$

4. Results of Regional Economic Upgrading and Development

This paper uses the data of 31 provinces in China from 2017 to 2021 as the research data. The four indicators of the number of R&D institutions in the scale of the digital industry, the internal expenditure of R&D funds, the full-time equivalent of R&D personnel, and the number of effective invention patents in the high-tech industry in the digital innovation capacity are taken from the "China Science and Technology Statistical Yearbook." The data related to the proportion of fixed investment in the ICT industry in the total investment in the whole society come from the National Bureau of Statistics and are calculated through the proportion [21–23]. The added value of the primary industry, the added value of the tertiary industry, the industrial added value in the digital lagging industry value, and the total economic volume, China's gross domestic product GDP, per capita wealth per capita GDP, economic growth rate GDP growth rate in the economic growth subsystem, and the other six indicators come from the "China Statistical Yearbook". In terms of data processing, linear interpolation was used to fill in missing data. The descriptive statistics on the digital economy and economic growth indicators are shown in Table 1. The data on indicators such as digital economy development and economic growth are sourced from the "China Science and Technology Statistical Yearbook," "Statistical Report on China's Internet Development Status," and "National Statistical Yearbook".

It standardizes the data of each subindicator of the digital economy and economic growth. Using the extreme value entropy weight method to calculate the weight of each index, the results are shown in Table 2. According to the standardized index values and their weights, and according to the statistical results of the weights, the weight of the digital infrastructure dimension is 0.333. Among them, the top three weights in descending order are the ipv4 number ($w = 0.097$), the number of domain names ($w = 0.092$), and the Internet port access ($w = 0.073$). The weight of the digital industry scale dimension is 0.308. Among them, the top three weights are the internal expenditure of R&D funds ($w = 0.098$), the full-time equivalent of R&D personnel ($w = 0.093$), and the number of R&D institutions ($w = 0.071$). The weight of the dimension of digital innovation capability is 0.066. The weight of the digital lagging industry value dimension is 0.294. Among them, the weight rankings from high to low are industrial added value ($w = 0.142$), primary industry added value ($w = 0.080$), and tertiary industry added value ($w = 0.072$). In the economic growth subsystem: the weight of the economic aggregate dimension is 0.534. The weight of the per capita wealth dimension is 0.398. The weight of the economic growth dimension is 0.068.

Table 1: Descriptive statistics on digital economy and economic growth indicators.

Coupling system	Indicator layer	Mean	Standard deviation
Digital economy subsystem	Primary industry added value	67.71	4979.07
	The value added of the tertiary industry	174.71	51751.17
	Industrial value added	39.73	37931.77
Economic growth subsystem	GDP gross domestic product	507.46	99945.11
	GDPE2 per capita (ten thousand yuan)	1.31	15.31

Table 2: The results of calculating the weight of each index using the extreme value entropy weight method.

First-level indicator	Secondary indicators	Weights
Digital infrastructure	Internet port access	0.0731
	Internet penetration	0.0372
	Number of R&D institutions	0.0717
Digital industry scale	Internal expenditure of R&D funds	0.0979
	Full-time equivalent of R&D personnel	0.0934

According to the standardized index values and their weights, the comprehensive index of the digital economy development system and economic growth development system in each region is shown in Figure 3. Province A and B have the best development. With its superior geographical location, A province has become the vanguard of reform and opening up. It has been committed to the construction of the national digital economy innovation and development pilot zone and has achieved obvious results. The comprehensive index of digital economy development ranks first, increasing from 0.6302 in 2017 to 1.317 in 2021. The comprehensive development index of economic growth increased from 0.4501 in 2017 to 0.8177, ranking second. The comprehensive development index of digital economy in province B has increased from 0.5504 in 2017 to 1.1340 in 2021, ranking second. The economic growth composite index of B province with strong economic strength and prosperous trade increased from 0.4527 in 2017 to 0.8514, ranking first. Province C ranks third in both economic growth index and digital economy development index. Provincial D ranks fourth in the country in terms of economic growth index and digital economy growth index. The economic growth index and the digital economy development index have similar development trends in each province (city, district). High-index areas are mainly concentrated in the eastern regions of A, B, C, D, E, and other provinces.

The digital economy index in eastern China generally shows an upward trend year by year. Among them, province F saw a decline in the digital economy composite index in 2018 and then changed little. The digital economy index of province A has ranked first among all eastern regions every year from 2017 to 2021 and will continue to widen the gap thereafter. Relatively speaking, province F has little change in the digital economy from 2017 to 2021. The digital economy index remained almost at around 0.2. The digital economy index of the eastern region is shown in Figure 4.

The digital economy index in central China is generally lower than 0.7. Among the central provinces and cities, the digital economy of H province has developed better, leading other provinces and cities. And the index rose from around 0.4 in 2017 to above 0.6 in 2020, which is a good breakthrough and leap. Figure 5 shows the statistics of the digital economy index in western China.

From the perspective of provincial and municipal averages, the provincial and municipal averages of the coordination degree of China's digital economy and economic growth from 2017 to 2021 are between 0.5113 and 0.6322. The highest value is 0.6322, and the lowest value is 0.5113. Since 2017, there has been a slight upward trend on the whole, indicating that the overall level of coordination between the digital economy and economic growth has continued to improve during this period, and the development has been relatively stable. Figure 6 shows the provincial and municipal average comparison of the degree of coordination between the digital economy and economic growth. The essence of the coordination degree of economic growth is to achieve the coordination of speed, structure, and efficiency, coordination of population, resources, and environment, coordination of investment, consumption, and export, and coordination of urban and rural development and regional development in accordance with the requirements of the scientific concept of development, thus, promoting the sound and rapid development of the economy.

The results of the coordination level between the digital economy and economic growth in various provinces and cities in China show that the first- and second-ranked provinces A and B have a coupling coordination degree between 0.8 and 0.9, which is in good coordination. The coupling coordination degree between the digital economy and economic growth in the third and fourth provinces C and D is between 0.7 and 0.8, which is in the middle level of coordination. The coordination level results are shown in Figure 7.

The calculation results of the coupling coordination degree model reflect the coupling coordination degree of the provincial regional innovation system and the economic development system. In order to further reflect the results of the empirical analysis more intuitively, combined with the specific characteristics of the empirical analysis in this study, the number of the coupling coordination degree levels of the provincial regional innovation system and the economic development system is divided into intervals as shown in Table 3. The digital economy is organically combined with economic growth. Combined with the theory of digital

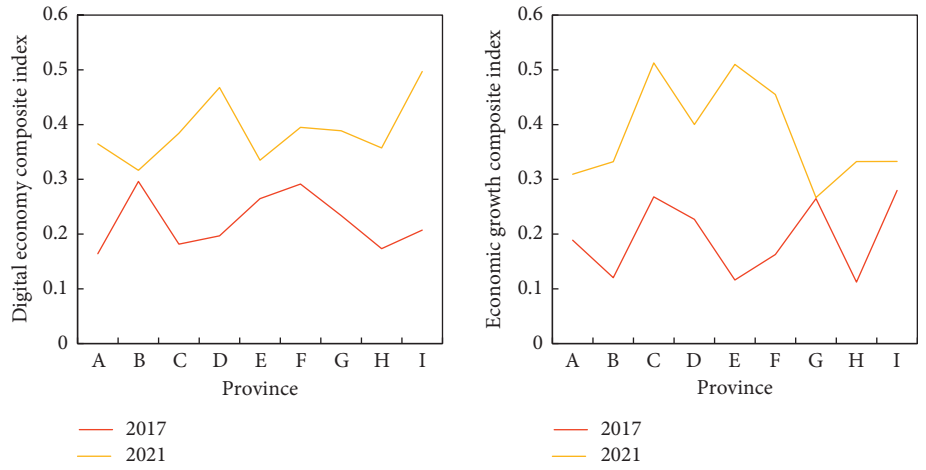

Figure 3: Comprehensive index of digital economy development system and economic growth development system in each region.

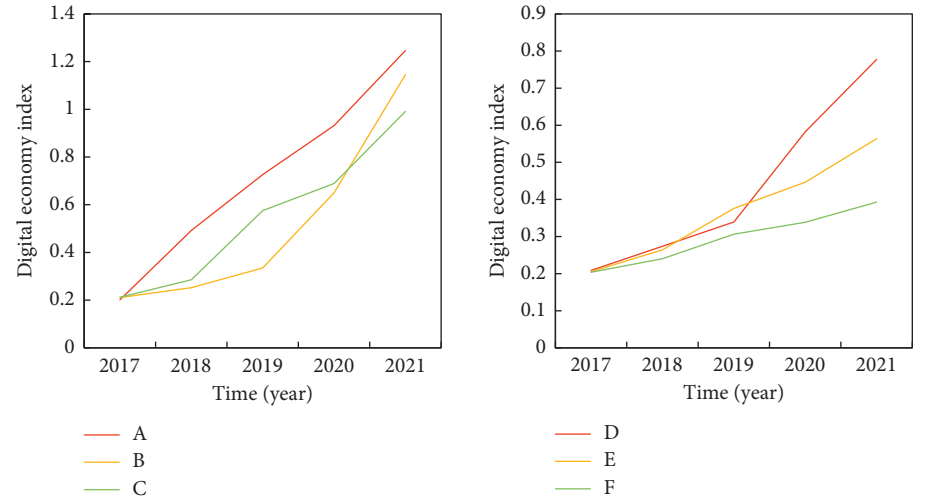

Figure 4: Digital economy index in eastern region.

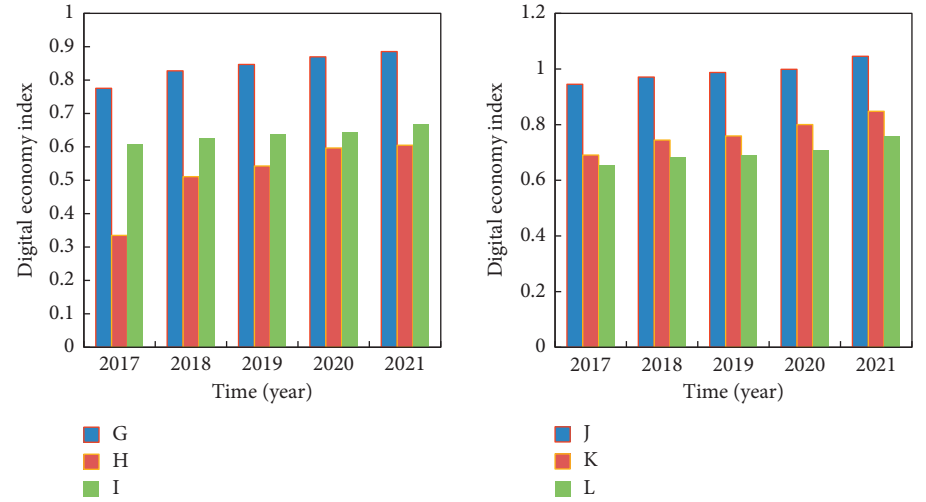

Figure 5: Statistics of digital economy index in western regions.

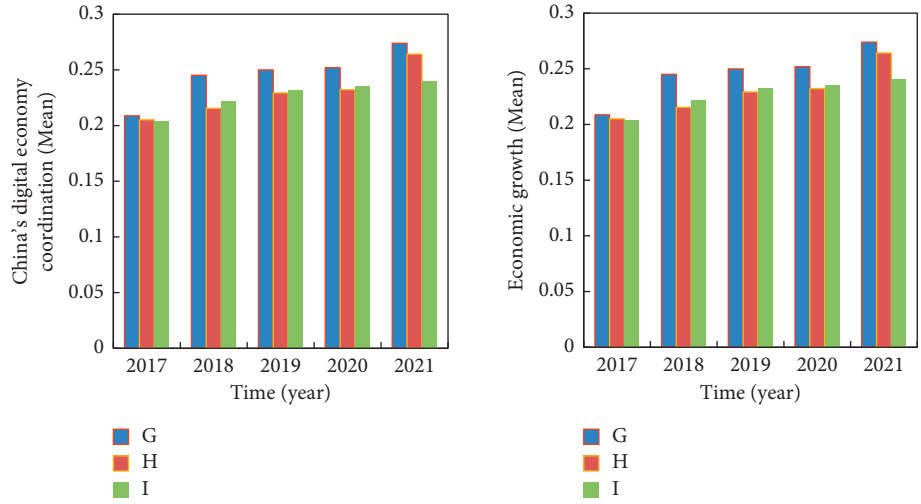

Figure 6: Provincial and municipal averages of the degree of coordination between the digital economy and economic growth.

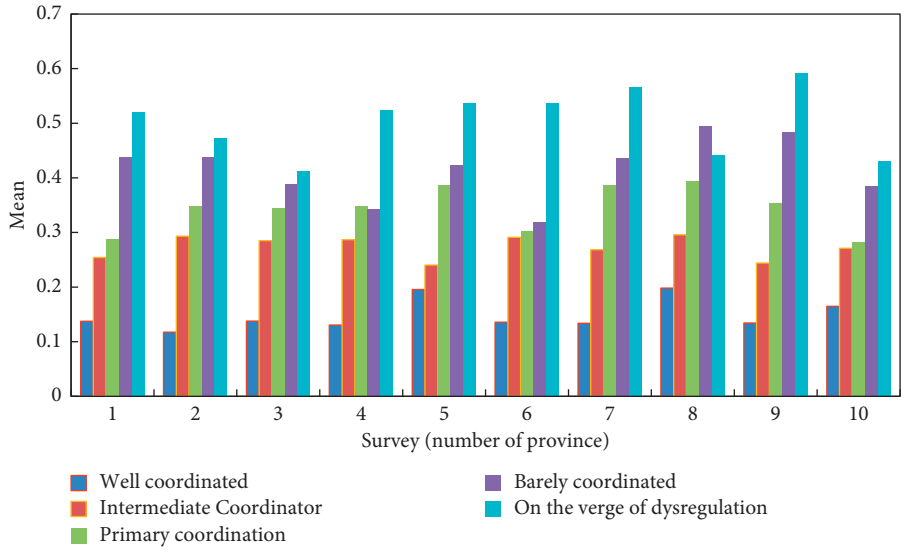

Figure 7: Coordination level results.

Table 3: Quantitative division criteria for the degree of coupling and coordination between the provincial regional innovation system and the economic development system.

Ranges	Level
$0 < D \leq 0.3$	Low coordination coupling
$0.3 < D \leq 0.5$	Moderately coordinated coupling
$0.5 < D \leq 0.8$	Highly coordinated coupling
$0.8 < D \leq 1$	Extremely coordinated coupling

economy and the coupling coordination degree model, the conclusion is drawn on the degree of coordinated development between digital economy and economic growth in China and various provinces and cities.

In the 2017 data, the difference between the regions with the highest coupling coordination and the regions with the lowest coupling coordination is 0.7055. It can be seen that the gap between regional development is significant. The comparison between the economic development index and the regional innovation index is shown in Figure 8. Over the past five years, the economic development system of M province has been running relatively smoothly. However, its regional innovation system started in 2015, and the comprehensive evaluation index has dropped significantly. This also reflects a decline in its regional innovation capacity. Since the decline is not large, the impact of this downward trend on economic development is not obvious. From 2013 to 2015, the regional innovation index of M province was higher than the economic development index. However, a higher regional innovation index has a weaker pulling effect on the economic level. The main reason is the low innovation performance and the low value conversion rate of innovation achievements. From 2015 to 2017, the stabilizing effect of economic development on regional innovation was also weak. It shows that the regional economic development results are less invested in innovation. Looking back at the

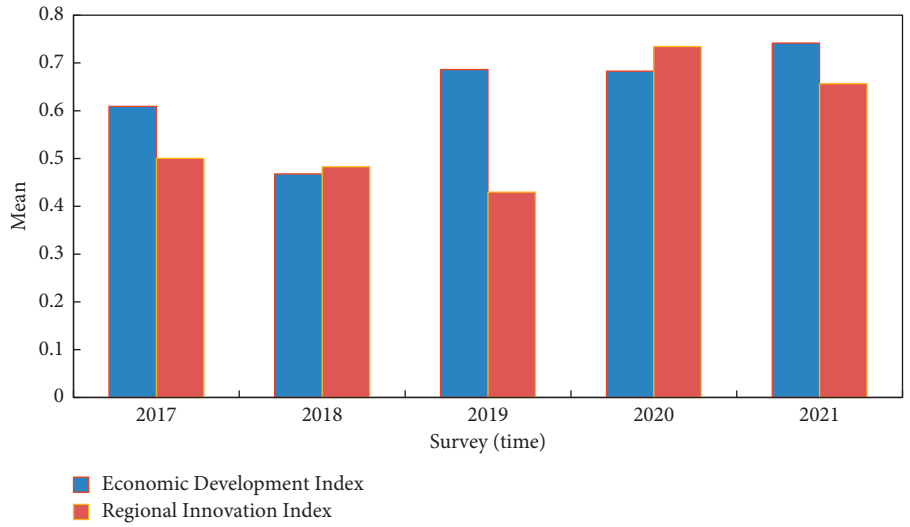

Figure 8: Comparison of economic development index and regional innovation index.

Table 4: Economical level of some regions in the country.

Province	2018	2019	2020	2021
A	0.695	0.601	0.627	0.647
B	0.642	0.604	0.622	0.623
C	0.634	0.634	0.645	0.622
D	0.572	0.610	0.621	0.697

original data, the reasons for the decline of the regional innovation comprehensive index in M province are the decline in the number of researchers and experimenters and the reduction in the ratio of local financial science and technology appropriations and government funds to R&D expenditures. The above are the reasons for the current situation of the coupling development of the two systems in the M province.

The economical level of some regions in the country is shown in Table 4. As far as the national regional economic level is concerned, by 2021, the average value of China's regional economic level will increase from 0.552 to 0.633. This is also directly related to actively taking measures to promote regional economic transformation and upgrading and strive to improve regional economic competitiveness. In order to comprehensively evaluate the regional economic development reasonably, it is necessary to establish a relatively complete set of economic development index system. In order to construct an economic indicator system, it needs to analyze the economic aggregate and various influencing factors of its growth.

5. Conclusion

Since the 18th National Congress of the Communist Party of China, China has put forward a major national strategy of "innovation-driven development." Actively implementing the "innovation-driven development" strategy can rapidly improve China's level of independent innovation, the quality of workers, and the innovation capability of related management work in various fields. This paper systematically sorts out the connotation and research of the core concepts of industrial intelligence. It uses the factor analysis method based on the improvement of entropy value to comprehensively measure the comprehensive level and geographical distribution of regional economic development in China's provinces and cities. On this basis, the intelligent development index of regional economic development obtained after the evaluation is taken as the observation factor. It adopts a fixed effect model to analyze the mechanism of action of regional economic development intelligence on sustainable development of regional economy, that is, economic scale growth, industrial structure transformation and upgrading, and environmental biased technological progress. This paper aims to build a scientific and effective evaluation system to measure the intelligence level of regional economic development in various regions of China and to clarify the internal correlation between the intelligence of regional economic development and the sustainable development of regional economy. This provides theoretical support and empirical evidence for relevant management departments to rationally formulate intelligent development policies and promote high-quality and sustainable economic development. Accordingly, an economic development framework with technological innovation as the core point and innovation-driven as the key guiding feature can be constructed. Economic intelligence is an evolving concept. Judging the regional economic intelligence level of a region involves many aspects and multidimensional content, and there are many related discipline systems. Limited by the

availability and operability of research data, the indicators and evaluation methods used in this paper still have certain limitations. Future research needs to be more refined and standardized to measure the development level of regional economic intelligence. Future research can expand the sample area and enhance the comprehensiveness of the research on the impact of industrial structure upgrading on the high-quality economic development of Guangdong and Guangxi.

Data Availability

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

Conflicts of Interest

The authors state that this article has no conflicts of interest.

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