Research Article

Innovative Economic Development Path Using Double-Cycle New Pattern Data Discovery for Industrial Internet of Things

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The use of smart sensors and actuators to improve industrial and manufacturing processes is known as the industrial internet of things (IIoT). Innovative economic growth is one of the key elements required for the success of IIoT in contemporary industry. Innovation in IIoT is essential for fostering high-quality economic growth and achieving a competitive edge. This study aims to conduct in-depth research on the development path of an innovative economy based on data mining under the new pattern of double circulation in order to enhance industrial innovation capability, realize the modernization of the industrial chain, and accelerate the development of industrial innovation in IIoT. The first step is to use the five urban agglomerations for path analysis of innovative economic development. The five metropolitan agglomerations' pertinent facts are provided, and their industrial structure's composition and proportion as well as the input and output of innovation are all examined. We then constructed a model for analyzing the link between technological innovation and economic growth. The investigation of the innovative economic development path based on data mining is achieved using the Microsoft time series technique and the expectation-maximization algorithm to examine the data of innovative economic development. The experiment demonstrates that the method proposed in this study has strong data mining stability and ideal data clustering advantages. In IIoT, it can be used to effectively increase data mining's efficiency and innovation capacity for the growth of a knowledge-based economy and creating a new pattern in which innovation and market growth are mutually reinforcing.

1. Introduction

In IIoT, instead of relying on a tangible connection to a particular object, the innovation economy relies on individuals' inventiveness to develop and execute new concepts, goods, and services. A company's ability to adapt and face the difficulties of change frequently depends on innovation [1]. It encourages growth because stagnation can be harmful to any company. In today's extremely competitive environment, it is essential to achieve organizational and economic success through innovation. Innovation helps to boost economic growth, which is one of its key advantages. In other words, innovation can increase productivity, which is the ability to produce more with the same amount of input [2]. The economy expands as productivity increases and more products and services are produced.

With the development of the industrial internet of things, the new double circulation pattern aims to improve the stability of China's economic development by taking the demand for China's economic development as its primary priority. We employed the domestic circular economy's smoothness to create a new, large circular economy system, which grows gradually and improves the industrial chain and supply chain, as well as reduces the country's reliance on external and international markets [3]. The full use of China's advantages in super-large-scale economic markets develops China's advantages in participating in international competition and cooperation under the new circumstances, thereby strengthening the initiative of China's economic opening up and thus creating a new pattern of double circular economic development. All of them are dependent on increased industrial innovation capacity, and it follows

that increasing the growth of the industrial innovative economy is essential for implementing the new model of double circulation development [4].

In the field of IIoT, some developed nations have made their objective to slow down China's transformation and upgrading, especially with developments in the global competition of science and technology between China and other developed countries. China's core technology has not been effectively developed in recent years using IIoT, and its development has been seriously hampered, reflecting the poor quality of innovation in China [5]. This has slowed down the industrial chain, supply chain, and innovation of China's important strategic industries in the development process. The majority of the fundamental technologies for industrial development are ineffectively developed [6]. Therefore, strengthening industrial innovation capacity is essential for achieving industrial upgrading and modernizing the industrial chain. It has a special role in the formation of the new double-cycle pattern. Therefore, by using the industrial internet of things, the direction of industrial innovation and economic development is studied in this article.

The innovations of this study are as follows:

(1) Using the five urban agglomerations, we perform a path analysis of innovative economic development, present the pertinent data of the five urban agglomerations, and analyze the composition and proportion of the industrial structure of the five urban agglomerations, as well as analyze the innovation input and output and construct an analysis model of innovative technology and economic development. Then, the data of innovative economic development are explored using the Microsoft time series technique and the expectation-maximization algorithm, and the data mining study of the innovative economic development path is carried out.

(2) The approach outlined in this research study offers optimum data clustering benefits and excellent data mining stability when compared with previous creative economic growth route analyses. It can significantly increase the effectiveness and capacity for the invention of data mining for creative economic growth and create a new pattern where innovation and market are mutually reinforcing.

The remaining parts of the study are structured as follows: Section 2 is the related work. Section 3 is the research on the development path of the innovative economy using data mining for IIoT. Section 4 is the analysis of the IIoT's multiagent innovation economy's development path. Section 5 is the experimental result, and section 6 is the conclusion of the study.

2. Related Work

In the field of IIoT, enhancing industrial innovation capabilities can successfully implement the modernization of the industrial chain against the new double circulation pattern. Therefore, the innovative economy's growth trajectory is carefully examined. Bai et al. [7] conducted the Yangtze River Economic Belt panel data analysis from 2008 to 2018, to estimate the degree of provincial digital economy growth and examined the effects of regional innovation capability on digital economy development using the spatial Dobbin model. The study's findings indicate that the degree to which the digital economy is developing significantly affects the industry's capacity for innovation and contributes to the advancement of both product and technological innovation. The development of the innovative economy is negatively impacted by the research matrix. The level of economic development, the input of financial resources for scientific research, and the input of human resources influence the growth of the innovative economy. Therefore, it enhances the industrial technology connections and resource sharing, removes obstacles to innovation and growth of the digital economy, allocates innovation resources effectively, enables precise resource input for innovation, and raises the application level of the digital economy. However, this approach does not enhance industrial innovation capacity. Yi [8] proposed a method for completing the transition from the conventional economic mode to the intelligent mode and the quantitative growth mode, with the goal of extending the development space of the digital economy to the real economy. The development level of the digital economy and the innovation efficiency of high-tech panel data from 30 Chinese provinces are used to assess and analyze the businesses between 2014 and 2020, and the impact of the digital economy on the innovation efficiency of high-tech industries is empirically tested. The findings of the investigation indicate that the growth of the digital economy can significantly increase the effectiveness of industrial innovation. However, the efficacy of technical industrial innovation is influenced by economic progress although the impact has continuously diminished due to regional and industrial heterogeneity. The innovative efficiency of the industry that develops the innovative economy can be significantly increased by the growth of the innovative economy in China. The growth of the digital economy has a significant impact on the communication equipment manufacturing and electronic sectors. As a result, various recommendations for development are made, including the effective growth of the digital economy and an increase in research and development (R&D) spending, although the implementation of these ideas is difficult. Zhang et al. [9] used nonphysician practitioner (NPP)/VIIRS day/night band (DNB) data as well as pertinent information permitted by provincial patents and developed a geographically weighted regression model to analyze the spatial clustering of the number of patents granted in 31 provinces from 2013 to 2018, except for Hong Kong, Macao, and Taiwan. This model examines technological innovation's effects on economic development. It is based on the results of Moran's I measurement and Lisa's clustering. The results of the experimental study demonstrate that there is a substantial polarization in the geographical distribution of technical innovation in China, with low levels of creativity in the central and western regions and a concentration of

invention in the eastern coastal districts. Governments have created strategic policies that are appropriate for the growth of innovation in the local area and those which enhance the quality and transformational path of patents, increase investment in innovative research and development, enhance the intensity of economic opening, strengthen the mechanism of innovation cooperation among provinces, and create an ideal innovation system. However, this method does not improve the efficiency of innovative economic development. Litvinenko [10] increased the degree of opening up the western area and supported the high-level growth of the open economy in light of the new pattern created by the large-scale development of the western region in the new age. The characteristics of Western open economy is relatively small development scale and low competitiveness. China's western economy can avoid several drawbacks, such as weak competitiveness and poor internal and external connection, because of the new design, which places China's massive cycle at its center and supports the expansion of both domestic and worldwide double cycles. We thereby create an innovative pilot zone that combines the import absorption and transformation accumulation zone with the innovation technology system in response to new growth points and development prospects. The western area can use multilevel development channels to promote both external growth and regional development. However, it has the ability to coordinate and optimize the construction and market issues as well as the opening management mechanism. It can utilize open innovation as a platform to support the coupling of linkage and economic marketization. Due to the realization of the elements affecting the flow of commodities, creative economic development can progressively transit into high-quality development. However, this article does not propose specific measures.

3. Research on the Development Path of Innovative Economy Using Data Mining for IIoT

The IIoT is a subcategory of the Internet of Things (IoT) that focuses on its applications and uses cases in contemporary industries and manufacturing and is well suited to the architecture of intelligent manufacturing industries. An innovative economy in the IIoT aims to realize new ideas, originate them, and propose policies that will promote the growth of new approaches [11]. The economics of innovation is becoming increasingly important as countries are shifting from industrial production models to a knowledge-based economy. Instead of the physical attribution to a specific product, the creative potential of citizens to develop and execute new ideas, products, and services is used to study increasingly massive datasets and to enhance market segmentation using IIoT [12]. This section of research on the development path of the innovative economy using data mining for IIoT is further divided into the following subsections.

3.1. Data Description

3.1.1. Overview of Urban Agglomeration.
The five largest urban agglomerations in China are used in this article to analyze the data. The Yangtze River Delta, Beijing Tianjin Hebei, the Pearl River Delta, the middle sections of the Yangtze River, and Chengdu Chongqing are considered China's five urban agglomerations. The five metropolitan agglomerations collectively cover 993200 square kilometers. In Figure 1 [13], the specifics of the five metropolitan agglomerations are displayed. China's five largest urban agglomerations' population densities and per capita gross domestic product (GDP) are displayed in Table 1 for the year 2019.

According to the statistics in Table 1, there are certain discrepancies between different urban agglomerations' levels of innovation, scientific research, international exchange, and collaboration. Population density and per capita GDP are used for measuring an urban agglomeration's present degree of innovation and economic growth. The urban agglomeration's population density and the regional yearly GDP are positively correlated. Among the five urban agglomerations, the Pearl River Delta urban agglomeration has the greatest per capita GDP and the largest population density. Compared with the other four urban agglomerations, there has been a greater overall degree of innovation and economic development. In addition, the Yangtze River Delta urban agglomeration has the lowest population density among the five urban agglomerations, but it has a higher per capita GDP because it has institutions for scientific research and foreign exchange, as well as the growth of innovation fields speeding up the increase in per capita GDP [14].

3.1.2. Composition and Proportion of Industrial Structure.
The industrial structure is shown in Figure 2. The tertiary industry in China is larger than the secondary industry, and the secondary industry cares about the primary industry, according to its five major industrial structures. The proportion of industrial structure in the five urban agglomerations varies significantly, nonetheless, and some industrial elements, including the Beijing Tianjin Hebei Urban Agglomeration Research Institute and high-tech, are quite advanced. Beijing Tianjin Hebei urban agglomeration, one of the five main urban agglomerations, has the highest percentage of tertiary industry. In addition to Shanghai, which is regarded as the financial hub, the Yangtze River Delta urban agglomeration benefits from improved topographical circumstances and two provinces (Zhejiang Province and Jiangsu Province) where the Internet of Things is relatively advanced. In the urban agglomeration of the Yangtze River Delta, the tertiary and secondary industries are comparatively balanced, producing an economy of coordinated cooperation and scientific labor division [15]. The Chengdu Chongqing urban agglomeration, which has been controlled by Chengdu for the past two years, has a strong
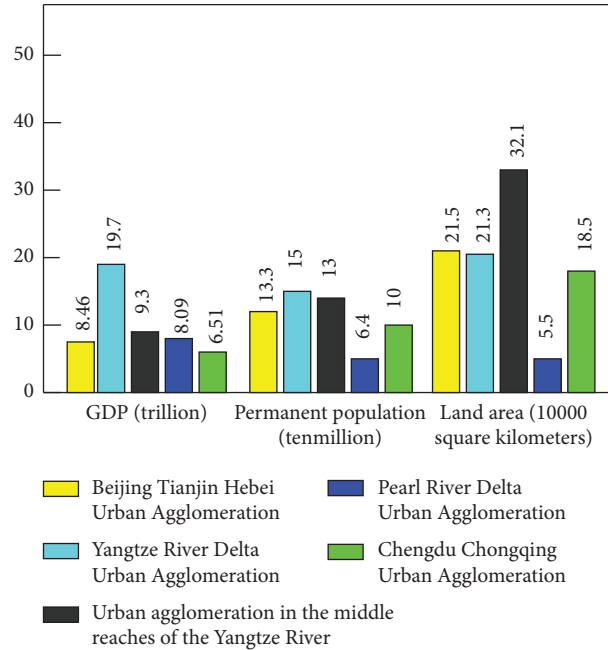
FIGURE 1: Basic data about China's five largest metropolitan agglomerations.

TABLE 1: Statistics of population density and per capita GDP of the five largest urban areas in China in 2019.

Urban agglomeration	Population density (person/km^2)	Per capita GDP (10000 yuan)
Beijing Tianjin Hebei urban agglomeration	525.7	7.48
Yangtze River Delta urban agglomeration	707.4	13.12
Middle Yangtze River urbanization	398.6	7.22
The urban agglomeration of the Pearl River Delta	1163.5	13.57
Chengdu Chongqing urban agglomeration	540.4	6.50

historical backdrop, beautiful natural surroundings, and a rapidly expanding high-tech zone that fuels the growth of the urban innovative economy. The neighborhood is developing extremely quickly.

3.1.3. Input and Output of Innovation. The R&D industry specifically refers to research and development industries. The development of the R&D industry represents the innovation level largely, as shown in Figure 3. The number of employees for the R&D institutions in Beijing Tianjin Hebei Urban Agglomeration ranks first among the five urban agglomerations. This is primarily related to the top universities and scientific research facilities in the nation being located in the Beijing Tianjin Hebei Urban agglomeration, which has a greater capacity for knowledge production that supports the growth of regional innovation. The Yangtze River Delta urban agglomeration is among the five urban agglomerations in terms of investments in research and development projects. A cultural province with numerous top-notch universities includes the Jiangsu Province. In comparison to the other five major urban agglomerations, the urban agglomeration has the best capacity for knowledge generation. The innovation indicators of the Yangtze River

Delta urban agglomeration are relatively uniform and have an important foundation for high-quality innovation and development [16]. The Chengdu Chongqing urban agglomeration tops the list of the five urban agglomerations for the innovation process in terms of invention authorization, patent authorization, and patent application. In several areas, including human resources, innovation capacity, and innovation input-output, it is fairly balanced. As seen in Figure 4, the international exchange cooperation platform introduces and puts into practice externally great innovation knowledge to support the improvement of innovation accomplishments.

Figure 4 shows that, among the five urban agglomerations, the urban area in the middle of the Yangtze River has the lowest number of workers and the lowest contribution to the R&D industry. There are no core cities in the area because of the wide disparity in inventive skills and the low degree of innovation and development, such as scientific research level. Therefore, to promote innovation and coordinated growth, the urban agglomerations in the middle reaches of the Yangtze River must take advantage of the new pattern of double circulation and must absorb outside knowledge and top talent through the huge circulation. [17].
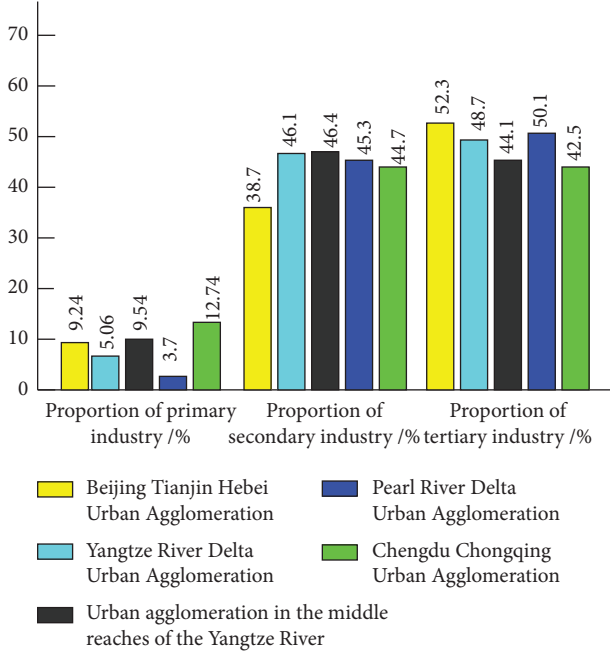
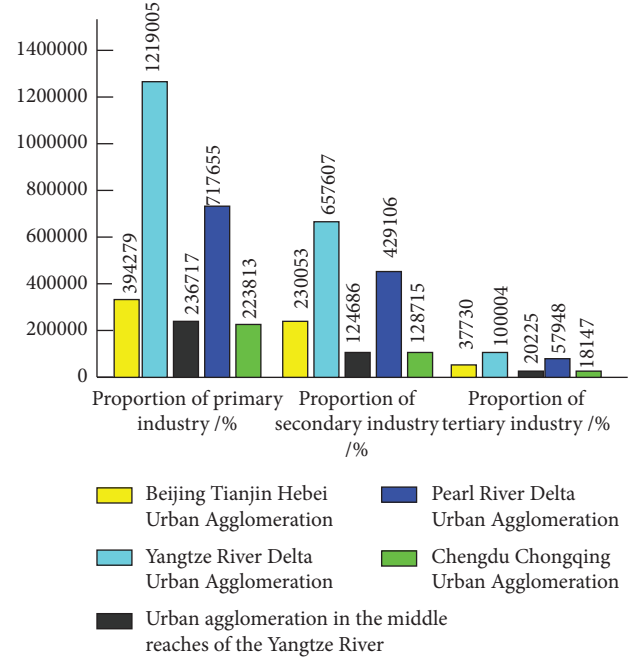FIGURE 2: Proportion of industrial structure types of the five major urban agglomerations in China.

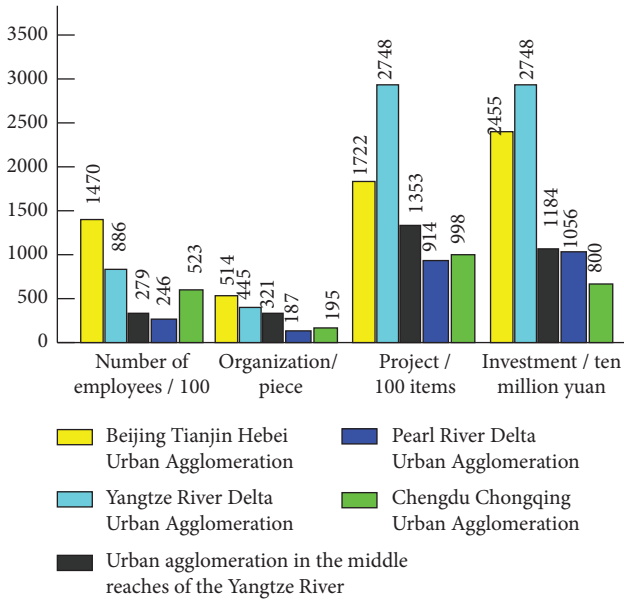FIGURE 4: Statistics of innovation achievements in the five urban agglomerations in China.

FIGURE 3: Statistics of the R&D industry development in the five urban agglomerations of China.

3.2. Model Building.

The relationship between innovative technology and economic development can be represented as

$$\text{eco}_{i,t} = \alpha_1 + a\text{eff}_{i,t} + \beta_{i,t}X_{i,t} + \varepsilon_{i,t}. \tag{1}$$

In equation (1), $\text{eco}_{i,t}$ represents the economic development level of the city i in the t-th year, $\text{eff}_{i,t}$ represents the efficiency of technological innovation in the city i in the t-th year, $X_{i,t}$ represents the controlled variable, and a represents the total effect of technological innovation on the economic development level.

The relationship between technological innovation and digital economy development is

$$de_{i,t} = \alpha_2 + b\text{eff}_{i,t} + \gamma_{i,t}X_{i,t} + \varepsilon_{i,t}. \tag{2}$$

In equation (2), $de_{i,t}$ represents the level of digital economic development of the city i in the t-th year and b represents the effect of independent variables on intermediary variables.

The relationship between digital economic development and regional economic development is as follows:

$$\text{eco}_{i,t} = \alpha_3 + \lambda \, de_{i,t} + \Phi_{i,t}X_{i,t} + \varepsilon_{i,t}. \tag{3}$$

In equation (3), λ the coefficient represents the impact of digital economic development on regional economic development.

The intermediary effect of the digital economy can be verified as

$$\text{eco}_{i,t} = \alpha_4 + c\text{eff}_{i,t} + d \, de_{i,t} + \Psi_{i,t}X_{i,t} + \varepsilon_{i,t}. \tag{4}$$

In equation (4), c represents the effect of technological innovation on economic development after adding intermediary variables and d represents the effect of digital economic development on the economic development level [18].

4. Analysis of the IIoT's Multiagent Innovation Economy's Development Path

To get accurate results and influence the growth of the innovative economy, it is crucial to pick certain economic

development-related data, preprocess the economic data, and apply data analysis and mining because the economic study of innovation is reliant on technology from earlier data. The novel economic data are mined and analyzed using the Microsoft time series approach, and economic indicators are forecasted. The essential data of the prediction indicators are mined and examined using the clustering technique.

4.1. Microsoft Time Series Method.
The historical time points can be used to calculate the autoregression in a specific time t to obtain the predicted value of the current time. Considering n previous time points, the functional relationship of t at the current time point can be obtained as follows:

$$X_t = a_1 X_{t-1} + a_2 X_{t-2} + \cdots + a_n X_{t-n} + \varepsilon_t. \tag{5}$$

In equation (5), X_t represents the predicted value at a time t, a_i represents the coefficient of autoregression at a time i, and ε_t represents the threshold, and the values are from 0 to 1.

The row and column allowed algorithm is produced by converting the various time series of innovative economic development into many events using the autoregressive time series approach. According to the prior value, the computed value is acquired at a specific time and the mean value of time series and observation time series is established and the autoregressive coefficient is minimized [19].

4.2. Microsoft Clustering.
Microsoft's clustering technique must be used to identify the grouping from the economic development data if the suitable grouping of innovation and economic development data are not immediately apparent.

The expectation maximization technique is used in the data clustering algorithm to distribute the cases to the data clustering. For the database d containing m elements and D continuous attributes, let each case $\in D$, and the probability expansion calculation of the cluster $h = 1, 2, \cdots, k$ to which x belongs can be expressed as

$$w_h^j(x) = \frac{\omega_h^j \times f_h\left(x \mid \mu_h^j \times \sum_h^j\right)}{\sum_i \omega_i^j \times f_i\left(x \mid \mu_i^j \times \sum_i^j\right)}. \tag{6}$$

In equation (6), ω_h^j represents the weight of aggregation h in the innovation economy database, f_h represents the function of the density of h aggregation components, and μ_h^j represents the j-dimensional vector composed in aggregation h.

We then update the mixed model parameter value and insert the acquired element probability structure into the model as shown

$$w_h^{j+1} = \sum_{x \in D} w_h^j(x). \tag{7}$$

A hypothetical function $\Phi | w_k, \mu_k, \sum_k |$ is used to construct a discriminant of functional relationships.

$$L(\Phi) = \sum_{x \in D} \log \left\langle \sum_{h=1}^k w_h \times f_h \left(x, \mu_k, \sum_k \right) \right\rangle. \tag{8}$$

When the model result satisfies $|L(\Phi^j) - L(\Phi^{j+1})| \leq \varepsilon$ If $j \leftarrow j + 1$, then we calculate the probability value of the other case [20].

The category of an object is determined using the expectation-maximization approach by calculating its probability. To get the standard deviation and mean deviation, the method treats any dimension as a bell curve [21]. A point's computation probability is classified into a certain class when it falls within the bell curve. The research on the trajectory of an innovative economy based on data mining in IIoT is finished through the aforementioned approach.

5. Experimental Results

To evaluate the performance of the innovation economy development path research based on data mining for IIoT proposed in this study, simulation experiments are carried out. Table 2 shows the experimental parameter settings.

The data clustering results of creative economic development data utilizing the data clustering technique proposed in this study and the multilevel distributed clustering approach are compared in Figures 5 and 6.

The analysis results of the data on innovative economic development using the clustering method proposed in this study are shown in Figures 5 and 6, respectively. The analysis results of the data on innovative economic development using the multilevel distributed clustering method are also shown in Figures 5 and 6. When the data on innovative economic development are clustered using the multilevel distributed clustering approach, the clustering impact is highly dispersed, which makes it difficult to effectively raise the level of innovative economic development, as can be observed by comparing Figures 5 and 6. The clustering impact is better and the stability of data mining is increased when the clustering approach described in this study is applied to cluster the innovative economic development data. The experimental findings demonstrate the effectiveness of the strategy proposed in this research in enhancing the capacity for creativity and economic growth.

Table 3 shows the comparison of the multilevel distributed clustering approach with the methods recommended in this research for data mining speed for innovative economic development for IIoT.

The five experimental data in Table 3 show that the speed of data mining for innovative economic development for IIoT using the multilevel distributed clustering method is maintained at 9.22 s, while the speed of data mining for innovative economic development using the method proposed in this study is maintained at 1.38 s. By contrasting the two approaches, the proposed approach requires less time for data mining than the multilevel distributed clustering approach. The outcomes of the experiments demonstrate that the proposed approach performs better.

TABLE 2: Settings for experimental parameters.

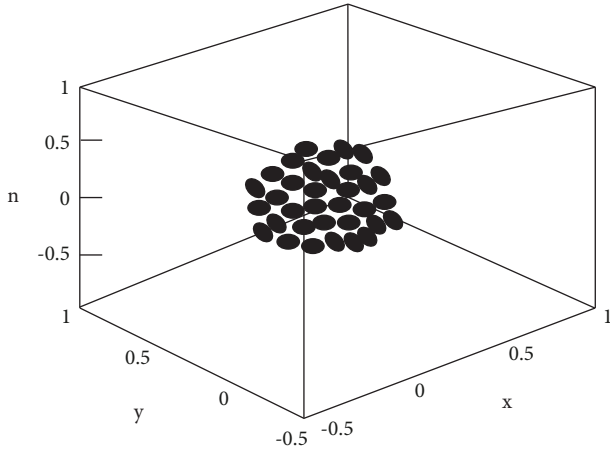| Experimental parameters	Data settings
Operating system	Windows 10
CPU	PIII/1gup
Database	MySQL database
Memory	16G
Simulation platform	MATLAB 2020

FIGURE 5: Clustering effect of innovative economic development data of the clustering method proposed in this study.
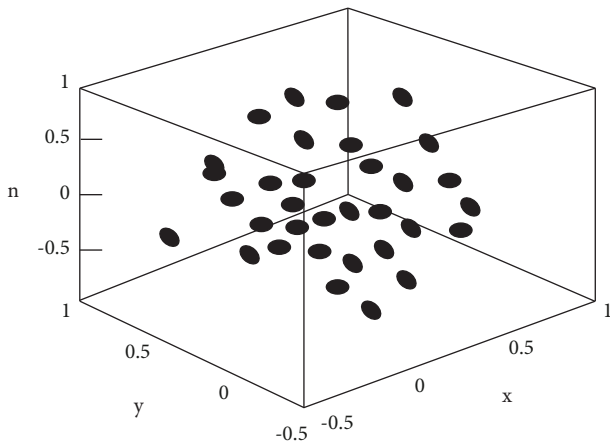

FIGURE 6: Clustering effect of the multilevel distributed clustering method on innovative economic development data.

TABLE 3: Comparison of data mining speed of innovative economic development by different methods.

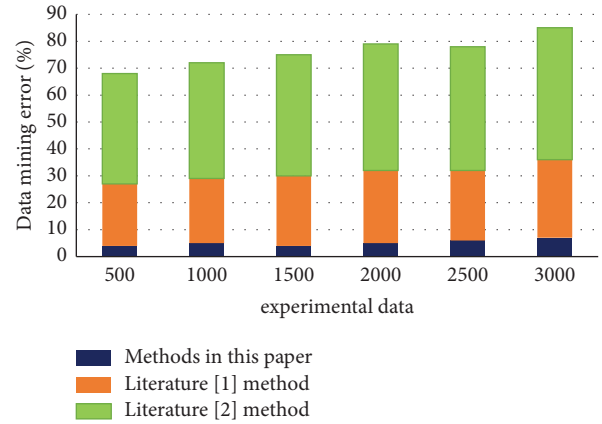| Number of experiments	The clustering method used in this study/s	The multilevel distributed clustering method/s
1	1.3	8.9
2	1.4	9.2
3	1.5	9.6
4	1.4	9.1
5	1.3	9.3

FIGURE 7: Comparison of data mining errors of the innovative economic development by different methods.

Figure 7 compares the approaches proposed in this article and literature [1, 2], to examine the data mining inefficiency of innovative economic development for IIoT.

The analysis of Figure 7 shows that the data mining error has remained steady at around 20% with the gradual expansion of experimental data when the approach suggested in literature [1] is applied to extract the data of innovative economic development. The data mining error has been maintained at around 40% with the steady expansion of experimental data when the approach provided in literature [2] is employed to dig the data of innovative economic development. The data mining error remained consistent below 10% while utilizing the approach proposed in this work to explore the data of creative economic development as the experimental data had been gradually increased. The experimental results demonstrated the effectiveness of the strategy proposed in this research for data mining of creative economic growth in the field of IIoT. The justification is that the method proposed in this study introduces the Microsoft time series algorithm and the expectation-maximization algorithm to conduct data mining of innovative economic development, using IIoT which can successfully reduce the error of data mining and the clustering mining performance has significant advantages.

6. Conclusion

The industrial sectors frequently use the concept "industrial internet of things" to refer to the IoT's industrial subset. The industrial internet of things has the potential to enhance productivity, improve analytics, and change the workplace. Innovative Economics, an emerging area of economics in the IIoT, combines the investigation of technology, knowledge, and entrepreneurship with an emphasis on innovation. A crucial strategic decision to redefine the new path of economic growth and strengthen the nation's global competitiveness is the new pattern of twofold circulation using IIoT. China's scientific and technical innovation needs to meet new criteria because it enters the next stage of its historical growth after the construction of a new double-cycle pattern. This study is specifically based on the pattern and perspective

of global strategy, and it analyzes the development path of the innovative economy against the new pattern of the double cycle and uses data mining technology to cluster the development data of the innovative economy so as to improve the industrial innovation capability in the field of IIoT. This study's observations keep a sharp focus on innovation and development to get around technical challenges in crucial areas such as national defense and military affairs and advance fundamental science and technology and establishes a new dynamic and double-cycle pattern with technological advancement to support the high-quality development of the social economy through innovation in science and technology using IIoT.

Data Availability

Data are available upon reasonable request from the corresponding author.

Conflicts of Interest

The author declares that there are no conflicts of interest.

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